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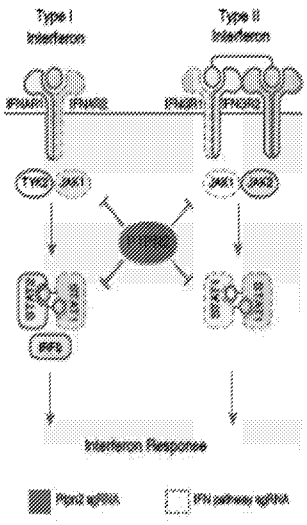
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(54) **Title:** MODULATING BIOMARKERS TO INCREASE TUMOR IMMUNITY AND IMPROVE THE EFFICIACY OF CANCER IMMUNOTHERAPY

(57) **Abstract:** The present invention relates, in part, to methods of treating a cancer in a subject comprising administering to the subject a therapeutically effective amount of an agent that inhibits one or more biomarkers in Table 1 in combination with an immunotherapy.

Figure 11 (cont.)

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WO 2018/148378 A1

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MODULATING BIOMARKERS TO INCREASE TUMOR IMMUNITY AND IMPROVE THE EFFICACY OF CANCER IMMUNOTHERAPY

Cross-Reference to Related Applications

This application claims the benefit of U.S. Provisional Application No. 62/456,432, filed on 8 February 2017, and U.S. Provisional Application No. 62/532,587, filed on 14 July 2017; the entire contents of each of said applications are incorporated herein in their entirety by this reference.

Background of the Invention

The striking clinical success of cancer immunotherapy with checkpoint blockade suggests it is likely to form the foundation of curative therapy for many malignancies (Reck *et al.* (2016) *N. Engl. J. Med.* 375:1823-1833; Hodi *et al.* (2010) *N. Engl. J. Med.* 363:711-723; Postow *et al.* (2015) *N. Engl. J. Med.* 372:2006-2017; Wolchok *et al.* (2013) *N. Engl. J. Med.* 369:122-133; Ferris *et al.* (2016) *N. Engl. J. Med.* 375:1856-1867; Brahmer *et al.* (2012) *N. Engl. J. Med.* 366:2455-2465; Nghiem *et al.* (2016) *N. Engl. J. Med.* 374:2542-2552; Topalian *et al.* (2012) *N. Engl. J. Med.* 366:2443-2454); Motzer *et al.* (2015) *N. Engl. J. Med.* 373:1803-1813). However, despite these successes, checkpoint blockade does not achieve sustained clinical response in most patients (Tumeh *et al.* (2014) *Nature* 515:568-571; Kelderman *et al.* (2014) *Mol. Oncol.* 8:1132-1139; Zaretsky *et al.* (2016) *N. Engl. J. Med.* 375:819-829). Additional therapeutic strategies are therefore needed to increase the clinical efficacy of immunotherapy. Moreover, the optimal strategy for combining emerging cancer immunotherapies with checkpoint blockade remains uncertain.

A relatively small number of genes, such as PD-L1, that enable tumors to evade the immune system have been discovered and most of these are already the focus of intense efforts to develop new immunotherapies (Freeman *et al.* (2000) *J. Exp. Med.* 192:1027-1034; Hirano *et al.* (2005) *Cancer Res.* 65:1089-1096; Dong *et al.* (2002) *Nat. Med.* 8:793-800; Balachandran *et al.* (2011) *Nat. Med.*17:1094-1100; Spranger *et al.* (2013) *Sci Transl Med.* 5:200ra116; Holmgaard *et al.* (2013) *J. Exp. Med.* 210:1389-1402; Sockolosky *et al.* (2016) *Proc. Natl. Acad. Sci. U.S.A.* 113:E2646-654; Liu *et al.* (2015) *Nat. Med.* 21:1209-1215; Weiskopf *et al.* (2016) *J. Clin. Invest.* 126:2610-2620; Tseng *et al.* (2013) *Proc. Natl. Acad. Sci. U.S.A.* 110: 11103-11108; Sica *et al.* (2003) *Immunity* 18:849-861; Zang *et al.* (2007) *Proc. Natl. Acad. Sci. U.S.A.* 104, 19458-19463). Although cancer cells could, in

theory, express many more genes that regulate their response or resistance to tumor immunity, strategies to systematically discover such genes are lacking.

Loss-of-function genetic screens have been increasingly used to study the functional consequences of gene deletion on tumor cells (Howard *et al.* (2016) Functional Genomic Characterization of Cancer Genomes. *Cold Spring Harb. Symp. Quant. Biol.* (2016); Ebert *et al.* (2008) *Nature* 451:335-339; Cowley *et al.* (2014) *Scientific Data* 1:article number 140035). These approaches include pooled genetic screens using CRISPR-Cas9-mediated genome editing that simultaneously test the role of a large number of genes on tumor cell growth, viability or drug resistance (Wang *et al.* (2014) *Science* 343:80-84; Shalem *et al.* (2014) *Science* 343:84-87). However, these screens have generally been conducted *in vitro*, where the contribution of the immune system is absent, or have studied phenotypes such as metastasis that do not directly evaluate the role of tumor immunity (Hart *et al.* (2015) *Cell* 163:1515-1526; Yu *et al.* (2016) *Nat. Biotechnol.* 34:419-423; Chen *et al.* (2015) *Cell* 160:1246-1260).

Despite the dramatic clinical success of cancer immunotherapy with PD-1 checkpoint blockade, most patients do not experience sustained clinical benefit from treatment. Accordingly a great need in the art exists for additional therapeutic strategies.

Summary of the Invention

The present invention is based, at least in part, on the discovery that modifying (*e.g.*, inhibiting/blocking or promoting one or more biomarkers listed in Table 1, such as one or more kinase signaling inhibitors (*e.g.*, PTPN2 and SOCS1)), in combination with an immunotherapy, results in a synergistic therapeutic benefit for treating cancers that is unexpected given the lack of such benefit observed for the immunotherapy alone.

In one aspect, a method of treating a subject afflicted with a cancer comprising administering to the subject a therapeutically effective amount of an agent that modifies the copy number, the expression level, and/or the activity of one or more biomarkers listed in Table 1 or a fragment thereof, in combination with an immunotherapy, optionally wheren in the agent inhibits the copy number, the expression level, and/or the activity of one or more biomarkers listed in Table 1 or a fragment thereof, is provided.

Numerous embodiments are further provided that can be applied to any aspect of the present invention and/or combined with any other embodiment described herein. For example, in one embodiment, the agent described herein decreases the copy number, the

expression level, and/or the activity of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors , such as tyrosine-protein phosphatase non-receptor type 2 (Ptpn2) and/or Suppressor Of Cytokine Signaling 1 (SOCS1)). In another embodiment, the agent selectively decreases the activity of one or more biomarkers in Table 1, such as decreasing the phosphatase activity and/or the substrate binding activity of one or more kinase signaling inhibitors (*e.g.*, Ptpn2 and/or SOCS1). In still another embodiment, the agent described herein is a small molecule inhibitor, CRISPR single-guide RNA (sgRNA), RNA interfering agent, antisense oligonucleotide, peptide or peptidomimetic inhibitor, aptamer, or intrabody. In another embodiment, the RNA interfering agent is a small interfering RNA (siRNA), CRISPR RNA (crRNA), a small hairpin RNA (shRNA), a microRNA (miRNA), or a piwi-interacting RNA (piRNA). In still another embodiment, the RNA interfering agent is a CRISPR single-guide RNA (sgRNA). In yet another embodiment, the sgRNA comprises a nucleic acid sequence selected from the group consisting of nucleic acid sequence listed in Table 2. In one embodiment, the agent described herein comprises an intrabody, or an antigen binding fragment thereof, which specifically binds to the one or more biomarkers in Table 1 and/or a substrate of the one or more biomarkers in Table 1. In another embodiment, the intrabody, or antigen binding fragment thereof, is murine, chimeric, humanized, composite, or human. In still another embodiment, the intrabody, or antigen binding fragment thereof, is detectably labeled, comprises an effector domain, comprises an Fc domain, and/or is selected from the group consisting of Fv, Fav, F(ab')2, Fab', dsFv, scFv, sc(Fv)2, and diabodies fragments. In yet another embodiment, the intrabody, or antigen binding fragment thereof, is conjugated to a cytotoxic agent. In one embodiment, the cytotoxic agent is selected from the group consisting of a chemotherapeutic agent, a biologic agent, a toxin, and a radioactive isotope. In still another embodiment, the agent described herein increases the sensitivity of the cancer cells to an immunotherapy. In another embodiment, the immunotherapy and/or a cancer therapy is administered before, after, or concurrently with the agent. In still another embodiment, the immunotherapy comprises an anti-cancer vaccine and/or virus. In yet embodiment, the immunotherapy is cell-based. In one embodiment, immunotherapy inhibits an immune checkpoint. In another embodiment, the immune checkpoint is selected from the group consisting of CTLA-4, PD-1, VISTA, B7-H2, B7-H3, PD-L1, B7-H4, B7-H6, ICOS, HVEM, PD-L2, CD160, gp49B, PIR-B, KIR family receptors, TIM-1, TIM-3, TIM-4, LAG-3, GITR, 4-IBB, OX-40, BTLA, SIRP, CD47, CD48, 2B4 (CD244), B7.1,

B7.2, ILT-2, ILT-4, TIGIT, HHLA2, butyrophilins, IDO, CD39, CD73 and A2aR. In still another embodiment, the immune checkpoint is selected from the group consisting of PD-1, PD-L1, and PD-L2. In yet another embodiment, the immune checkpoint is PD-1. In another embodiment, the one or more biomarker described herein comprises a nucleic acid sequence having at least 95% identity to a nucleic acid sequence listed in Table 1 and/or encodes an amino acid sequence having at least 95% identity to an amino acid sequence listed in Table 1. In another embodiment, the one or more biomarker is human, mouse, chimeric, or a fusion. In still another embodiment, the agent reduces the number of proliferating cells in the cancer and/or reduces the volume or size of a tumor comprising the cancer cells. In another embodiment, the agent increases the sensitivity of the cancer to the immunotherapy. In still another embodiment, the immunotherapy is T-cell-mediated. In yet another embodiment, the agent increases the amount of CD8+ T cells in a tumor comprising the cancer cells. In another another embodiment, the agent increases the level of MHC-I on the surface of the cancer cells. In one embodiment, the anti-cancer function of the agent is dependent on IFNγ signaling. In still another embodiment, the method described herein further comprises administering to the subject at least one additional cancer therapy or regimen. In another embodiment, the at least one additional cancer therapy or regimen is administered before, after, or concurrently with the agent and/or the immunotherapy. In another embodiment, the agent described herein is administered in a pharmaceutically acceptable formulation.

In another aspect, a method of killing cancer cells comprising contacting the cancer cells with an agent that inhibits the copy number, the expression level, and/or the activity of one or more biomarkers listed in Table 1 or a fragment thereof, in combination with an immunotherapy, is provided. As described above, numerous embodiments are further provided that can be applied to any aspect of the present invention and/or combined with any other embodiment described herein. For example, in one embodiment, the agent described herein decreases the copy number, the expression level, and/or the activity of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors , such as PTPN2 and SOCS1). In another embodiment, the agent selectively decreases activity of one or more biomarkers in Table 1, such as decreasing the phosphatase activity and/or the substrate binding activity of one or more kinase signaling inhibitors. In still another embodiment, the agent is a small molecule inhibitor, CRISPR single-guide RNA (sgRNA), RNA interfering agent, antisense oligonucleotide, peptide or peptidomimetic inhibitor,

aptamer, or intrabody. In one embodiment, the RNA interfering agent described herein is a small interfering RNA (siRNA), CRISPR RNA (crRNA), a small hairpin RNA (shRNA), a microRNA (miRNA), or a piwi-interacting RNA (piRNA). In another embodiment, the RNA interfering agent is a CRISPR single-guide RNA (sgRNA). In still another embodiment, the sgRNA comprises a nucleic acid sequence selected from the group consisting of nucleic acid sequence listed in Table 2. In one embodiment, the agent described herein comprises an intrabody, or an antigen binding fragment thereof, which specifically binds to the one or more biomarkers in Table 1 and/or a substrate of the one or more biomarkers in Table 1. In another embodiment, the intrabody, or antigen binding fragment thereof, is murine, chimeric, humanized, composite, or human. In still another embodiment, the intrabody, or antigen binding fragment thereof, is detectably labeled, comprises an effector domain, comprises an Fc domain, and/or is selected from the group consisting of Fv, Fav, F(ab')2, Fab', dsFv, scFv, sc(Fv)2, and diabodies fragments. In yet another embodiment, the intrabody, or antigen binding fragment thereof, is conjugated to a cytotoxic agent. In one embodiment, the cytotoxic agent is selected from the group consisting of a chemotherapeutic agent, a biologic agent, a toxin, and a radioactive isotope. In one embodiment, the agent described herein increases the sensitivity of the cancer cells to an immunotherapy. In another embodiment, the cancer cells are contacted with an immunotherapy and/or a cancer therapy before, after, or concurrently with the agent. In still another embodiment, the immunotherapy comprises an anti-cancer vaccine and/or virus. In one embodiment, the immunotherapy is cell-based. In another embodiment, the immunotherapy inhibits an immune checkpoint. In still another embodiment, the immune checkpoint is selected from the group consisting of CTLA-4, PD-1, VISTA, B7-H2, B7-H3, PD-L1, B7-H4, B7-H6, ICOS, HVEM, PD-L2, CD160, gp49B, PIR-B, KIR family receptors, TIM-1, TIM-3, TIM-4, LAG-3, GITR, 4-IBB, OX-40, BTLA, SIRP, CD47, CD48, 2B4 (CD244), B7.1, B7.2, ILT-2, ILT-4, TIGIT, HHLA2, butyrophilins, IDO, CD39, CD73 and A2aR. In yet another embodiment, the immune checkpoint is selected from the group consisting of PD-1, PD-L1, and PD-L2. In one embodiment, the immune checkpoint is PD-1. In another embodiment, the biomarker described herein comprises a nucleic acid sequence having at least 95% identity to a nucleic acid sequence listed in Table 1 and/or encodes an amino acid sequence having at least 95% identity to an amino acid sequence listed in Table 1. In still another embodiment, the one or more biomarker is human, mouse, chimeric, or a fusion. In one embodiment, the agent described herein

reduces the number of proliferating cells in the cancer and/or reduces the volume or size of a tumor comprising the cancer cells. In another embodiment, the agent increases the sensitivity of the cancer to the immunotherapy. In still another embodiment, the immunotherapy is T-cell-mediated. In yet another embodiment, the agent increases the amount of CD8+ T cells in a tumor comprising the cancer cells. In one embodiment, the agent increases the level of MHC-I on the surface of the cancer cells. In another embodiment, the anti-cancer function of the agent is dependent on IFNγ signaling. In one embodiment, the method described herein further comprises administering to the subject at least one additional cancer therapy or regimen. In another embodiment, the at least one additional cancer therapy or regimen is administered before, after, or concurrently with the agent and/or the immunotherapy. In another embodiment, the agent described herein is administered in a pharmaceutically acceptable formulation.

In still another aspect, a method of determining whether a subject afflicted with a cancer or at risk for developing a cancer would benefit from inhibiting the copy number, amount, and/or activity of at least one biomarker listed in Table 1 is provided, the method comprising a) obtaining a biological sample from the subject; b) determining the copy number, amount, and/or activity of at least one biomarker listed in Table 1; c) determining the copy number, amount, and/or activity of the at least one biomarker in a control; and d) comparing the copy number, amount, and/or activity of the at least one biomarker detected in steps b) and c); wherein the presence of, or a significant increase in, the copy number, amount, and/or activity of, the at least one biomarker listed in Table 1 in the subject sample relative to the control copy number, amount, and/or activity of the at least one biomarker indicates that the subject afflicted with the cancer or at risk for developing the cancer would benefit from inhibiting the copy number, amount, and/or activity of the at least one biomarker listed in Table 1. In one embodiment, the method described herein further comprises recommending, prescribing, or administering an agent that inhibits the at least one biomarker listed in Table 1 if the cancer is determined to benefit from the agent. In another embodiment, the method described herein further comprises administering at least one additional cancer therapy that is administered before, after, or concurrently with the agent. In still another embodiment, the method described herein further comprises recommending, prescribing, or administering cancer therapy other than an agent that inhibits the at least one biomarker listed in Table 1 if the cancer is determined to not benefit from the agent. In yet another embodiment, the cancer therapy is selected from the group

consisting of immunotherapy, targeted therapy, chemotherapy, radiation therapy, hormonal therapy, an anti-cancer vaccine, an anti-cancer virus, and a checkpoint inhibitor. In one embodiment, the control sample is determined from a cancerous or non-cancerous sample from either the patient or a member of the same species to which the patient belongs. In another embodiment, the control sample comprises cells.

In yet another aspect, a method for predicting the clinical outcome of a subject afflicted with a cancer expressing one or more biomarkers listed in Table 1 or a fragment thereof to treatment with an immunotherapy is provided, the method comprising a) determining the copy number, amount, and/or activity of at least one biomarker listed in Table 1 in a subject sample; b) determining the copy number, amount, and/or activity of the at least one biomarker in a control having a good clinical outcome; and c) comparing the copy number, amount, and/or activity of the at least one biomarker in the subject sample and in the control; wherein the presence of, or a significant increase in, the copy number, amount, and/or activity of, the at least one biomarker listed in Table 1 in the subject sample as compared to the copy number, amount and/or activity in the control, is an indication that the subject has a poor clinical outcome.

In another aspect, a method for monitoring the progression of a cancer in a subject, wherein the subject is administered a therapeutically effective amount of an agent that inhibits the copy number, amount, and/or activity of at least one biomarker listed in Table 1 and an immunotherapy is provided, the method comprising a) detecting in a subject sample at a first point in time the copy number, amount, and/or activity of at least one biomarker listed in Table 1; b) repeating step a) at a subsequent point in time; and c) comparing the amount or activity of at least one biomarker listed in Table 1 detected in steps a) and b) to monitor the progression of the cancer in the subject.

In still another aspect, a method of assessing the efficacy of an agent that inhibits the copy number, amount, and/or activity of at least one biomarker listed in Table 1 and an immunotherapy for treating a cancer in a subject is provided, comprising a) detecting in a subject sample at a first point in time the copy number, amount, and/or or activity of at least one biomarker listed in Table 1; b) repeating step a) during at least one subsequent point in time after administration of the agent and the immunotherapy; and c) comparing the copy number, amount, and/or activity detected in steps a) and b), wherein the absence of, or a significant decrease in, the copy number, amount, and/or activity of, the at least one biomarker listed in Table 1, in the subsequent sample as compared to the copy number,

amount, and/or activity in the sample at the first point in time, indicates that the agent and immunotherapy treats the cancer in the subject. In one embodiment, between the first point in time and the subsequent point in time, the subject has undergone treatment, completed treatment, and/or is in remission for the cancer. In another embodiment, the cancer treatment is selected from the group consisting of immunotherapy, targeted therapy, chemotherapy, radiation therapy, hormonal therapy, an anti-cancer vaccine, an anti-cancer virus, and a checkpoint inhibitor. In still another embodiment, the first and/or at least one subsequent sample is selected from the group consisting of *ex vivo* and *in vivo* samples. In yet another embodiment, the first and/or at least one subsequent sample is a portion of a single sample or pooled samples obtained from the subject.

In one embodiment, the sample described herein comprises cells, serum, peritumoral tissue, and/or intratumoral tissue obtained from the subject. In one embodiment, the one or more biomarkers listed in Table 1 comprises Ptpn2 and/or SOCS1. In another embodiment, the cancer is responsive to IFNγ. In still another embodiment, the cancer cells are in a parainflamed tumor. In yet another embodiment, the cancer cells produce interferon.

In one embodiment, the cancer described herein is selected from the group consisting of melanoma, colorectal cancer, gliomas, neuroblastoma, prostate cancer, breast cancer, pancreatic ductal carcinoma, epithelial ovarian cancer, B-CLL, leukemia, B cell lymphoma, and renal cell carcinoma. In another embodiment, the cancer is in a subject and the subject is an animal model of the cancer. In still another embodiment, the animal model is a mouse model. In one embodiment, the cancer is in a subject and the subject is a mammal. In another embodiment, the mammal is a mouse or a human. In still another embodiment, the mammal is a human.

In still another aspect, an agent that inhibits one or more kinase signaling inhibitors (*e.g.*, biomarkers in Table 1, such as PTPN2 and SOCS1) is provided for treating a cancer in a subject, in combination with an immunotherapy. Such agent may comprise a small molecule inhibitor, an RNA interfering agent, an antisense oligonucleotide, a peptide or peptidomimetic inhibitor, an aptamer, and/or an intrabody, as described herein.

In yet another aspect, a vector comprising an agent that inhibits one or more kinase signaling inhibitors (*e.g.*, biomarkers in Table 1, such as PTPN2 and SOCS1) for treating a cancer in a subject, in combination with an immunotherapy, is provided.

In another aspect, a host cell which comprises an agent that inhibits one or more kinase signaling inhibitors (*e.g.*, biomarkers in Table 1, such as PTPN2 and SOCS1) for treating a cancer in a subject, in combination with an immunotherapy, is provided.

In still another aspect, a host cell which comprises a vector comprising an agent that inhibits one or more kinase signaling inhibitors (*e.g.*, biomarkers in Table 1, such as PTPN2 and SOCS1) for treating a cancer in a subject, in combination with an immunotherapy, is provided.

In yet another aspect, a device or kit comprising the agent that inhibits one or more kinase signaling inhibitors (*e.g.*, biomarkers in Table 1, such as PTPN2 and SOCS1) for treating a cancer in a subject, in combination with an immunotherapy, is provided.

Although the aspects and embodiments described above provide representative embodiments for biomarkers of the present invention, such as those listed in Table 1, for which inhibition in combination with an immunotherapy, results in a synergistic therapeutic benefit for treating cancers that is unexpected given the lack of such benefit observed for the immunotherapy alone, certain biomarkers clearly described herein, especially at Table 1, whose promoted expression rather than inhibition in combination with an immunotherapy (*e.g.*, identified as being enriched in the sgRNA screen rather than being depleted), results in a synergistic therapeutic benefit for treating cancers, are readily apparent. Thus, any aspect and embodiment described herein and above can use such biomarkers and their promoted expression in diagnostic, prognostic, therapeutic, etc. applications regarding immunotherapy and cancers. For example, in one aspect, a method of killing cancer cells comprising contacting the cancer cells with an agent that promotes rather than inhibits the copy number, the expression level, and/or the activity of one or more such biomarkers listed in Table 1 or a fragment thereof, in combination with an immunotherapy, is provided. In another representative aspect, a method of determining whether a subject afflicted with a cancer or at risk for developing a cancer would benefit from promoting the copy number, amount, and/or activity of such at least one biomarker listed in Table 1 is provided, the method comprising a) obtaining a biological sample from the subject; b) determining the copy number, amount, and/or activity of at least one biomarker listed in Table 1; c) determining the copy number, amount, and/or activity of the at least one biomarker in a control; and d) comparing the copy number, amount, and/or activity of the at least one biomarker detected in steps b) and c); wherein the absence of, or a significant decrease in, the copy number, amount, and/or activity of, the at least one

biomarker listed in Table 1 in the subject sample relative to the control copy number, amount, and/or activity of the at least one biomarker indicates that the subject afflicted with the cancer or at risk for developing the cancer would benefit from promoting the copy number, amount, and/or activity of the at least one biomarker listed in Table 1.

Brief Description of the Drawings

Figure 1 includes 6 panels, identified as panels A, B, C, D, E, and F, which show that *in vivo* pooled loss-of-function screening using CRISPR/Cas9 in tumor cells recovers known mediators of immune evasion. Panel A shows a schematic diagram of the *in vivo* screening system using the B16 transplantable tumor model. Tumor volumes (in mm^3) were compared under each condition, averaged for each group at each time point (Panel B, left) or for individual animals on the day of sacrifice (Panel B, right). Bars represent means, while whiskers represent standard deviation. Enrichment analysis was carried out using a hypergeometric test to show functional classes of genes, (from the Gene Ontology Consortium database (GO)) targeted by sgRNAs, that were enriched or depleted in tumors in animals, including animals treated with irradiated tumor cell vaccine (GVAX) and anti-PD-1 antibody and the $TCR\alpha^{-/-}$ animals (Panel C). Frequency histogram (Panel D, top) and collapsed histograms (Panel D, middle) of enrichment or depletion (normalized as Z scores) are shown for all 9,992 sgRNAs screened. Enrichment/depletion scores are averaged from 10 mice per condition. sgRNAs targeting PD-L1 are indicated by the red lines (Panel D, middle). PD-L1 expression is compared among Cas9-expressing B16 tumor cells transfected with one of the four sgRNAs targeting PD-L1 (red) or a control sgRNA (grey) (Panel D, bottom). Similar to Panel D, Panel E shows the depletion of CD47 by its specific sgRNAs (indicated in red (top and middle) and CD47 expression after CRISPR editing with sgRNAs targeting CD47 (bottom). Panel F compares tumor volumes over time between CD47 null (red) and control (grey) tumors growing in mice treated with GVAX and PD-1 blockade (average and standard error of the mean; n = 10 animals per group). ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$.

Figure 2 includes 6 panels, identified as panels A, B, C, D, E, and F, which show the performance analysis of the screening in Figure 1. Panel A shows Western blot of B16 cell lysate for Cas9 and β-ACTIN with or without transduction with a lentiviral vector encoding Cas9. A pie chart shows the fraction of genes targeted in the screening in each of the GO term categories indicated (Panel B). Two-dimensional histograms show the pair-

wise distribution of sgRNAs abundance (averaged for each condition) (Panel C). Saturation analysis of animal replicates from the three *in vivo* screening conditions is shown in Panel D. Pearson correlations are calculated for the library distribution in one animal vs. any other animal, then for two animals averaged versus any other two averaged, and so on. Saturation approaches r = 0.95. A matrix of the Pearson correlations of the library distribution from one animal compared to any other animal for B16 Pool 1 is shown (Panel E). Expression of CD47 by B16 cells transfected with either CD47-targeting (red) or control (grey) sgRNA is compared (Panel F).

Figure 3 includes 9 panels, identified as panels A, B, C, D, E, F, G, H, and I, which show that loss of IFNγ pathway genes causes resistance to immunotherapy. Panel A shows frequency histogram (top) and collapsed histograms (below) of enrichment or depletion (normalized as z scores) for all sgRNAs in GVAX+ PD-1 blockade-treated mice relative to $TCR\alpha^{-/-}$ mice, as in Figure 1. Red bars indicate the sgRNAs for the genes listed on the left. Schematic diagram of *in vivo* competitive growth assay using B16 cells is shown for different mice receiving a mixture of tumor cells containing targeting sgRNA or control sgRNA (Panel B). Representative flow plots show the frequencies of control or *Stat1* null B16 cells for the conditions indicated (Panel C). Specifically, mixtures of *Stat1* null tumors and control tumors (in a 1:10 ratio) were tested *in vitro*, in $TCR\alpha^{-/-}$ mice, or GVAX + PD-1 blockade-treated wild-type mice. The B16 cell numbers in immunotherapy-treated wild-type mice (treated with different sgRNAs) were compared relative to those in $TCR\alpha^{-/-}$ mice, the change in the ratios (log_2 normalized fold change) is shown in Panel D (mean and standard deviation; n = 8-10 mice per group). Tumor growth in immunotherapy-treated animals challenged with B16 cells lacking the indicated genes is compared (Panel E, each line represents one animal; n = 5 animals per group). Tumor volume averaged for each group at each time point (left) and survival (right) for *Braf/Pten* melanoma cells lacking the indicated gene (by treatment of the indicated sgRNAs) are compared in mice treated with PD-1 blockade (mean and standard error of the mean; n = 5 animals per group) (Panel F). The increases in cell number of B16 cells from wild-type mice treated with different sgRNAs were compared after an *in vitro* treatment with cytokines, and the change in the ratios (log_2 normalized fold change) is shown in Panel G (mean and standard deviation; n = 3 replicates per group). Expression of MHC-I (H2K(b)/H2D(b)) on B16 cells lacking the indicated genes is compared with or without IFNγ treatment (Panel H). In an *in vitro* killing assay, wild-type B16 cells (treated with control sgRNA) and *Stat1* null ovalbumin-

expressing B-16 cells (treated with *Stat1* sgRNA) were co-cultured with ovalbumin-specific T cells in different ratios as indicated. The B16 cell number was compared for each condition and the change in the ratios (log_2 normalized fold change) (mean and standard deviation; $n = 3$ replicates per group) is shown in Panel I. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$.

Figure 4 includes 7 panels, identified as panels A, B, C, D, E, and F, which show the deletion of interferon pathway molecules from tumor cells. Panel A shows a Western blot of B16 cell lysate for STAT1 (left) and JAK1 (right) after transfection with the indicated sgRNA and Cas9. β-ACTIN serves as a loading control. The numbers below the lane indicate the percent expression of the target relative to control sgRNA cells. Same blots were also carried out for *Braf/Pten* melanoma cells (Panel B). Expression of *Ifngr1* by B16 cells transfected with the indicated *Ifngr1*-targeting (red) or control (grey) sgRNA and Cas9 is compared (left) and quantified in mean fluorescence intensity (right) (mean and standard deviation) (Panel C). The same expression was compared for *Braf/Pten* melanoma cells (Panel D). Expression of *Ifnar2* by B16 cells transfected with the indicated *Ifnar2*-targeting (red) or control (grey) sgRNA and Cas9 is compared (left) and quantified in mean fluorescence intensity (right) (mean and standard deviation) (Panel E). Western blot of *Braf/Pten* melanoma cell lysate for PTPN2 and β-ACTIN after transfection with either control or *Ptpn2*-targeting sgRNAs is shown (Panel F, left) and *Ptpn2* transcript abundance for the same conditions is measured by qPCR (mean and standard deviation) (Panel F, right). ** $p < 0.01$.

Figure 5 includes 10 panels, identified as panels A, B, C, D, E, F, G, H, I, and J, which show that deletion of *Ptpn2* sensitizes tumor cells to immunotherapy. Panel A shows frequency histogram (top) and collapsed histogram (below) of enrichment or depletion (normalized as Z scores) for all sgRNAs in GVAX + PD-1 blockade-treated mice relative to $TCR\alpha^{-/-}$ mice, as in previous figures. sgRNAs are indicated in red. Western blot of B16 cell lysate for PTPN2 and β-ACTIN after transfections with either control or *Ptpn2*-targeting sgRNAs is compared (Panel B, left). Corresponding *Ptpn2* transcript abundance was measured by qPCR and is shown in the percentage to control level (mean and standard deviation) (Panel B, right). Representative flow plots show frequencies of *Ptpn2* null and control B16 tumor cells in mixture *in vitro* or *in vivo* (Panel C, right), compared to the mixture of tumor cells treated with either one of two control sgRNAs (Panel C, left). Panel D shows the change in the ratios (log_2 normalized fold change) of B16 cells lacking the

indicated genes:control cells in immunotherapy-treated mice compared to TCRα$^{-/-}$ mice (mean and standard deviation; n = 3-5 mice per group). The cell number of either *Ptpn2* null or control B16 cells grown in GVAX + PD-1 blockade-treated wild-type mice, relative to the cell number of those cells grown in TCRα$^{-/-}$ mice, is shown in change in the ratios (log_2 normalized fold change) (mean and standard deviation; $n = 5$ animals per group) (Panel E). Representative flow plots show the frequencies of *Ptpn2* null, rescued, or overexpressing B16 cells and control B16 cells for the conditions indicated on the left (Panel F). The cell number of *Ptpn2* null, rescued, or overexpressing B16 cells or control B16 cells in immunotherapy-treated mice is compared relative to the input population, and shown in change in the ratios (log_2 normalized fold change) (mean and standard deviation; $n = 5$ animals per group) (Panel G). Tumor volume, averaged for each group at each time point, for *Ptpn2* null (red) or control (grey) B16 cells growing in mice treated with GVAX and PD-1 blockade was compared (mean and standard error of the mean; $n = 20$ animals per group) (Panel H). Survival analysis for such groups is also shown (Panel I). Panel J shows tumor volume, averaged for each group at each time point, for *Ptpn2* null (red) or control (grey) *Braf/Pten* melanoma cells growing in untreated WT mice is compared (mean and standard error of the mean; $n = 10$ animals per group). * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$.

Figure 6 includes 10 panels, identified as panels A, B, C, D, E, F, G, H, I, and J, which show that *Ptpn2* null tumor cells do not have a growth disadvantage *in vivo* in the absence of T cells or immunotherapy. Tumor volume, averaged for each group at each time point, for *Ptpn2* null (red) or control (grey) B16 cells growing in wild-type (WT) mice with no treatment is shown (mean and standard error of the mean; $n = 10$ animals per group) (Panel A). The corresponding survival analysis for the groups is shown in Panel B. Similarly, tumor volume, averaged for each group at each time point, for *Ptpn2* null (red) or control (grey) B16 cells growing in TCRα$^{-/-}$ mice with no treatment is shown in Panel C (mean and standard error of the mean; $n = 10$ animals per group) and the corresponding survival analysis is shown in Panel D. Tumor volume, averaged for each group at each time point, for *Ptpn2* null (red) or control (grey) *Braf/Pten* melanoma cells growing in TCRα$^{-/-}$ mice with no treatment is shown in Panel E (mean and standard error of the mean; $n = 5$ animals per group). The corresponding survival analysis is shown in Panel F. The tumor volume averaged for each group is compared at each time point for *Ptpn2* null (red) or control (grey) MC38 cells growing in WT (Panel G) or TCRα$^{-/-}$ (Panel I) mice with no

treatment (mean and standard error of the mean; $n = 10$ animals per group). The corresponding survival analyses are shown in Panel H and Panel J, respectively.

Figure 7 includes 6 panels, identified as panels A, B, C, D, E, and F, which show that *Ptpn2* deficient tumor cells present antigen and stimulate T cells better than wild-type tumor cells. The number of different lymphoid cells per milligram of tumor was quantified in either *Ptpn2* null (red) or control (grey) B16 tumors (mean and standard deviation; $n = 8$-10 animals per group) (Panel A). Panel B shows representative images of immunohistochemistry staining for CD8α in either control or *Ptpn2* null tumors (left) and quantification of the average number of infiltrating CD8+ cells in each group (right) (mean and standard devation; $n = 4$-5 animals per group). Granzyme B expression by $CD8^+$ T cells in *Ptpn2* null (red) or control (grey) B16 tumors (left) was analyzed by representative histogram (Panel C, left) and quantified in the percentage of Granzyme B^+ $CD8^+$ T cells from each group (Panel C, right) (mean and standard deviation; $n = 8$-10 animals per group). SIINFEKL-H2K(b) presentation on the surface of *Ptpn2* null (red) or control (grey) B16 cells after IFNγ stimulation for 72 hours was measured (Panel D, left) and quantified in mean fluorescence intensity (Panel D, right) (mean and standard deviation). Intracellular expression of IFNγ and TNF by $CD8^+$ T cells after re-stimulation with *Ptpn2* null (red) or control (grey) B16 cells was measured (Panel E, left) and quantified for indicated populations (Panel E, right) (mean and standard deviation). *Ptpn2* null (red) or control (grey) B16 cells were co-cultured with antigen-specific T cells, in the indicated ratio of T cells:tumor cells. The increased cell number after co-culturing was compared and is shown in change in the ratios (log_2 normalized fold change) (Panel F). * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Figure 8 includes 4 panels, identified as panels A, B, C, and D, which show that *Ptpn2* null tumors have increased effector T cell populations but no other significant differences in immune infiltrates compared with control tumors. Panel A contains representative plots showing the gating strategy used in Panel A of Figure 7. Populations of interest are gated in blue. The number of CD45+ cells per mg of tumor for *Ptpn2* null (red) and control (grey) B16 tumors is compared (Panel B) (mean and standard deviation). Populations of interest are gated in blue. Effector T cell populations in either *Ptpn2* null (red) or control (grey) B16 tumors were quantified and compared (Panel D) (mean and standard deviation). Data pooled from 2 independent experiments with a minimum of 8

mice per group. The corresponding gating strategy for the quantification in Panel D is shown with representative plots (Panel C).

Figure 9 includes 2 panels, identified as panels A and B, which show that *Ptpn2* null tumors show no significant differences in myeloid cell infiltration compared to control tumors. Numbers of myeloid cells per mg of tumor for *Ptpn2* null (red) and control (grey) B16 tumors were quantified and compared (Panel B) (mean and standard deviation). Data pooled from 2 independent experiments with a minimum of 8 mice per group. The corresponding gating strategy is shown with representative plots (Panel A) (Broz *et al.* (2014) *Cancer Cell* 26: 638-652). Populations of interest are gated in blue.

Figure 10 includes 2 panels, identified as panels A and B, which show that *Ptpn2* null tumor cells have increased MHC-I expression after IFNγ stimulation and have increased sensitivity to costimulation with TNF and IFNγ. Expression of MHC-I (H2K(b)/H2D(b)) on either *Ptpn2* null (red) or control (grey) B16 cells after stimulation with IFNγ for 72 hours were compared (left) and quantified in mean fluorescence intensity (right) (Panel A) (mean and standard deviation). Panel B shows gene set enrichment analysis showing enrichment of signatures for IFNγ, IFNα, and TNFα signaling via NFκB in *Ptpn2* null B16 cells after costimulation with TNF and IFNγ relative to *Ptpn2* null cells stimulated with IFNγ alone.

Figure 11 includes 9 panels, identified as panels A, B, C, D, E, F, G, H, and I, which show that *Ptpn2* deficiency renders tumor cells more sensitive to immunotherapy by increasing sensitivity to IFNγ. Western blot show levels of phosphorylated STAT1 after IFNγ treatment of control, *Ptpn2* null, rescued, or overexpressing B16 cells (Panel A). Principle components analysis of gene expression profiles from *Ptpn2* null (closed symbols) or control (open symbols) B16 cells was carried out with or without the cytokine treatment indicated (Panel B). Numbered vectors correspond to the correlation of the gene signatures indicated to the principle component vectors shown. Panel C shows heat map of differentially expressed genes in the IFNγ signature in either *Ptpn2* null or control B16 cells after treatment with the indicated combinations of cytokines. B16 cells transfected with the indicated sgRNAs or control B16 cells were treated with different cytokines. Panel D shows gene set enrichement analysis for IFNγ signature genes in *Ptpn2* null cells relative to control cells for B16 melanoma (top) and four human cancer cell lines (bottom). The increase of cell numbers before and after cytokine treatment was compared and shown in change in the ratios (log_2 normalized fold change) (Panel E) (mean and standard deviation;

$n = 3$ replicates per group). Panel F shows the change in the ratios (log_2 normalized fold change) of human A375 melanoma cells or HT-29 colon carcinoma cells infected with the indicated sgRNA:control cells after cell culture with the cytokines indicated below (mean and standard deviation; $n = 3$ replicates per group). Panel G shows a diagram of the type I and type II interferon pathway and further shows the targets of *Ptpn2*. Genetic epistasis in the pathway was tested by transfecting cells with a sgRNA for *Ptpn2* (filled red circle) and a sgRNA for a member of the interferon pathway (dashed red line) potentially epistatic to Ptpn2 (Panel G). Representative flow plots show the frequencies of *Stat1*/*Ptpn2* double-null cells and *Stat1* null cells in the conditions indicated (*in vitro* or in GVAX + PD-1 blockade-treated wild-type mice) (Panel H, right) and the frequencies of *Ptpn2* null cells and control cells (Panel H, left). Population 2 (blue) B16 cells were grown in immunotherapy-treated mice and their increase of cell number were compared and shown in change in the ratios (log_2 normalized fold change) relative to the input population (Panel I) (mean and standard deviation; $n = 5$ mice per group). ** $p < 0.01$; *** $p < 0.001$.

Figure 12 shows that sensitivity to IFNγ can be increased using small molecule inhibitors of PTP1B. Change in the ratios (log_2 normalized fold change) of B16 cells transfected with the *Ptpn2* sgRNA:control cells is compared after either IFNγ or IFNγ + PTP1B inhibitor treatment (mean and standard deviation; n = 3 replicates per group). * $P < 0.05$.

Detailed Description of the Invention

It has been determined herein that modulatory regulators of one or more biomarkers in Table 1, *e.g.*, inhibitors one or more kinase signaling inhibitors, such as PTPN2 and SOCS1, can be used to augment tumor immunity and immunotherapies, such as by increase interferon sensing by tumor cells. Thus, the instant disclosure provides at least a method of treating cancers, *e.g.*, those cancer types otherwise not responsive or weakly responsive to immunotherapies, with a combination of a biomarker modulator, such as a negative regulator of PTPN2, and/or SOCS1, and another immunotherapy. Tyrosine-protein phosphatase non-receptor type 2 (PTPN2) is a member of the protein tyrosine phosphatase (PTP) family. PTPN2 dephosphorylates receptor protein tyrosine kinases, including INSR, EGFR, CSF1R, PDGFR, as well as non-receptor protein tyrosine kinases like JAK1, JAK2, JAK3, Src family kinases, STAT1, STAT3, STAT5A, STAT5B and STAT6, either in the nucleus or the cytoplasm (Shuai *et al.* (2003) *Nat. Rev. Immunol.* 3:900-911; Wiede *et al.*

(2011) *J. Clin. Invest.* 121:4758-4774; Simoncic *et al.* (2006) *Mol. Cell Biol.* 26:4149-4160; Kleppe *et al.* (2010) *Nat. Genet.* 42:530-535; Zhou *et al.* (2014) *Nature* 506:52-57). Since PTPN2 has numerous pleiotropic activties, such as negatively regulating numerous signaling pathways and biological processes like hematopoiesis, inflammatory response, cell proliferation and differentiation, and glucose homeostasis, the particular heretofore unknown and critical effect that PTPN2 exerts on interferon sensing as a gateway regulator of tumor immunity and immunotherapy is surprising. The results described herein ares all the more unexpected given that analyses of PTPN2 function has heretofore been largely confined to hematopoietic cells and not examined in cancer cells, as well as the fact that modulating sensitivity to interferon signaling is critical for immunotherapy effects rather than simply modulating interferon availability since interferon therapy is known to not significantly augment immunotherapy effects. Accordingly, the present invention provides exemplary RNA interfering agents inhibiting one or more biomarkers in Table 1, *e.g.*, one or more kinase signaling inhibitors , such as PTPN2 and SOCS1, which may be used in the combination therapy and other methods described herein, such as agents that inhibit the function of one or more biomarkers in Table 1 and/or their ability to interact/bind to their substrates described herein, or by increasing its degradation and/or stability and/or interaction/binding to their inhibitors. Similarly, methods of screening for inhibitors of one or more biomarkers in Table 1, *e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1, and methods of diagnosing, prognosing, and monitoring cancer involving such inhibitor/immunotherapy combination therapies are provided. As described above, certain of the one or more biomarkers described herein and especially in Table 1 can be inhibited to promote anti-cancer immunotherapy effects and related cancer diagnostic, prognostic, and monitoring methods and certain other biomarkers described herein and especially in Table 1 can have the opposite modulation to effect similar results (e.g., they can be promoted to promote anti-cancer immunotherapy effects and related cancer diagnostic, prognostic, and monitoring methods).

I. Definitions

The articles "a" and "an" are used herein to refer to one or to more than one (*i.e.* to at least one) of the grammatical object of the article. By way of example, "an element" means one element or more than one element.

The term "altered amount" or "altered level" refers to increased or decreased copy number (*e.g.*, germline and/or somatic) of a biomarker nucleic acid, *e.g.,* increased or decreased expression level in a cancer sample, as compared to the expression level or copy number of the biomarker nucleic acid in a control sample. The term "altered amount" of a biomarker also includes an increased or decreased protein level of a biomarker protein in a sample, *e.g.,* a cancer sample, as compared to the corresponding protein level in a normal, control sample. Furthermore, an altered amount of a biomarker protein may be determined by detecting posttranslational modification such as methylation status of the marker, which may affect the expression or activity of the biomarker protein.

The amount of a biomarker in a subject is "significantly" higher or lower than the normal amount of the biomarker, if the amount of the biomarker is greater or less, respectively, than the normal level by an amount greater than the standard error of the assay employed to assess amount, and preferably at least 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 150%, 200%, 300%, 350%, 400%, 500%, 600%, 700%, 800%, 900%, 1000% or than that amount. Alternately, the amount of the biomarker in the subject can be considered "significantly" higher or lower than the normal amount if the amount is at least about two, and preferably at least about three, four, or five times, higher or lower, respectively, than the normal amount of the biomarker. Such "significance" can also be applied to any other measured parameter described herein, such as for expression, inhibition, cytotoxicity, cell growth, and the like.

The term "altered level of expression" of a biomarker refers to an expression level or copy number of the biomarker in a test sample, *e.g.,* a sample derived from a patient suffering from cancer, that is greater or less than the standard error of the assay employed to assess expression or copy number, and is preferably at least twice, and more preferably three, four, five or ten or more times the expression level or copy number of the biomarker in a control sample (*e.g.*, sample from a healthy subjects not having the associated disease) and preferably, the average expression level or copy number of the biomarker in several control samples. The altered level of expression is greater or less than the standard error of the assay employed to assess expression or copy number, and is preferably at least 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 150%, 200%, 300%, 350%, 400%, 500%, 600%, 700%, 800%, 900%, 1000% or more times the expression level or copy number of the biomarker in a control sample (*e.g.*, sample from a healthy subjects not having the associated disease) and preferably, the average expression level or copy number of the

biomarker in several control samples. In some embodiments, the level of the biomarker refers to the level of the biomarker itself, the level of a modified biomarker (*e.g.*, phosphorylated biomarker), or to the level of a biomarker relative to another measured variable, such as a control (*e.g.*, phosphorylated biomarker relative to an unphosphorylated biomarker).

The term "altered activity" of a biomarker refers to an activity of the biomarker which is increased or decreased in a disease state, *e.g.,* in a cancer sample, as compared to the activity of the biomarker in a normal, control sample. Altered activity of the biomarker may be the result of, for example, altered expression of the biomarker, altered protein level of the biomarker, altered structure of the biomarker, or, *e.g.,* an altered interaction with other proteins involved in the same or different pathway as the biomarker or altered interaction with transcriptional activators or inhibitors.

The term "altered structure" of a biomarker refers to the presence of mutations or allelic variants within a biomarker nucleic acid or protein, *e.g.,* mutations which affect expression or activity of the biomarker nucleic acid or protein, as compared to the normal or wild-type gene or protein. For example, mutations include, but are not limited to substitutions, deletions, or addition mutations. Mutations may be present in the coding or non-coding region of the biomarker nucleic acid.

Unless otherwise specified here within, the terms "antibody" and "antibodies" refers to antigen-binding portions adaptable to be expressed within cells as "intracellular antibodies." (Chen *et al.* (1994) *Human Gene Ther.* 5:595-601). Methods are well-known in the art for adapting antibodies to target (*e.g.*, inhibit) intracellular moieties, such as the use of single-chain antibodies (scFvs), modification of immunoglobulin VL domains for hyperstability, modification of antibodies to resist the reducing intracellular environment, generating fusion proteins that increase intracellular stability and/or modulate intracellular localization, and the like. Intracellular antibodies can also be introduced and expressed in one or more cells, tissues or organs of a multicellular organism, for example for prophylactic and/or therapeutic purposes (*e.g.*, as a gene therapy) (see, at least PCT Publs. WO 08/020079, WO 94/02610, WO 95/22618, and WO 03/014960; U.S. Pat. No. 7,004,940; Cattaneo and Biocca (1997) *Intracellular Antibodies: Development and Applications* (Landes and Springer-Verlag publs.); Kontermann (2004) *Methods* 34:163-170; Cohen *et al.* (1998) *Oncogene* 17:2445-2456; Auf der Maur *et al.* (2001) *FEBS Lett.* 508:407-412; Shaki-Loewenstein *et al.* (2005) *J. Immunol. Meth.* 303:19-39).

Antibodies may be polyclonal or monoclonal; xenogeneic, allogeneic, or syngeneic; or modified forms thereof (*e.g.* humanized, chimeric, etc.). Antibodies may also be fully human. Preferably, antibodies of the present invention bind specifically or substantially specifically to a biomarker polypeptide or fragment thereof. The terms "monoclonal antibodies" and "monoclonal antibody composition", as used herein, refer to a population of antibody polypeptides that contain only one species of an antigen binding site capable of immunoreacting with a particular epitope of an antigen, whereas the term "polyclonal antibodies" and "polyclonal antibody composition" refer to a population of antibody polypeptides that contain multiple species of antigen binding sites capable of interacting with a particular antigen. A monoclonal antibody composition typically displays a single binding affinity for a particular antigen with which it immunoreacts.

Antibodies may also be "humanized", which is intended to include antibodies made by a non-human cell having variable and constant regions which have been altered to more closely resemble antibodies that would be made by a human cell. For example, by altering the non-human antibody amino acid sequence to incorporate amino acids found in human germline immunoglobulin sequences. The humanized antibodies of the present invention may include amino acid residues not encoded by human germline immunoglobulin sequences (*e.g.*, mutations introduced by random or site-specific mutagenesis *in vitro* or by somatic mutation *in vivo*), for example in the CDRs. The term "humanized antibody", as used herein, also includes antibodies in which CDR sequences derived from the germline of another mammalian species, such as a mouse, have been grafted onto human framework sequences.

The term "assigned score" refers to the numerical value designated for each of the biomarkers after being measured in a patient sample. The assigned score correlates to the absence, presence or inferred amount of the biomarker in the sample. The assigned score can be generated manually (*e.g.*, by visual inspection) or with the aid of instrumentation for image acquisition and analysis. In certain embodiments, the assigned score is determined by a qualitative assessment, for example, detection of a fluorescent readout on a graded scale, or quantitative assessment. In one embodiment, an "aggregate score," which refers to the combination of assigned scores from a plurality of measured biomarkers, is determined. In one embodiment the aggregate score is a summation of assigned scores. In another embodiment, combination of assigned scores involves performing mathematical operations

on the assigned scores before combining them into an aggregate score. In certain, embodiments, the aggregate score is also referred to herein as the "predictive score."

The term "biomarker" refers to a measurable entity of the present invention that has been determined to be predictive of inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors , such as PTPN2 and/or SOCS1) and immunotherapy (*e.g.*, immune checkpoint inhibitors) combinatorial therapy effects on a cancer. Biomarkers can include, without limitation, nucleic acids and proteins, including those shown in the Tables, the Examples, the Figures, and otherwise described herein. As described herein, any relevant characteristic of a biomarker can be used, such as the copy number, amount, activity, location, modification (*e.g.*, phosphorylation), and the like.

A "blocking" antibody or an antibody "antagonist" is one which inhibits or reduces at least one biological activity of the antigen(s) it binds. In certain embodiments, the blocking antibodies or antagonist antibodies or fragments thereof described herein substantially or completely inhibit a given biological activity of the antigen(s).

The term "body fluid" refers to fluids that are excreted or secreted from the body as well as fluids that are normally not (*e.g.* amniotic fluid, aqueous humor, bile, blood and blood plasma, cerebrospinal fluid, cerumen and earwax, cowper's fluid or pre-ejaculatory fluid, chyle, chyme, stool, female ejaculate, interstitial fluid, intracellular fluid, lymph, menses, breast milk, mucus, pleural fluid, pus, saliva, sebum, semen, serum, sweat, synovial fluid, tears, urine, vaginal lubrication, vitreous humor, vomit).

The terms "cancer" or "tumor" or "hyperproliferative" refer to the presence of cells possessing characteristics typical of cancer-causing cells, such as uncontrolled proliferation, immortality, metastatic potential, rapid growth and proliferation rate, and certain characteristic morphological features. Unless otherwise stated, the terms include metaplasias. In some embodiments, such cells exhibit such characteristics in part or in full due to the expression and activity of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and/or their related signaling pathways (*e.g.*, PTPN2-regulated signaling pathways, including NF-kappaB signaling pathway, MAP kinase pathway, JAK-STAT signaling pathway, or other signaling pathways involving receptor tyrosine kinases, non-receptor tyrosine kinases, Src family kinases, and/or signal transducer and activator of transcription (STAT) proteins and/or SOCS1-regulated signaling pathways, including *e.g.*activated Toll Like Receptror 4 (TLR4) or Toll Like Receptror 2 (TLR2) signaling, MyD88-Mal cascade initiated on plasma membrane,

prolactin signaling pathway, IL-2 pathway, calss I MHC mediated antigen processing and presentation, immune response interferon α/β signaling pathway, etc.). In certain embodiments, the cancer cells are capable of responding to interferon because they express functional proteins of the type I interferon signaling pathway and/or type II interferon signaling pathway, such as those shown in panel E of Figure 11. In some embodiments, the cancer cells described herein are not sensitive to at least one of immunotherapies. Such insensitivity, without limitation, may be related to the inactivation or decreased activation, compared to control cells (*e.g.*, normal and/or wild-type non-cancer cells, and/or cancer cells without this insensitivity to immunotherapies), of interferon signaling (*e.g.*, IFNγ signaling) in such cancer cells and/or other surrounding cells and/or cells localized near to such cancer cells. Such inactivation or decreased activation of interferon signaling, without limitation, may be related to the inhibition of interferon signaling by one or more biomarkers in Table 1, *e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and/or SOCS1 (*e.g.*, by overexpression and/or gain-of-function of the gene, RNA transcript, and/or protein of such one or more biomarkers in Table 1, and/or by reduced expression and/or loss-of-funciton of endogenous negative regulator(s) of such one or more biomarkers in Table 1). In some embodiments, the cancer cells are treatable with an agent capable of antagonizing one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and/or SOCS1), such as inhibiting expression and/or function of one or more biomarkers in Table 1, as described herein. An exemplary agent, without limitation, may relieve the inhibition of interferon (*e.g.*, IFNγ) signaling by PTPN2 and/or SOCS1 in such cancer cells and/or other cells surrounding or localized near such cancer cells, thus restoring the IFNγ signaling and the sensitivity of such cancer cells to immunotherapies, especially those immunotherapies related to interferon signaling pathways. In some embodiments, the treatment with the agent antagonizing one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) as described herein would increase IFNγ signaling in such cancer cells, compared to pre-treatment situations, or would restore IFNγ signaling in such cancer cells to at least comparable to the levels in control cells, so that such cancer cells would regain sensitivity to immunotherapies. The term "interferon signaling" or "IFNγ signaling" used herein refers to any cell signaling downstream and/or related to the interaction of interferon (*e.g.*, IFNγ) and their receptor(s). Some exemplary IFNγ cell signaling include, without limitation, the activation of macrophages and/or induction of Class II major

histocompatibility complex (MHC) molecule expression, and/or activation of multiple immune effector genes through the Janus kinase (JAK)-STAT signaling pathway (*e.g.*, through STAT1 transcription factor). The receptor specific for IFNγ is IFNγR, comprising two chains, namely IFNγR1 (also known as the IFNγR alpha chain) and IFNγR2 (also known as the IFNγR beta chain). IFNγR1 is the ligand binding receptor and is required but not sufficient for signal transduction, whereas IFNγR2 do not bind IFNγ independently but mainly plays a role in IFNγ signaling and is generally the limiting factor in IFNγ responsiveness. Both IFNγR chains lack intrinsic kinase/phosphatase activity and thus rely on other signaling proteins like Janus-activated kinase 1 (JAK1), JAK2 and signal transducer and activator of transcription 1 (STAT-1) for signal transduction. IFNγR complex in its resting state is a preformed tetramer and upon IFNγ association undergoes a conformational change. This conformational change induces the phosphorylation and activation of JAK1, JAK2, and STAT1 which in turn induces genes containing the gamma-interferon activation sequence (GAS) in the promoter. Many IFNγ functions are mediated by direct activation of immune effector genes by STAT1, including genes encoding antiviral proteins, microbicidal molecules, phagocytic receptors, chemokines, cytokines, and antigen-presenting molecules. Canonical Jak-STAT signaling mechanisms leading to activation of well-characterized STAT1 target genes have been previously reviewed (Stark (2007) *Cytokine Growth Factor Rev.*, 18:419-423). In addition, activation of other STATs and alternative signaling pathways can contribute to IFNγ function in certain cell contexts (reviewed in van Boxel-Dezaire and Stark, 2007 *Curr. Top. Microbiol. Immunol.*, 316:119-154 and Gough *et al.*, 2008 *Cytokine Growth Factor Rev.*, 19:383-394). Importantly, many key IFNγ functions are mediated by cross-regulation of cellular responses to other cytokines and inflammatory factors, such as, at least, tumor necrosis factor-alpha, interleukin-4, type I IFNs, and lipopolysaccharide. The capacity of IFNγ to cross-regulate signaling pathways induced by other endogenous and exogenous factors is less appreciated, and the underlying mechanisms are more recently described. The mechanisms and (patho)physiological impact of IFNγ-mediated cross-regulation of signal transduction is reviewed by Hu and Ivashkiv (2009) *Immunity* 31:539-550. For reviews of multiple IFNγ responsive genes, see Samarajiwa *et al.* (2009) *Nucl. Acids Res.* 37:D852-D857 and Schneider *et al.* (2014) *Annu. Rev. Immunol.* 32:513-545. IFNγ signaling can at least promote NK cell activity, increase antigen presentation and lysosome activity of macrophages, activate inducible nitric oxide synthase (iNOS), and induce the production of

IgG2a and IgG3 from activated plasma B cells. Many IFN-stimulated genes control viral, bacterial, and parasite infection by directly targeting pathways and functions required during pathogen life cycles. Upregulation of chemokines and chemokine receptors enables cell-to-cell communication, whereas negative regulators of signaling help resolve the IFN-induced state and facilitate the return to cellular homeostasis. Additional IFN-stimulated genes encode for proapoptotic proteins, leading to cell death under certain conditions. IFNγ signaling, as described herein, include at least activation or inhibition of at least one IFNγ responsive genes well known in the art. The detection methods for such activation or inhibitor of IFNγ responsive genes are also well known in the art. In some embodiments, the cancer cells described herein have defective or at least reduced IFNγ signaling, preferably due to inhibition by one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1). Upon treatment with the antagonizing agent for such one or more biomarkers in Table 1, as described herein, such cancer cells restore IFNγ signaling. Such defective, reduced, or restored IFNγ signaling can be detected and/or measured through the expression and/or function of IFN-responsive genes, as described herein, using any known method in the art.

Cancer cells are often in the form of a tumor, but such cells may exist alone within an animal, or may be a non-tumorigenic cancer cell, such as a leukemia cell. As used herein, the term "cancer" includes premalignant as well as malignant cancers. Cancers include, but are not limited to, B cell cancer, *e.g.,* multiple myeloma, Waldenström's macroglobulinemia, the heavy chain diseases, such as, for example, alpha chain disease, gamma chain disease, and mu chain disease, benign monoclonal gammopathy, and immunocytic amyloidosis, melanomas, breast cancer, lung cancer, bronchus cancer, colorectal cancer, prostate cancer, pancreatic cancer, stomach cancer, ovarian cancer, urinary bladder cancer, brain or central nervous system cancer, peripheral nervous system cancer, esophageal cancer, cervical cancer, uterine or endometrial cancer, cancer of the oral cavity or pharynx, liver cancer, kidney cancer, testicular cancer, biliary tract cancer, small bowel or appendix cancer, salivary gland cancer, thyroid gland cancer, adrenal gland cancer, osteosarcoma, chondrosarcoma, cancer of hematologic tissues, and the like. Other non-limiting examples of types of cancers applicable to the methods encompassed by the present invention include human sarcomas and carcinomas, *e.g.*, fibrosarcoma, myxosarcoma, liposarcoma, chondrosarcoma, osteogenic sarcoma, chordoma, angiosarcoma, endotheliosarcoma, lymphangiosarcoma, lymphangioendotheliosarcoma,

synovioma, mesothelioma, Ewing's tumor, leiomyosarcoma, rhabdomyosarcoma, colon carcinoma, colorectal cancer, pancreatic cancer, breast cancer, ovarian cancer, prostate cancer, squamous cell carcinoma, basal cell carcinoma, adenocarcinoma, sweat gland carcinoma, sebaceous gland carcinoma, papillary carcinoma, papillary adenocarcinomas, cystadenocarcinoma, medullary carcinoma, bronchogenic carcinoma, renal cell carcinoma, hepatoma, bile duct carcinoma, liver cancer, choriocarcinoma, seminoma, embryonal carcinoma, Wilms' tumor, cervical cancer, bone cancer, brain tumor, testicular cancer, lung carcinoma, small cell lung carcinoma, bladder carcinoma, epithelial carcinoma, glioma, astrocytoma, medulloblastoma, craniopharyngioma, ependymoma, pinealoma, hemangioblastoma, acoustic neuroma, oligodendroglioma, meningioma, melanoma, neuroblastoma, retinoblastoma; leukemias, *e.g.*, acute lymphocytic leukemia and acute myelocytic leukemia (myeloblastic, promyelocytic, myelomonocytic, monocytic and erythroleukemia); chronic leukemia (chronic myelocytic (granulocytic) leukemia and chronic lymphocytic leukemia); and polycythemia vera, lymphoma (Hodgkin's disease and non-Hodgkin's disease), multiple myeloma, Waldenstrom's macroglobulinemia, and heavy chain disease. In some embodiments, cancers are epithlelial in nature and include but are not limited to, bladder cancer, breast cancer, cervical cancer, colon cancer, gynecologic cancers, renal cancer, laryngeal cancer, lung cancer, oral cancer, head and neck cancer, ovarian cancer, pancreatic cancer, prostate cancer, or skin cancer. In other embodiments, the cancer is breast cancer, prostate cancer, lung cancer, or colon cancer. In still other embodiments, the epithelial cancer is non-small-cell lung cancer, nonpapillary renal cell carcinoma, cervical carcinoma, ovarian carcinoma (*e.g.*, serous ovarian carcinoma), or breast carcinoma. The epithelial cancers may be characterized in various other ways including, but not limited to, serous, endometrioid, mucinous, clear cell, Brenner, or undifferentiated.

In certain embodiments, the cancer encompasses colorectal cancer (*e.g.*, colorectal carcinoma).

The term "colorectal cancer" as used herein, is meant to include cancer of cells of the intestinal tract below the small intestine (*e.g.*, the large intestine (colon), including the cecum, ascending colon, transverse colon, descending colon, and sigmoid colon, and rectum). Additionally, as used herein, the term "colorectal cancer" is meant to further include cancer of cells of the duodenum and small intestine (jejunum and ileum). Colorectal cancer also includes neoplastic diseases involving proliferation of a single clone

of cells of the colon and includes adenocarcinoma and carcinoma of the colon whether in a primary site or metastasized.

Colorectal cancer (CRC) is the third most commonly diagnosed cancer and ranks second in cancer mortality. Extensive genetic and genomic analysis of human CRC has uncovered germline and somatic mutations relevant to CRC biology and malignant transformation (Fearon *et al.* (1990) *Cell* 61, 759-767). These mutations have been linked to well-defined disease stages from aberrant crypt proliferation or hyperplasic lesions to benign adenomas, to carcinoma *in situ*, and finally to invasive and metastatic disease, thereby establishing a genetic paradigm for cancer initiation and progression. Genetic and genomic instability are catalysts for colon carcinogenesis (Lengauer *et al.* (1998) *Nature* 396:643-649). CRC can present with two distinct genomic profiles that have been termed (i) chromosomal instability neoplasia (CIN), characterized by rampant structural and numerical chromosomal aberrations driven in part by telomere dysfunction (Artandi *et al.* (2000) *Nature* 406:641-645; Fodde *et al.* (2001) *Nat. Rev. Cancer* 1:55-67; Maser and DePinho (2002) *Science* 297:565-569; Rudolph *et al.* (2001) *Nat. Genet.* 28:155-159) and mitotic aberrations (Lengauer *et al.* (1998) *Nature* 396:643-649) and (ii) microsatellite instability neoplasia (MIN), characterized by near diploid karyotypes with alterations at the nucleotide level due to mutations in mismatch repair (MMR) genes (Fishel *et al.* (1993) *Cell* 75:1027-1038; Ilyas *et al.* (1999) *Eur. J. Cancer* 35:335-351; Modrich (1991) *Annu. Rev. Genet.* 25:229-253; Parsons *et al.* (1995) *Science* 268:738-740; Parsons *et al.* (1993) *Cell* 75:1227-1236). Germline MMR mutations are highly penetrant lesions which drive the MIN phenotype in hereditary nonpolyposis colorectal cancers, accounting for 1-5% of CRC cases (de la Chapelle (2004) *Nat. Rev. Cancer* 4:769-780; Lynch and de la Chapelle (1999) *J. Med. Genet.* 36:801-818; Umar *et al.* (2004) *Nat. Rev. Cancer* 4:153-158). While CIN and MIN are mechanistically distinct, their genomic and genetic consequences emphasize the requirement of dominant mutator mechanisms to drive intestinal epithelial cells towards a threshold of oncogenic changes needed for malignant transformation.

A growing number of genetic mutations have been identified and functionally validated in CRC pathogenesis. Activation of the WNT signaling pathway is an early requisite event for adenoma formation. Somatic alterations are present in *APC* in greater than 70% of nonfamilial sporadic cases and appear to contribute to genomic instability and induce the expression of *c-myc* and *Cyclin D1* (Fodde *et al.* (2001) *Nat. Rev. Cancer* 1:55-67), while activating *β-catenin* mutations represent an alternative means of WNT pathway

deregulation in CRC (Morin (1997) *Science* 275:1787-1790). *K-Ras* mutations occur early in neoplastic progression and are present in approximately 50% of large adenomas (Fearon and Gruber (2001) Molecular abnormalities in colon and rectal cancer, ed. J. Mendelsohm, P.H., M. Israel, and L. Liotta, W.B. Saunders, Philadelphia). The *BRAF* serine/threonine kinase and *PIK3CA* lipid kinase are mutated in 5-18% and 28% of sporadic CRCs, respectively (Samuels *et al.* (2004) *Science* 304:554; Davies *et al.* (2002) *Nature* 417:949-954; Rajagopalan *et al.* (2002) *Nature* 418:934; Yuen *et al.* (2002) *Cancer Res.* 62:6451-6455). *BRAF* and *K-ras* mutations are mutually exclusive in CRC, suggesting over-lapping oncogenic activities (Davies *et al.* (2002) *Nature* 417:949-954; Rajagopalan *et al.* (2002) *Nature* 418:934). Mutations associated with CRC progression, specifically the adenoma-to-carcinoma transition, target the *TP53* and the TGF-β pathways (Markowitz *et al.* (2002) *Cancer Cell* 1:233-236). Greater than 50% of CRCs harbor *TP53* inactivating mutations (Fearon and Gruber (2001) Molecular abnormalities in colon and rectal cancer, ed. J. Mendelsohm, P.H., M. Israel, and L. Liotta, W.B. Saunders, Philadelphia) and 30% of cases possess *TGFβ-RII* mutations (Markowitz (2000) *Biochim. Biophys. Acta* 1470:M13-M20; Markowitz *et al.* (1995) *Science* 268:1336-1338). MIN cancers consistently inactivate *TGFβ-RII* by frameshift mutations, whereas CIN cancers target the pathway via inactivating somatic mutations in the *TGFβ-RII* kinase domain (15%) or in the downstream signaling components of the pathway, including *SMAD4* (15%) or *SMAD2* (5%) transcription factors (Markowitz (2000) *Biochim. Biophys. Acta* 1470:M13-M20). In some embodiments, the colorectal cancer is microsatellite instable (MSI) colorectal cancer (Llosa *et al.* (2014) *Cancer Disc.* CD-14-0863; published online Oct. 30, 2014). MSI represents about 15% of sporadic CRC and about 5-6% of stage IV CRCs. MSI is caused by epigenetic silencing or mutation of DNA mismatch repair genes and typically presents with lower stage disease than microsatellite stable subset (MSS) CRC. MSI highly express immune checkpoints, such as PD-1, PD-L1, CTLA-4, LAG-3, and IDO. In other embodiments, the colorectal cancer is MSS CRC.

In certain embodiments, the cancer encompasses melanoma. The term "melanoma" as used herein, is generally meant to include cancers that develop from the pigment-containing cells, known as melanocytes, in the basal layer of the epidermis. Melanomas typically occur in the skin but may rarely occur in the mouth, intestines, or eye. In women they most commonly occur on the legs, while in men they are most common on the back. Sometimes they develop from a mole with concerning changes including an increase in

size, irregular edges, change in color, itchiness, or skin breakdown. Thus, the term "melanoma" also includes cancers developing from these cells, tissues, and organs.

Melanomas are among the most dangerous forms of skin cancer and develop when unrepaired DNA damage to skin cells (most often caused by ultraviolet radiation from sunshine or tanning beds) triggers gene mutations that lead the skin cells to multiply rapidly and form malignant tumors. The primary cause of melanoma is ultraviolet light (UV) exposure in those with low levels of skin pigment. Melanomas often resemble moles; some develop from moles. Those with many moles, a history of affected family members, and who have poor immune function are at greater risk. A number of rare genetic defects such as xeroderma pigmentosum also increase risk (Azoury and Lange, 2014 *Surg Clin North Am.* 2014 94:945-962).

Melanoma can be divided into different types, including, at least, lentigo maligna, lentigo maligna melanoma, superficial spreading melanoma, acral lentiginous melanoma, mucosal melanoma, nodular melanoma, polypoid melanoma, desmoplastic melanoma, amelanotic melanoma, soft-tissue melanoma, melanoma with small nevus-like cells, melanoma with features of a Spitz nevus, uveal melanoma, etc. (see James, et al., 2006 *Andrews' Diseases of the Skin: clinical Dermatology.* Saunders Elsevier. pp. 694–9)

Diagnosis is by biopsy of any concerning skin lesion, including, at least, shave (tangential) biopsy, punch biopsy, incisional and excisional biopsies, "optical" biopsies (*e.g.*, by reflectance confocal microscopy (RCM)), fine needle aspiration (FNA) biopsy, surgical lymph node biopsy, sentinel lymph node biopsy, etc. In addition, visual inspection may also be used for diagnosis, such as a popular method for the signs and symptoms of melanoma as mnemonic "ABCDE": Asymmetrical skin lesion, Border of the lesion is irregular, Color: melanomas usually have multiple colors, Diameter: moles greater than 6 mm are more likely to be melanomas than smaller moles, and Enlarging: Enlarging or evolving. Another method as the "ugly duckling sign" is also known in the art (Mascaro and Mascaro, 1998 *Arch Dermatol.* 134: 1484-1485).

Treatment of melanoma includes surgery, chemotherapy (such as temozolomide, dacarbazine (also termed DTIC), etc.), radiation therapy, oncolytic virotherapy (*e.g.*, see Forbes *et al.*, 2013 *Front. Genet.* 4:184), and immunotherapy (*e.g.*, interleukin-2 (IL-2), interferon, etc.). Targeted therapies (*e.g.*, as in Maverakis *et al.*, 2015 *Acta Derm Venereol.* 95: 516-524) may include: 1) adoptive cell therapy (ACT) using TILs immune cells (tumor infiltrating lymphocytes) isolated from a person's own melanoma tumor). Cells are grown

in large numbers in a laboratory and returned to the patient after a treatment that temporarily reduces normal T cells in the patient's body. TIL therapy following lymphodepletion can result in durable complete response in a variety of setups (Besser *et al.*, 2010 *Clin. Cancer Res.* 16:2646-2655); and 2) adoptive transfer of genetically altered (expressing T cell receptors (TCRs)) autologous lymphocytes into patient's lymphocytes, where the altered lymphocytes recognize and bind to the surface of melanoma cells and kill them. Other therapies include, at least, B-Raf inhibitors (such as vemurafenib, see Chapman *et al.*, 2011 *N. Engl. J. Med.* 364:2507-2516) and ipilimumab (alone or in combination with dacarbazine, see, *e.g.*, Robert *et al.* (2011) *N. Engl. J. Med.* 364:2517-2526).

The term "coding region" refers to regions of a nucleotide sequence comprising codons which are translated into amino acid residues, whereas the term "noncoding region" refers to regions of a nucleotide sequence that are not translated into amino acids (*e.g.*, 5' and 3' untranslated regions).

The term "complementary" refers to the broad concept of sequence complementarity between regions of two nucleic acid strands or between two regions of the same nucleic acid strand. It is known that an adenine residue of a first nucleic acid region is capable of forming specific hydrogen bonds ("base pairing") with a residue of a second nucleic acid region which is antiparallel to the first region if the residue is thymine or uracil. Similarly, it is known that a cytosine residue of a first nucleic acid strand is capable of base pairing with a residue of a second nucleic acid strand which is antiparallel to the first strand if the residue is guanine. A first region of a nucleic acid is complementary to a second region of the same or a different nucleic acid if, when the two regions are arranged in an antiparallel fashion, at least one nucleotide residue of the first region is capable of base pairing with a residue of the second region. Preferably, the first region comprises a first portion and the second region comprises a second portion, whereby, when the first and second portions are arranged in an antiparallel fashion, at least about 50%, and preferably at least about 75%, at least about 90%, or at least about 95% of the nucleotide residues of the first portion are capable of base pairing with nucleotide residues in the second portion. More preferably, all nucleotide residues of the first portion are capable of base pairing with nucleotide residues in the second portion.

The term "control" refers to any reference standard suitable to provide a comparison to the expression products in the test sample. In one embodiment, the control comprises

obtaining a "control sample" from which expression product levels are detected and compared to the expression product levels from the test sample. Such a control sample may comprise any suitable sample, including but not limited to a sample from a control cancer patient (can be stored sample or previous sample measurement) with a known outcome; normal tissue or cells isolated from a subject, such as a normal patient or the cancer patient, cultured primary cells/tissues isolated from a subject such as a normal subject or the cancer patient, adjacent normal cells/tissues obtained from the same organ or body location of the cancer patient, a tissue or cell sample isolated from a normal subject, or a primary cells/tissues obtained from a depository. In another preferred embodiment, the control may comprise a reference standard expression product level from any suitable source, including but not limited to housekeeping genes, an expression product level range from normal tissue (or other previously analyzed control sample), a previously determined expression product level range within a test sample from a group of patients, or a set of patients with a certain outcome (for example, survival for one, two, three, four years, etc.) or receiving a certain treatment (for example, standard of care cancer therapy). It will be understood by those of skill in the art that such control samples and reference standard expression product levels can be used in combination as controls in the methods of the present invention. In one embodiment, the control may comprise normal or non-cancerous cell/tissue sample. In another preferred embodiment, the control may comprise an expression level for a set of patients, such as a set of cancer patients, or for a set of cancer patients receiving a certain treatment, or for a set of patients with one outcome versus another outcome. In the former case, the specific expression product level of each patient can be assigned to a percentile level of expression, or expressed as either higher or lower than the mean or average of the reference standard expression level. In another preferred embodiment, the control may comprise normal cells, cells from patients treated with combination chemotherapy, and cells from patients having benign cancer. In another embodiment, the control may also comprise a measured value for example, average level of expression of a particular gene in a population compared to the level of expression of a housekeeping gene in the same population. Such a population may comprise normal subjects, cancer patients who have not undergone any treatment (*i.e.*, treatment naive), cancer patients undergoing standard of care therapy, or patients having benign cancer. In another preferred embodiment, the control comprises a ratio transformation of expression product levels, including but not limited to determining a ratio of expression product levels of two genes in the test sample and

comparing it to any suitable ratio of the same two genes in a reference standard; determining expression product levels of the two or more genes in the test sample and determining a difference in expression product levels in any suitable control; and determining expression product levels of the two or more genes in the test sample, normalizing their expression to expression of housekeeping genes in the test sample, and comparing to any suitable control. In particularly preferred embodiments, the control comprises a control sample which is of the same lineage and/or type as the test sample. In another embodiment, the control may comprise expression product levels grouped as percentiles within or based on a set of patient samples, such as all patients with cancer. In one embodiment a control expression product level is established wherein higher or lower levels of expression product relative to, for instance, a particular percentile, are used as the basis for predicting outcome. In another preferred embodiment, a control expression product level is established using expression product levels from cancer control patients with a known outcome, and the expression product levels from the test sample are compared to the control expression product level as the basis for predicting outcome. As demonstrated by the data below, the methods of the present invention are not limited to use of a specific cut-point in comparing the level of expression product in the test sample to the control.

The "copy number" of a biomarker nucleic acid refers to the number of DNA sequences in a cell (*e.g.*, germline and/or somatic) encoding a particular gene product. Generally, for a given gene, a mammal has two copies of each gene. The copy number can be increased, however, by gene amplification or duplication, or reduced by deletion. For example, germline copy number changes include changes at one or more genomic loci, wherein said one or more genomic loci are not accounted for by the number of copies in the normal complement of germline copies in a control (*e.g.*, the normal copy number in germline DNA for the same species as that from which the specific germline DNA and corresponding copy number were determined). Somatic copy number changes include changes at one or more genomic loci, wherein said one or more genomic loci are not accounted for by the number of copies in germline DNA of a control (*e.g.*, copy number in germline DNA for the same subject as that from which the somatic DNA and corresponding copy number were determined).

The "normal" copy number (*e.g.*, germline and/or somatic) of a biomarker nucleic acid or "normal" level of expression of a biomarker nucleic acid or protein is the

activity/level of expression or copy number in a biological sample, *e.g.,* a sample containing tissue, whole blood, serum, plasma, buccal scrape, saliva, cerebrospinal fluid, urine, stool, and bone marrow, from a subject, *e.g.,* a human, not afflicted with cancer, or from a corresponding non-cancerous tissue in the same subject who has cancer.

As used herein, the term "costimulate" with reference to activated immune cells includes the ability of a costimulatory molecule to provide a second, non-activating receptor mediated signal (a "costimulatory signal") that induces proliferation or effector function. For example, a costimulatory signal can result in cytokine secretion, *e.g.,* in a T cell that has received a T cell-receptor-mediated signal. Immune cells that have received a cell-receptor mediated signal, *e.g.,* via an activating receptor are referred to herein as "activated immune cells."

The term "determining a suitable treatment regimen for the subject" is taken to mean the determination of a treatment regimen (*i.e.*, a single therapy or a combination of different therapies that are used for the prevention and/or treatment of the cancer in the subject) for a subject that is started, modified and/or ended based or essentially based or at least partially based on the results of the analysis according to the present invention. One example is starting an adjuvant therapy after surgery whose purpose is to decrease the risk of recurrence, another would be to modify the dosage of a particular chemotherapy. The determination can, in addition to the results of the analysis according to the present invention, be based on personal characteristics of the subject to be treated. In most cases, the actual determination of the suitable treatment regimen for the subject will be performed by the attending physician or doctor.

The term "diagnosing cancer" includes the use of the methods, systems, and code of the present invention to determine the presence or absence of a cancer or subtype thereof in an individual. The term also includes methods, systems, and code for assessing the level of disease activity in an individual.

A molecule is "fixed" or "affixed" to a substrate if it is covalently or non-covalently associated with the substrate such that the substrate can be rinsed with a fluid (*e.g.* standard saline citrate, pH 7.4) without a substantial fraction of the molecule dissociating from the substrate.

The term "expression signature" or "signature" refers to a group of one or more coordinately expressed biomarkers related to a measured phenotype. For example, the genes, proteins, metabolites, and the like making up this signature may be expressed in a

specific cell lineage, stage of differentiation, or during a particular biological response. The biomarkers can reflect biological aspects of the tumors in which they are expressed, such as the cell of origin of the cancer, the nature of the non-malignant cells in the biopsy, and the oncogenic mechanisms responsible for the cancer. Expression data and gene expression levels can be stored on computer readable media, *e.g.*, the computer readable medium used in conjunction with a microarray or chip reading device. Such expression data can be manipulated to generate expression signatures.

"Homologous" as used herein, refers to nucleotide sequence similarity between two regions of the same nucleic acid strand or between regions of two different nucleic acid strands. When a nucleotide residue position in both regions is occupied by the same nucleotide residue, then the regions are homologous at that position. A first region is homologous to a second region if at least one nucleotide residue position of each region is occupied by the same residue. Homology between two regions is expressed in terms of the proportion of nucleotide residue positions of the two regions that are occupied by the same nucleotide residue. By way of example, a region having the nucleotide sequence 5'-ATTGCC-3' and a region having the nucleotide sequence 5'-TATGGC-3' share 50% homology. Preferably, the first region comprises a first portion and the second region comprises a second portion, whereby, at least about 50%, and preferably at least about 75%, at least about 90%, or at least about 95% of the nucleotide residue positions of each of the portions are occupied by the same nucleotide residue. More preferably, all nucleotide residue positions of each of the portions are occupied by the same nucleotide residue.

The term "immune cell" refers to cells that play a role in the immune response. Immune cells are of hematopoietic origin, and include lymphocytes, such as B cells and T cells; natural killer cells; myeloid cells, such as monocytes, macrophages, eosinophils, mast cells, basophils, and granulocytes.

The term "immunotherapy" or "immunotherapies" refer to any treatment that uses certain parts of a subject's immune system to fight diseases such as cancer. The subject's own immune system is stimulated (or suppressed), with or without administration of one or more agent for that purpose. Immunotherapies that are designed to elicit or amplify an immune response are referred to as "activation immunotherapies." Immunotherapies that are designed to reduce or suppress an immune response are referred to as "suppression immunotherapies." Any agent believed to have an immune system effect on the genetically modified transplanted cancer cells can be assayed to determine whether the agent is an

immunotherapy and the effect that a given genetic modification has on the modulation of immune response. In some embodiments, the immunotherapy is cancer cell-specific. In some embodiments, immunotherapy can be "untargeted," which refers to administration of agents that do not selectively interact with immune system cells, yet modulates immune system function. Representative examples of untargeted therapies include, without limitation, chemotherapy, gene therapy, and radiation therapy.

Immunotherapy is one form of targeted therapy that may comprise, for example, the use of cancer vaccines and/or sensitized antigen presenting cells. For example, an oncolytic virus is a virus that is able to infect and lyse cancer cells, while leaving normal cells unharmed, making them potentially useful in cancer therapy. Replication of oncolytic viruses both facilitates tumor cell destruction and also produces dose amplification at the tumor site. They may also act as vectors for anticancer genes, allowing them to be specifically delivered to the tumor site. The immunotherapy can involve passive immunity for short-term protection of a host, achieved by the administration of pre-formed antibody directed against a cancer antigen or disease antigen (*e.g.*, administration of a monoclonal antibody, optionally linked to a chemotherapeutic agent or toxin, to a tumor antigen). For example, anti-VEGF and mTOR inhibitors are known to be effective in treating renal cell carcinoma. Immunotherapy can also focus on using the cytotoxic lymphocyte-recognized epitopes of cancer cell lines. Alternatively, antisense polynucleotides, ribozymes, RNA interference molecules, triple helix polynucleotides and the like, can be used to selectively modulate biomolecules that are linked to the initiation, progression, and/or pathology of a tumor or cancer.

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In some embodiments, the immunotherapy described herein comprises at least one immunogenic chemotherapies. The term "immunogenic chemotherapy" refers to any chemotherapy that has been demonstrated to induce immunogenic cell death, a state that is

detectable by the release of one or more damage-associated molecular pattern (DAMP) molecules, including, but not limited to, calreticulin, ATP and HMGB1 (Kroemer *et al.* (2013), *Annu. Rev. Immunol.*, 31:51-72). Specific representative examples of consensus immunogenic chemotherapies include 5'-fluorouracil, anthracyclines, such as doxorubicin, and platinum drugs, such as oxaliplatin, among others.

In some embodiments, immunotherapy comprises inhibitors of one or more immune checkpoints. The term "immune checkpoint" refers to a group of molecules on the cell surface of CD4+ and/or CD8+ T cells that fine-tune immune responses by down-modulating or inhibiting an anti-tumor immune response. Immune checkpoint proteins are well-known in the art and include, without limitation, CTLA-4, PD-1, VISTA, B7-H2, B7-H3, PD-L1, B7-H4, B7-H6, ICOS, HVEM, PD-L2, CD160, gp49B, PIR-B, KIR family receptors, TIM-1, TIM-3, TIM-4, LAG-3, GITR, 4-IBB, OX-40, BTLA, SIRP, CD47, CD48, 2B4 (CD244), B7.1, B7.2, ILT-2, ILT-4, TIGIT, HHLA2, butyrophilins, IDO, CD39, CD73 and A2aR (see, for example, WO 2012/177624). The term further encompasses biologically active protein fragment, as well as nucleic acids encoding full-length immune checkpoint proteins and biologically active protein fragments thereof. In some embodiment, the term further encompasses any fragment according to homology descriptions provided herein. In one embodiment, the immune checkpoint is PD-1.

Immune checkpoints and their sequences are well-known in the art and representative embodiments are described below. For example, the term "PD-1" refers to a member of the immunoglobulin gene superfamily that functions as a coinhibitory receptor having PD-L1 and PD-L2 as known ligands. PD-1 was previously identified using a subtraction cloning based approach to select for genes upregulated during TCR-induced activated T cell death. PD-1 is a member of the CD28/CTLA-4 family of molecules based on its ability to bind to PD-L1. Like CTLA-4, PD-1 is rapidly induced on the surface of T-cells in response to anti-CD3 (Agata *et al.* 25 (1996) *Int. Immunol.* 8:765). In contrast to CTLA-4, however, PD-1 is also induced on the surface of B-cells (in response to anti-IgM). PD-1 is also expressed on a subset of thymocytes and myeloid cells (Agata *et al.* (1996) *supra;* Nishimura *et al.* (1996) *Int. Immunol.* 8:773).

The nucleic acid and amino acid sequences of a representative human PD-1 biomarker is available to the public at the GenBank database under NM_005018.2 and NP_005009.2 and is shown in Table 1 (see also Ishida *et al.* (1992) 20 *EMBO J* 11:3887; Shinohara *et al.* (1994) *Genomics* 23:704; U.S. Patent 5,698,520). PD-1 has an

extracellular region containing immunoglobulin superfamily domain, a transmembrane domain, and an intracellular region including an immunoreceptor tyrosine-based inhibitory motif (ITIM) (Ishida *et al.* (1992) *EMBO J.* 11:3887; Shinohara *et al.* (1994) *Genomics* 23:704; and U.S. Patent 5,698,520) and an immunoreceptor tyrosine-based switch motif (ITSM). These features also define a larger family of polypeptides, called the immunoinhibitory receptors, which also includes gp49B, PIR-B, and the killer inhibitory receptors (KIRs) (Vivier and Daeron (1997) *Immunol. Today* 18:286). It is often assumed that the tyrosyl phosphorylated ITIM and ITSM motif of these receptors interacts with SH2-domain containing phosphatases, which leads to inhibitory signals. A subset of these immunoinhibitory receptors bind to MHC polypeptides, for example the KIRs, and CTLA4 binds to B7-1 and B7-2. It has been proposed that there is a phylogenetic relationship between the MHC and B7 genes (Henry *et al.* (1999) *Immunol. Today* 20(6):285-8). Nucleic acid and polypeptide sequences of PD-1 orthologs in organisms other than humans are well-known and include, for example, mouse PD-1 (NM_008798.2 and NP_032824.1), rat PD-1 (NM_001106927.1 and NP_001100397.1), dog PD-1 (XM_543338.3 and XP_543338.3), cow PD-1 (NM_001083506.1 and NP_001076975.1), and chicken PD-1 (XM_422723.3 and XP_422723.2).

PD-1 polypeptides are inhibitory receptors capable of transmitting an inhibitory signal to an immune cell to thereby inhibit immune cell effector function, or are capable of promoting costimulation (*e.g.*, by competitive inhibition) of immune cells, *e.g.*, when present in soluble, monomeric form. Preferred PD-1 family members share sequence identity with PD-1 and bind to one or more B7 family members, *e.g.*, B7-1, B7-2, PD-1 ligand, and/or other polypeptides on antigen presenting cells.

The term "PD-1 activity," includes the ability of a PD-1 polypeptide to modulate an inhibitory signal in an activated immune cell, *e.g.*, by engaging a natural PD-1 ligand on an antigen presenting cell. Modulation of an inhibitory signal in an immune cell results in modulation of proliferation of, and/or cytokine secretion by, an immune cell. Thus, the term "PD-1 activity" includes the ability of a PD-1 polypeptide to bind its natural ligand(s), the ability to modulate immune cell costimulatory or inhibitory signals, and the ability to modulate the immune response.

The term "PD-1 ligand" refers to binding partners of the PD-1 receptor and includes both PD-L1 (Freeman *et al.* (2000) *J. Exp. Med.* 192:1027-1034) and PD-L2 (Latchman *et al.* (2001) *Nat. Immunol.* 2:261). At least two types of human PD-1 ligand polypeptides

exist. PD-1 ligand proteins comprise a signal sequence, and an IgV domain, an IgC domain, a transmembrane domain, and a short cytoplasmic tail. Both PD-L1 (See Freeman *et al.* (2000) for sequence data) and PD-L2 (See Latchman *et al.* (2001) *Nat. Immunol.* 2:261 for sequence data) are members of the B7 family of polypeptides. Both PD-L1 and PD-L2 are expressed in placenta, spleen, lymph nodes, thymus, and heart. Only PD-L2 is expressed in pancreas, lung and liver, while only PD-L1 is expressed in fetal liver. Both PD-1 ligands are upregulated on activated monocytes and dendritic cells, although PD-L1 expression is broader. For example, PD-L1 is known to be constitutively expressed and upregulated to higher levels on murine hematopoietic cells (*e.g.*, T cells, B cells, macrophages, dendritic cells (DCs), and bone marrow-derived mast cells) and non-hematopoietic cells (*e.g.*, endothelial, epithelial, and muscle cells), whereas PD-L2 is inducibly expressed on DCs, macrophages, and bone marrow-derived mast cells (see Butte *et al.* (2007) *Immunity* 27:111).

PD-1 ligands comprise a family of polypeptides having certain conserved structural and functional features. The term "family" when used to refer to proteins or nucleic acid molecules, is intended to mean two or more proteins or nucleic acid molecules having a common structural domain or motif and having sufficient amino acid or nucleotide sequence homology, as defined herein. Such family members can be naturally or non-naturally occurring and can be from either the same or different species. For example, a family can contain a first protein of human origin, as well as other, distinct proteins of human origin or alternatively, can contain homologues of non-human origin. Members of a family may also have common functional characteristics. PD-1 ligands are members of the B7 family of polypeptides. The term "B7 family" or "B7 polypeptides" as used herein includes costimulatory polypeptides that share sequence homology with B7 polypeptides, *e.g.*, with B7-1, B7-2, B7h (Swallow *et al.* (1999) *Immunity* 11:423), and/or PD-1 ligands (*e.g.*, PD-L1 or PD-L2). For example, human B7-1 and B7-2 share approximately 26% amino acid sequence identity when compared using the BLAST program at NCBI with the default parameters (Blosum62 matrix with gap penalties set at existence 11 and extension 1 (See the NCBI website). The term B7 family also includes variants of these polypeptides which are capable of modulating immune cell function. The B7 family of molecules share a number of conserved regions, including signal domains, IgV domains and the IgC domains. IgV domains and the IgC domains are art-recognized Ig superfamily member domains. These domains correspond to structural units that have distinct folding patterns

called Ig folds. Ig folds are comprised of a sandwich of two β sheets, each consisting of anti-parallel β strands of 5-10 amino acids with a conserved disulfide bond between the two sheets in most, but not all, IgC domains of Ig, TCR, and MHC molecules share the same types of sequence patterns and are called the C1-set within the Ig superfamily. Other IgC domains fall within other sets. IgV domains also share sequence patterns and are called V set domains. IgV domains are longer than IgC domains and contain an additional pair of β strands.

Preferred B7 polypeptides are capable of providing costimulatory or inhibitory signals to immune cells to thereby promote or inhibit immune cell responses. For example, B7 family members that bind to costimulatory receptors increase T cell activation and proliferation, while B7 family members that bind to inhibitory receptors reduce costimulation. Moreover, the same B7 family member may increase or decrease T cell costimulation. For example, when bound to a costimulatory receptor, PD-1 ligand can induce costimulation of immune cells or can inhibit immune cell costimulation, *e.g.*, when present in soluble form. When bound to an inhibitory receptor, PD-1 ligand polypeptides can transmit an inhibitory signal to an immune cell. Preferred B7 family members include B7-1, B7-2, B7h, PD-L1 or PD-L2 and soluble fragments or derivatives thereof. In one embodiment, B7 family members bind to one or more receptors on an immune cell, *e.g.*, CTLA4, CD28, ICOS, PD-1 and/or other receptors, and, depending on the receptor, have the ability to transmit an inhibitory signal or a costimulatory signal to an immune cell, preferably a T cell.

Modulation of a costimulatory signal results in modulation of effector function of an immune cell. Thus, the term "PD-1 ligand activity" includes the ability of a PD-1 ligand polypeptide to bind its natural receptor(s) (*e.g.* PD-1 or B7-1), the ability to modulate immune cell costimulatory or inhibitory signals, and the ability to modulate the immune response.

The term "PD-L1" refers to a specific PD-1 ligand. Two forms of human PD-L1 molecules have been identified. One form is a naturally occurring PD-L1 soluble polypeptide, *i.e.,* having a short hydrophilic domain and no transmembrane domain, and is referred to herein as PD-L1S (shown in Table 1 as SEQ ID NO: 4). The second form is a cell-associated polypeptide, *i.e.,* having a transmembrane and cytoplasmic domain, referred to herein as PD-L1M (shown in SEQ ID NO: 6). The nucleic acid and amino acid sequences of representative human PD-L1 biomarkers regarding PD-L1M are also available

to the public at the GenBank database under NM_014143.3 and NP_054862.1. PD-L1 proteins comprise a signal sequence, and an IgV domain and an IgC domain. The signal sequence of SEQ ID NO: 4 is shown from about amino acid 1 to about amino acid 18. The signal sequence of SEQ ID NO: 6 is shown :from about amino acid 1 to about amino acid 18. The IgV domain of SEQ ID NO: 4 is shown from about amino acid 19 to about amino acid 134 and the IgV domain of SEQ ID NO: 6 is shown from about amino acid 19 to about amino acid 134. The IgC domain of SEQ ID NO: 4 is shown from about amino acid 135 to about amino acid 227 and the IgC domain of SEQ ID NO: 6 is shown from about amino acid 135 to about amino acid 227. The hydrophilic tail of the PD-L1 exemplified in SEQ ID NO: 4 comprises a hydrophilic tail shown from about amino acid 228 to about amino acid 245. The PD-L1 polypeptide exemplified in SEQ ID NO: 6 comprises a transmembrane domain shown from about amino acids 239 to about amino acid 259 of SEQ ID NO: 6 and a cytoplasmic domain shown from about 30 amino acid 260 to about amino acid 290 of SEQ ID NO: 6. In addition, nucleic acid and polypeptide sequences of PD-L1 orthologs in organisms other than humans are well-known and include, for example, mouse PD-L1 (NM_021893.3 and NP_068693.1), rat PD-L1 (NM_001191954.1 and NP_001178883.1), dog PD-L1 (XM_541302.3 and XP_541302.3), cow PD-L1 (NM_001163412.1 and NP_001156884.1), and chicken PD-L1 (XM_424811.3 and XP_424811.3).

The term "PD-L2" refers to another specific PD-1 ligand. PD-L2 is a B7 family member expressed on various APCs, including dendritic cells, macrophages and bone-marrow derived mast cells (Zhong *et al.* (2007) Eur. J. Immunol. 37:2405). APC-expressed PD-L2 is able to both inhibit T cell activation through ligation of PD-1 and costimulate T cell activation, through a PD-1 independent mechanism (Shin *et al.* (2005) J. Exp. Med. 201:1531). In addition, ligation of dendritic cell-expressed PD-L2 results in enhanced dendritic cell cytokine expression and survival (Radhakrishnan *et al.* (2003) J. Immunol. 37:1827; Nguyen *et al.* (2002) J. Exp. Med. 196:1393). The nucleic acid and amino acid sequences of representative human PD-L2 biomarkers (*e.g.*, SEQ ID NOs: 7 and 8) are well-known in the art and are also available to the public at the GenBank database under NM_025239.3 and NP_079515.2. PD-L2 proteins are characterized by common structural elements. In some embodiments, PD-L2 proteins include at least one or more of the following domains: a signal peptide domain, a transmembrane domain, an IgV domain, an IgC domain, an extracellular domain, a transmembrane domain, and a cytoplasmic domain.

For example, amino acids 1-19 of SEQ ID NO: 8 comprises a signal sequence. As used herein, a "signal sequence" or "signal peptide" serves to direct a polypeptide containing such a sequence to a lipid bilayer, and is cleaved in secreted and membrane bound polypeptides and includes a peptide containing about 15 or more amino acids which occurs at the N-terminus of secretory and membrane bound polypeptides and which contains a large number of hydrophobic amino acid residues. For example, a signal sequence contains at least about 10-30 amino acid residues, preferably about 15- 25 amino acid residues, more preferably about 18-20 amino acid residues, and even more preferably about 19 amino acid residues, and has at least about 35-65%, preferably about 38-50%, and more preferably about 40-45% hydrophobic amino acid residues (*e.g.*, valine, leucine, isoleucine or phenylalanine). In another embodiment, amino acid residues 220-243 of the native human PD-L2 polypeptide and amino acid residues 201-243 of the mature polypeptide comprise a transmembrane domain. As used herein, the term "transmembrane domain" includes an amino acid sequence of about 15 amino acid residues in length which spans the plasma membrane. More preferably, a transmembrane domain includes about at least 20, 25, 30, 35, 40, or 45 amino acid residues and spans the plasma membrane. Transmembrane domains are rich in hydrophobic residues, and typically have an alpha-helical structure. In a preferred embodiment, at least 50%, 60%, 70%, 80%, 90%, 95% or more of the amino acids of a transmembrane domain are hydrophobic, *e.g.*, leucines, isoleucines, tyrosines, or tryptophans. Transmembrane domains are described in, for example, Zagotta, W. N. *et al.* (1996) Annu. Rev. Neurosci. 19: 235-263. In still another embodiment, amino acid residues 20-120 of the native human PD-L2 polypeptide and amino acid residues 1-101 of the mature polypeptide comprise an IgV domain. Amino acid residues 121- 219 of the native human PD-L2 polypeptide and amino acid residues 102-200 of the mature polypeptide comprise an IgC domain. As used herein, IgV and IgC domains are recognized in the art as Ig superfamily member domains. These domains correspond to structural units that have distinct folding patterns called Ig folds. Ig folds are comprised of a sandwich of two ß sheets, each consisting of antiparallel (3 strands of 5-10 amino acids with a conserved disulfide bond between the two sheets in most, but not all, domains. IgC domains of Ig, TCR, and MHC molecules share the same types of sequence patterns and are called the Cl set within the Ig superfamily. Other IgC domains fall within other sets. IgV domains also share sequence patterns and are called V set domains. IgV domains are longer than C-domains and form an additional pair of strands. In yet another embodiment, amino acid

residues 1-219 of the native human PD-L2 polypeptide and amino acid residues 1-200 of the mature polypeptide comprise an extracellular domain. As used herein, the term "extracellular domain" represents the N-terminal amino acids which extend as a tail from the surface of a cell. An extracellular domain of the present invention includes an IgV domain and an IgC domain, and may include a signal peptide domain. In still another embodiment, amino acid residues 244-273 of the native human PD-L2 polypeptide and amino acid residues 225-273 of the mature polypeptide comprise a cytoplasmic domain. As used herein, the term "cytoplasmic domain" represents the C-terminal amino acids which extend as a tail into the cytoplasm of a cell. In addition, nucleic acid and polypeptide sequences of PD-L2 orthologs in organisms other than humans are well-known and include, for example, mouse PD-L2 (NM_021396.2 and NP_067371.1), rat PD-L2 (NM_001107582.2 and NP_001101052.2), dog PD-L2 (XM_847012.2 and XP_852105.2), cow PD-L2 (XM_586846.5 and XP_586846.3), and chimpanzee PD-L2 (XM_001140776.2 and XP_001140776.1).

The term "PD-L2 activity," "biological activity of PD-L2," or "functional activity of PD-L2," refers to an activity exerted by a PD-L2 protein, polypeptide or nucleic acid molecule on a PD-L2-responsive cell or tissue, or on a PD- L2 polypeptide binding partner, as determined *in vivo*, or *in vitro*, according to standard techniques. In one embodiment, a PD-L2 activity is a direct activity, such as an association with a PD-L2 binding partner. As used herein, a "target molecule" or "binding partner" is a molecule with which a PD-L2 polypeptide binds or interacts in nature, such that PD-L2-mediated function is achieved. In an exemplary embodiment, a PD-L2 target molecule is the receptor RGMb. Alternatively, a PD-L2 activity is an indirect activity, such as a cellular signaling activity mediated by interaction of the PD- L2 polypeptide with its natural binding partner (*i.e.*, physiologically relevant interacting macromolecule involved in an immune function or other biologically relevant function), *e.g.*, RGMb. The biological activities of PD-L2 are described herein. For example, the PD-L2 polypeptides of the present invention can have one or more of the following activities: 1) bind to and/or modulate the activity of the receptor RGMb, PD-1, or other PD-L2 natural binding partners, 2) modulate intra-or intercellular signaling, 3) modulate activation of immune cells, *e.g.* , T lymphocytes, and 4) modulate the immune response of an organism, *e.g.*, a mouse or human organism.

"Anti-immune checkpoint therapy" refers to the use of agents that inhibit immune checkpoint nucleic acids and/or proteins. Inhibition of one or more immune checkpoints

can block or otherwise neutralize inhibitory signaling to thereby upregulate an immune response in order to more efficaciously treat cancer. Exemplary agents useful for inhibiting immune checkpoints include antibodies, small molecules, peptides, peptidomimetics, natural ligands, and derivatives of natural ligands, that can either bind and/or inactivate or inhibit immune checkpoint proteins, or fragments thereof; as well as RNA interference, antisense, nucleic acid aptamers, etc. that can downregulate the expression and/or activity of immune checkpoint nucleic acids, or fragments thereof. Exemplary agents for upregulating an immune response include antibodies against one or more immune checkpoint proteins block the interaction between the proteins and its natural receptor(s); a non-activating form of one or more immune checkpoint proteins (*e.g.*, a dominant negative polypeptide); small molecules or peptides that block the interaction between one or more immune checkpoint proteins and its natural receptor(s); fusion proteins (*e.g.* the extracellular portion of an immune checkpoint inhibition protein fused to the Fc portion of an antibody or immunoglobulin) that bind to its natural receptor(s); nucleic acid molecules that block immune checkpoint nucleic acid transcription or translation; and the like. Such agents can directly block the interaction between the one or more immune checkpoints and its natural receptor(s) (*e.g.*, antibodies) to prevent inhibitory signaling and upregulate an immune response. Alternatively, agents can indirectly block the interaction between one or more immune checkpoint proteins and its natural receptor(s) to prevent inhibitory signaling and upregulate an immune response. For example, a soluble version of an immune checkpoint protein ligand such as a stabilized extracellular domain can binding to its receptor to indirectly reduce the effective concentration of the receptor to bind to an appropriate ligand. In one embodiment, anti-PD-1 antibodies, anti-PD-L1 antibodies, and/or anti-PD-L2 antibodies, either alone or in combination, are used to inhibit immune checkpoints. These embodiments are also applicable to specific therapy against particular immune checkpoints, such as the PD-1 pathway (*e.g.*, anti-PD-1 pathway therapy, otherwise known as PD-1 pathway inhibitor therapy).

Protein tyrosine phosphatases (PTPs or PTPases) are a group of enzymes that remove phosphate groups from phosphorylated tyrosine residues on proteins (He *et al.* (2014) *Acta Pharmacol. Sin.* 35:1227-1246; Barr *et al.* (2009) *Cell* 136:352-363). Protein tyrosine (pTyr) phosphorylation is a common post-translational modification that can create novel recognition motifs for protein interactions and cellular localization, affect protein stability, and regulate enzyme activity. As a consequence, maintaining an appropriate level

of protein tyrosine phosphorylation is essential for many cellular functions. Tyrosine-specific protein phosphatases (PTPase; EC 3.1.3.48) catalyze the removal of a phosphate group attached to a tyrosine residue, using a cysteinyl-phosphate enzyme intermediate. These enzymes are key regulatory components in signal transduction pathways (such as the MAP kinase pathway) and cell cycle control, and are important in the control of cell growth, proliferation, differentiation, transformation, and synaptic plasticity (Denu and Dixon (1998) *Curr. Opin. Chem. Biol.* 2:633-641; Lombroso (2003) *Cell. Mol. Life Sci.* 60:2465-2482). Together with tyrosine kinases, PTPs regulate the phosphorylation state of many important signaling molecules, such as the MAP kinase family. PTPs are increasingly viewed as integral components of signal transduction cascades. PTPs have been implicated in regulation of many cellular processes, including, but not limited to: cell growth, cellular differentiation, mitotic cycles, oncogenic transformation, receptor endocytosis, etc. The classification of PTPs can be achieved by mechanism or location. By mechanism, PTP activity can be found in four protein families, including: 1) class I PTPs, which is the largest group of PTPs comprising at least 99 members, such as at least 38 classical PTPs (21 receptor tyrosine phosphatase and 17 non-receptor-type PTPs) and 61 VH-1-like or dual-specific (dTyr and dSer/dThr) phosphatases (DSPs) (*e.g.*, 11 MAPK phosphatases (MPKs), 3 Slingshots, 3 PRLs, 4 CDC14s, 19 atypical DSPs, 5 Phosphatase and tensin homologs (PTENs), and 16 Myotubularins); 2) class II PTP, comprising only one member low-molecular-weight phosphotyrosine phosphatase (LMPTP); 3) class III PTPs, comprising at least CDC25 A, B, and C proteins; and 4) Class IV PTPs, comprising at least Eya 1-4 proteins, which are pTyr-specific phosphatases and believed to have evolved separately from the other three classes. By cellular location, PTPs can be classified as receptor-like PTPs and non-receptor (intracellular) PTPs. The former are transmembrane receptors that contain PTPase domains. In terms of structure, all known receptor PTPases are made up of a variable-length extracellular domain, followed by a transmembrane region and a C-terminal catalytic cytoplasmic domain. Some of the receptor PTPases contain fibronectin type III (FN-III) repeats, immunoglobulin-like domains, MAM domains, or carbonic anhydrase-like domains in their extracellular region. In general, the cytoplasmic region contains two copies of the PTPase domain. The first has enzymatic activity, whereas the second is inactive (Sun *et al.* (2003) *Curr Top Med Chem.* 3:739-748; Alonso *et al.* (2004) *Cell* 117:699–711). All class I, II, and III PTPs carry a highly conserved active site motif $C(X)_5R$ (PTP signature motif), employ a common catalytic mechanism, and possess a

similar core structure made of a central parallel beta-sheet with flanking alpha-helices containing a beta-loop-alpha-loop that encompasses the PTP signature motif (Barford *et al.* (1998) *Annu. Rev. Biophys. Biomol. Struct.* 27:133-164). Functional diversity between PTPases is endowed by regulatory domains and subunits. For most PTPs, the consensus sequence (I/V)HCXAGXXR(S/T)G (*i.e.*, the $C(X)_5R$ PTP signature motif) contains the catalytically essential Cys and Arg residues. Intracellular PTPs are often modular molecules containing structural motifs such as Src homology 2 (SH2) domains, PEST sequences, and band 4.1 domains on either the N- or C-terminal side of their catalytic domains.

Among non-receptor PTPs, tyrosine-protein phosphatase non-receptor type 2 (PTPN2) is an enzyme that in humans is encoded by the *PTPN2* gene (Brown-Shimer *et al.* (1990) *Proc. Natl. Acad. Sci. USA* 87:5148–5152). Epidermal growth factor receptor and the adaptor protein Shc were reported to be substrates of this PTP, which suggests a role in growth factor-mediated cell signaling. Three alternatively spliced variants of this gene, which encode isoforms differing at their extreme C-termini, have been described. The different C-termini are thought to determine the substrate specificity, as well as the cellular localization of the isoforms. Two highly related but distinctly processed pseudogenes that localize to distinct human chromosomes have been reported. The human *PTPN2* gene localizes to chromosome 18p11.2-p11.3, whereas pseudogenes (gene symbol PTPN2P1 and PTPN2P2) are mapped to chromosomes 1q22-q24 and 13q12-q13, respectively. A direct comparison of the specificity of genomic and cDNA probes demonstrated that under identical conditions the genomic probes (containing both exon and intron sequences) readily identified a single specific site of hybridization, whereas the cDNA identified sites of both the gene and its pseudogenes (Johnson *et al.* (1993) *Genomics* 16:619-629). Human PTPN2 exists as two forms generated by alternative splicing: a 48-kDa endoplasmic reticulum (ER)-associated form (TC48, 415 amino acid) and a 45-kDa nuclear form (TC45). The three-dimensional PDB structure of PTPN2 is also well-known and described in at least the OCA database (protein ID: 1L8K) at the Weizmann Institute of Science (Rehovot, Israel) available on the World Wide Web at oca.weizmann.ac.il/oca-bin/ocashort?id=1L8K. PTPN2 has a protein tryrosine phosphatase catalytic (PTPc) domain, for example, from amino acid residues 5 to 275 of SEQ ID NO: 2. The PTPc domain comprises different motifs for various functions, such as substrate binding (amino acid residues 216-222 of SEQ ID NO: 2), endoplasmic reticulum (ER) location (amino acid

residues 346-415 of SEQ ID NO: 2), and STX17 interaction (amino acid residues 376-415 of SEQ ID NO: 2, also see Muppirala et al. (2012) *Biochim. Biophys. Acta* 1823:2109-2119).

The nucleic acid and amino acid sequences of a representative human PTPN2 is available to the public at the GenBank database (Gene ID 5771) and is shown in Table 1. Human PTPN2 isoforms include the longest isoform 1 (GenBank database numbers NM_002828.3 and NP_002819.2), and the shorter isoforms 2 (NM_080422.2 and NP_536347.1, which contains an alternate 3' region including a part of the C-terminal coding region, resulting in a shorter and distinct C-terminus, as compared to isoform 1), 3 (NM_080423.2 and NP_536348.1; which contains an alternate 3' region including a part of the C-terminal coding region, resulting in a shorter and distinct C-terminus, as compared to isoform 1), 4 (NM_001207013.1 and NP_001193942.1; which contains an additional in-frame exon in the middle coding region and an alternate 3' region including a part of the C-terminal coding region, resulting in an additional internal segment and a shorter and distinct C-terminus, as compared to isoform 1), and 5 (NM_001308287.1 and NP_001295216.1; which differs in the 5' UTR by lacking a portion of the 5' coding region and using an alternative start codon to initiates translation, resulting in a shorter and distinct N-terminus, as compared to isoform 1).

Nucleic acid and polypeptide sequences of PTPN2 orthologs in organisms other than humans are well-known and include, for example, chimpanzee (*Pan troglodytes*) PTPN2 (XM_009433614.2 and XP_009431889.2; XM_009433613.2 and XP_009431888.2; XM_009433615.2 and XP_009431890.2; XM_003953237.2 and XP_003953286.2; XM_001171536.4 and XP_001171536.2; XM_009433617.2 and XP_009431892.1; XM_016933257.1 and XP_016788746.1; XM_009433619.2 and XP_009431894.2; XM_009433618.2 and XP_009431893.2; XM_016933256.1 and XP_016788745.1; XM_016933258.1 and XP_016788747.1; and XM_009433620.2 and XP_009431895.2), dog PTPN2 (XM_014115598.1 and XP_013971073.1; XM_005623101.2 and XP_005623158.1; XM_005623100.2 and XP_005623157.1; and XM_005623099.2 and XP_005623156.1), mouse PTPN2 (NM_001127177.1 and NP_001120649.1, which represent the longer transcript, and NM_008977.3 and NP_033003.1, which differs in the 3' UTR and has multiple coding region differences, resulting in a distinct C-terminus and is shorter than the isoform encoded by the longer transcript), cattle PTPN2 (NM_001035431.2 and NP_001030508.1), Norway rat (*Rattus*

norvegicus) PTPN2 (NM_053990.1 and NP_446442.1), chicken PTPN2 (NM_001199387.1 and NP_001186316.1), tropical clawed frog (*Xenopus tropicalis*) PTPN2 (XM_004915252.3 and XP_004915309.2; and XM_002936076.4 and XP_002936122.1); zebrafish (*Danio rerio*) PTPN2 (NM_200466.2 and NP_956760.2; and NM_212654.1 and NP_997819.1); and fruit fly (*Drosophila melanogaster*) PTPN2 (NM_167874.2 and NP_728600.1; NM_057340.4 and NP_476688.1; NM_001274324.2 and NP_001261253.1; NM_167875.2 and NP_728601.1; and NM_057339.5 and NP_476687.1).

The term "PTPN2 activity," includes the ability of a PTPN2 polypeptide (and its fragments, domains, and/or motifs thereof, discussed herein) to bind and catalyze the removal of one or more phosphate groups from one or more its substrates in a cell (*e.g.*, a cancer cell, and/or an immune cell), *e.g.*, by engaging a natural PTPN2 substrate (*e.g.*, INSR, EGFR, CSF1R, PDGFR, JAK1, JAK2, JAK3, Src family kinases, STAT1, STAT3, STAT5A, STAT5B, STAT6, etc.) either in the nucleus or the cytoplasm of the cell (Shuai *et al.* (2003) *Nat. Rev. Immunol.* 3:900-911; Wiede *et al.* (2011) *J. Clin. Invest.* 121:4758-4774). Thus, the term "PTPN2 activity" includes the ability of a PTPN2 polypeptide to bind its natural substrate(s), the ability to modulate dephosphorylation of such substrate(s), and the ability to modulate the immune response through such substrate(s) in PTPN2-regulated signaling pathways.

The term "PTPN2 substrate(s)" refers to binding partners of a PTPN2 polypeptide (and its fragments, domains, and/or motifs thereof, discussed herein) from which one or more phosphate groups can be removed by the PTPN2 polypeptide. Such binding partners are usually members in PTPN2-regulated signaling pathways, such as INSR, EGFR, CSF1R, PDGFR, JAK1, JAK2, JAK3, Src family kinases, STAT1, STAT3, STAT5A, STAT5B, STAT6, etc. The term "INSR" refers to a member of gene superfamily that functions as insulin receptors. INSR is also commonly known under the names CD220, HHF5, insulin receptor isoform Long preproprotein, insulin receptor isoform Short preproprotein, and IR. *INSR*, localizing on 19p13.2, encodes a long protein that may be cleaved into four parts: two alpha subunits and two beta subunits. These subunits work together as a functioning receptor. The alpha subunits stick out from the surface of the cell, while the beta subunits remain inside the cell. The alpha subunits attach (bind) to insulin, which causes the beta subunits to trigger signaling pathways within the cell that influence many cell functions. The *INSR* gene mutations have been associated with at least Donohue

Syndrome, Rabson-Mendenhall Syndrome, and type A insulin resistance syndrome. The nucleic acid and amino acid sequences of a representative human INSR is available to the public at the GenBank database. Human INSR isoforms include the longer isoform 1 (GenBank database numbers NM_000208.3 and NP_000199.2; a.k.a. insulin receptor isoform Long preproprotein) and the shorter isoform 2 (NM_001079817.2 and NP_001073285.1; a.k.a. insulin receptor isoform Short preproprotein).

The term "PTPN2-regulated signaling pathway(s)" includes signaling pathways in which PTPN2 (and its fragments, domains, and/or motifs thereof, discussed herein) binds to at least one of its substrate, through which at least one cellular function and/or activity and/or cellular protein profiles is changed. In some embodiments, PTPN2 dephosphorylates at least one of its substates which bind to it. PTPN2-regulated signaling pathways include at least NF-kappaB signaling pathway, MAP kinase signaling pathway, Jak-STAT signaling pathway, cytokine signaling pathway, interferon gamma (IFNγ) signaling pathway, etc. In some embodiments, the PTPN2-regulated signaling pathway is a type I interferon signaling pathway and/or type II interferon signaling pathway, which are summarized in at least Platanias (2005) *Nat. Rev. Immunol.* 5:375-386. The most studied members of the Type I interferons (IFNs) are the multiple IFNα isotypes and IFNβ. Type I IFNs are responsible for inducing transcription of a large group of genes which play a role in host resistance to viral infections, as well as activating key components of the innate and adaptive immune systems, including antigen presentation and production of cytokines involved in activation of T cells, B cells, and natural killer cells. Type I IFNs are transcriptionally regulated, and are induced following recognition of pathogen components during infection by various host pattern recognition receptors. Virtually all humans cells are able to synthesize IFNα/β, however some cells have a more pronounced ability to produce these cytokines. At least three pathways (*i.e.*, the RIG-I pathway, the TRIF pathway, and TLR7/8/9-IRF7 pathway) the are involved in producing Type I IFN. Following their production, Type I IFNs trigger antiviral responses by binding to a common receptor (IFNAR). IFNα/β binding to IFNAR stimulates the JAK1-STAT pathway leading to the assembly of the ISGF3 complex which is composed of STAT1-STAT2 dimers and IRF9. ISGF3 binds to IFN-stimulated response elements (ISRE) in the promoters of IFN-stimulated genes to regulate their expression. Among these genes is IRF7 which initiates the transcription of a second wave of Type I IFNs. This autocrine/paracrine feed-back allows Type I IFNs to create an antiviral state in surrounding cells. IFNγ is the only type II

interferon. While it does not share structural homology or a common receptor with the type I IFNs, it too has antiviral and immunomodulatory properties. The biologically active form of IFNγ is a noncovalently-linked homodimer. This homodimer binds to the extracellular domain of two IFNγR1/CD119 chains, which interact with IFNγR2 to form the functional IFNγ receptor complex. The IFNγR1 subunits of the receptor complex are associated with Jak1, while the IFNγR2 subunits are associated with Jak2. Activation of Jak1 and Jak2 results in phosphorylation of the receptor and subsequent recruitment and phosphorylation of STAT1. STAT1 phosphorylation leads to its homodimerization and nuclear translocation. Once in the nucleus, STAT1 homodimers bind to IFNγ-activated sequence (GAS) elements in the promoters of target genes to regulate their transcription. Many of the target genes that are induced by IFNγ/STAT1 signaling are transcription factors that then drive the expression of secondary response genes. In addition, IFNγ signaling can activate MAPK, PI3K-Akt, and NF-kappa B signaling pathways to regulate the expression of a number of other genes. IFNγ signaling plays a key role in host defense by promoting macrophage activation, upregulating the expression of antigen processing and presentation molecules, driving the development and activation of Th1 cells, enhancing natural killer cell activity, regulating B cell functions, and inducing the production of chemokines that promote effector cell trafficking to sites of inflammation. While IFNγ has historically been known for its cytotoxic, cytostatic, and anti-tumor properties, multiple studies have also suggested that IFNγ may also have context-dependent proliferative and pro-tumorigenic effects. For a summary of the Type II interferon signaling pathway, see at least Raza *et al.* (2008) *BMC Sys. Biol.* 2:36). IFNγ signaling can at least promote NK cell activity, increase antigen presentation and lysosome activity of macrophages, activate inducible nitric oxide synthase (iNOS), and induce the production of IgG2a and IgG3 from activated plasma B cells. Many IFN-stimulated genes control viral, bacterial, and parasite infection by directly targeting pathways and functions required during pathogen life cycles. The detection methods for such activation or inhibitor of IFNγ responsive genes are also well known in the art. In some embodiments, the cancer cells described herein have functional IFNγ signaling pathway but inactivated or at least reduced activation of IFNγ-responsive target genes, probably due to the inhibition by PTPN2. Upon a treatment with the antagonizing agent for PTPN2, as described herein, such cancer cells restore active IFNγ signaling. Such restoration of IFNγ signaling can be detected and/or measured through the expression

and/or function of IFN-responsive genes, as described herein, using any known method in the art.

The term "PTPN2 inhibitor(s)" includes any natural or non-natural agent prepared, synthesized, manufactured, and/or purified by human that is capable of reducing, inhibiting, blocking, preventing, and/or that inhibits the ability of a PTPN2 polypeptide (and its fragments, domains, and/or motifs thereof, discussed herein). In one embodiment, such inhibitors may reduce or inhibit the binding/interaction between PTPN2 and its substrates or other binding partners. In another embodiment, such inhibitors may reduce or inhibit the catalytic function of PTPN2 as a phosphatase. In still another embodiment, such inhibitors may increase or promote the turnover rate, reduce or inhibit the expression and/or the stability (*e.g.*, the half-life), and/or change the cellular localization of PTPN2, resulting in at least a decrease in PTPN2 levels and/or activity. Such inhibitors may be any molecule, including but not limited to small molecule compounds, antibodies or intrabodies, RNA interfereing (RNAi) agents (including at least siRNAs, shRNAs, microRNAs (miRNAs), piwi, and other well-known agents). Smalle molecule inhibitors of PTPN2 are known in the art and include, for example, 4-(aminosulfonyl)-7-fluoro-2,1,3-benzoxadiazole (ABDF; see Hansen *et al.* (2005) *Biochemistry* 44(21):7704-7712), imatinib mesylate (STI571; see Shimizu *et al.* (2004) *Exp Hematol.* 32(11):1057-1063), PTP inhibitor V (PHPS1, see Kim and Cho (2013) *Bull. Korean Chem. Soc.* 34:3874-3876), ethyl-3,4-dephospatin or other PTPN2 inhibitors described in the PCT Publ. No. WO 2015/188228, inhibitors described in Romsicki *et al.* (2003) *Arch Biochem Biophys.* 414:40-50, Iversen *et al.* (2002) *J. Biol. Chem.* 277(22):19982-19990, and Asante-Appiah *et al.* (2001) *J. Biol. Chem.* 276(28):26036-26043; commercial available PTP and/or PTPN2 inhibitors (*e.g.*, products from EMD Millipore, Billerica, MA, such as anti-PTPN2 antibodies, ursolic acid, sodium orthovanadate, Dephostatin, Phenylarsine Oxide, PTP Inhibitor I, bpV(HOpic), bpV(phen), bpV(bipy), etc.), inhibitory nucleotide-related inhibitors (such as CRISPR products from OriGene (Rockville, MD) (*e.g.*, gRNA vectors KN202161G1 and KN202161G2), GenScript® (Piscataway, NJ), or Santa Cruz Biotechnology (Dallas, Texas) (*e.g.*, TC-PTP CRISPR/Cas9 KO Plasmid (h); sc-403071), miRNA products from ViGene Biosciences, inhibitory RNA products from Origene (*e.g.*, siRNA, shRNA, etc.) and ViGene Biosciences (*e.g.*, ready-to-package AAV shRNA), etc. Methods for developoing PTPN2-specific inhibitors based on its structure can be found in, *e.g.*, Iversen *et al.* (2001) *Biochemistry* 40(49):14812-14820. An exemplary method, without limitation, of analyzing

the activity of the PTPN2 inhibitors described herein is to analyze whether such inhibitors are capable of 1) inhibiting the phosphatase function of Ptpn2; and/or 2) restoring IFNγ signaling and/or cellular sensitivity to immunotherapy. Methods for detecting the phosphatase function of Ptpn2 are well-known in the art. For example, the phosphorylation of Ptpn2 targets, including receptor tyrosine kinases (*e.g.*, INSR, EGFR, CSF1R, PDGFR, etc.), non-receptor tyrosine kinases (*e.g.*, JAK1, JAK2, JAK3, etc.), Src family kinases (*e.g.*, Fyn, Lck, etc.) and STAT family members (*e.g.*, STAT1, STAT3, STAT5A, STAT5B, STAT6, etc.), can be measured and compared before and after the Ptpn2 inhibitor treatment.

The term "SOCS1," *a.k.a.*, suppressor of cytokine signaling 1, also known as JAB or TIP3, refers to a group of proteins in the family of STAT-induced STAT inhibitor (SSI) proteins, also known as suppressor of cytokine signalling (SOCS). SSI family members are cytokine-inducible negative regulators of cytokine signaling. The expression of this gene can be induced by a subset of cytokines, including IL2, IL3 erythropoietin (EPO), GM-CSF, and interferon-gamma (IFN-γ). SOCS1 functions downstream of cytokine receptors, and takes part in a negative feedback loop to attenuate cytokine signaling. Knockout studies in mice suggested the role of SOCS1 as a modulator of IFN-γ action, which is required for normal postnatal growth and survival. SOCS1 is involved in negative regulation of cytokines that signal through the JAK/STAT3 pathway. Through binding to JAKs, SOCS1 inhibits their kinase activity. SOCS1 also suppresses Tec protein-tyrosine activity at least *in vitro*. SOCS1 is a major regulator of signaling by interleukin 6 (IL6) and leukemia inhibitory factor (LIF). SOCS1 is believed to regulate interferon-gamma mediated sensory neuron survival. SOCS1 is believed to be the substrate recognition component of an ECS (Elongin BC-CUL2/5-SOCS-box protein) E3 ubiquitin ligase complex, which mediates the ubiquitination and subsequent proteasomal degradation of target proteins. SOCS1 also appears to be a negative regulator in IGF1R signaling pathway. Known interaction partners of SOCS1 include, at least, CD117 (De Sepulveda *et al.* (1999) *EMBO J.* 18:904-915), colony stimulating factor 1 receptor (Bourette *et al.* (2001) *J. Biol. Chem.* 276:22133-22139), growth hormone receptor (Ram and Waxman (1999) *J. Biol. Chem.* 274:35553-35561), IRS2 (Rui *et al.* (2002) *J. Biol. Chem.* 277:42394-42398), Janus kinase 2 (Yasukawa *et al.* (1999) *EMBO J.* 18:1309-1320), and TEC (Ohya *et al.* (1997) *J. Biol. Chem.* 272:27178-27182). Other predicted binding partners for SOCS1 include, *e.g.*, AXL, FGFR3, INSR, TRIM8, COMMD1, ELOC,

ERBB2, RELA, and CUL2. SOCS1 is known to be involved in activated Toll-Like Receptor 4 (TLR4) signaling (*e.g.*, MyD88-Mal cascade initiated on plasma membrane, TLR1, TLR2, TLR4, and TLR6 cascades), prolactin signaling pathway, IL-2 pathway (*e.g.*, growth hormone signaling, IL-2, IL-4 signaling pathway, etc.), class I MHC mediated antigen processing and presentation, mmune response interferon α/β signaling pathway, Jak-Stat signaling pathway, NF-κB signaling, etc.

The nucleic acid and amino acid sequences of a representative human SOCS1 is available to the public at the GenBank database (Gene ID 8651) and is shown in Table 1. For example, the nucleic acid and amino acid sequences of human SOCS1 polypeptide is well known (GenBank database numbers NM_003745.1 and NP_003736.1). The domain structure of SOCS1 polypeptide is also well known. For example, as shown in UniProt database reference number O15524, human SOCS1 polypeptide has a SH2 domain comprising, *e.g.*, amino acid residue number 79-174 of NP_003736.1, and a SOCS box domain comprising, *e.g.*, amino acid residue number 161-210 of NP_003736.1. Other known regions include a kinase inhibitory region (KIR) comprising, *e.g.*, amino acid residue number 55-66 of NP_003736.1, an extended SH2 subdomain (ESS) comprising *e.g.*, amino acid residue number 67-78 of NP_003736.1, and a domain capable of interacting with Elongin BC complex comprising *e.g.*, amino acid residue number 173-182 of NP_003736.1.

Nucleic acid and polypeptide sequences of SOCS1 orthologs in organisms other than humans are well-known and include, for example, chimpanzee (*Pan troglodytes*) SOCS1 (XM_016929424.1 and XP_016784913.1), Rhesus monkey SOCS1 (XM_001104595.3 and XP_001104595.1), dog SOCS1 (XM_005622079.1 and XP_005622136.1), mouse SOCS1 (NM_001271603.1 and NP_001258532.1, which represent the longer transcript variant 1, and NM_009896.2 and NP_034026.1, which represent the shorter transcript variant 2 which differs in the 5' UTR compared to variant 1 but encodes the same protein), cattle SOCS1 (XM_002697964.4 and XP_002698010.1), Norway rat (*Rattus norvegicus*) SOCS1 (NM_145879.2 and NP_665886.2), chicken SOCS1 (NM_001137648.1 and NP_001131120.1), tropical clawed frog (*Xenopus tropicalis*) SOCS1 (NM_001011327.1 and NP_001011327.1); and zebrafish (*Danio rerio*) SOCS1 (NM_001003467.1 and NP_001003467.1).

The term "SOCS1 activity," includes the ability of a SOCS1polypeptide (and its fragments, domains, and/or motifs thereof, discussed herein) to bind and exert one or more

of its biological functions to one or more its substrates in a cell (*e.g.*, a cancer cell, and/or an immune cell), *e.g.*, by engaging a natural SOCS1substrate (*e.g.*, those cytokine signaling molecues which are negatively regulated by SOCS1) either in the nucleus or the cytoplasm of the cell (Shuai *et al.* (2003) *Nat. Rev. Immunol.* 3:900-911; Wiede *et al.* (2011) *J. Clin. Invest.* 121:4758-4774). Thus, the term "SOCS1activity" includes the ability of a SOCS1polypeptide to bind its natural substrate(s), as described herein, the ability to modulate dephosphorylation of such substrate(s), and the ability to modulate the immune response through such substrate(s) in SOCS1-regulated signaling pathways.

The term "SOCS1 substrate(s)" refers to binding partners of a SOCS1polypeptide (and its fragments, domains, and/or motifs thereof, discussed herein) from which one or more phosphate groups can be removed by the SOCS1 polypeptide. Such binding partners are usually members in SOCS1-regulated signaling pathways, as described herein.

The term "SOCS1-regulated signaling pathway(s)" includes signaling pathways in which SOCS1 (and its fragments, domains, and/or motifs thereof, discussed herein) binds to at least one of its substrate, through which at least one cellular function and/or activity and/or cellular protein profiles is changed. In some embodiments, such signaling pathways include at least those activating SOCS1 expression and/or functions after cytokine signaling, downstream of cytokine receptors. In other embodiments, such signaling pathways include at least those utilized by SOCS1 in a negative feedback loop to attenuate cytokine signaling.

The term "SOCS1 inhibitor(s)" includes any natural or non-natural agent prepared, synthesized, manufactured, and/or purified by human that is capable of reducing, inhibiting, blocking, preventing, and/or that inhibits the ability of a SOCS1polypeptide (and its fragments, domains, and/or motifs thereof, discussed herein). In one embodiment, such inhibitors may reduce or inhibit the binding/interaction between SOCS1and its substrates or other binding partners, as described herein. In another embodiment, such inhibitors may reduce or inhibit the function of SOCS1as a negtaive regulator of cytokine signaling. In still another embodiment, such inhibitors may increase or promote the turnover rate, reduce or inhibit the expression and/or the stability (*e.g.*, the half-life), and/or change the cellular localization of SOCS1, resulting in at least a decrease in SOCS1levels and/or activity. Such inhibitors may be any molecule, including but not limited to small molecule compounds, antibodies or intrabodies, RNA interfereing (RNAi) agents (including at least siRNAs, shRNAs, microRNAs (miRNAs), piwi, and other well-known agents). Such inhibitors may

be specific to SOCS1 or also inhibit at least one of other related proteins (*e.g.*, aminopeptidases). RNA interference for SOCS1 polypepitdes are well known and commercially available (*e.g.*, human or mouse shRNA products (Cat. # TG309195, TG513972, TF713151, etc.) and siRNA products (Cat # SR305688, SR405596, SR508208, etc.) and CRISPR knockout products (Cat. # KN220847 and KN316454) from Origene (Rockville, MD), siRNA/shRNA products (Cat. # sc-40996 and sc-40997) and human or mouse gene knockout kit via CRISPR (Cat. # sc- sc-419667) from Santa Cruz Biotechonology (Dallas, Texas), and Ready-to-package AAV shRNA clones from Vigene Biosciences (Rockville, MD, Cat. # SH833775). Methods for detection, purification, and/or inhibition of SOCS1 (*e.g.*, by anti-SOCS1 antibodies) are also well known and commercially available (*e.g.*, multiple anti-SOCS1 antibodies from Origene (Cat. # TA890038, AM26561BT-N, AM26561AF-N, etc.), Novus Biologicals (Littleton, CO, Cat. # NB100-56637, NBP1-54563, 26930002, etc.), and abcam (Cambridge, MA, Cat. # ab9870, ab211288, ab62584, etc.). SOCS1 knockout human cell lines are also well known and available at the Horizon (Cambridge, UK, Cat. # HZGHC8651, etc.).

Methods of detecting the activation or inhibition of IFNγ-responsive genes and/or the corresponding cellular functionality are well-known in the art and taught throughout the instant disclosure. For example, different cell growth rates are associated with cells with normal or defective interferon (*e.g.*, IFNγ) signaling (*e.g.*, cells containing gene deletion of *Stat1*, *Jak1*, *Ifngr1*, or other IFNγ-responsive genes as shown in Figure 1, panel C and Figure 11, panels B and C) in response to TNF, IFNγ and/or IFNβ. Thus, cell growth can be measured and compared before and after treatment with inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) with well known techniques, such as an *in vitro* competition assay. While IFNγ-pathway deficient cells (*e.g.*, cancer cells) may have a significant growth advantage over wild type cancer cells or non-cancer cells, when exposed to IFNγ or IFNβ, an effective inhibitor described herein may ameliorate such growth advantage or cause growth disadvantages, relative to controls. Other readouts for testing the inhibitory function of such inhibitors may include the expression and/or function of IFNγ-responsive genes and/or cellular functions. For example, the activation of *Stat1*, *Jak1*, *Ifngr1*, or other IFNγ-responsive genes as shown in Figure 1, panel C and Figure 11, panels B and C may be detected and such inhibitors may increase or restore the expression of such responsive genes, such as increased expression of Granzyme B in CCD8+ T cells, MHC-I on tumor

cell surface, cytokines (*e.g.*, at least *Cxcl9*, *Cxcl10*, *Cxcl11*, *Ccl5*, *Tap1*, *Tapbp*, *B2m*, *Cdkn1a*, *Casp4*, *Casp8*, *Ifit2*, *Ripk1*, and *Bak1*), etc. Other readouts on cellular function for such inhibitors may include, *e.g.*, tumor size, responsiveness to immunotherapies, overall survival, antigen presentation, T cell recogniation of tumors, CD8+ T cell and γδ+ T cell numbers, apoptosis, T cell infiltration into tumors, or other methods taught in the instant disclosure.

The term "immune response" includes T cell mediated and/or B cell mediated immune responses. Exemplary immune responses include T cell responses, *e.g.*, cytokine production and cellular cytotoxicity. In addition, the term immune response includes immune responses that are indirectly effected by T cell activation, *e.g.*, antibody production (humoral responses) and activation of cytokine responsive cells, *e.g.*, macrophages.

The term "immunotherapeutic agent" can include any molecule, peptide, antibody or other agent which can stimulate a host immune system to generate an immune response to a tumor or cancer in the subject. Various immunotherapeutic agents are useful in the compositions and methods described herein.

The term "inhibit" includes the decrease, limitation, or blockage, of, for example a particular action, function, or interaction. In some embodiments, cancer is "inhibited" if at least one symptom of the cancer is alleviated, terminated, slowed, or prevented. As used herein, cancer is also "inhibited" if recurrence or metastasis of the cancer is reduced, slowed, delayed, or prevented.

The term "interaction", when referring to an interaction between two molecules, refers to the physical contact (*e.g.*, binding) of the molecules with one another. Generally, such an interaction results in an activity (which produces a biological effect) of one or both of said molecules.

An "isolated protein" refers to a protein that is substantially free of other proteins, cellular material, separation medium, and culture medium when isolated from cells or produced by recombinant DNA techniques, or chemical precursors or other chemicals when chemically synthesized. An "isolated" or "purified" protein or biologically active portion thereof is substantially free of cellular material or other contaminating proteins from the cell or tissue source from which the antibody, polypeptide, peptide or fusion protein is derived, or substantially free from chemical precursors or other chemicals when chemically synthesized. The language "substantially free of cellular material" includes preparations of a biomarker polypeptide or fragment thereof, in which the protein is separated from cellular

components of the cells from which it is isolated or recombinantly produced. In one embodiment, the language "substantially free of cellular material" includes preparations of a biomarker protein or fragment thereof, having less than about 30% (by dry weight) of non-biomarker protein (also referred to herein as a "contaminating protein"), more preferably less than about 20% of non-biomarker protein, still more preferably less than about 10% of non-biomarker protein, and most preferably less than about 5% non-biomarker protein. When antibody, polypeptide, peptide or fusion protein or fragment thereof, *e.g.*, a biologically active fragment thereof, is recombinantly produced, it is also preferably substantially free of culture medium, *i.e.*, culture medium represents less than about 20%, more preferably less than about 10%, and most preferably less than about 5% of the volume of the protein preparation.

As used herein, the term "isotype" refers to the antibody class (*e.g.*, IgM, IgG1, IgG2C, and the like) that is encoded by heavy chain constant region genes.

As used herein, the term "K_D" is intended to refer to the dissociation equilibrium constant of a particular antibody-antigen interaction. The binding affinity of antibodies of the disclosed invention may be measured or determined by standard antibody-antigen assays, for example, competitive assays, saturation assays, or standard immunoassays such as ELISA or RIA.

A "kit" is any manufacture (*e.g.* a package or container) comprising at least one reagent, *e.g.* a probe or small molecule, for specifically detecting and/or affecting the expression of a marker of the present invention. The kit may be promoted, distributed, or sold as a unit for performing the methods of the present invention. The kit may comprise one or more reagents necessary to express a composition useful in the methods of the present invention. In certain embodiments, the kit may further comprise a reference standard, *e.g.*, a nucleic acid encoding a protein that does not affect or regulate signaling pathways controlling cell growth, division, migration, survival or apoptosis. One skilled in the art can envision many such control proteins, including, but not limited to, common molecular tags (*e.g.*, green fluorescent protein and beta-galactosidase), proteins not classified in any of pathway encompassing cell growth, division, migration, survival or apoptosis by GeneOntology reference, or ubiquitous housekeeping proteins. Reagents in the kit may be provided in individual containers or as mixtures of two or more reagents in a single container. In addition, instructional materials which describe the use of the compositions within the kit can be included.

The term "neoadjuvant therapy" refers to a treatment given before the primary treatment. Examples of neoadjuvant therapy can include chemotherapy, radiation therapy, and hormone therapy. For example, in treating breast cancer, neoadjuvant therapy can allows patients with large breast cancer to undergo breast-conserving surgery.

The "normal" level of expression of a biomarker is the level of expression of the biomarker in cells of a subject, *e.g.*, a human patient, not afflicted with a cancer. An "over-expression" or "significantly higher level of expression" of a biomarker refers to an expression level in a test sample that is greater than the standard error of the assay employed to assess expression, and is preferably at least 10%, and more preferably 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5, 10, 10.5, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 times or more higher than the expression activity or level of the biomarker in a control sample (*e.g.*, sample from a healthy subject not having the biomarker associated disease) and preferably, the average expression level of the biomarker in several control samples. A "significantly lower level of expression" of a biomarker refers to an expression level in a test sample that is at least 10%, and more preferably 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5, 10, 10.5, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 times or more lower than the expression level of the biomarker in a control sample (*e.g.*, sample from a healthy subject not having the biomarker associated disease) and preferably, the average expression level of the biomarker in several control samples.

An "over-expression" or "significantly higher level of expression" of a biomarker refers to an expression level in a test sample that is greater than the standard error of the assay employed to assess expression, and is preferably at least 10%, and more preferably 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5, 10, 10.5, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 times or more higher than the expression activity or level of the biomarker in a control sample (*e.g.*, sample from a healthy subject not having the biomarker associated disease) and preferably, the average expression level of the biomarker in several control samples. A "significantly lower level of expression" of a biomarker refers to an expression level in a test sample that is at least 10%, and more preferably 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5, 10, 10.5, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 times or more lower than the expression level

of the biomarker in a control sample (*e.g.*, sample from a healthy subject not having the biomarker associated disease) and preferably, the average expression level of the biomarker in several control samples.

The term "pre-determined" biomarker amount and/or activity measurement(s) may be a biomarker amount and/or activity measurement(s) used to, by way of example only, evaluate a subject that may be selected for a particular treatment, evaluate a response to a treatment such as inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1)/immunotherapy combination therapy, and/or evaluate the disease state. A pre-determined biomarker amount and/or activity measurement(s) may be determined in populations of patients with or without cancer. The pre-determined biomarker amount and/or activity measurement(s) can be a single number, equally applicable to every patient, or the pre-determined biomarker amount and/or activity measurement(s) can vary according to specific subpopulations of patients. Age, weight, height, and other factors of a subject may affect the pre-determined biomarker amount and/or activity measurement(s) of the individual. Furthermore, the pre-determined biomarker amount and/or activity can be determined for each subject individually. In one embodiment, the amounts determined and/or compared in a method described herein are based on absolute measurements. In another embodiment, the amounts determined and/or compared in a method described herein are based on relative measurements, such as ratios (*e.g.*, serum biomarker normalized to the expression of housekeeping or otherwise generally constant biomarker). The pre-determined biomarker amount and/or activity measurement(s) can be any suitable standard. For example, the pre-determined biomarker amount and/or activity measurement(s) can be obtained from the same or a different human for whom a patient selection is being assessed. In one embodiment, the pre-determined biomarker amount and/or activity measurement(s) can be obtained from a previous assessment of the same patient. In such a manner, the progress of the selection of the patient can be monitored over time. In addition, the control can be obtained from an assessment of another human or multiple humans, *e.g.*, selected groups of humans, if the subject is a human. In such a manner, the extent of the selection of the human for whom selection is being assessed can be compared to suitable other humans, *e.g.*, other humans who are in a similar situation to the human of interest, such as those suffering from similar or the same condition(s) and/or of the same ethnic group.

The term "predictive" includes the use of a biomarker nucleic acid and/or protein status, *e.g.,* over- or under- activity, emergence, expression, growth, remission, recurrence or resistance of tumors before, during or after therapy, for determining the likelihood of response of a cancer to inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1)/immunotherapy combination therapy (*e.g.*, treatment with a combination of such an inhibitor and an immunotherapy, such as an immune checkpoint inhibitor). Such predictive use of the biomarker may be confirmed by, *e.g.,* (1) increased or decreased copy number (*e.g.,* by FISH, FISH plus SKY, single-molecule sequencing, *e.g.*, as described in the art at least at J. Biotechnol., 86:289-301, or qPCR), overexpression or underexpression of a biomarker nucleic acid (*e.g.,* by ISH, Northern Blot, or qPCR), increased or decreased biomarker protein (*e.g.,* by IHC), or increased or decreased activity, *e.g.,* in more than about 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 100%, or more of assayed human cancers types or cancer samples; (2) its absolute or relatively modulated presence or absence in a biological sample, *e.g.,* a sample containing tissue, whole blood, serum, plasma, buccal scrape, saliva, cerebrospinal fluid, urine, stool, or bone marrow, from a subject, *e.g.* a human, afflicted with cancer; (3) its absolute or relatively modulated presence or absence in clinical subset of patients with cancer (*e.g.*, those responding to a particular inhibitor of one or more biomarkers in Table 1/immunotherapy combination therapy or those developing resistance thereto).

The term "pre-malignant lesions" as described herein refers to a lesion that, while not cancerous, has potential for becoming cancerous. It also includes the term "pre-malignant disorders" or "potentially malignant disorders." In particular this refers to a benign, morphologically and/or histologically altered tissue that has a greater than normal risk of malignant transformation, and a disease or a patient's habit that does not necessarily alter the clinical appearance of local tissue but is associated with a greater than normal risk of precancerous lesion or cancer development in that tissue (leukoplakia, erythroplakia, erytroleukoplakia lichen planus (lichenoid reaction) and any lesion or an area which histological examination showed atypia of cells or dysplasia. In one embodiment, a metaplasia is a pre-malignant lesion.

The terms "prevent," "preventing," "prevention," "prophylactic treatment," and the like refer to reducing the probability of developing a disease, disorder, or condition in a

subject, who does not have, but is at risk of or susceptible to developing a disease, disorder, or condition.

The term "probe" refers to any molecule which is capable of selectively binding to a specifically intended target molecule, for example, a nucleotide transcript or protein encoded by or corresponding to a biomarker nucleic acid. Probes can be either synthesized by one skilled in the art, or derived from appropriate biological preparations. For purposes of detection of the target molecule, probes may be specifically designed to be labeled, as described herein. Examples of molecules that can be utilized as probes include, but are not limited to, RNA, DNA, proteins, antibodies, and organic molecules.

The term "prognosis" includes a prediction of the probable course and outcome of cancer or the likelihood of recovery from the disease. In some embodiments, the use of statistical algorithms provides a prognosis of cancer in an individual. For example, the prognosis can be surgery, development of a clinical subtype of cancer (*e.g.*, solid tumors, such as esophageal cancer and gastric cancer), development of one or more clinical factors, or recovery from the disease.

The term "response to immunotherapy" or "response to inhibitors of one or more biomarkers in Table 1/immunotherapy combination therapy" relates to any response of the hyperproliferative disorder (*e.g.*, cancer) to an anti-cancer agent, such as an inhibitor of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and an immunotherapy, preferably to a change in tumor mass and/or volume after initiation of neoadjuvant or adjuvant therapy. Hyperproliferative disorder response may be assessed, for example for efficacy or in a neoadjuvant or adjuvant situation, where the size of a tumor after systemic intervention can be compared to the initial size and dimensions as measured by CT, PET, mammogram, ultrasound or palpation. Responses may also be assessed by caliper measurement or pathological examination of the tumor after biopsy or surgical resection. Response may be recorded in a quantitative fashion like percentage change in tumor volume or in a qualitative fashion like "pathological complete response" (pCR), "clinical complete remission" (cCR), "clinical partial remission" (cPR), "clinical stable disease" (cSD), "clinical progressive disease" (cPD) or other qualitative criteria. Assessment of hyperproliferative disorder response may be done early after the onset of neoadjuvant or adjuvant therapy, *e.g.*, after a few hours, days, weeks or preferably after a few months. A typical endpoint for response assessment is upon termination of neoadjuvant chemotherapy or upon surgical removal of residual

tumor cells and/or the tumor bed. This is typically three months after initiation of neoadjuvant therapy. In some embodiments, clinical efficacy of the therapeutic treatments described herein may be determined by measuring the clinical benefit rate (CBR). The clinical benefit rate is measured by determining the sum of the percentage of patients who are in complete remission (CR), the number of patients who are in partial remission (PR) and the number of patients having stable disease (SD) at a time point at least 6 months out from the end of therapy. The shorthand for this formula is CBR=CR+PR+SD over 6 months. In some embodiments, the CBR for a particular cancer therapeutic regimen is at least 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, or more. Additional criteria for evaluating the response to cancer therapies are related to "survival," which includes all of the following: survival until mortality, also known as overall survival (wherein said mortality may be either irrespective of cause or tumor related); "recurrence-free survival" (wherein the term recurrence shall include both localized and distant recurrence); metastasis free survival; disease free survival (wherein the term disease shall include cancer and diseases associated therewith). The length of said survival may be calculated by reference to a defined start point (*e.g.*, time of diagnosis or start of treatment) and end point (*e.g.*, death, recurrence or metastasis). In addition, criteria for efficacy of treatment can be expanded to include response to chemotherapy, probability of survival, probability of metastasis within a given time period, and probability of tumor recurrence. For example, in order to determine appropriate threshold values, a particular cancer therapeutic regimen can be administered to a population of subjects and the outcome can be correlated to biomarker measurements that were determined prior to administration of any cancer therapy. The outcome measurement may be pathologic response to therapy given in the neoadjuvant setting. Alternatively, outcome measures, such as overall survival and disease-free survival can be monitored over a period of time for subjects following cancer therapy for which biomarker measurement values are known. In certain embodiments, the doses administered are standard doses known in the art for cancer therapeutic agents. The period of time for which subjects are monitored can vary. For example, subjects may be monitored for at least 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 25, 30, 35, 40, 45, 50, 55, or 60 months. Biomarker measurement threshold values that correlate to outcome of a cancer therapy can be determined using well-known methods in the art, such as those described in the Examples section.

The term "resistance" refers to an acquired or natural resistance of a cancer sample or a mammal to a cancer therapy (*i.e.*, being nonresponsive to or having reduced or limited response to the therapeutic treatment), such as having a reduced response to a therapeutic treatment by 25% or more, for example, 30%, 40%, 50%, 60%, 70%, 80%, or more, to 2-fold, 3-fold, 4-fold, 5-fold, 10-fold, 15-fold, 20-fold or more. The reduction in response can be measured by comparing with the same cancer sample or mammal before the resistance is acquired, or by comparing with a different cancer sample or a mammal that is known to have no resistance to the therapeutic treatment. A typical acquired resistance to chemotherapy is called "multidrug resistance." The multidrug resistance can be mediated by P-glycoprotein or can be mediated by other mechanisms, or it can occur when a mammal is infected with a multi-drug-resistant microorganism or a combination of microorganisms. The determination of resistance to a therapeutic treatment is routine in the art and within the skill of an ordinarily skilled clinician, for example, can be measured by cell proliferative assays and cell death assays as described herein as "sensitizing." In some embodiments, the term "reverses resistance" means that the use of a second agent in combination with a primary cancer therapy (*e.g.*, chemotherapeutic or radiation therapy) is able to produce a significant decrease in tumor volume at a level of statistical significance (*e.g.*, $p<0.05$) when compared to tumor volume of untreated tumor in the circumstance where the primary cancer therapy (*e.g.*, chemotherapeutic or radiation therapy) alone is unable to produce a statistically significant decrease in tumor volume compared to tumor volume of untreated tumor. This generally applies to tumor volume measurements made at a time when the untreated tumor is growing log rhythmically.

The terms "response" or "responsiveness" refers to an anti-cancer response, *e.g.* in the sense of reduction of tumor size or inhibiting tumor growth. The terms can also refer to an improved prognosis, for example, as reflected by an increased time to recurrence, which is the period to first recurrence censoring for second primary cancer as a first event or death without evidence of recurrence, or an increased overall survival, which is the period from treatment to death from any cause. To respond or to have a response means there is a beneficial endpoint attained when exposed to a stimulus. Alternatively, a negative or detrimental symptom is minimized, mitigated or attenuated on exposure to a stimulus. It will be appreciated that evaluating the likelihood that a tumor or subject will exhibit a favorable response is equivalent to evaluating the likelihood that the tumor or subject will not exhibit favorable response (*i.e.*, will exhibit a lack of response or be non-responsive).

An "RNA interfering agent" as used herein, is defined as any agent which interferes with or inhibits expression of a target biomarker gene by RNA interference (RNAi). Such RNA interfering agents include, but are not limited to, nucleic acid molecules including RNA molecules which are homologous to the target biomarker gene of the present invention, or a fragment thereof, short interfering RNA (siRNA), and small molecules which interfere with or inhibit expression of a target biomarker nucleic acid by RNA interference (RNAi).

"RNA interference (RNAi)" is an evolutionally conserved process whereby the expression or introduction of RNA of a sequence that is identical or highly similar to a target biomarker nucleic acid results in the sequence specific degradation or specific post-transcriptional gene silencing (PTGS) of messenger RNA (mRNA) transcribed from that targeted gene (*see* Coburn and Cullen (2002) *J. Virol.* 76:9225), thereby inhibiting expression of the target biomarker nucleic acid. In one embodiment, the RNA is double stranded RNA (dsRNA). This process has been described in plants, invertebrates, and mammalian cells. In nature, RNAi is initiated by the dsRNA-specific endonuclease Dicer, which promotes processive cleavage of long dsRNA into double-stranded fragments termed siRNAs. siRNAs are incorporated into a protein complex that recognizes and cleaves target mRNAs. RNAi can also be initiated by introducing nucleic acid molecules, *e.g.,* synthetic siRNAs or RNA interfering agents, to inhibit or silence the expression of target biomarker nucleic acids. As used herein, "inhibition of target biomarker nucleic acid expression" or "inhibition of marker gene expression" includes any decrease in expression or protein activity or level of the target biomarker nucleic acid or protein encoded by the target biomarker nucleic acid. The decrease may be of at least 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95% or 99% or more as compared to the expression of a target biomarker nucleic acid or the activity or level of the protein encoded by a target biomarker nucleic acid which has not been targeted by an RNA interfering agent.

The term "sample" used for detecting or determining the presence or level of at least one biomarker is typically brain tissue, cerebrospinal fluid, whole blood, plasma, serum, saliva, urine, stool (*e.g.*, feces), tears, and any other bodily fluid (*e.g.*, as described above under the definition of "body fluids"), or a tissue sample (*e.g.*, biopsy) such as a small intestine, colon sample, or surgical resection tissue. In certain instances, the method of the present invention further comprises obtaining the sample from the individual prior to detecting or determining the presence or level of at least one marker in the sample.

The term "sensitize" means to alter cancer cells or tumor cells in a way that allows for more effective treatment of the associated cancer with a cancer therapy (*e.g.*, anti-immune checkpoint, chemotherapeutic, and/or radiation therapy). In some embodiments, normal cells are not affected to an extent that causes the normal cells to be unduly injured by the therapies. An increased sensitivity or a reduced sensitivity to a therapeutic treatment is measured according to a known method in the art for the particular treatment and methods described herein below, including, but not limited to, cell proliferative assays (Tanigawa N, Kern D H, Kikasa Y, Morton D L, Cancer Res 1982; 42: 2159-2164), cell death assays (Weisenthal L M, Shoemaker R H, Marsden J A, Dill P L, Baker J A, Moran E M, Cancer Res 1984; 94: 161-173; Weisenthal L M, Lippman M E, Cancer Treat Rep 1985; 69: 615-632; Weisenthal L M, In: Kaspers G J L, Pieters R, Twentyman P R, Weisenthal L M, Veerman A J P, eds. Drug Resistance in Leukemia and Lymphoma. Langhorne, P A: Harwood Academic Publishers, 1993: 415-432; Weisenthal L M, Contrib Gynecol Obstet 1994; 19: 82-90). The sensitivity or resistance may also be measured in animal by measuring the tumor size reduction over a period of time, for example, 6 month for human and 4-6 weeks for mouse. A composition or a method sensitizes response to a therapeutic treatment if the increase in treatment sensitivity or the reduction in resistance is 25% or more, for example, 30%, 40%, 50%, 60%, 70%, 80%, or more, to 2-fold, 3-fold, 4-fold, 5-fold, 10-fold, 15-fold, 20-fold or more, compared to treatment sensitivity or resistance in the absence of such composition or method. The determination of sensitivity or resistance to a therapeutic treatment is routine in the art and within the skill of an ordinarily skilled clinician. It is to be understood that any method described herein for enhancing the efficacy of a cancer therapy can be equally applied to methods for sensitizing hyperproliferative or otherwise cancerous cells (*e.g.*, resistant cells) to the cancer therapy.

"Short interfering RNA" (siRNA), also referred to herein as "small interfering RNA" is defined as an agent which functions to inhibit expression of a target biomarker nucleic acid, *e.g.,* by RNAi. An siRNA may be chemically synthesized, may be produced by *in vitro* transcription, or may be produced within a host cell. In one embodiment, siRNA is a double stranded RNA (dsRNA) molecule of about 15 to about 40 nucleotides in length, preferably about 15 to about 28 nucleotides, more preferably about 19 to about 25 nucleotides in length, and more preferably about 19, 20, 21, or 22 nucleotides in length, and may contain a 3' and/or 5' overhang on each strand having a length of about 0, 1, 2, 3, 4, or 5 nucleotides. The length of the overhang is independent between the two strands, *i.e.,*

the length of the overhang on one strand is not dependent on the length of the overhang on the second strand. Preferably the siRNA is capable of promoting RNA interference through degradation or specific post-transcriptional gene silencing (PTGS) of the target messenger RNA (mRNA).

In another embodiment, an siRNA is a small hairpin (also called stem loop) RNA (shRNA). In one embodiment, these shRNAs are composed of a short (*e.g.,* 19-25 nucleotide) antisense strand, followed by a 5-9 nucleotide loop, and the analogous sense strand. Alternatively, the sense strand may precede the nucleotide loop structure and the antisense strand may follow. These shRNAs may be contained in plasmids, retroviruses, and lentiviruses and expressed from, for example, the pol III U6 promoter, or another promoter (*see, e.g.,* Stewart, *et al.* (2003) *RNA* Apr;9(4):493-501 incorporated by reference herein).

RNA interfering agents, *e.g.,* siRNA molecules, may be administered to a patient having or at risk for having cancer, to inhibit expression of a biomarker gene which is overexpressed in cancer and thereby treat, prevent, or inhibit cancer in the subject.

The term "small molecule" is a term of the art and includes molecules that are less than about 1000 molecular weight or less than about 500 molecular weight. In one embodiment, small molecules do not exclusively comprise peptide bonds. In another embodiment, small molecules are not oligomeric. Exemplary small molecule compounds which can be screened for activity include, but are not limited to, peptides, peptidomimetics, nucleic acids, carbohydrates, small organic molecules (*e.g.*, polyketides) (Cane *et al.* (1998) *Science* 282:63), and natural product extract libraries. In another embodiment, the compounds are small, organic non-peptidic compounds. In a further embodiment, a small molecule is not biosynthetic.

The term "specific binding" refers to antibody binding to a predetermined antigen. Typically, the antibody binds with an affinity (K_D) of approximately less than 10^{-7} M, such as approximately less than 10^{-8} M, 10^{-9} M or 10^{-10} M or even lower when determined by surface plasmon resonance (SPR) technology in a BIACORE® assay instrument using an antigen of interest as the analyte and the antibody as the ligand, and binds to the predetermined antigen with an affinity that is at least 1.1-, 1.2-, 1.3-, 1.4-, 1.5-, 1.6-, 1.7-, 1.8-, 1.9-, 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 6.0-, 7.0-, 8.0-, 9.0-, or 10.0-fold or greater than its affinity for binding to a non-specific antigen (*e.g.*, BSA, casein) other than the predetermined antigen or a closely-related antigen. The phrases "an antibody recognizing

an antigen" and "an antibody specific for an antigen" are used interchangeably herein with the term "an antibody which binds specifically to an antigen." Selective binding is a relative term refering to the ability of an antibody to discriminate the binding of one antigen over another.

The term "subject" refers to any healthy animal, mammal or human, or any animal, mammal or human afflicted with a cancer, *e.g.*, brain, lung, ovarian, pancreatic, liver, breast, prostate, and/or colorectal cancers, melanoma, multiple myeloma, and the like. The term "subject" is interchangeable with "patient."

The term "survival" includes all of the following: survival until mortality, also known as overall survival (wherein said mortality may be either irrespective of cause or tumor related); "recurrence-free survival" (wherein the term recurrence shall include both localized and distant recurrence); metastasis free survival; disease free survival (wherein the term disease shall include cancer and diseases associated therewith). The length of said survival may be calculated by reference to a defined start point (*e.g.* time of diagnosis or start of treatment) and end point (*e.g.* death, recurrence or metastasis). In addition, criteria for efficacy of treatment can be expanded to include response to chemotherapy, probability of survival, probability of metastasis within a given time period, and probability of tumor recurrence.

The term "synergistic effect" refers to the combined effect of two or more anti-cancer agents (*e.g.*, inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1)/immunotherapy combination therapy) can be greater than the sum of the separate effects of the anti-cancer agents/therapies alone.

The term "T cell" includes $CD4^+$ T cells and $CD8^+$ T cells. The term T cell also includes both T helper 1 type T cells and T helper 2 type T cells. The term "antigen presenting cell" includes professional antigen presenting cells (*e.g.*, B lymphocytes, monocytes, dendritic cells, Langerhans cells), as well as other antigen presenting cells (*e.g.*, keratinocytes, endothelial cells, astrocytes, fibroblasts, and oligodendrocytes).

The term "therapeutic effect" refers to a local or systemic effect in animals, particularly mammals, and more particularly humans, caused by a pharmacologically active substance. The term thus means any substance intended for use in the diagnosis, cure, mitigation, treatment or prevention of disease or in the enhancement of desirable physical or mental development and conditions in an animal or human. The phrase "therapeutically-

effective amount" means that amount of such a substance that produces some desired local or systemic effect at a reasonable benefit/risk ratio applicable to any treatment. In certain embodiments, a therapeutically effective amount of a compound will depend on its therapeutic index, solubility, and the like. For example, certain compounds discovered by the methods of the present invention may be administered in a sufficient amount to produce a reasonable benefit/risk ratio applicable to such treatment.

The terms "therapeutically-effective amount" and "effective amount" as used herein means that amount of a compound, material, or composition comprising a compound of the present invention which is effective for producing some desired therapeutic effect in at least a sub-population of cells in an animal at a reasonable benefit/risk ratio applicable to any medical treatment. Toxicity and therapeutic efficacy of subject compounds may be determined by standard pharmaceutical procedures in cell cultures or experimental animals, *e.g.*, for determining the LD_{50} and the ED_{50}. Compositions that exhibit large therapeutic indices are preferred. In some embodiments, the LD_{50} (lethal dosage) can be measured and can be, for example, at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 200%, 300%, 400%, 500%, 600%, 700%, 800%, 900%, 1000% or more reduced for the agent relative to no administration of the agent. Similarly, the ED_{50} (*i.e.*, the concentration which achieves a half-maximal inhibition of symptoms) can be measured and can be, for example, at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 200%, 300%, 400%, 500%, 600%, 700%, 800%, 900%, 1000% or more increased for the agent relative to no administration of the agent. Also, Similarly, the IC_{50} (*i.e.*, the concentration which achieves half-maximal cytotoxic or cytostatic effect on cancer cells) can be measured and can be, for example, at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 200%, 300%, 400%, 500%, 600%, 700%, 800%, 900%, 1000% or more increased for the agent relative to no administration of the agent. In some embodiments, cancer cell growth in an assay can be inhibited by at least about 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, or even 100%. In another embodiment, at least about a 10% , 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, or even 100% decrease in a solid malignancy can be achieved.

A "transcribed polynucleotide" or "nucleotide transcript" is a polynucleotide (*e.g.* an mRNA, hnRNA, a cDNA, or an analog of such RNA or cDNA) which is complementary to or homologous with all or a portion of a mature mRNA made by transcription of a

biomarker nucleic acid and normal post-transcriptional processing (*e.g.* splicing), if any, of the RNA transcript, and reverse transcription of the RNA transcript.

As used herein, the term "unresponsiveness" includes refractivity of cancer cells to therapy or refractivity of therapeutic cells, such as immune cells, to stimulation, *e.g.*, stimulation via an activating receptor or a cytokine. Unresponsiveness can occur, *e.g.*, because of exposure to immunosuppressants or exposure to high doses of antigen. As used herein, the term "anergy" or "tolerance" includes refractivity to activating receptor-mediated stimulation. Such refractivity is generally antigen-specific and persists after exposure to the tolerizing antigen has ceased. For example, anergy in T cells (as opposed to unresponsiveness) is characterized by lack of cytokine production, *e.g.*, IL-2. T cell anergy occurs when T cells are exposed to antigen and receive a first signal (a T cell receptor or CD-3 mediated signal) in the absence of a second signal (a costimulatory signal). Under these conditions, reexposure of the cells to the same antigen (even if reexposure occurs in the presence of a costimulatory polypeptide) results in failure to produce cytokines and, thus, failure to proliferate. Anergic T cells can, however, proliferate if cultured with cytokines (*e.g.*, IL-2). For example, T cell anergy can also be observed by the lack of IL-2 production by T lymphocytes as measured by ELISA or by a proliferation assay using an indicator cell line. Alternatively, a reporter gene construct can be used. For example, anergic T cells fail to initiate IL-2 gene transcription induced by a heterologous promoter under the control of the 5' IL-2 gene enhancer or by a multimer of the AP1 sequence that can be found within the enhancer (Kang *et al.* (1992) *Science* 257:1134).

There is a known and definite correspondence between the amino acid sequence of a particular protein and the nucleotide sequences that can code for the protein, as defined by the genetic code (shown below). Likewise, there is a known and definite correspondence between the nucleotide sequence of a particular nucleic acid and the amino acid sequence encoded by that nucleic acid, as defined by the genetic code.

GENETIC CODE

Alanine (Ala, A)	GCA, GCC, GCG, GCT
Arginine (Arg, R)	AGA, ACG, CGA, CGC, CGG, CGT
Asparagine (Asn, N)	AAC, AAT
Aspartic acid (Asp, D)	GAC, GAT
Cysteine (Cys, C)	TGC, TGT
Glutamic acid (Glu, E)	GAA, GAG

Glutamine (Gln, Q)	CAA, CAG
Glycine (Gly, G)	GGA, GGC, GGG, GGT
Histidine (His, H)	CAC, CAT
Isoleucine (Ile, I)	ATA, ATC, ATT
Leucine (Leu, L)	CTA, CTC, CTG, CTT, TTA, TTG
Lysine (Lys, K)	AAA, AAG
Methionine (Met, M)	ATG
Phenylalanine (Phe, F)	TTC, TTT
Proline (Pro, P)	CCA, CCC, CCG, CCT
Serine (Ser, S)	AGC, AGT, TCA, TCC, TCG, TCT
Threonine (Thr, T)	ACA, ACC, ACG, ACT
Tryptophan (Trp, W)	TGG
Tyrosine (Tyr, Y)	TAC, TAT
Valine (Val, V)	GTA, GTC, GTG, GTT
Termination signal (end)	TAA, TAG, TGA

An important and well-known feature of the genetic code is its redundancy, whereby, for most of the amino acids used to make proteins, more than one coding nucleotide triplet may be employed (illustrated above). Therefore, a number of different nucleotide sequences may code for a given amino acid sequence. Such nucleotide sequences are considered functionally equivalent since they result in the production of the same amino acid sequence in all organisms (although certain organisms may translate some sequences more efficiently than they do others). Moreover, occasionally, a methylated variant of a purine or pyrimidine may be found in a given nucleotide sequence. Such methylations do not affect the coding relationship between the trinucleotide codon and the corresponding amino acid.

In view of the foregoing, the nucleotide sequence of a DNA or RNA encoding a biomarker nucleic acid (or any portion thereof) can be used to derive the polypeptide amino acid sequence, using the genetic code to translate the DNA or RNA into an amino acid sequence. Likewise, for polypeptide amino acid sequence, corresponding nucleotide sequences that can encode the polypeptide can be deduced from the genetic code (which, because of its redundancy, will produce multiple nucleic acid sequences for any given amino acid sequence). Thus, description and/or disclosure herein of a nucleotide sequence which encodes a polypeptide should be considered to also include description and/or

disclosure of the amino acid sequence encoded by the nucleotide sequence. Similarly, description and/or disclosure of a polypeptide amino acid sequence herein should be considered to also include description and/or disclosure of all possible nucleotide sequences that can encode the amino acid sequence.

Finally, nucleic acid and amino acid sequence information for the loci and biomarkers of the present invention (*e.g.*, biomarkers listed in Tables 1 and 2) are well-known in the art and readily available on publicly available databases, such as the National Center for Biotechnology Information (NCBI). For example, exemplary nucleic acid and amino acid sequences derived from publicly available sequence databases are provided below and include, for example, PCT Publ. WO 2014/022759, which is incorporated herein in its entirety by this reference.

Table 1

SEQ ID NO: 1 Human PTPN2 isoform 1 cDNA Sequence (NM_002828.3)

```
   1 gctcgggcgc cgagtctgcg cgctgacgtc cgacgctcca ggtactttcc ccacggccga
  61 cagggcttgg cgtgggggcg gggcgcggcg cgcagcgcgc atgcgccgca gcgccagcgc
 121 tctccccgga tcgtgcgggg cctgagcctc tccgccggcg caggctctgc tcgcgccagc
 181 tcgctcccgc agccatgccc accaccatcg agcgggagtt cgaagagttg gatactcagc
 241 gtcgctggca gccgctgtac ttggaaattc gaaatgagtc ccatgactat cctcatagag
 301 tggccaagtt tccagaaaac agaaatcgaa acagatacag agatgtaagc ccatatgatc
 361 acagtcgtgt taaactgcaa aatgctgaga atgattatat taatgccagt ttagttgaca
 421 tagaagaggc acaaaggagt tacatcttaa cacagggtcc acttcctaac acatgctgcc
 481 atttctggct tatggtttgg cagcagaaga ccaaagcagt tgtcatgctg aaccgcattg
 541 tggagaaaga atcggttaaa tgtgcacagt actggccaac agatgaccaa gagatgctgt
 601 ttaaagaaac aggattcagt gtgaagctct tgtcagaaga tgtgaagtcg tattatacag
 661 tacatctact acaattagaa aatatcaata gtggtgaaac cagaacaata tctcactttc
 721 attatactac ctggccagat tttggagtcc ctgaatcacc agcttcattt ctcaatttct
 781 tgtttaaagt gagagaatct ggctccttga accctgacca tgggcctgcg gtgatccact
 841 gtagtgcagg cattgggcgc tctggcacct tctctctggt agacacttgt cttgttttga
 901 tggaaaaagg agatgatatt aacataaaac aagtgttact gaacatgaga aaataccgaa
 961 tgggtcttat tcagacccca gatcaactga gattctcata catggctata atagaaggag
1021 caaaatgtat aaagggagat tctagtatac agaaacgatg gaaagaactt tctaaggaag
1081 acttatctcc tgcctttgat cattcaccaa acaaaataat gactgaaaaa tacaatggga
1141 acagaatagg tctagaagaa gaaaaactga caggtgaccg atgtacagga ctttcctcta
1201 aaatgcaaga tacaatggag gagaacagtg agagtgctct acggaaacgt attcgagagg
1261 acagaaaggc caccacagct cagaaggtgc agcagatgaa acagaggcta aatgagaatg
1321 aacgaaaaag aaaaaggtgg ttatattggc aacctattct cactaagatg gggtttatgt
1381 cagtcatttt ggttggcgct tttgttggct ggacactgtt ttttcagcaa aatgccctat
1441 aaacaattaa ttttgcccag caagcttctg cactagtaac tgacagtgct acattaatca
1501 taggggtttg tctgcagcaa acgcctcata tcccaaaaac ggtgcagtag aatagacatc
1561 aaccagataa gtgatattta cagtcacaag cccaacatct caggactctt gactgcaggt
1621 tcctctgaac cccaaactgt aaatggctgt ctaaaataaa gacattcatg tttgttaaaa
1681 actggtaaat tttgcaactg tattcataca tgtcaaacac agtatttcac ctgaccaaca
1741 ttgagatatc ctttatcaca ggatttgttt ttggaggcta tctggatttt aacctgcact
1801 tgatataagc aataaatatt gtggttttat ctacgttatt ggaaagaaaa tgacatttaa
1861 ataatgtgtg taatgtataa tgtactattg acatgggcat caacactttt attcttaagc
1921 atttcagggt aaatatattt tataagtatc tatttaatct tttgtagtta actgtacttt
1981 ttaagagctc aatttgaaaa atctgttact aaaaaaataa attgtatgtc gattgaattg
2041 tactggatac attttccatt tttctaaaga gaagtttgat atgagcagtt agaagttgga
2101 ataagcaatt tctactatat attgcatttc ttttatgttt tacagttttc cccattttaa
```

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2161 aaagaaaagc aaacaaagaa acaaaagttt ttcctaaaaa tatctttgaa ggaaaattct
2221 ccttactggg atagtcaggt aaacagttgg tcaagacttt gtaaagaaat tggtttctgt
2281 aaatcccatt attgatatgt ttatttttca tgaaaatttc aatgtagttg gggtagatta
2341 tgatttagga agcaaaagta agaagcagca ttttatgatt cataatttca gtttactaga
2401 ctgaagtttt gaagtaaaca cttttcagtt tctttctact tcaataaata gtatgattat
2461 atgcaaacct tacattgtca ttttaactta atgaatattt tttaaagcaa actgtttaat
2521 gaatttaact gctcatttga atgctagctt tcctcagatt tcaacattcc attcagtgtt
2581 taatttgtct tacttaaact tgaaattgtt gttacaaatt taattgctag gaggcatgga
2641 tagcatacat tattatggat agcatacctt atttcagtgg ttttcaaact atgctcattg
2701 gatgtccagg tgggtcaaga ggttactttc aaccacagca tctctgcctt gtctctttat
2761 atgccacata agatttctgc ataaggctta agtattttaa agggggcagt tatcatttaa
2821 aaacagtttg gtcgggcgcg gtggctcatg cctgtaatcc cagcactttg ggaggctgaa
2881 gtgggcagat cacctgaggt caggagttca agaccagcct ggccaacgtg gtgaaacacc
2941 atctctacta aaaatgcaaa aattagctgg gcatggtgga gggcacctgt aatctcagct
3001 actcaggagg ctgaggtagg agaattgctt gaacccagga gatggaggtt gcagtgagct
3061 gagatcacgt cactgcactc cagccagggc gacagagcga gactccatct caaaagaaac
3121 aaacaaaaaa aacagtttgg gccgggtgtg gtggctcacg cttgtaatcc cagcacttcg
3181 gaaggccaag gcgggcggat cacgaggtca agagatggag actgtcctgg ccaacatggt
3241 gaaatccctt ctttactaaa aatacaaaaa ttatctgggc gtggtggtgc atgcctgtag
3301 tcccagctcc ttgggaggct aaggcaggag aatcacttga acccgggagg cagaggttgc
3361 agtgagccga gattgcacca ctgcactcca gcctggcaac agagcaagac ttcgtctc
```

SEQ ID NO: 2 Human PTPN2 isoform 1 Amino Acid Sequence (NP_002819.2)

```
   1 mpttierefe eldtqrrwqp lyleirnesh dyphrvakfp enrnrnryrd vspydhsrvk
  61 lqnaendyin aslvdieeaq rsyiltqgpl pntcchfwlm vwqqktkavv mlnrivekes
 121 vkcaqywptd dqemlfketg fsvkllsedv ksyytvhllq leninsgetr tishfhyttw
 181 pdfgvpespa sflnflfkvr esgslnpdhg pavihcsagi grsgtfslvd tclvlmekgd
 241 dinikqvlln mrkyrmgliq tpdqlrfsym aiiegakcik gdssiqkrwk elskedlspa
 301 fdhspnkimt ekyngnrigl eeekltgdrc tglsskmqdt meensesalr kriredrkat
 361 taqkvqqmkq rlnenerkrk rwlywqpilt kmgfmsvilv gafvgwtlff qqnal
```

SEQ ID NO: 3 Human PTPN2 isoform 2 cDNA Sequence (NM_080422.2)

```
   1 gctcgggcgc cgagtctgcg cgctgacgtc cgacgctcca ggtactttcc ccacggccga
  61 cagggcttgg cgtgggggcg gggcgcggcg cgcagcgcgc atgcgccgca gcgccagcgc
 121 tctccccgga tcgtgcgggg cctgagcctc tccgccggcg caggctctgc tcgcgccagc
 181 tcgctcccgc agccatgccc accaccatcg agcgggagtt cgaagagttg gatactcagc
 241 gtcgctggca gccgctgtac ttggaaattc gaaatgagtc ccatgactat cctcatagag
 301 tggccaagtt tccagaaaac agaaatcgaa acagatacag agatgtaagc ccatatgatc
 361 acagtcgtgt taaactgcaa aatgctgaga atgattatat taatgccagt ttagttgaca
 421 tagaagaggc acaaaggagt tacatcttaa cacagggtcc acttcctaac acatgctgcc
 481 atttctggct tatggtttgg cagcagaaga ccaaagcagt tgtcatgctg aaccgcattg
 541 tggagaaaga atcggttaaa tgtgcacagt actggccaac agatgaccaa gagatgctgt
 601 ttaaagaaac aggattcagt gtgaagctct tgtcagaaga tgtgaagtcg tattatacag
 661 tacatctact acaattagaa aatatcaata gtggtgaaac cagaacaata tctcactttc
 721 attatactac ctggccagat tttggagtcc ctgaatcacc agcttcattt ctcaatttct
 781 tgtttaaagt gagagaatct ggctccttga accctgacca tgggcctgcg gtgatccact
 841 gtagtgcagg cattgggcgc tctggcacct tctctctggt agacacttgt cttgttttga
 901 tggaaaaagg agatgatatt aacataaaac aagtgttact gaacatgaga aaataccgaa
 961 tgggtcttat tcagacccca gatcaactga gattctcata catggctata atagaaggag
1021 caaaatgtat aaagggagat tctagtatac agaaacgatg gaaagaactt tctaaggaag
1081 acttatctcc tgcctttgat cattcaccaa acaaaataat gactgaaaaa tacaatggga
1141 acagaatagg tctagaagaa gaaaaactga caggtgaccg atgtacagga ctttcctcta
1201 aaatgcaaga tacaatggag gagaacagtg agagtgctct acggaaacgt attcgagagg
1261 acagaaaggc caccacagct cagaaggtgc agcagatgaa acagaggcta aatgagaatg
1321 aacgaaaaag aaaaaggcca agattgacag acacctaata ttcatgactt gagaatattc
1381 tgcagctata aattttgaac cattgatgtg caaagcaaga cctgaagccc actccggaaa
1441 ctaaagtgag gctcgctaac cctctagatt gcctcacagt tgtttgttta caaagtaaac
1501 tttacatcca ggggatgaag agcacccacc agcagaagac tttgcagaac ctttaattgg
1561 atgtgttaag tgtttttaat gagtgtatga aatgtagaaa gatgtacaag aaataaatta
1621 ggggagatta ctttgtattg tactgccatt cctactgtat ttttatactt tttggcagca
```

1681 ttaaatattt ttgttaaata gtcaaaaaaa aaaaaaaaaa a

SEQ ID NO: 4 Human PTPN2 isoform 2 Amino Acid Sequence (NP_536347.1)

```
   1 mpttierefe eldtqrrwqp lyleirnesh dyphrvakfp enrnrnryrd vspydhsrvk
  61 lqnaendyin aslvdieeaq rsyiltqgpl pntcchfwlm vwqqktkavv mlnrivekes
 121 vkcaqywptd dqemlfketg fsvkllsedv ksyytvhllq leninsgetr tishfhyttw
 181 pdfgvpespa sflnflfkvr esgslnpdhg pavihcsagi grsgtfslvd tclvlmekgd
 241 dinikqvlln mrkyrmgliq tpdqlrfsym aiiegakcik gdssiqkrwk elskedlspa
 301 fdhspnkimt ekyngnrigl eeekltgdrc tglsskmqdt meensesalr kriredrkat
 361 taqkvqqmkq rlnenerkrk rprltdt
```

SEQ ID NO: 5 Human PTPN2 isoform 3 cDNA Sequence (NM_080423.2)

```
   1 gctcgggcgc cgagtctgcg cgctgacgtc cgacgctcca ggtactttcc ccacggccga
  61 cagggcttgg cgtgggggcg gggcgcggcg cgcagcgcgc atgcgccgca gcgccagcgc
 121 tctccccgga tcgtgcgggg cctgagcctc tccgccggcg caggctctgc tcgcgccagc
 181 tcgctcccgc agccatgccc accaccatcg agcgggagtt cgaagagttg gatactcagc
 241 gtcgctggca gccgctgtac ttggaaattc gaaatgagtc ccatgactat cctcatagag
 301 tggccaagtt tccagaaaac agaaatcgaa acagatacag agatgtaagc ccatatgatc
 361 acagtcgtgt taaactgcaa aatgctgaga atgattatat taatgccagt ttagttgaca
 421 tagaagaggc acaaaggagt tacatcttaa cacagggtcc acttcctaac acatgctgcc
 481 atttctggct tatggtttgg cagcagaaga ccaaagcagt tgtcatgctg aaccgcattg
 541 tggagaaaga atcggttaaa tgtgcacagt actggccaac agatgaccaa gagatgctgt
 601 ttaaagaaac aggattcagt gtgaagctct tgtcagaaga tgtgaagtcg tattatacag
 661 tacatctact acaattagaa aatatcaata gtggtgaaac cagaacaata tctcactttc
 721 attatactac ctggccagat tttggagtcc ctgaatcacc agcttcattt ctcaatttct
 781 tgtttaaagt gagagaatct ggctccttga accctgacca tgggcctgcg gtgatccact
 841 gtagtgcagg cattgggcgc tctggcacct tctctctggt agacacttgt cttgttttga
 901 tggaaaaagg agatgatatt aacataaaac aagtgttact gaacatgaga aaataccgaa
 961 tgggtcttat tcagacccca gatcaactga gattctcata catggctata atagaaggag
1021 caaaatgtat aaagggagat tctagtatac agaaacgatg gaaagaactt tctaaggaag
1081 acttatctcc tgcctttgat cattcaccaa acaaaataat gactgaaaaa tacaatggga
1141 acagaatagg tctagaagaa gaaaaactga caggtgaccg atgtacagga ctttcctcta
1201 aaatgcaaga tacaatggag gagaacagtg agaggccaag attgacagac acctaatatt
1261 catgacttga gaatattctg cagctataaa ttttgaacca ttgatgtgca aagcaagacc
1321 tgaagcccac tccggaaact aaagtgaggc tcgctaaccc tctagattgc ctcacagttg
1381 tttgtttaca aagtaaactt tacatccagg ggatgaagag cacccaccag cagaagactt
1441 tgcagaacct ttaattggat gtgttaagtg tttttaatga gtgtatgaaa tgtagaaaga
1501 tgtacaagaa ataaattagg ggagattact ttgtattgta ctgccattcc tactgtattt
1561 ttatactttt tggcagcatt aaatattttt gttaaatagt caaaaaaaaa aaaaaaaaa
```

SEQ ID NO: 6 Human PTPN2 isoform 3 Amino Acid Sequence (NP_536348.1)

```
   1 mpttierefe eldtqrrwqp lyleirnesh dyphrvakfp enrnrnryrd vspydhsrvk
  61 lqnaendyin aslvdieeaq rsyiltqgpl pntcchfwlm vwqqktkavv mlnrivekes
 121 vkcaqywptd dqemlfketg fsvkllsedv ksyytvhllq leninsgetr tishfhyttw
 181 pdfgvpespa sflnflfkvr esgslnpdhg pavihcsagi grsgtfslvd tclvlmekgd
 241 dinikqvlln mrkyrmgliq tpdqlrfsym aiiegakcik gdssiqkrwk elskedlspa
 301 fdhspnkimt ekyngnrigl eeekltgdrc tglsskmqdt meenserprl tdt
```

SEQ ID NO: 7 Human PTPN2 isoform 4 cDNA Sequence (NM_001207013.1)

```
   1 gctcgggcgc cgagtctgcg cgctgacgtc cgacgctcca ggtactttcc ccacggccga
  61 cagggcttgg cgtgggggcg gggcgcggcg cgcagcgcgc atgcgccgca gcgccagcgc
 121 tctccccgga tcgtgcgggg cctgagcctc tccgccggcg caggctctgc tcgcgccagc
 181 tcgctcccgc agccatgccc accaccatcg agcgggagtt cgaagagttg gatactcagc
 241 gtcgctggca gccgctgtac ttggaaattc gaaatgagtc ccatgactat cctcatagag
 301 tggccaagtt tccagaaaac agaaatcgaa acagatacag agatgtaagc ccatatgatc
 361 acagtcgtgt taaactgcaa aatgctgaga atgattatat taatgccagt ttagttgaca
 421 tagaagaggc acaaaggagt tacatcttaa cacagggtcc acttcctaac acatgctgcc
 481 atttctggct tatggtttgg cagcagaaga ccaaagcagt tgtcatgctg aaccgcattg
 541 tggagaaaga atcggttaaa tgtgcacagt actggccaac agatgaccaa gagatgctgt
```

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 601 ttaaagaaac aggattcagt gtgaagctct tgtcagaaga tgtgaagtcg tattatacag
 661 tacatctact acaattagaa aatatcaatt atattgagaa cttgtggatc acactgtatt
 721 tgaaattatt aatgctggat gttaaaaggt cactaaaaag tggtgaaacc agaacaatat
 781 ctcactttca ttatactacc tggccagatt ttggagtccc tgaatcacca gcttcatttc
 841 tcaatttctt gtttaaagtg agagaatctg gctccttgaa ccctgaccat gggcctgcgg
 901 tgatccactg tagtgcaggc attgggcgct ctggcacctt ctctctggta gacacttgtc
 961 ttgttttgat ggaaaaagga gatgatatta acataaaaca agtgttactg aacatgagaa
1021 aataccgaat gggtcttatt cagaccccag atcaactgag attctcatac atggctataa
1081 tagaaggagc aaaatgtata aagggagatt ctagtataca gaaacgatgg aaagaacttt
1141 ctaaggaaga cttatctcct gcctttgatc attcaccaaa caaaataatg actgaaaaat
1201 acaatgggaa cagaataggt ctagaagaag aaaaactgac aggtgaccga tgtacaggac
1261 tttcctctaa aatgcaagat acaatggagg agaacagtga gagtgctcta cggaaacgta
1321 ttcgagagga cagaaaggcc accacagctc agaaggtgca gcagatgaaa cagaggctaa
1381 atgagaatga acgaaaaaga aaaaggccaa gattgacaga cacctaatat tcatgacttg
1441 agaatattct gcagctataa attttgaacc attgatgtgc aaagcaagac ctgaagccca
1501 ctccggaaac taaagtgagg ctcgctaacc ctctagattg cctcacagtt gtttgtttac
1561 aaagtaaact ttacatccag gggatgaaga gcacccacca gcagaagact ttgcagaacc
1621 tttaattgga tgtgttaagt gtttttaatg agtgtatgaa atgtagaaag atgtacaaga
1681 aataaattag gggagattac tttgtattgt actgccattc ctactgtatt tttatacttt
1741 ttggcagcat taaatatttt tgttaaatag tcaaaaaaaa aaaaaaaaaa
```

SEQ ID NO: 8 Human PTPN2 isoform 4 Amino Acid Sequence (NP_001193942.1)

```
   1 mpttierefe eldtqrrwqp lyleirnesh dyphrvakfp enrnrnryrd vspydhsrvk
  61 lqnaendyin aslvdieeaq rsyiltqgpl pntcchfwlm vwqqktkavv mlnrivekes
 121 vkcaqywptd dqemlfketg fsvkllsedv ksyytvhllq leninyienl witlylkllm
 181 ldvkrslksg etrtishfhy ttwpdfgvpe spasflnflf kvresgslnp dhgpavihcs
 241 agigrsgtfs lvdtclvlme kgddinikqv llnmrkyrmg liqtpdqlrf symaiiegak
 301 cikgdssiqk rwkelskedl spafdhspnk imtekyngnr igleeekltg drctglsskm
 361 qdtmeenses alrkriredr kattaqkvqq mkqrlnener krkrprltdt
```

SEQ ID NO: 9 Human PTPN2 isoform 5 cDNA Sequence (NM_001308287.1)

```
   1 tattcaatgc agggaacaga ccagttcatc atggaggcat tccatcagag cgtctagtta
  61 gagaagatat gtcatggact gcatcggcac agaagtgggg tttatgtgag agaggagttg
 121 gaagtcacac ctgagtggag agcaacgtga aaaggtgatg tcagcaagaa tttaggatgt
 181 atggaaagga tggtaaaggc accaactgga tggatcaggg agacatggaa tgcagaatgc
 241 aggaaataga tgatcacagt cgtgttaaac tgcaaaatgc tgagaatgat tatattaatg
 301 ccagtttagt tgacatagaa gaggcacaaa ggagttacat cttaacacag ggtccacttc
 361 ctaacacatg ctgccatttc tggcttatgg tttggcagca gaagaccaaa gcagttgtca
 421 tgctgaaccg cattgtggag aaagaatcgg ttaaatgtgc acagtactgg ccaacagatg
 481 accaagagat gctgtttaaa gaaacaggat tcagtgtgaa gctcttgtca gaagatgtga
 541 agtcgtatta tacagtacat ctactacaat tagaaaatat caatagtggt gaaaccagaa
 601 caatatctca ctttcattat actacctggc cagattttgg agtccctgaa tcaccagctt
 661 catttctcaa tttcttgttt aaagtgagag aatctggctc cttgaaccct gaccatgggc
 721 ctgcggtgat ccactgtagt gcaggcattg ggcgctctgg caccttctct ctggtagaca
 781 cttgtcttgt tttgatggaa aaaggagatg atattaacat aaaacaagtg ttactgaaca
 841 tgagaaaata ccgaatgggt cttattcaga ccccagatca actgagattc tcatacatgg
 901 ctataataga aggagcaaaa tgtataaagg gagattctag tatacagaaa cgatggaaag
 961 aactttctaa ggaagactta tctcctgcct ttgatcattc accaaacaaa ataatgactg
1021 aaaaatacaa tgggaacaga ataggtctag aagaagaaaa actgacaggt gaccgatgta
1081 caggactttc ctctaaaatg caagatacaa tggaggagaa cagtgagagt gctctacgga
1141 aacgtattcg agaggacaga aaggccacca cagctcagaa ggtgcagcag atgaaacaga
1201 ggctaaatga gaatgaacga aaaagaaaaa ggtggttata ttggcaacct attctcacta
1261 agatggggtt tatgtcagtc attttggttg gcgcttttgt tggctggaca ctgtttttc
1321 agcaaaatgc cctataaaca attaattttg cccagcaagc ttctgcacta gtaactgaca
1381 gtgctacatt aatcataggg gtttgtctgc agcaaacgcc tcatatccca aaaacggtgc
1441 agtagaatag acatcaacca gataagtgat atttacagtc acaagcccaa catctcagga
1501 ctcttgactg caggttcctc tgaaccccaa actgtaaatg gctgtctaaa ataaagacat
1561 tcatgtttgt taaaaactgg taaattttgc aactgtattc atacatgtca aacacagtat
1621 ttcacctgac caacattgag atatccttta tcacaggatt tgtttttgga ggctatctgg
```

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1681 attttaacct gcacttgata taagcaataa atattgtggt tttatctacg ttattggaaa
1741 gaaaatgaca tttaaataat gtgtgtaatg tataatgtac tattgacatg ggcatcaaca
1801 cttttattct taagcatttc agggtaaata tattttataa gtatctattt aatcttttgt
1861 agttaactgt acttttttaag agctcaattt gaaaaatctg ttactaaaaa aataaattgt
1921 atgtcgattg aattgtactg gatacatttt ccatttttct aaagagaagt ttgatatgag
1981 cagttagaag ttggaataag caatttctac tatatattgc atttctttta tgttttacag
2041 ttttccccat tttaaaaaga aaagcaaaca aagaaacaaa agtttttcct aaaaatatct
2101 ttgaaggaaa attctcctta ctgggatagt caggtaaaca gttggtcaag actttgtaaa
2161 gaaattggtt tctgtaaatc ccattattga tatgtttatt tttcatgaaa atttcaatgt
2221 agttggggta gattatgatt taggaagcaa aagtaagaag cagcatttta tgattcataa
2281 tttcagttta ctagactgaa gttttgaagt aaacactttt cagtttcttt ctacttcaat
2341 aaatagtatg attatatgca aaccttacat tgtcatttta acttaatgaa tatttttaa
2401 agcaaactgt ttaatgaatt taactgctca tttgaatgct agctttcctc agatttcaac
2461 attccattca gtgtttaatt tgtcttactt aaacttgaaa ttgttgttac aaatttaatt
2521 gctaggaggc atggatagca tacattatta tggatagcat accttatttc agtggttttc
2581 aaactatgct cattggatgt ccaggtgggt caagaggtta ctttcaacca cagcatctct
2641 gccttgtctc tttatatgcc acataagatt tctgcataag gcttaagtat tttaaagggg
2701 gcagttatca tttaaaaaca gtttggtcgg gcgcggtggc tcatgcctgt aatcccagca
2761 ctttgggagg ctgaagtggg cagatcacct gaggtcagga gttcaagacc agcctggcca
2821 acgtggtgaa acaccatctc tactaaaaat gcaaaaatta gctgggcatg gtggagggca
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3001 catctcaaaa gaaacaaaca aaaaaaacag tttgggccgg gtgtggtggc tcacgcttgt
3061 aatcccagca cttcggaagg ccaaggcggg cggatcacga ggtcaagaga tggagactgt
3121 cctggccaac atggtgaaat cccttcttta ctaaaaatac aaaaattatc tgggcgtggt
3181 ggtgcatgcc tgtagtccca gctccttggg aggctaaggc aggagaatca cttgaacccg
3241 ggaggcagag gttgcagtga gccgagattg caccactgca ctccagcctg gcaacagagc
3301 aagacttcgt ctc
```

SEQ ID NO: 10 Human PTPN2 isoform 5 Amino Acid Sequence (NP_001295216.1)

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   1 mygkdgkgtn wmdqgdmecr mqeiddhsrv klqnaendyi naslvdieea qrsyiltqgp
  61 lpntcchfwl mvwqqktkav vmlnriveke svkcaqywpt ddqemlfket gfsvkllsed
 121 vksyytvhll qleninsget rtishfhytt wpdfgvpesp asflnflfkv resgslnpdh
 181 gpavihcsag igrsgtfslv dtclvlmekg ddinikqvll nmrkyrmgli qtpdqlrfsy
 241 maiiegakci kgdssiqkrw kelskedlsp afdhspnkim tekyngnrig leeekltgdr
 301 ctglsskmqd tmeensesal rkriredrka ttaqkvqqmk qrlnenerkr krwlywqpil
 361 tkmgfmsvil vgafvgwtlf fqqnal
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SEQ ID NO: 11 Mouse PTPN2 isoform 1 cDNA Sequence (NM_001127177.1)

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   1 ggcggggcgg ggcgcggagc gcgcatgcgc cacagtgcca gcgctctccc cggatagagc
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1321 ctttttcact aaatgttcta taaattaata gttttaccca gcacctttct gcactagtag
1381 ctgaccgtgg tgcattaatc tcaagggttt gttagcaatg cctcataccc agaaacactg
1441 cgctagagta gacatcagcc agataaggga tattacagtc acaagcccag catctcagga
1501 ctcatcactg caggttcctc tgagacccag actgtcaatg gctcacaata aagacaagca
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2101 gaagtgacag ttggtcaaaa tatagttgaa aacaaacaaa aacttggttt ctgcaggatg
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8281 aaatgtagaa agatgtaaag gaaataaatt aggagcgact actttgtatt gtactgccat
8341 tcctaatgta tttttatact ttttggcagc attaaatatt tttattaaat agactatgtt
8401 ggttaaaaaa aaaaaaaaaa aaa
```

SEQ ID NO: 12 Mouse PTPN2 isoform 1 Amino Acid Sequence (NP_001120649.1)

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   1 msatierefe eldaqcrwqp lyleirnesh dyphrvakfp enrnrnryrd vspydhsrvk
  61 lqstendyin aslvdieeaq rsyiltqgpl pntcchfwlm vwqqktkavv mlnrtvekes
 121 vkcaqywptd dremvfketg fsvkllsedv ksyytvhllq lenintgetr tishfhyttw
 181 pdfgvpespa sflnflfkvr esgcltpdhg pavihcsagi grsgtfslvd tclvlmekge
 241 dvnvkqllln mrkyrmgliq tpdqlrfsym aiiegakytk gdsniqkrwk elskedlspi
 301 cdhsqnrvmv ekyngkrigs edekltglps kvqdtveess esilrkrire drkattaqkv
 361 qqmkqrlnet erkrkrwlyw qpiltkmgfv svilvgalvg wtllfh
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SEQ ID NO: 13 Mouse PTPN2 isoform 2 cDNA Sequence (NM_008977.3)

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   1 ggcggggcgg ggcgcggagc gcgcatgcgc cacagtgcca gcgctctccc cggatagagc
  61 ggggcccgag cctgtccgct gtggtagttc cgctcgcgct gccccgccgc catgtcggca
 121 accatcgagc gggagttcga ggaactggat gctcagtgtc gctggcagcc gttatacttg
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 301 actgaaaatg attatattaa tgccagctta gttgacatag aagaggcaca aagaagttac
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1321 agacctgaag cccactccgg aaactaaagt gaggcttgct aaccctgtag attgcctcac
1381 aagttgtctg tttacaaagt aagctttcca tccaggggat gaagaacgcc accagcagaa
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1501 atgtaaagga aataaattag gagcgactac tttgtattgt actgccattc ctaatgtatt
1561 tttatacttt ttggcagcat taaatatttt tattaaatag actatgttgg ttaaaaaaaa
1621 aaaaaaaaaa a
```

SEQ ID NO: 14 Mouse PTPN2 isoform 2 Amino Acid Sequence (NP_033003.1)

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   1 msatierefe eldaqcrwqp lyleirnesh dyphrvakfp enrnrnryrd vspydhsrvk
  61 lqstendyin aslvdieeaq rsyiltqgpl pntcchfwlm vwqqktkavv mlnrtvekes
 121 vkcaqywptd dremvfketg fsvkllsedv ksyytvhllq lenintgetr tishfhyttw
 181 pdfgvpespa sflnflfkvr esgcltpdhg pavihcsagi grsgtfslvd tclvlmekge
 241 dvnvkqllln mrkyrmgliq tpdqlrfsym aiiegakytk gdsniqkrwk elskedlspi
 301 cdhsqnrvmv ekyngkrigs edekltglps kvqdtveess esilrkrire drkattaqkv
 361 qqmkqrlnet erkrkrprlt dt
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SEQ ID NO: 15 Human SOCS1 cDNA Sequence (NM_003745.1, CDS regions from 155 to 790)

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   1 ggcagctgca cggctcctgg ccccggagca tgcgcgagag ccgccccgga gcgccccgga
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1201 tgaaagtttt tttttt
```

SEQ ID NO: 16 Human SOCS1 Amino Acid Sequence (NP_003736.1)

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   1 mvahnqvaad navstaaepr rrpepsssss sspaaparpr pcpavpapap gdthfrtfrs
  61 hadyrritra salldacgfy wgplsvhgah erlraepvgt flvrdsrqrn cffalsvkma
 121 sgptsirvhf qagrfhldgs resfdclfel lehyvaaprr mlgaplrqrr vrplqelcrq
 181 rivatvgren lariplnpvl rdylssfpfq i
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SEQ ID NO: 17 Mouse SOCS1 cDNA Sequence Transcript Varaint 1 (NM_001271603.1, CDS regions from 277 to 915)

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   1 agcagagaga actgcggccg tggcagcggc acggctccca gccccggagc atgcgcgaca
  61 gccgccccgg agcccccagc cgcggctccc cgcgtcctgc cgccagatga gcccaccgag
 121 gctcaagctc cgggcggatt ctgcgtgccg ctctcgctcc ttggggtctg ttggccggcc
 181 tgtgccaccc ggacgcccgg ctcactgcct ctgtctcccc catcagcgca gccccggacg
 241 ctatggccca cccctccagc tggcccctcg agtaggatgg tagcacgcaa ccaggtggca
 301 gccgacaatg cgatctcccc ggcagcagag ccccgacggc ggtcagagcc ctcctcgtcc
 361 tcgtcttcgt cctcgccagc ggcccccgtg cgtccccggc cctgcccggc ggtcccagcc
 421 ccagcccctg gcgacactca cttccgcacc ttccgctccc actccgatta ccggcgcatc
 481 acgcggacca gcgcgctcct ggacgcctgc ggcttctatt ggggacccct gagcgtgcac
 541 ggggcgcacg agcggctgcg tgccgagccc gtgggcacct tcttggtgcg cgacagtcgc
 601 caacggaact gcttcttcgc gctcagcgtg aagatggctt cgggccccac gagcatccgc
 661 gtgcacttcc aggccggccg cttccacttg gacggcagcc gcgagacctt cgactgcctt
 721 ttcgagctgc tggagcacta cgtggcggcg ccgcgccgca tgttgggggc cccgctgcgc
 781 cagcgccgcg tgcggccgct gcaggagctg tgtcgccagc gcatcgtggc cgccgtgggt
 841 cgcgagaacc tggcgcgcat ccctcttaac ccggtactcc gtgactacct gagttccttc
 901 cccttccaga tctgaccggc tgccgctgtg ccgcagcatt aagtgggggc gccttattat
 961 ttcttattat taattattat tatttttctg gaaccacgtg ggagccctcc ccgcctgggt
1021 cggagggagt ggttgtggag ggtgagatgc ctcccacttc tggctggaga cctcatccca
1081 cctctcaggg gtgggggtgc tcccctcctg gtgctccctc cgggtccccc ctggttgtag
1141 cagcttgtgt ctggggccag gacctgaatt ccactcctac ctctccatgt ttacatattc
1201 ccagtatctt tgcacaaacc aggggtcggg gagggtctct ggcttcattt ttctgctgtg
1261 cagaatatcc tattttatat ttttacagcc agtttaggta ataaacttta ttatgaaagt
1321 tttttttaa aagaaacaaa
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SEQ ID NO: 18 Mouse SOCS1 cDNA Sequence Transcript Varaint 2 (NM_009896.2, CDS regions from 157 to 795)

```
   1 agcagagaga actgcggccg tggcagcggc acggctccca gccccggagc atgcgcgaca
  61 gccgccccgg agcccccagc cgcggctccc cgcgtcctgc cgccagcgca gccccggacg
 121 ctatggccca cccctccagc tggcccctcg agtaggatgg tagcacgcaa ccaggtggca
 181 gccgacaatg cgatctcccc ggcagcagag ccccgacggc ggtcagagcc ctcctcgtcc
 241 tcgtcttcgt cctcgccagc ggcccccgtg cgtccccggc cctgcccggc ggtcccagcc
 301 ccagcccctg gcgacactca cttccgcacc ttccgctccc actccgatta ccggcgcatc
 361 acgcggacca gcgcgctcct ggacgcctgc ggcttctatt ggggacccct gagcgtgcac
 421 ggggcgcacg agcggctgcg tgccgagccc gtgggcacct tcttggtgcg cgacagtcgc
 481 caacggaact gcttcttcgc gctcagcgtg aagatggctt cgggccccac gagcatccgc
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 541 gtgcacttcc aggccggccg cttccacttg gacggcagcc gcgagacctt cgactgcctt
 601 ttcgagctgc tggagcacta cgtggcggcg ccgcgccgca tgttgggggc cccgctgcgc
 661 cagcgccgcg tgcggccgct gcaggagctg tgtcgccagc gcatcgtggc cgccgtgggt
 721 cgcgagaacc tggcgcgcat ccctcttaac ccggtactcc gtgactacct gagttccttc
 781 cccttccaga tctgaccggc tgccgctgtg ccgcagcatt aagtgggggc gccttattat
 841 ttcttattat taattattat tatttttctg gaaccacgtg ggagccctcc ccgcctgggt
 901 cggagggagt ggttgtggag ggtgagatgc ctcccacttc tggctggaga cctcatccca
 961 cctctcaggg gtgggggtgc tcccctcctg gtgctccctc cgggtccccc ctggttgtag
1021 cagcttgtgt ctggggccag gacctgaatt ccactcctac ctctccatgt ttacatattc
1081 ccagtatctt tgcacaaacc aggggtcggg gagggtctct ggcttcattt ttctgctgtg
1141 cagaatatcc tattttatat ttttacagcc agtttaggta ataaacttta ttatgaaagt
1201 tttttttaa aagaaacaaa
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SEQ ID NO: 19 Mouse SOCS1 Amino Acid Sequence (NP_001258532.1)

```
   1 mvarnqvaad naispaaepr rrsepsssss ssspaapvrp rpcpavpapa pgdthfrtfr
  61 shsdyrritr tsalldacgf ywgplsvhga herlraepvg tflvrdsrqr ncffalsvkm
 121 asgptsirvh fqagrfhldg sretfdclfe llehyvaapr rmlgaplrqr rvrplqelcr
 181 qrivaavgre nlariplnpv lrdylssfpf qi
```

Summary of genes depleted or enriched in KO mice with or without immunotherapies

Part I Genes depleted in wild type C57BL6 mice treated with both GVAX and anti-PD-1 antibody against the TCRα KO mice without treatment as control

p-value=0 means <3.3e-05, FDR=0 means <0.00106140768321

GeneSymbol	Rank of pertur bations	STARS Score	Average Score	p-value	FDR	q-value	Mouse MarkerID	Mouse NCBI EntrezID	Mouse NCBI RefSeq Transcript ID	Mouse NCBI RefSeq Protein ID	Homolo geneID	HGNC ID	Human NCBI EntrezID	Human NCBI RefSeq Transcript ID	Human NCBI RefSeq Protein ID
Irf1	9;12;14;91	8.1489	5.1444	0.0000	0.0000	0.0000	MGI:96590	16362	NM_008390|NM_001159393|NM_001159396	NP_001152865|NP_032416|NP_001152868	16582	HGNC:6116	3659	NM_002198	NP_002189,XP_011541681,XP_011541680
Prmt7	118;143;1	6.6089	3.8982	0.0000	0.0000	0.0002	MGI:2384848	214572	NM_145404|XM_006530828	XP_006530891|NP_663379	103822	HGNC:25255	54496	NM_001290018,NM_001184824,NM_001351143,NM_019023,NM_001351144	XP_016878785,XP_016878783,XP_011521423,XP_016878789,XP_011521415,XP_016878781,XP_016878797,XP_011521428,XP_011521430,XP_016878805,XP_016

	64;221					79					57				878804,XP_016878803,XP_016878787,XP_016878802,XP_016878791,XP_016878779,XP_016878788,XP_016878795,NP_001338073,XP_016878799,XP_011521414,XP_016878801,XP_011521426,XP_011521427,XP_016878794,XP_016878800,XP_016878786,XP_016878792,XP_011521433,NP_001171753,XP_011521418,NP_061896,NP_001276947,XP_011521417,XP_016878793,XP_016878782,XP_016878798,XP_016878780,XP_016878784,XP_016878790,NP_001338072,XP_016878796
Ptpn2	6;23;44;741	64.45278	00000000	MGI:978806	192555	XM_006525723|NM_008977|XM_011246858|XM_011246859|NM_001127177	XP_011245161|NP_001120649|XP_006525786|NP_033003|XP_011245160	74975	HGNC:9650	577	NM_080422,NM_001308287,NM_002828,NM_080423,NM_001207013	NP_001193942,NP_536347,NP_002819,XP_016881377,XP_011524007,XP_005258182,XP_016881374,XP_016881376,NP_536348,XP_005258181,XP_011524009,NP_001295216,XP_016881373,XP_011524008,XP_016881375
Pcif1	158;181;216;243	63.43522	36872	00000000	00000002	MGI:2443858	228866	XM_011239494|NM_146129|XM_011239495	NP_666241|XP_011237797|XP_011237796	11134	HGNC:16200	6393	NM_022104	XP_011527282,XP_011527283,XP_016883503,XP_016883502,NP_071387
Gpi1	59;73;330;420	5.4846	36112	00000009	00000008	MGI:957977	147511	NM_008155	NP_032181	145	HGNC:4458	2821	NM_001329909,NM_001289789,NM_001329910,NM_001329911,NM_001289790,NM_000175,NM_001184722	NP_001171651,NP_001276718,XP_005258821,NP_001316838,XP_011525056,XP_006723211,NP_001276719,NP_001316839,NP_000166,NP_001316840
Cdc7	169;302	5.2892	30454	00001122	00001122	MGI:130	125445	NM_001271568|XM_017320634|NM_009863|XM_006534737|NM_001271567|NM_001271566	NP_001258495|NP_001258497|NP_033993|XP_006534800|XP_017176123|NP_001258496	31166	HGNC:17	8317	NM_003503,NM_001134419,NM_001134420	NP_001127891,XP_005271298,XP_016857915,XP_016857916,XP_005271301,XP_016857914,NP_001127892,NP_003494

	;455;;470						9511				45				
Cd47	11;37;132;1015	5.0253	3.8517	0.0001	0.0024	0.0023	MGI:1966177	1643	XM_006521806|XM_006521810|XR_384530|XM_006521809|XM_006521807|NM_010581|XM_006521808|XM_006521811|XR_384529	XP_006521872|XP_006521874|XP_006521871|XP_006521869|XP_006521870|XP_006521873|NP_034711	1346	HGNC:1682	961	NM_001777,NM_001025079,NM_001025080,NM_198793	XP_005247966,XP_005247965,NP_942088,NP_001768,XP_016863025
Psen1	88;123;134;1099	5.005858	3.0330	0.0001	0.0024	0.0024	MGI:1913590	6634	NM_025498	NP_079774	1195	HGNC:30100	5585	NM_172341,NM_001281532	NP_001268461,NP_758844
Maea	151;198;206;5944	4.882599	3.0000	0.0003	0.0031	0.0031	MGI:1891748	5903	XM_006504041|NM_021500	XP_006504104|NP_067475	4298	HGNC:13731	1029	NM_001297432,NM_001017405,NM_005882,NM_001297431,NM_001297433,NM_001297430	NP_005873,NP_001284361,XP_016863126,XP_006713912,XP_006713913,NP_001284362,XP_011511679,XP_011511678,NP_001284360,XP_016863125,NP_001284359,NP_001017405
Ncstn	77;235;615;622	4.802256	2.9000	0.0003	0.0038	0.0038	MGI:1891700	5928	XM_006496952|XR_373613|XM_017321872|NM_021607	NP_067620|XP_017177361|XP_006497015	4102	HGNC:17091	2338	NM_001349729,NM_001290186,NM_015331,NM_001290184	XP_011507665,NP_056146,NP_001277115,NP_001277113,NP_001336658,XP_005245110
Adrm1	137;528;6	4.667	2.7000	0.0000	0.0052	0.0052	MGI:1929292	5643	XM_006500680|NM_019822	NP_062796|XP_006500743	1051	HGNC:157	1104	NM_001281438,NM_007002,NM_001281437,NM_175573	XP_016883093,XP_005260314,XP_011526805,XP_016883092,NP_008933,NP_001268367,NP_783163,NP_001268366,XP_016883091,XP_016883096,XP_01688309

	02:672					89					59					8,XP_016883095,XP_016883097,XP_016883099,XP_016883094
Adnp	63;102:382;728	43.52913	3000463	0000578	0000778	MGI:1338758	115	NM_001310088|NM_009628|NM_001310086	NP_001297017|NP_033758|NP_001297015	7617	HGNC:15766	233	394	NM_001282532,NM_001347511,NM_001282531,NM_015339,NM_181442	NP_852107,NP_001334440,XP_011527050,NP_056154,XP_016883248,NP_001269461,NP_001269460,XP_011527049,XP_016883246,XP_016883247
Ywhaz	74;240;256;4653	4.16781	2000145	0000144	0000144	MGI:1094844	226	XM_011245352|NM_011740|NM_001253806|NM_001253807|NM_001253805	NP_035870|XP_011243654|NP_001240736|NP_001240734|NP_001240735	5652	HGNC:12855	753	34	NM_003406,NM_001135699,NM_001135700,NM_001135701,NM_145690,NM_001135702	NP_663723,XP_016869300,NP_001129171,XP_005251118,NP_001129174,NP_003397,NP_001129172,XP_011515592,XP_016869299,XP_005251120,XP_016869301,NP_001129173
Scrib	98;111;261;95311	4.18956	2000145	0000144	0000144	MGI:2145950	105	NM_001310543|XR_875208|XM_017316354|NM_134089|XR_001781490|XM_017316355|XM_006520242|XM_006520239|XR_875207|NM_001310542|XM_006520238	XP_017171844|XP_006520305|XP_017171843|NP_598850|XP_006520302|XP_006520301|NP_001297472|NP_001297471	4428	HGNC:30377	235	13	NM_015356,NM_182706	NP_056171,NP_874365
Atf4	119;204;263;95700	4.16933	2000144	0000144	0000144	MGI:8809696	119	NM_001287180|NM_009716	NP_033846|NP_001274109	1266	HGNC:7866	468		NM_001675,NM_182810	NP_001666,XP_016884296,NP_877962
Cr1l	371;448;6	4.06670	2000168	0000168	0000168	MGI:8851513	129	XM_006497226|XM_017314176|NM_013499|XM_011238928	XP_011237230|XP_017169665|NP_038527|XP_006497289	12827	HGNC:2335	137	9	NM_175710	NP_783641

	88;950														
Cebpg	50;1855;6400;9666	4.0377	2.8555	0.0.0.1.4	0.0.1.7.3	0.0.1.7.3	MGI:1049822	12611	NM_009884	NP_034014	1368	HGNC:18377	10544	NM_001252296,NM_001239225	NP_001797,NP_001239225
Gpaa1	148;1800;2855;3401	4.0293	2.6624	0.0.1.4	0.0.1.7.6	0.0.1.7.6	MGI:1202392	14731	XM_017316432|NM_010331	XP_017171921|NP_034461	378522	HGNC:4446	87333	NM_003801	NP_003792
Kdm5a	112;122;3006;15922	3.9377	2.8786	0.0.1.7	0.0.2.0.7	0.0.2.0.7	MGI:2136980	21489	XM_011241281|NM_145997|XR_001785118|XR_377436	XP_011239583|NP_666109	3419	HGNC:9886	59327	NM_005056,NM_001042603	NP_001036068
Otub1	96;2122;3096;6824	3.9251	2.6416	0.0.1.1.8	0.0.2.0.9	0.0.2.0.9	MGI:2147616	10726	NM_134150	NP_598911	9772	#N/A	#N/A	#N/A	#N/A
Setdb1	157;4733;	3.8731	2.5676	0.0.0.2.2.0	0.0.2.2.8	0.0.2.2.8	MGI:19344	84505	NM_001163642|NM_018877|NM_001163641	NP_061365|NP_001157114|NP_001157113	32157	HGNC:107	98689	NM_001145415,NM_001243491,NM_012432	NP_036564,XP_016858442,NP_001230420,NP_001138887,XP_016858444,XP_016858443,XP_005245698

	512;1062					229				61					
Socs1	46;251;1036;1105	3.8042	2.5892	0.0024	0.0264	0.0258	MGI:1354910	127103	NM_009896|NM_001271603	NP_001258532|NP_034026	2776	HGNC:19383	8651	NM_003745	NP_003736
Seph s1	195;516;649;1106	3.8026	2.4342	0.0024	0.0258	0.0258	MGI:1923580	109079	XM_006497309|XM_017314904|NM_175400	XP_006497372|XP_017170393|NP_780609	5658	HGNC:19685	2292 9	NM_001195602,NM_012247,NM_001195604	XP_016871431,XP_016871432,XP_016871433,NP_001182531,NP_001182533,NP_036379,XP_016871434
Rer1	61;201;366;3167	3.7071	2.6481	0.0030	0.0313	0.0313	MGI:1915080	678330	NM_026395|XM_006539133|XM_006539131|XM_006539130|XM_006539132|XM_011250328	XP_011248630|XP_006539193|NP_080671|XP_006539196|XP_006539195|XP_006539194	5468	HGNC:30309	1107 9	NM_007033	XP_005244770,XP_016855623,XP_016855620,XP_006710369,XP_011538845,XP_016855621,XP_016855624,XP_016855622,NP_008964,XP_011538844
Tsc1	270;633;1014;1204	3.6518	2.1003	0.0034	0.0348	0.0348	MGI:1929183	649300	XM_006498222|XM_011239142|NM_001289576|NM_022887|XM_006498221|XM_011239144|XM_006498223|XM_006498220|XM_011239143|NM_001289575	NP_001276504|XP_011237445|XP_011237444|NP_075025|NP_001276505|XP_006498286|XP_006498283|XP_011237446|XP_006498284|XP_006498285	314	HGNC:12362	7248	NM_000368,NM_001008567,NM_001162426,NM_001162427	XP_011517281,XP_016870585,XP_016870586,XP_016870588,XP_016870587,XP_016870589,NP_001155898,XP_006717334,XP_016870590,NP_001155899,XP_005272268,NP_000359
Gng	87;	3.58	2.00	0.00	0.00		MGI	147	NM_025278|NM_001177557|NM_001177556|NM_00117	NP_001171028|NP_079554|NP_001171030|	324	HGN	559	NM_018841	XP_016857299,NP_061329,XP_0168

12	124;421;1302	272	864	0445	444	:1361	71	01	7559|NM_001177560|NM_001177558|XM_006505542	NP_001171029|NP_001171027|NP_001171031|XP_006505605	27	C:1963	70		57298,XP_016857300
Trim28	35;522;1070;1346	3.4614	2.1302	0.0052	0.0507	0.0507	MGI:1092774	2184	9	NM_011588	NP_035718	2175	HGNC:16384	10155	NM_005762	NP_005753
Zfyve27	161;474;1131;1424	3.3636	2.1865	0.0065	0.0619	0.0619	MGI:1919602	3197	40	NM_177319|NM_001164531	NP_796293|NP_001158003	16939	HGNC:26559	11813	NM_001174119,NM_001174121,NM_001002262,NM_001174120,NM_001174122,NM_001002261,NM_144588	XP_016871141,XP_005269566,XP_005269567,XP_016871133,XP_005269568,XP_016871144,XP_016871134,XP_016871136,XP_005269561,XP_005269562,XP_016871135,XP_016871140,NP_001002262,XP_011537555,XP_016871139,XP_011537557,XP_016871137,NP_001167590,XP_005269560,NP_001167593,NP_653189,NP_001167591,XP_016871142,NP_001002261,XP_005269563,XP_011537554,XP_005269559,XP_016871143,XP_011537556,XP_016871138,XP_005269565,NP_001167592
Plxna1	273;354;500;3281	3.3068	2.1480	0.0074	0.0691	0.0691	MGI:1076855	1844		NM_008881	NP_032907	56426	HGNC:9099	5361	NM_032242	XP_011511211,XP_011511210,NP_115618
Pi	13	3.	2.	0.	0.	0.	MG	23		NM_001252522|XM_006507604|XM_	XP_006507657|NP_00123945	11	HG	83	NM_001008660,NM_00	XP_005274389,XP_005274387,XP_0

calm	0;342;517;738	2640	2443	00820	07490	0749	I:23859	3489	006507600|XM_006507596|XM_006507601|XM_006507599|XM_006507595|NM_001252520|NM_001252521|XM_006507605|XM_006507597|XM_006507598|XM_006507594|NM_001252524|NM_146194|NM_001252523|XM_006507602|XM_006507603	3|XP_006507666|XP_006507663|NP_666306|XP_006507664|XP_006507658|NP_001239451|NP_001239452|NP_001239450|XP_006507665|XP_006507667|XP_006507661|XP_006507668|XP_006507659|NP_001239449|XP_006507660|XP_006507662	1783	NC:1554	01	1206946,NM_007166,NM_001206947	06718763,XP_005274383,XP_005274385,XP_005274386,XP_016873871,NP_001193876,XP_016873875,XP_005274388,XP_016873877,XP_006718762,XP_005274393,XP_005274381,NP_001008660,XP_011543595,XP_005274392,XP_005274391,NP_009097,XP_016873872,XP_016873873,NP_001193875,XP_005274382,XP_016873874,XP_005274394,XP_005274397,XP_016873876,XP_005274384,XP_016873870,XP_005274379,XP_005274390,XP_005274380,XP_006718764
Xrn1	75;971;3058	3.2.4.1.2.4.5.7	2.4.1.2.5	0.0.0.8.6	0.0.7.7.0	0.0.7.7.0	MGI:891964	2412 7	XM_006511156|NM_011916|NM_001311130|XM_006511154|XR_001778898|XM_011242743|XM_006511155	NP_001298059|NP_036046|XP_006511219|XP_006511217|XP_011241045|XP_006511218	5894	HGNC:30654	544 64	NM_001282859,NM_019001,NM_001282857,NM_001042604	XP_011511224,XP_011511221,NP_001269786,XP_016862131,NP_001269788,XP_006713736,XP_016862129,XP_011511222,NP_061874,XP_016862130
Tab1	398;567;1018;15344	3.2.3.4.3	2.0.6.0.1	0.0.0.8.9	0.0.7.7.6	0.0.7.7.6	MGI:1913763	6651 13	NM_025609|XM_006521259	XP_006521322|NP_079885	4461	HGNC:181557	104 54	NM_153497,NM_006116	NP_705717,NP_006107
Chic2	360;587;669;15500	3.2.1.6.3	2.1.9.0.7	0.0.0.9.2	0.0.7.9.2	0.0.7.9.2	MGI:1921527	7427 7	NM_028850	NP_083126	8105	HGNC:19355	26 51 1	NM_012110	NP_036242,XP_006714100,XP_011532684

Rnf19b	403;4811;10544;15776	3.1.1.74	2.7.7.70	0.0.0.09	0.0.0.83	0.0.0.28	MGI:1922484	7523 4	NM_029219|XM_006503458	XP_006503521|NP_083495	3499 9	HGNC:26886	12754	NM_001300826,NM_001127361,NM_153341	NP_001120833,XP_006710419,NP_699172,NP_001287755,XP_006710420,XP_006710421
Ube2n	5;104;3783;6732	3.1.1.85	2.3.9.99	0.0.1.00	0.0.0.28	0.0.0.28	MGI:1934835	9376 5	XM_006514344|NM_080560	NP_542127|XP_006514407	1284 06	HGNC:12492	7334	NM_003348	XP_011537021,XP_016875407,NP_003339
Sp140	62;105;3508;8747	3.1.7.76	2.3.9.29	0.0.1.02	0.0.8.31	0.0.3.31	MGI:3702467	4344 84	XM_017321619|XM_017321615|XR_001785136|XR_001785139|XM_017321620|XM_017321613|XM_017321617|NM_001013817	XP_017177109|XP_017177102|XP_017177106|NP_001013839|XP_017177108|XP_017177104	1283 91	HGNC:17133	11262	NM_001278452,NM_001278453,NM_007237,NM_001278451,NM_001005176	XP_005246312,XP_016858738,XP_016858739,XP_016858730,NP_001265381,XP_005246311,XP_011508817,XP_016858731,XP_005246313,XP_011508821,XP_006712286,XP_016858733,XP_016858735,XP_016858728,NP_001265380,XP_016858729,NP_001005176,XP_005246309,XP_016858740,XP_016858737,NP_001265382,XP_016858741,XP_011508820,XP_005246310,NP_009168,XP_011508822,XP_011508819,XP_016858736,XP_016858734,XP_011508818,XP_016858732,XP_016858742
Tox4	238;8555;13555;16	3.1.4.82	1.9.1.76	0.0.1.09	0.0.8.68	0.0.6.88	MGI:1915389	2687 41	NM_023434	NP_075923	8889	HGNC:20161	9878	NM_014828,NM_001303523	NP_055643,NP_001290452

Smg7	122;620;705;1628	32.1130	2.1872	0.0.1.1	0.0.8.2	0.0.8.2	MGI:2682334	2651 7	XM_017319981|XM_006529451|XM_006529452|XM_017319979|XM_017319978|NM_001160256|XM_006529450|NM_001005507|NM_001160257	XP_006529513|XP_006529514|NP_001005507|XP_017175468|NP_001153728|NP_001153729|XP_017175467|XP_017175470|XP_006529515	32235	HGNC:16792	987	NM_001174061,NM_001350222,NM_001350219,NM_001350221,NM_001331007,NM_201568,NM_014837,NM_201569,NM_173156,NM_001350220	NP_001337150,NP_001167532,XP_016858455,XP_016858457,XP_005245710,XP_011508510,XP_016858456,XP_011508509,XP_011508512,NP_963863,XP_005245709,XP_006711741,NP_001337149,NP_963862,XP_006711739,NP_775179,XP_016858460,XP_016858459,NP_001317936,NP_001337151,NP_001337148,XP_005245706,XP_011508508,XP_011508511,XP_005245705,XP_011508507,XP_016858458
Ric8	117;519;586;3686	3.1040	2.0903	0.0.1.2	0.0.9.2	0.0.9.1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Atrx	2863;324;936;1656	3.1001	2.0012	0.0.1.2	0.0.9.1	0.0.9.1	MGI:1030667	2258 9	XM_011247571|XM_011247563|XM_011247570|XR_878099|XM_011247565|XM_011247562|XR_001782745|XM_011247573|XM_011247564|XM_011247575|XM_011247568|XM_006527948|XM_011247574|XM_011247572|XM_011247569|XM_011247567|XM_011247560|NM_009530|XM_011247561|XM_011247566	XP_011245867|XP_011245871|XP_011245865|NP_033556|XP_011245863|XP_011245866|XP_011245872|XP_011245862|XP_011245874|XP_011245870|XP_011245877|XP_011245869|XP_011245875|XP_011245876|XP_011245868|XP_011245864|XP_011245873|XP_006528011	416	HGNC:886	546	NM_000489,NM_138271,NM_138270	XP_005262211,XP_016885091,XP_016885098,XP_006724731,XP_016885099,XP_005262213,XP_016885092,NP_000480,XP_016885090,XP_016885095,NP_612114,XP_016885097,XP_005262212,XP_016885100,XP_006724729,XP_016885094,XP_016885096,XP_005262214,XP_005262210,XP_006724730,XP_016885093
Tead1	345;610;1524;1	3.0764	1.0.8.9.4.4	0.0.1.2.4.8	0.0.9.4.0.0	0.0.9.4.0.0	MGI:1018766	2167 6	XM_006507564|NM_009346|XM_006507563|NM_001166585|XM_006507561|XM_011241723|XM_011241724|NM_001166584|XM_006507565|XM_006507562	XP_011240025|XP_011240026|XP_006507628|XP_006507626|XP_006507624|XP_006507627|NP_033372|NP_001160056|NP_001160057|XP_006507625	2418	HGNC:11714	7003	NM_021961	NP_068780

Pigu	680;80;199;1161;1812	22.9450	2.3291	0.0172	0.0122	0.0126	MGI:3039607	228812	XM_006499333|NM_001004721	XP_006499396|NP_001004721	653	HGNC:15791	1288691	NM_080476	XP_016883154,XP_016883153,NP_536724,XP_011526844
Abl1	67;316;683;53611	22.9090	2.2412	0.0189	0.0132	0.0132	MGI:878559	113501	NM_001112703|NM_001283045|NM_001283046|NM_009594|XM_006497621|NM_001283047	NP_001269976|NP_033724|NP_001269975|XP_006497684|NP_001269974|NP_001106174	3783	HGNC:76	25	NM_005157,NM_007313	NP_005148,NP_009297
Atrn	730;824;863;18900	2.8718	1.8921	0.0204	0.0407	0.1407	MGI:1341628	119901	XM_011239259|XM_006498606|NM_009730	NP_033860|XP_006498669|XP_011237561	22542	HGNC:8855	84555	NM_139321,NM_012070,NM_001207047,NM_139322,NM_001323332	NP_001193976,NP_647538,NP_001310261,NP_647537
Ap2m1	116;1602;18800;19009	2.8544	1.4873	0.0212	0.0143	0.1438	MGI:1298405	117733	NM_009679|NM_001302970	NP_001289899|NP_033809	3000	HGNC:564	1173	NM_001311198,NM_004068,NM_001025205	NP_001298127,NP_004059,NP_001020376
Smg1	50;505;50	2.8298	1.8112	0.0225	0.0150	0.0150	MGI:19	233789	XM_006507678|NM_001031814|XM_006507677	NP_001026984|XP_006507741|XP_006507740	56697	HGNC:3	23049	NM_015092	XP_005255241,XP_011544072,NP_055907,XP_011544071,XP_005255239,XP_005255240,X

	7;7277;8602					19742					00445				P_016878555,XP_016878556
Nckap1	551;8122;15791;19711	2.7989	1.7132	0.0240	0.1582	0.1582	MGI:1355333	5084	XM_006499881|NM_016965|XM_006499882|NM_001290745	XP_006499945|XP_006499944|NP_058661|NP_001277674	8384	HGNC:7666	1078	NM_205842,NM_013436	XP_006712264,NP_995314,NP_038464,XP_006712263
Slc30a1	220;593;750;19944	2.7903	1.8626	0.0244	0.1586	0.1586	MGI:1345281	2278 2	XM_006497158|NM_009579	NP_033605|XP_006497221	6681	HGNC:11012	7779	NM_021194	NP_067017
Rbm26	136;703;766;48066	2.7635	1.8738	0.0254	0.1631	0.1596	MGI:1921463	74213	NM_134077	NP_598838	41468	HGNC:20327	64062	NM_022118,NM_001286632,NM_001286631,NM_018605	XP_016876189,NP_001273560,XP_016876184,XP_011533489,XP_016876192,XP_016876178,XP_016876181,XP_011533484,XP_011533483,XP_016876179,XP_006719920,XP_011533493,XP_016876177,XP_011533494,XP_011533492,XP_016876190,XP_016876185,XP_011533487,XP_005266554,XP_016876186,XP_016876182,XP_016876183,XP_011533495,XP_011533488,XP_016876188,XP_016876180,NP_001273561,NP_071401,XP_011533491,XP_011533482,XP_011533490,XP_011533497,XP_011533485,XP_005266548,XP_016876187,XP_011533486,XP_0

															16876191,XP_011533481
Pi4kb	142;1711;14900;83911	2.7598388	1.9.025617	0.1.0596	0.1.15	MGI:1344333	1076	NM_001293715|NM_001293716|NM_175356	NP_001280644|NP_780565|NP_001280645	6741	HGNC:8984	529	NM_001198775,NM_001198774,NM_001198773,NM_002651,NM_001330721	XP_016856980,NP_001185703,XP_011507937,XP_011507940,XP_005245321,XP_011507936,XP_016856979,XP_011507938,NP_001185702,XP_016856976,XP_016856978,NP_001185704,XP_011507939,XP_016856977,NP_002642,XP_016856981,XP_016856975,NP_001317650
Xpo6	259;329;769;2483	2.7586	1.9.9270256	0.1.1596	0.1.1596	MGI:2429950	7420 4	XM_017312342|XM_017312341|XM_006508250|XM_017312344|XM_017312345|NM_001311143|XM_017312343|NM_028816	NP_083092|NP_001298072|XP_017167833|XP_017167832|XP_017167831|XP_017167830|XP_006508313|XP_017167834	1254 4	HGNC:19733	2321 4	NM_001270940,NM_015171	XP_005255256,XP_005255255,NP_001257869,XP_005255254,NP_055986,XP_011544074
Arf1	55;178;41150;91700	2.7256	2.1.9248	0.1.0268	0.1.1649	MGI:994311	1184 0	NM_001130408|NM_007476	NP_031502|NP_001123880	1393 0	HGNC:652	375	NM_001024226,NM_001024227,NM_001024228,NM_001658	NP_001019399,NP_001019398,NP_001019397,XP_016856722,NP_001649
H13	100;184;11763;41633	2.6974	2.1.0938 0	0.1.0699	0.1.1699	MGI:958586	1495 0	NM_001159552|XR_374416|NM_001159553|NM_001159551|XR_001780858|NM_010376|XM_017315666|XM_006498783	NP_001153023|NP_001153025|NP_001153024|NP_034506|XP_017171155|XP_006498846	7749	HGNC:16435	81502	NM_178580,NM_178581,NM_030789,NM_178582	NP_848697,NP_110416,NP_848695,NP_848696
Acin1	68;194;	2.6523	2.0.4390	0.0.3097	0.1.797	MGI:189	5621 5	XM_006519299|XM_006519308|XM_006519298|NM_023190|NM_001085472|NM_001242606|NM_019567|NM_001242605|NM_001	XP_006519364|XP_006519363|XP_006519361|NP_001229534|NP_075679|XP_006519360|XP_006519	2285 3	HGNC:17	2298 5	NM_001164817,NM_001164815,NM_001164814,NM_014977,NM_001164816	NP_001158289,NP_001158286,XP_011534872,NP_055792,XP_005267475,NP_001158288,XP_005267473,XP_005267472,XP_00

	151:217:176						182:4		085473|XM_006519296|XM_006519301|XM_006519297|XM_006519300|XM_006519304	367|NP_062513|XP_006519359|NP_001229535|XP_006519362|NP_001078942|NP_001078941|XP_006519371		066			6720144,NP_001158287
Zeb2	355:533:909:4318	2.5.4.7.4	1.7.4.7.6	0.0.3.5.6	0.2.1.0.4	0.1.0.4	MGI:1344407	241:336	NM_015753|XM_017318063|NM_001289521|XM_017318065|XM_017318061|XM_006498042|XM_011239102|XM_006498043	XP_006498106|XP_006498105|NP_056568|NP_001276450|XP_017173550|XP_017173552|XP_017173554|XP_011237404	886:888	HGNC:14881	983:989	NM_001171653,NM_014795	NP_001165124,XP_016860904,XP_016860903,XP_011510534,NP_055610,XP_006712945,XP_006712944
Rpap2	215:224:515:295:858	2.5.3.0.1	1.8.0.9.3	0.0.3.6.7	0.2.1.4.1	0.1.4.1	MGI:2141142	231:571	NM_001163461|NM_001289570|XM_006534897|NM_001289569|XM_006534902|NM_144911|XM_011249440|XM_006534901|XM_006534903|NM_001163462|XM_006534900	NP_001276498|NP_001156934|XP_006534963|NP_001276499|XP_006534965|XP_006534966|XP_006534960|XP_011247742|XP_006534964|NP_001156933|NP_659160	117:733	HGNC:25791	798:871	NM_024813	XP_011540469,XP_016857852,XP_016857853,NP_079089,XP_016857851,XP_005271280
Mfsd7b	636:865:958:914:1	2.4.8.1.4	1.5.2.4.4	0.0.4.0.1	0.2.3.0.7	0.2.3.0.3	MGI:2444881	226:844	NM_198025|NM_001313747|NM_001081259|XR_001784141	NP_001300676|NP_932142|NP_001074728	566:611	HGNC:24682	289:882	NM_014053	XP_011507750,XP_011507749,NP_054772,XP_011507748
Ptpn1	721:868:964:482:2	2.4.7.3.5	1.5.0.6.8	0.0.4.0.7	0.2.3.1.3	0.2.3.0.3	MGI:978005	192:46	NM_011201|XM_006498981	NP_035331|XP_006499044	211:19	HGNC:9642	577:70	NM_002827,NM_001278618	NP_001265547,NP_002818

Dok	6;738;968;9503	2.4683	1.5518	0.0410	0.0230	0.0230	MGI:2677836	22769 7	NM_177648	NP_808316	8940	HGNC:23406	22845	NM_014908	NP_055723
Atg12	564;611;976;4959	2.4580	1.6233	0.0418	0.0232	0.0231	MGI:1914776	67526	XM_006526187|NM_026217	XP_006526250|NP_080493	37953	HGNC:588	9140	NM_001277783,NM_004707	NP_001264712,NP_004698
Ccnl2	575;771;984;63466	2.4478	1.5553	0.0426	0.0237	0.0233	MGI:1927119	5603 6	XM_011250305|XR_001784166|XM_017320328|XR_881434|NM_207678|XM_017320327|XR_001784165|XM_011250304	XP_017175817|XP_017175816|XP_011248607|NP_997561|XP_011248606	69477	HGNC:20570	8169	NM_001320155,NM_001350497,NM_001039577,NM_001350498,NM_001350500,NM_030937,NM_001144867,NM_001350499,NM_001320153,NM_001144868	XP_016857909,NP_001337426,NP_112199,XP_011540518,XP_016857910,XP_011540521,NP_001337429,NP_001337427,XP_016857911,NP_001307084,NP_001307082,XP_016857912,NP_001337428,NP_001034666,XP_011540523
Chp1	641;630;999;3773	2.4288	1.9610	0.0443	0.0239	0.0238	MGI:1927185	56398	NM_019769	NP_062743	5235	HGNC:17433	11261	NM_007236	NP_009167,XP_016877368
Prkacb	704;707;1022	2.4003	1.5393	0.0466	0.0249	0.0249	MGI:975594	187449	NM_001164198|NM_011100|NM_001164200|NM_001164199	NP_035230|NP_001157671|NP_001157670|NP_001157672	12171 8	HGNC:9381	5567	NM_182948,NM_001242862,NM_001242860,NM_001300915,NM_207578,NM_001300916,NM_001300917,NM_001242861,NM_00124285	XP_016857199,NP_891993,XP_016857207,XP_016857203,NP_001229786,NP_001287846,NP_001287845,NP_997461,XP_016857200,XP_005271075,XP_016857208,XP_016857201,XP_016857195,XP_016857206,NP_00

	;5097												8,NM_001242857,NM_002731,NM_001242859	1229790,XP_016857202,NP_001229791,NP_002722,XP_016857196,NP_001229787,XP_016857205,NP_001229789,XP_016857209,XP_005271073,XP_005271072,XP_016857197,XP_005271076,XP_016857204,NP_001229788,XP_016857198,XP_005271074,XP_005271077,XP_006710821,NP_001287844
Stk35	282;7440;1052;;44500	2.3640	1.6265	0.0497	0.0263	0.0263	MGI:1914583	673333	NM_183262|NM_001038635	NP_899085|NP_001033724	15441	HGNC:16254	140901	NM_080836	XP_011527476,NP_543026
Ppa2	3944;1078;10874;;84277	2.3231	1.4730	0.0539	0.0817	0.0787	MGI:1922026	747776	NM_146141|XM_006502217|XM_006502216|NM_001293641	NP_666253|NP_001280570|XP_006502280|XP_006502279	13424	HGNC:28883	27068	NM_176866,NM_001034193,NM_001034191,NM_001034192,NM_006903,NM_176867,NM_176869	NP_789843,NP_789842,NP_789845,NP_008834
Cdk12	3173;549;1088;;83500	2.3220	1.6790	0.0539	0.0787	0.0787	MGI:1098802	691131	XM_011249225|NM_001109628|NM_001109626|XM_006534108|XM_011249224|NM_026952|XM_011249226	NP_081228|XP_011247527|XP_006534171|XP_011247528|NP_001103098|XP_011247526|NP_001103096	12863 2	HGNC:24224	51755	NM_016507,NM_015083	XP_011523197,XP_011523203,XP_016880238,XP_011523202,XP_016880237,XP_011523196,XP_005257513,XP_005257515,XP_016880240,XP_011523207,XP_016880234,NP_057591,XP_011523201,XP_011523198,XP_016880235,XP_016880242,XP_011523194,XP_011523208,NP_055898,XP_016880233,XP_016880236,XP_011523209,XP_011523205,XP_016880241,XP_016880239,XP_011523204,XP_011523195,XP_

															011523199,XP_011523200
Ipmk	188;1004;1162;3119	2.2.3.1	1.5.6.2	0.0.3.3	0.0.2.6	0.0.5.1	MGI:1916968	697178	XM_011243555|NM_001347191|XM_125641|XM_006514056	NP_081460|XP_006514119|NP_001334120|XP_011241857	76214	HGNC:20739	25343 0	NM_152230	XP_011537867,XP_016871502,NP_689416
Akr1b3	295;322;7653;8460	2.2.2.8	1.5.2.9	0.0.3.5	0.0.3.4	0.0.3.4	MGI:1353494	116777	NM_009658	NP_033788	13374 3	HGNC:3811	231	NM_001628,NM_001346142	NP_001333071,NP_001619,XP_005250291
Anapc5	310;334;3492;4149	2.1.9.3	1.5.6.7	0.0.3.5	0.0.3.5	0.0.0.1	MGI:1929722	590 08	NM_001289517|XM_006530429|NM_001289520|NM_001289518|XR_387575|NM_001289519|NM_021505|XM_017321048|NM_001042491	NP_001276446|NP_001276449|NP_001276448|NP_001035956|NP_067480|XP_006530492|NP_001276447|XP_017176537	41118	HGNC:15713	51433	NM_016237,NM_001137559,NM_001330489	XP_005253957,XP_016874912,NP_001131031,XP_016874913,NP_001317418,NP_057321
Arfrp1	275;3401;2660;9457	2.1.7.8	1.5.8.4	0.0.7.2	0.0.5.7	0.0.1.3	MGI:1923938	766 88	NM_001165991|XR_867138|NR_028585|NM_001165995|XM_011239965|NM_029702|XR_867137|NM_001165992	NP_083978|NP_001159463|NP_001159467|XP_011238267|NP_001159464	24 25	HGNC:662	10139	NM_001267549,NM_001267544,NM_001267546,NM_001267545,NM_001267548,NM_001134758,NM_003224,NM_001267547	NP_001254477,NP_001254475,NP_001254473,XP_016883065,NP_001254478,NP_001254476,XP_011526785,NP_001254474,NP_003215,NP_001128230,XP_011526784
Igsf	294;	2.1.7	1.6.8	0.0.7	0.0.5	0.0.5	MGI:	2076	NM_170599|XM_011245851|XM_006521892|XM_006521893	XP_011244153|NP_733548|XP_006521955|XP_006521956	176	HGNC	1524	NM_152538,NM_001015887	NP_689751,XP_011510765,XP_011510769,XP_011510773,XP_01151076

11	466;1224;2468	53	49	26	13	13	23847	83				13:1669	04		6,XP_011510771,XP_011510772,XP_006713580,XP_011510770,XP_011510776,XP_011510764,NP_001015887,XP_016861279,XP_011510768,XP_016861278,XP_011510774,XP_011510767
Map2k3	801;1059;12311;4040	2.1682	1.3422	0.07326	0.03526	0.03526	MGI:1346868	2637	XM_006533368|NM_008928	NP_032954|XP_006533431	56430	HGNC:6843	5606	NM_145109,NM_001316332,NM_002756,NM_145110	NP_002747,NP_001303261,XP_005256780,XP_011522261,XP_011522260,XP_016880348,XP_016880347,NP_659731,XP_016880346
Rapgef2	872;1068;12377;93044	2.1622	1.3292	0.07455	0.03529	0.03529	MGI:2659071	7608 9	NM_001310536|XM_006502254|XM_006502250|XM_011240277|XM_006502252|NM_001099624|XM_011240276	XP_006502313|XP_006502317|XP_011238579|NP_001297465|XP_006502315|XP_011238578|NP_001093094	35477	HGNC:16854	9693	NM_001351727,NM_001351728,NM_001351725,NM_001351724,NM_014247,NM_001351726	XP_011530729,NP_001338654,XP_016864347,XP_005263417,XP_005263415,XP_006714483,XP_011530728,XP_005263416,XP_016864348,XP_016864346,XP_005263418,NP_055062,XP_016864345,XP_006714484,NP_001338656,XP_011530727,NP_001338653,NP_001338657,XP_006714485,NP_001338655
Siah1a	1008;10211;12511;30622	2.1482	1.3216	0.07658	0.03588	0.03588	MGI:1080644	2043 7	NM_009172|XM_006530784	XP_006530847|NP_033198	20654	HGNC:10857	6477	NM_003031,NM_001006610	NP_003022,NP_001006611,XP_006721309,XP_011521581
Pyurf	207;356	2.1397	1.6822	0.07079	0.03618	0.03616	MGI:1911	66459	NM_025574	NP_079850	49832	HGNC:44	1E+08	NM_032906	NP_116295

	;1657;;27644						3709					3177			
Khdrbs1	24949;3508;;22044;;25911	21.1582287	10.0781616	00.0361	00.0361	MGI:893579	2021	XR_001784112|NR_045036|NM_011317|XR_376300	NP_035447	4781	HGNC:18116	1065	7	NM_001271878,NM_006559	NP_001258807,NP_006550
Dnm2	38.;37849;;34900;;54800	21.0895364	10.0863932	00.0393932	00.0393932	MGI:1095477	1343	0	XM_006509984|XM_006509982|XM_006509975|XM_017313125|XM_006509981|NM_001253893|NM_001253894|XR_001778793|XM_006509973|XM_006509980|NM_001039520|XM_006509983|XM_006509979|NM_007871|XM_006509977|XM_017313127|XM_017313129|XM_017313126|XM_006509976|XM_006509978|XM_017313128|XM_006509974|XM_006509985	XP_017168615|XP_006510044|XP_006510039|XP_006510037|XP_017168617|XP_006510043|XP_006510047|XP_006510042|NP_001240823|XP_017168614|XP_017168618|NP_001034609|XP_006510036|XP_006510040|XP_017168616|NP_001240822|XP_006510045|XP_006510046|XP_006510041|XP_006510048|NP_031897|XP_006510038	9083	HGNC:2974	1785		NM_001190716,NM_004945,NM_001005360,NM_001005362,NM_001005361	NP_001005360,NP_001177645,NP_001005361,NP_004936,NP_001005362
Gdnf	489;995;;13180;;36499	21.0836875	10.0879426	00.0393936	00.0393936	MGI:1074300	1457	3	NM_010275|NM_001301357|NM_001301332|NM_001301333	NP_001288262|NP_001288261|NP_001288286|NP_034405	433	HGNC:42332	2668		NM_199231,NM_199234,NM_001278098,NM_001190468,NM_000514,NM_001190469	XP_011512332,NP_954701,NP_001265027,XP_016864826,NP_001177398,NP_001177397,NP_000505
Rictor	685;;113	21.0799	10.0882	00.0393936	00.0393936	MGI:1922	7875	7	XM_006520003|XM_006520004|NM_030168	XP_006520066|XP_006520067|NP_084444	34317	HGNC:28	25326	0	NM_001285440,NM_152756,NM_001285439	NP_001272369,XP_016864801,XP_016864803,XP_016864802,XP_006714526,NP_689969,NP_001272368,XP_016864804,XP_0

	6;13222;61399					6007				611				11512308,XP_016864800,XP_011512307
Morf4l1	67;1148;13355;55911	2.0678	1.3066	0.0905	0.3999	0.3999	MGI:1096551	2176 1	NM_024431|XM_006511018|NM_001039147	NP_001034236|NP_077751|XP_006511081	8604 3	HGNC:16989	10933	NM_001265603,NM_006791,NM_206839,NM_001265604,NM_001265605	NP_001252534,XP_016877361,NP_006782,NP_001252532,NP_001252533,NP_996670
Chkb	838;9522;13455;94822	2.0586	1.3282	0.0922	0.4033	0.4014	MGI:1328313	1265 1	NR_037154|NR_037153|NM_007692	NP_031718	8871 8	HGNC:19388	11203	NM_005198,NM_152253	NP_005189
Fam120a	203;5492;13499;23288	2.0549	1.6289	0.0930	0.4033	0.4014	MGI:2446163	2182 36	XR_001780774|XR_001780775|NM_001033268|XR_001780776	NP_001028440	8752	HGNC:13247	23196	NM_001286722,NM_014612,NM_001286724,NM_001286723	NP_001273652,NP_001273653,XP_005251899,XP_011516715,NP_055427,XP_011516716,XP_011516718,NP_001273651,XP_011516714
Ap3b1	675;10133;135	2.0522	1.3337	0.0935	0.4014	0.4014	MGI:1337879	1774	NM_009680|XM_006517523|XR_001780749|XR_382728	XP_006517586|NP_033810	6812 5	HGNC:566	8546	NM_001271769,NM_003664	XP_005248675,NP_001258698,NP_003655,XP_016865490,XP_005248676

	2:5946														
Gne	155:399:5958:7585	2.0445	1.6336	0.0950	0.0411	0.0411	MGI:1354951	507978	XM_017320310|XM_006538074|NM_015828|NM_001190414|XM_006538073	XP_006538136|XP_006538137|NP_056643|XP_017175799|NP_001177343	396	HGNC:23657	10020	NM_005476,NM_001190388,NM_001190383,NM_001128227,NM_001190384	NP_005467,XP_016869657,XP_016869656,XP_005251391,NP_001177312,NP_001177313,NP_001121699,NP_001177317
Pin2	383;402;1693;2373	2.0383	1.5586	0.0963	0.0405	0.0405	MGI:879200	115200	XM_006537557|XM_011249907|NM_007408	XP_011248209|XP_006537620|NP_031434	872	HGNC:248	123	NM_001122	NP_001113,XP_016869748
Usp6nl	442;639;1382;7969	2.0251	1.4965	0.0989	0.0412	0.0412	MGI:2138893	989100	XM_011238992|XM_006497570|XM_006497569|XM_006497568|XM_011238993|NM_001080548|NM_181399	NP_852064|XP_006497631|XP_011237295|XP_011237294|NP_001074017|XP_006497632|XP_006497633	6879	HGNC:16858	97112	NM_014688,NM_001080491	NP_055503,XP_011518064,XP_006717605,XP_011518065,NP_001073960,XP_016872461,XP_016872460,XP_016872462
Zdhhc5	308;1303;1388;9024	2.0198	1.3562	0.1000	0.0413	0.0413	MGI:1923573	228136	NM_144887	NP_659136	9147	HGNC:18472	25921	NM_015457	XP_016872987,XP_011543201,XP_011543202,NP_056272,XP_011543203

Dgke	65;681;1396;2336	2.1.4.1.4.1.4.1.4.1.2.7.7.2	1.0.1.4.1.5.5.2	0.0.1.5.2	0.4.1.5.2	MGI:1889276	560777	XM_011249151|XR_001780032|XR_388496|NM_019505	NP_062378|XP_011247453	2705	HGNC:28526	852	NM_003647	XP_016880733,XP_016880734,XP_011523697,XP_011523696,NP_003638,XP_011523698,XP_016880732
Efr3a	116;1265;1401;3805	2.0.0.8.3.2.1.1.6	1.0.1.2.3	0.4.1.5.4	0.4.1.5.2	MGI:1923990	767740	XM_006521529|XM_006521530|NM_133766	NP_598527|XP_006521593|XP_006521592	442222	HGNC:28970	2316 7	NM_015137,NM_001323554,NM_001323555,NM_001323556,NM_001323557,NM_001323553,NM_001323558	NP_001310482,NP_055952,NP_001310487,NP_001310483,NP_001310484,NP_001310485,NP_001310486
Nsmf	768;1120;1405;2425	2.0.0.4.8.2.7.8.0	1.0.3.1	0.4.1.5.2	0.4.1.5.2	MGI:1861755	568776	XM_006498202|XM_017319144|XM_006498201|XM_017319141|XM_006498200|NM_001177655|NM_001039386|XM_017319140|NM_001039387|XM_017319145|NM_020276|XM_006498203|XM_017319143|XM_017319142|NM_001177654	NP_064672|XP_006498263|NP_001034476|XP_017174629|XP_017174632|NP_001034475|XP_017174631|NP_001171126|XP_017174633|XP_017174634|XP_006498265|XP_017174630|NP_001171125|XP_006498266|XP_006498264	10648	HGNC:29843	2601 2	NM_001130971,NM_015537,NM_001130969,NM_001178064,NM_001130970	NP_001171535,XP_016870086,XP_011516798,NP_056352,XP_005266118,XP_005266119,NP_001124441,XP_011516799,NP_001124442,NP_001124443
Vps35	71;1389;1414;6880	1.9.6.9	1.5.3.4.8	0.1.4.0.5.0	0.4.1.8.9	MGI:1890467	651114	NM_022997	NP_075373	6221	HGNC:13487	557 3 7	NM_018206	NP_060676,XP_005256102,XP_011521529
Ambr	290;	1.9.8	1.4.7	0.1.4.0	0.4.2	MGI:	22833	NM_172669|XM_006499252|NM_001080754|XM_006499253	XP_006499316|NP_766257|XP_006499315|NP_001074223	182	HGNC	556	NM_001300731,NM_001267782,NM_017749,	XP_006718323,NP_001254712,XP_005253068,XP_016873497,XP_00525

a1	429;566;793	43	66	79	69	58	2435641				04	:25990	26	NM_001267783	3071,XP_005253066,NP_001287660,NP_001254711,XP_016873496,XP_006718322,NP_060219
Rb1cc1	581;7000;1435;3738	1.978835	1.423589	0.108973	0.042758	0.04258	MGI:1341850	12421	XM_011238339|XM_011238341|XM_011238340|NM_009826|XM_006495443|XM_011238338	XP_006495506|XP_011236641|XP_011236642|XP_011236640|NP_033956|XP_011236643	7659	HGNC:15574	981	NM_014781,NM_001083617	NP_001077086,XP_011515947,XP_011515948,XP_016869597,XP_016869593,XP_011515945,XP_016869592,NP_055596,XP_016869594,XP_016869595,XP_016869601,XP_016869600,XP_011515951,XP_016869598,XP_016869599,XP_011515946,XP_016869596,XP_011515949
Map3k15	972;1218;1445;2779	1.970312	1.221122	0.114324	0.04258	0.04258	MGI:2448588	2706721	NM_001163085	NP_001156557	50401	HGNC:31689	38984	NM_001001671	XP_011543809,XP_011543812,XP_011543813,NP_001001671,XP_011543810,XP_016885000
Ctnbp2nl	413;439;4600;7928	1.965252	1.398287	0.112434	0.043344	0.04258	MGI:1933137	80281	XM_011240288|NM_030249|NM_001163332|NM_001163333	NP_001156804|XP_011238590|NP_001156805|NP_084525	36371	HGNC:25330	55917	NM_018704	NP_061174,XP_011540083,XP_016857295
Mcm3ap	560;1343;1	1.956828	1.255288	0.114428	0.043468	0.04258	MGI:1930000	54387	XM_006513894|NM_019434	XP_006513957|NP_062307	2902	HGNC:69466	88888	NM_003906	XP_005261261,XP_005261260,XP_005261262,NP_003897

	461:538689						MGI:2445019	225326							
Pik3c3	279;4455;4262;4916	1.9540	1.4690	0.1150	0.4360	0.4258	MGI:2445019	225326	NM_181414|XR_385985	NP_852079	1986	HGNC:8974	5289	NM_002647,NM_001308020	NP_001294949,NP_002638,XP_011524333
Gna11	244;7555;14677;29333	1.9517	1.5044	0.1156	0.4348	0.4258	MGI:957666	146772	NM_010301	NP_034431	20474	HGNC:43799	2767	NM_002067	NP_002058
Atg5	357;1242;14702;27333	1.9492	1.3254	0.1161	0.4331	0.4258	MGI:2771886	117793	XM_017313783|NM_001314013|XM_017313782|XM_011243108|NM_053069	NP_001300942|XP_017169271|XP_017169272|NP_444299|XP_011241410	3566	HGNC:589	9474	NM_001286111,NM_001286108,NM_004849,NM_001286106,NM_001286107	NP_001273037,NP_001273040,NP_001273035,NP_001273036,NP_004840
Eif2ak3	508;9204;14711;24	1.9484	1.3573	0.1165	0.4309	0.4258	MGI:1341830	136616	XM_011241202|XM_006505501|NM_010121|NM_001313918	XP_006505564|NP_034251|NP_001300847|XP_011239504	3557	HGNC:32555	9451	NM_004836,NM_001313915	XP_016860865,NP_004827,NP_001300844

Arpc2	59 37;931:1472;5602	1.1.1.9476	0.3.1.1066	0.0.4.2779	0.0.4.258	MGI:1923959	767 709	XM_006496317|XM_129773	XP_006496380|NP_083987	418 7	HGNC:7705	10 109	NM_152862,NM_005731	XP_016858604,XP_011508773,NP_690601,XP_016858603,XP_016858602,NP_005722
Pea15a	32 8;450:;8742:;90666	1.1.1.9448	0.4.3.1266	0.0.4.1174	0.0.4.273	0.0.4.258	MGI:1047999	18 611	XM_017319302|XM_006496702|NM_001329871|NM_011063|NM_001329869	XP_017174791|NP_035193|NP_001316800|XP_006496765|NP_001316798	78 84	HGNC:88222	86 82	NM_003768,NM_001297576,NM_001297577	NP_001284505,NP_003759,NP_001284507,XP_006711662,NP_001284506
Ip6k2	11 13;1456;1478;4436	1.1.1.9426	0.1.5.157	0.1.1.279	0.0.4.258	0.0.4.258	MGI:1923750	765 00	XM_006511856|NM_029634|XM_006511853|XM_006511850|XM_006511851|XM_006511854|XM_006511852|XM_006511855	XP_006511917|XP_006511913|NP_083910|XP_006511916|XP_006511918|XP_006511915|XP_006511919|XP_006511914	56 92 9	HGNC:17313	51 447	NM_001005911,NM_001005913,NM_001005912,NM_001146178,NM_016291,NM_001005910,NM_001190317,NM_001005909,NM_001190316,NM_001146179	NP_001177246,XP_016862082,XP_011532118,XP_011532124,XP_011532119,NP_001139650,XP_016862073,XP_016862079,XP_011532120,XP_006713262,XP_006713264,NP_001005911,XP_016862076,XP_006713263,XP_016862081,NP_001177245,NP_001005910,XP_006713265,XP_016862078,XP_016862075,XP_016862077,XP_016862080,XP_011532125,NP_001139651,XP_016862074,NP_057375,XP_016862072,NP_001005909
Mpdz	45 9;1051;1483;6	1.1.1.9384	0.3.1.1821	0.0.4.258	0.0.4.258	MGI:1343489	174 75	NM_001305284|XM_006537646|XM_006537643|NM_001305286|XM_006537644|XM_006537649|NM_010820|XM_006537650|XM_006537647|XM_011249940	XP_006537712|NP_034950|XP_006537706|XP_006537713|XP_006537707|XP_006537709|XP_011248242|NP_001292213|XP_006537710|NP_001292215	28 41	HGNC:7208	87 77	NM_001330637,NM_001261406,NM_003829,NM_001261407	XP_006716954,XP_016870746,XP_016870747,XP_016870744,XP_006716948,XP_005251679,XP_005251680,XP_016870741,XP_006716952,XP_016870742,NP_003820,XP_016870745,XP_006716951,XP_016870743,XP_006716949,XP_006716950,NP_001248335,NP_001248

	239														336,XP_016870748,NP_001317566
Dyrk1a	4778;10388;14955;55288	1.9285	1.3270	0.1214	0.4315	0.4291	MGI:1330299	1548	NM_007890|XM_011246095|NM_001347731|XM_011246094|NM_001113389|XM_011246098|XM_011246096|XM_011246099	XP_011244396|XP_011244401|XP_011244400|XP_011244398|NP_031916|XP_011244397|NP_001106860|NP_001334660	5576	HGNC:3091	1859	NM_130438,NM_130437,NM_130436,NM_001347723,NM_001347722,NM_001347721,NM_101395,NM_001396	NP_567824,XP_011527785,XP_006724039,NP_001387,XP_006724040,XP_011527784,NP_001334650,NP_001334652,XP_005260990,NP_569122,XP_006724042,XP_016883773,XP_016883774,XP_011527786,NP_569120,NP_001334651,XP_016883775,XP_006724041,XP_011527787
Nup35	3646;46027;24779	1.9266	1.4034	0.1221	0.4306	0.4291	MGI:1916732	6948	NM_027091|NM_001190179	NP_081367|NP_001177108	4451	HGNC:29797	1294	NM_138285,NM_001287585,NM_001008544,NM_001287584	NP_612142,NP_001274513,XP_006712317,XP_011508878,XP_016858797,XP_011508879,NP_001274514
Chmp3	9153;13477;15000;82588	1.9245	1.1872	0.1226	0.4291	0.4291	MGI:1913950	6670	XM_006506481|XM_017321713|XM_006506480|XM_006506482|NM_025783	XP_006506543|NP_080059|XP_017177202|XP_006506544|XP_006506545	6368	HGNC:29865	5165	NM_016079,NM_001005753,NM_001193517	NP_001005753,NP_057163,NP_001180446
Necap1	662;11904;15483;33233	1.8859	1.2397	0.1332	0.4626	0.4545	MGI:1914852	6760	NM_026267	NP_080543	22902	HGNC:24539	2597	NM_015509	NP_056324

Ncs1	40 5; 48 6; 21 60 ; 91 00	1 . 8 8 1 2	1 . 3 6 0 4	0 . 1 3 4 5	0 . 4 6 3 7	0 . 4 5 4 5	MG I: 10 91 66	14 29 9	XR_866007|NM_019681|XR_866008	NP_062655	57 19	HG NC : 39 53	23 41 3	NM_001128826,NM_014286	NP_055101,NP_001122298
Timp2	38 7; 48 7; 59 33 ; 63 17	1 . 8 7 9 5	1 . 3 6 8 1	0 . 1 3 5 2	0 . 4 6 2 5	0 . 4 5 4 5	MG I: 98 75 3	21 85 8	NM_011594	NP_035724	24 4 4	HG NC : 11 82 1	70 7 7	NM_003255	NP_003246
Ilk	39 3; 48 8; 26 71 ; 66 20	1 . 8 7 7 9	1 . 3 6 4 4	0 . 1 3 5 6	0 . 4 6 0 5	0 . 4 5 4 5	MG I: 11 95 26 7	16 20 2	XM_006507389|NM_001161724|NM_010562|XM_006507390	XP_006507452|NP_034692|XP_006507453|NP_001155196	33 1 8	HG NC : 60 40	36 1 1	NM_001278441,NM_004517,NM_001014794,NM_001278442,NM_001014795	NP_001014795,NP_001265371,XP_005252962,NP_004508,XP_005252961,XP_016873161,XP_011518367,NP_001014794,NP_001265370
Dmap1	79 4; 15 06 ; 15 59 ; 97 00	1 . 8 7 7 3	1 . 1 5 9 3	0 . 1 3 5 7	0 . 4 5 7 5	0 . 4 5 4 5	MG I: 19 13 48 3	66 23 3	XM_006503266|XM_006503268|XM_006503267|NM_023178	XP_006503330|XP_006503331|NP_075667|XP_006503329	41 31 1	HG NC : 18 29 1	55 9 2 9	NM_019100,NM_001034023,NM_001034024	XP_005271094,XP_005271096,XP_016857296,NP_001029196,XP_005271097,XP_011540086,XP_006710834,NP_061973,XP_011540087,XP_016857297,NP_001029195
Hmgn1	78 0; 11 1	1 . 8 7 6 5	1 . 2 1 1	0 . 1 3 5 9	0 . 4 5 4 5	0 . 4 5 4 5	MG I: 96	15 31 2	NM_008251	NP_032277	36 4 3	HG NC : 4	31 5 0	NM_004965	XP_016883823,XP_011527849,XP_016883825,XP_011527847,XP_016883822,XP_011527851,XP_016883824,

	77;1560;19988						120					984				XP_016883821,XP_011527846,NP_004956,XP_016883827,XP_011527845
Trim8	792;1196;1574;87644	1.8651	1.2118	0.1392	0.4624	0.4599	MGI:1933302	936	NM_053100|XM_006527488	NP_444330|XP_006527551	1279	HGNC:15579	816	03	NM_001345950,NM_030912	NP_001332879,NP_112174
Ep300	200;497;3438;97700	1.8628	1.4904	0.1400	0.4617	0.4599	MGI:1276116	3285	XM_006521090|XM_006521091|XM_006521089|NM_177821	XP_006521152|NP_808489|XP_006521153|XP_006521154	1094	HGNC:3373	203	3	NM_001429	NP_001420,XP_006724228
Ikbkg	410;498;2237;22855	1.8612	1.3480	0.1405	0.4599	0.4599	MGI:1380074	1611	XM_006527851|XM_006527850|NM_178590|NM_001161421|XM_006527852|XM_006527849|NM_010547|XM_006527853|XM_006527848|XM_006527847|NM_001161423|XM_011247527|NM_001136067|NM_001161424|NM_001161422	NP_001154896|NP_001154894|XP_006527911|NP_001154893|XP_006527915|XP_006527914|XP_006527916|NP_001154895|XP_011245829|XP_006527912|NP_848705|XP_006527910|NP_034677|NP_001129539|XP_006527913	2698	HGNC:5961	8517	7	NM_001321397,NM_003639,NM_001099856,NM_001099857,NM_001321396,NM_001145255	NP_001308326,NP_001093327,NP_003630,NP_001093326,NP_001308325,NP_001138727
Impa1	305;637;1599	1.8532	1.4875	0.1427	0.4638	0.4638	MGI:1933158	5598	0	XM_006530077|NM_018864|NM_001310433|XM_006530078	NP_061352|NP_001297362|XP_006530140|XP_006530141	4043	HGNC:60500	3612	NM_001144879,NM_005536,NM_001144878	NP_001138351,NP_005527,NP_001138350

	0:6713														
Itpk1	401;113;1599;7963	1.8464	1.2983	0.14514	0.46844	0.4684	MGI:2446159	2178 37	NM_172584	NP_766172	8588	HGNC:6177	3705	NM_001142594,NM_001142593,NM_014216	XP_016876753,XP_016876751,XP_016876752,NP_001136065,NP_001136066,NP_055031
Plec	408;775;1615;2183	1.8342	1.3913	0.14891	0.47769	0.4769	MGI:2779611	1881 0	NM_201394|NM_001163542|NM_201392|NM_201390|NM_001164203|NM_201386|NM_001163540|NM_011117|NM_201387|NM_201388|NM_201393|NM_001163549|NM_201389|NM_201385|NM_201391	NP_958796|NP_958793|NP_958794|NP_958788|NP_001157021|NP_001157014|NP_958790|NP_035247|NP_958789|NP_958792|NP_958787|NP_001157675|NP_958791|NP_001157012|NP_958795	384	HGNC:9069	5339	NM_201378,NM_201382,NM_000445,NM_201380,NM_201383,NM_201379,NM_201381,NM_201384	XP_006716653,XP_005251040,NP_958784,XP_005251036,XP_011515432,XP_005251037,XP_006716651,XP_006716652,NP_958780,XP_005251039,NP_958783,NP_000436,XP_005251033,XP_005251038,XP_011515434,XP_005251041,XP_011515433,XP_005251035,NP_958781,NP_958786,NP_958785,NP_958782
Trim56	174;1024;1619;2719	1.8312	1.4305	0.14999	0.47669	0.4769	MGI:2685298	3843 09	NM_201373|XM_011240883|XM_006504441	XP_006504504|NP_958761|XP_011239185	1281 2	HGNC:19028	8184 4	NM_030961	NP_112223,XP_011514891
Nfe2l2	432;527;7594;;77	1.8147	1.3149	0.15567	0.49057	0.4905	MGI:1084200	1802 4	NM_010902|NR_132727	NP_035032	2412	HGNC:7782	4780	NM_001313901,NM_001145413,NM_001145412,NM_001313900,NM_001313902,NM_001313904,NM_001313903,NM_006164	NP_001138884,NP_001300833,NP_001300829,NP_006155,NP_001300832,NP_001300831,NP_001300830,NP_001138885

Haus7	35526;90908;16447;71677	11.81126	11.31122	0.11564	0.4907	0.4905	MGI:1920988	737738	NM_028633|NM_207104	NP_996987|NP_082909	125513	HGNC:32979	555559	NM_017518,NM_207106,NM_207107	NP_059988
Cdk2	11739;14199;16488;73397	11.80960	11.31130	0.11574	0.4905	0.4905	MGI:1047722	125666	XM_011243321|NM_016756|NM_183417|XM_006513162	NP_058036|NP_904326|XP_011241623|XP_006513225	74409	HGNC:17771	10107	NM_001798,NM_052827,NM_001290230	XP_011536034,NP_001789,NP_439892,NP_001277159
Hdac2	82687;16699;37577	11.79420	11.26030	0.11630	0.5046	0.5003	MGI:1097691	151182	XM_017313806|XM_006512555|NM_008229	XP_006512618|XP_017169295|NP_032255	681887	HGNC:4853	3066	NM_001527	NP_001518,XP_011534090,XP_016866288
Dcbld2	24545;54229;72826	11.79178	11.41383	0.11639	0.5040	0.5003	MGI:1920629	737379	XR_001781870|XM_011246022|NM_028523|XM_006522622|XM_006522624	NP_082799|XP_006522685|XP_011244324|XP_006522687	124499	HGNC:24627	13156	NM_080927	NP_563615,XP_011510721
Inp53	11537	11.0	0.1	0.5	0.5	MGI	1633	NM_010567|NM_001122739|XM_017321991|XM_011244	NP_001116211|XP_006507454|XP_006507	12	HGN	36	NM_001567	XP_011543301,XP_016873162,NP_001558,XP_005274

pl1	1;1650;;1682;;74777	848848	663	077	003	:133378	7	32	1682|XM_006507392|XR_378218|XM_006507391	5555|XP_017177480|NP_034697|XP_011239984	04	C:6080	36		036,XP_005274035,XP_011543302
Polr3f	267;547;;2434;;98411	1.7842	1.3929	0.1665	0.0503	MGI:1924086	7040	8	NM_029763	NP_084039	4722	HGNC:15763	1062	1	NM_001282526,NM_006466	XP_011527443,NP_006457,NP_001269455,XP_016883085
Unc50	525;832;;1683;;89577	1.7841	1.3248	0.1666	0.0502	1	0.0503	MGI:1914637	6738	7	XM_006496221|NM_026123|XM_006496220|XM_006496222|XM_006496223	XP_006496284|XP_006496286|NP_080399|XP_006496283|XP_006496285	6391	HGNC:16046	2597	2	NM_001330353,NM_001330354,NM_014044	XP_006712466,NP_001317282,XP_005263970,XP_006712467,NP_001317283,NP_054763
Ube2v1	106;1635;;1688;;28099	1.7805	1.3675	0.1679	0.0502	5	0.0503	MGI:1913839	6658	9	NM_023230|XM_006500014|NM_001311131|NM_001311146	NP_001298060|NP_075719|XP_006500077|NP_001298075	8188	HGNC:12494	733	5	NM_199144,NM_001257399,NM_021988,NM_001257395,NM_001257393,NM_001282578,NM_001257397,NM_001282576,NM_022442,NM_001282579,NM_001257394,NM_001282580,NM_001282577,NM_001257396,NM_001257398,NM_001282575,NM_001032288	NP_001244325,NP_001269506,NP_001269504,NP_001244328,NP_001244327,NP_001244324,NP_001244322,NP_001027459,NP_001269509,NP_001269507,NP_001269505,NP_954595,NP_001244326,NP_001269508,NP_068823,NP_001244323,NP_071887

Ube2d3	53650;55044;;87099	1.7797	1.2578	0.1682	0.5003	0.5003	MGI:1913555	6610 5	XM_006501874|XM_006501873|XM_006501875|NM_025356	XP_006501937|XP_006501936|XP_006501938|NP_079632	12391 4	HGNC:12476	732 3	NM_181889,NM_181890,NM_181886,NM_181887,NM_181892,NM_181888,NM_181893,NM_181891,NM_001300795,NM_003340	XP_016864073,NP_003331,NP_871621,NP_871620,NP_871619,NP_001287724,NP_871618,NP_871615,NP_871622,NP_871616,NP_871617
Ccnc	12006;15533;;16955;;60000	1.7755	1.0777	0.1697	0.5014	0.5011	MGI:1858199	5181 3	NM_001290422|NM_001290420|NM_001122982|NM_016746	NP_001277351|NP_001116454|NP_001277349|NP_058026	3803	HGNC:15811	892	NM_005190,NM_001013399	XP_006715657,NP_005181,XP_016866925,NP_001013417,XP_011534534
Selk	23755;55644;;73733	1.7709	1.4101	0.1715	0.5035	0.5011	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Tsc2	16711;11603;;33266	1.7697	1.3840	0.1718	0.5011	0.5011	MGI:1025488	2208 4	XM_017317390|NM_001286714|XM_017317391|XM_017317393|XM_017317386|XM_017317385|XR_001782063|NM_001286720|XM_006524044|NM_001286718|XM_017317384|XM_017317388|NM_001286713|NM_001286716|XR_001782062|NM_001039363|NM_011647|XM_017317389|XM_017317392|XM_017317387|XM_006524040	XP_006524103|XP_017172874|XP_017172877|XP_017172873|NP_001273642|NP_001273647|XP_017172875|XP_017172879|NP_001273643|NP_035777|XP_006524107|XP_017172882|NP_001034452|NP_001273645|NP_001273649|XP_017172880|XP_017172876|XP_017172881|XP_017172878	4622	HGNC:1263	7249	NM_021056,NM_021055,NM_000548,NM_001318832,NM_001318831,NM_001077183,NM_001318827,NM_001318829,NM_001114382	NP_001107854,XP_011520941,XP_011520938,NP_001305761,XP_005255588,NP_001305760,XP_016879107,XP_011520940,XP_016879105,XP_005255586,NP_001305756,NP_000539,NP_001305758,XP_011520942,XP_011520939,NP_001070651,XP_016879106,XP_016879104

Ikbkap	365;566;6986;;71445	1.7563	1.3177	0.1769	0.5127	0.5103	MGI:1914544	2302333	NM_026079|XR_390319	NP_080355	269	HGNC:5959	85 18	NM_003640,NM_001330749,NM_001318360	NP_001305289,XP_011517438,NP_003631,XP_016870727,XP_011517439,NP_001317678
Fastk	152;1547;;17255;;40622	1.7542	1.0540	0.1777	0.5118	0.5103	MGI:1913837	665887	XR_389748|XM_017321066|XM_017321067|NM_023229	XP_017176555|NP_075718|XP_017176556	4884	HGNC:24676	10 92 2	NM_006712,NM_033015,NM_001258461	XP_016867195,NP_001245390,NP_148936,XP_011514065,XP_016867194,NP_006703,XP_005249990,XP_011514063,XP_011514064,XP_005249989,XP_016867193
Rc3h2	457;5707;;17302;;26488	1.7507	1.4318	0.1790	0.5122	0.5103	MGI:2442789	319817	XM_006498124|NM_001290642|XM_130233	NP_001094061|XP_006498187|NP_001277571	28276	HGNC:21461	54 54 2	NM_001100588,NM_018835	NP_001094058,NP_061323
Mapkap1	332;571;;4005;;75999	1.7491	1.3325	0.1799	0.5117	0.5103	MGI:2447454	227743	XM_011239083|NM_177345|XM_017317446|XM_011239085|XM_006497975|XM_006497980|XM_011239084|XM_006497978|XM_017317443|XM_011239082|XM_006497983|NM_001290625|XM_006497982|NM_001290626	XP_011237386|NP_001277555|XP_006498046|XP_011237387|NP_796319|XP_006498045|XP_006498043|NP_001277554|XP_011237385|XP_011237384|XP_017172932|XP_006498041|XP_017172935|XP_006498038	11473	HGNC:18752	79 10 9	NM_001006620,NM_024117,NM_001006619,NM_001006621,NM_001006617,NM_001006618	XP_016870616,XP_011517309,XP_011517311,XP_011517308,NP_001006618,XP_016870615,NP_001006622,XP_011517307,XP_011517310,NP_001006619,NP_001006621,NP_001006620,XP_011517312,NP_077022
Rbl1	758;;8	1.774	1.278	0.151	0.511	MGI:1	19650	NM_001139516|NM_011249|XM_006499018	XP_006499081|NP_001132988|NP_035379	2172	HGNC:	59 33	NM_183404,NM_001323282,NM_001323281,NM_002895	XP_006723905,NP_002886,XP_011527260,NP_001310211,NP_001310210,NP_899662,XP_

	23;1735;;3680	721	31	0603	0.0.03	033000					9893				016883481,XP_011527257
Pon2	95;1104;1739;;26788	1.1.744465	1.0.1817	0.0.5103	0.0.513	MGI:106687	330260	XM_006505122|NM_183308	XP_006505185|NP_899131	385	HGNC:9205	545	NM_000305,NM_001018161		XP_016867846,XP_016867847,XP_005250510,NP_001018171,NP_000296
Isg20	4766;9466;1750;;48666	1.1.736874	1.0.1846	0.0.5154	0.0.514	MGI:1928895	574	XM_006541030|NM_001291220|NM_001113527|NM_020583|NM_001291221|XM_006541028|XM_006541026	XP_006541089|NP_001278149|XP_006541093|NP_065608|NP_001106999|XP_006541091|NP_001278150	3108	HGNC:6130	369	NM_001303237,NM_001303234,NM_001303233,NM_002201,NM_001303236,NM_001303235		XP_005254956,NP_001290163,NP_001290162,NP_002192,XP_016877637,XP_006720551,NP_001290164,XP_016877636,NP_001290165,NP_001290166,XP_011519823
Akr1a1	1403;1620;;17566;;46922	1.1.732617	1.0.1864	0.0.5172	0.0.512	MGI:1929955	5810	NM_021473	NP_067448	74565	HGNC:380	103	NM_153326,NM_001202413,NM_001202414,NM_006066		NP_001189342,NP_006057,XP_011538794,NP_001189343,XP_011538793,NP_697021
Slc26a11	4562;1440;1	1.1.721217	1.0.1825	0.0.5212	0.0.521	MGI:2444445	26851 2	XM_006533419|XM_006533421|XM_006533418|XM_006533420|NM_178743	XP_006533483|XP_006533481|XP_006533482|XP_006533484|NP_848858	13685	HGNC:14471	28419	NM_001166349,NM_001166348,NM_001166347,NM_173626		XP_016879996,XP_006721896,XP_011522954,XP_016879995,NP_775897,XP_011522956,NP_001159819,XP_016879994,NP_001159821,XP_011522955,NP_001159820

	772;6862					89									
Ddit3	492;6042;74962;90811	1.1703402	1.2352	0.1990	0.5455	0.5440	MGI:1092447	131198	NM_001290183|XM_006513197|NM_007837|XM_017313791	XP_017169280|XP_006513260|NP_001277112|NP_031863	3012	HGNC:27266	1649	NM_001195053,NM_001195055,NM_001195056,NM_004083,NM_001195054,NM_001195057	NP_001181986,NP_001181982,NP_001181984,NP_001181983,NP_004074,NP_001181985
Pi4ka	2711;6053;38377;88566	1.1703489	1.3419970	0.1544040	0.5440	MGI:2448506	2240202	XM_006522037|NM_001001983|XM_006522036|XM_006522034	NP_001001983|XP_006522097|XP_006522099|XP_006522100	11171	HGNC:89833	5297	NM_002650,NM_058004	XP_005261691,NP_477352,XP_011528530,XP_016884319,XP_011528528,XP_016884318,XP_005261692
Snx4	3033;6162;21199;85800	1.6875	1.3195	0.2060	0.5579	0.5579	MGI:1916400	691150	NM_080557	NP_542124	36143	HGNC:11175	8723	NM_003794	XP_016862903,NP_003785
Gak	1081;1562;;18317;	1.6822	1.0549	0.2084	0.5612	0.5612	MGI:2442153	231580	XM_132229|XM_006534907|XM_017320853|XR_001784677|XR_001784678|XR_389271|NM_001282052|XR_880392|XM_006534905|NM_001282051	NP_001268980|NP_001268981|XP_017176342|XP_006534968|NP_705797|XP_006534970	38466	HGNC:41133	2580	NM_005255,NM_001286833,NM_001318134	XP_011511733,XP_016863480,XP_011511731,XP_011511727,XP_005272325,XP_011511734,XP_011511730,XP_016863483,NP_001305063,NP_005246,XP_005272327,XP_016863481,XP_011511729,XP_016863482,XP_011511728,XP_011511736,XP_016863484,XP_011511732

	984														
Sp100	266;623;651;685;55	1.6783	1.3407	0.0.2100	0.5620	0.5620	MGI:1095611	206;84	NM_013673|XM_006529286|XM_006529281|NM_001313714|XM_006529282|NM_001313713|XM_017319443|XM_006529283|XM_006529288|XM_006529285|NM_001313712|XM_006529284|XM_006529280|XM_017319442|XM_011247950	XP_006529345|XP_006529346|NP_001300643|NP_001300641|XP_006529348|NP_038701|XP_017174932|NP_001300642|XP_006529349|XP_006529344|XP_006529351|XP_017174931|XP_011246252|XP_006529343|XP_006529347	86761	#N/A	#N/A	#N/A	#N/A
Ldlrad3	1187;1699;1842;3123	1.6750	1.0247	0.0.2118	0.5635	0.5635	MGI:2138856	24157 6	NM_001290784|XM_006499482|XM_158875|XM_006499481	XP_006499544|NP_001277713|XP_006499545|NP_849217	18377	HGNC:27046	14345 8	NM_174902,NM_001304263,NM_001304264	NP_001291193,NP_777562,NP_001291192
Usp21	1394;1828;1864;7377	1.6607	0.9906	0.0.2187	0.5786	0.5667	MGI:1353665	309 41	NM_013919	NP_038947	56572	HGNC:12620	27005	NM_012475,NM_001319848,NM_001319847,NM_001014443	XP_016856530,NP_001306776,NP_001306777,XP_016856528,NP_036607,XP_016856525,XP_011507716,XP_016856527,XP_016856526,XP_016856531,NP_001014443,XP_016856529
Grem1	867;1862;1866;72	1.6594	1.0286	0.0.2193	0.5767	0.5767	MGI:1344337	23892	XM_006499444|XM_011824	NP_035954|XP_006499507	80222	HGNC:20001	26585	NM_001191323,NM_013372,NM_001191322	NP_001178252,NP_037504,NP_001178251,XP_016877566,XP_005254358

Dnajc5	35231;67715;18754;43944	1.6536	1.4415	0.2.2.21	0.5.80	0.5.07	MGI:892995	130.02	NR_073369|NM_001271584|NM_001271585|NM_016775|XM_011239923|XR_867108	NP_058055|NP_001258514|NP_001258513|XP_011238225	9631	HGNC:16235	80.31	NM_025219	XP_011527350,XP_011527351,NP_079495
Cdk20	39716;18811;42226	1.6498	1.4437	0.2.23.39	0.5.82.21	0.5.82.11	MGI:2145349	105.278	XR_001780743|NM_053180|XR_001780740|XM_006517033|XR_001780742|XR_001780741	XP_006517096|NP_444410	8109	HGNC:21420	23.55.2	NM_178432,NM_012119,NM_001170640,NM_001039803,NM_001170639	XP_016870050,XP_016870052,NP_001034892,XP_016870051,NP_848519,NP_036251,NP_001164110,XP_016870053,NP_001164111
Hyal2	13926;17491;18888;79411	1.6453	0.9955	0.2.26.0	0.5.84.2	0.5.83.8	MGI:1196334	155.87	XM_006511643|XM_006511644|NM_010489|XM_006511645	NP_034619|XP_006511706|XP_006511707|XP_006511708	7776	HGNC:53211	86.92	NM_003773,NM_033158	XP_005265581,XP_005265582,NP_003764,NP_149348
Tmed4	19926;13556;18911;43777	1.6434	1.0839	0.2.27.1	0.5.83.8	0.5.83.8	MGI:1915070	103.694	NM_134020	NP_598781	5308	HGNC:22301	22.06.8	NM_001303058,NM_001303062,NM_001303061,NM_182547,NM_001303059,NM_001303060	NP_001289989,NP_001289991,NP_001289987,NP_001289988,NP_872353,NP_001289990

Ap3d1	315;1488;19000;50099	1.6377	1.1938	0.2300	0.5878	0.5856	MGI:1077734	117746	NM_007460|XR_001779423|XR_380349|XR_001779424	NP_031486	29266	HGNC:568	894 3	NM_001077523,NM_001261826,NM_003938	NP_003929,XP_016882911,NP_001248755,XP_006722995
Fbxo7	253;6556;26322;40666	1.6366	1.3298	0.2304	0.5856	0.5856	MGI:1917004	697754	NM_153195|XM_017314077|XM_011243556|NM_001347151|NM_001310745|XM_006514059	XP_006514122|XP_011241858|NP_001297674|XP_017169566|NP_001334080|NP_694875	81362	HGNC:13586	257 93	NM_012179,NM_001257990,NM_001033024	NP_001028196,XP_011528408,NP_036311,NP_001244919
Dtnbp1	103;14255;19066;73100	1.6340	1.3552	0.2317	0.5857	0.5857	MGI:2137586	942455	XM_006516984|NM_025772	NP_080048|XP_006517047	12037	HGNC:17328	840 62	NM_001271667,NM_001271668,NM_183040,NM_032122,NM_001271669	NP_001258596,NP_898861,NP_001258597,XP_016866837,NP_115498,XP_011513238,NP_001258598,XP_005249504,XP_011513239,XP_016866838
Pin1	197;664;20066;56933	1.6268	1.3755	0.2355	0.5920	0.5870	MGI:1346036	23988	NM_023371	NP_075860	45311	HGNC:8988	530 0	NM_006221	XP_011526370,NP_006212
Tmem1	40;1	1.623	1.223	0.258	0.558	MGI:2	23 20	NM_144916	NP_659165	16378	HGNC:	12 93	NM_001031738,NM_153342	NP_001026908,XP_011530809,XP_016858796,XP_016858794,XP_011530810,XP_0067119	

50a	093;19118;63355	64	53	57	92	70	3852444	86				24677	03		95,XP_006711993,XP_006711994,XP_016858795,XP_011530807
Gpx1	277;66565;27844;33033	1.62566	1.3063	0.23061	0.5870	0.5870	MGI:1048877	1475	NM_001329528|NM_001329527|NM_008160	NP_001316456|NP_001316457|NP_032186	20155	HGNC:4553	287 6	NM_001329455,NM_001329502,NM_201397,NM_000581,NM_001329503	NP_958799,NP_001316432,NP_001316384,NP_001316431,NP_000572
Pfkfb1	947;11922;19244;78077	1.62277	1.1373	0.2374	0.5872	0.5872	MGI:1078166	1863 9	NM_008824|XM_011247791|XM_006528755|XM_006528756|XM_006528757	XP_006528820|XP_011246093|XP_006528819|XP_006528818|NP_032850	10565 4	HGNC:8872	52 07	NM_001271805,NM_002625,NM_001271804	NP_002616,XP_016885066,NP_001258733,XP_016885065,NP_001258734,XP_016885067
Csnk1d	229;14203;19333;80566	1.61701	1.2404	0.2406	0.5917	0.5917	MGI:1355272 2	1043 1 8	NM_139059|XM_011248663|XM_011248662|NM_027874	XP_011246964|NP_082150|NP_620690|XP_011246965	74841	HGNC:2452	14 53	NM_001893,NM_139062	XP_016879688,NP_620693,NP_001884,XP_005256393,XP_005256394
Tfpi	691;17288;	1.60514	1.0246 8	0.2403 8	0.5972	0.5972	MGI:1095 4	2178 8	XM_006499146|NM_001177319|XM_006499149|XM_006499147|NM_011576|XM_006499150|XM_006499148|XM_006499145|NM_001177320	XP_006499212|XP_006499208|XP_006499209|NP_001170790|XP_006499211|XP_006499213|NP_001170791|XP_00	45 79	HGNC:117	70 35	NM_001329240,NM_006287,NM_001329239,NM_001318941,NM_001329241,NM_001032281	XP_006712783,XP_005246875,XP_011510010,NP_001027452,XP_005246876,NP_001316170,NP_001305870,XP_011510009,XP_011510011,NP_001316168,NP_001

	1952:64277						18		6499210|NP_035706		60				316169,NP_006278
Cul4b	209:6822:73855:77677	1.60537	1.35271	0.24713	0.60132	0.59172	MGI:1919834	7258 4	NM_028288|NM_001110142	NP_001103612|NP_082564	2660	HGNC:25555	84 50	NM_001079872,NM_001330624,NM_003588	NP_001317553,XP_005262538,XP_006724847,XP_011529701,XP_006724848,NP_003579,NP_001073341,XP_011529703,XP_011529702
Gcc1	17241:18322:19555:41955	1.60375	0.95780	0.24800	0.60032	0.59172	MGI:1921625	7437 5	NM_028900	NP_083176	11567	HGNC:190955	79 571	NM_024523	NP_078799
Ppp2r3c	663:889:19562:22388	1.60299	1.21977	0.24822	0.59752	0.59172	MGI:1930009	590 32	NM_021529|XR_381536	NP_067504	9915	HGNC:17485	55 01 2	NM_001305155,NM_001305156,NM_017917	XP_016876878,NP_001292085,NP_001292084,XP_016876877,NP_060387,XP_005267839
Cdc25a	66;12933;19622;	1.59301	1.43005	0.25000	0.60000	0.59172	MGI:1031198	1253 0	XM_006511929|XM_006511930|NM_007658|XM_006511931	XP_006511992|NP_031684|XP_006511994|XP_006511993	1355	HGNC:1725	99 3	NM_201567,NM_001789	NP_963861,XP_006713497,XP_006713498,XP_011532618,NP_001780

	27888													
Ndt19	8967;10077;19655;70644	1.1.1.59752	0.2.5.1.5	0.5.9.9.2	0.5.9.7.2	MGI:3942033	110959	NM_033080|XR_391037	NP_149071	13211	HGNC:32036	39091	NM_001105570	XP_016882295,NP_001099040
Casp8	39167;15144;19668;36133	1.1.1.59692	0.2.5.2.0	0.5.9.7.2	0.5.9.7.2	MGI:1261423	12370	NM_001277926|NM_009812|NM_001080126|XM_006495634	NP_001073595|XP_006495697|NP_033942|NP_001264855	76577	HGNC:1509	841	NM_001080125,NM_033356,NM_033358,NM_001080124,NM_001228,NM_033355,NM_033357	XP_005246943,XP_005246950,XP_005246947,NP_203520,XP_006712853,XP_006712856,NP_001219,XP_005246944,XP_005246952,XP_005246949,XP_005246948,NP_203522,NP_203519,XP_006712852,XP_005246942,XP_005246951,XP_011510271,NP_001073594,NP_001073593,XP_005246946,XP_005246945
Smarca5	41570;42355;;65700	1.1.1.58320	0.2.5.7.0	0.6.0.5.9	0.6.0.5.5	MGI:1935129	93762	NM_053124	NP_444354	55764	HGNC:11101	8467	NM_003601	NP_003592
Bnc2	13571;;51793;;70933	1.1.1.57304	0.2.5.2.6	0.6.0.9.3	0.6.0.5.5	MGI:2443805	24250	XM_017320209|NM_172870|XM_017320207|XM_017320203|XM_017320211|XM_017320213|XM_006537933|XM_017320208|XM_017320212|XM_006537940|XM_017320205|XM_017320214|XM_017320204|XM_017320206|XM_017320210	XP_017175696|XP_006538003|XP_017175700|XP_017175692|NP_766458|XP_017175703|XP_017175702|XP_017175697|XP_017175699|XP_017175693|XP_006537996|XP_017175695|XP_017175701|XP_017175694|XP_017175698	18243	HGNC:30988	54796	NM_001317940,NM_017637,NM_001317939	NP_001304868,XP_016870314,XP_016870305,NP_001304869,XP_011516236,XP_016870306,XP_016870307,XP_016870313,XP_011516226,XP_016870317,XP_016870316,XP_016870312,XP_016870310,XP_016870315,XP_016870308,NP_060107,XP_016870311,XP_016870318,XP_016870309

Ppp5c	501;714;3861;3906	1.1.1.1	0.2.6.6	0.6.9.4	0.0.5.5	MGI:1026666	1906	NM_011155|XM_006539663|XM_017322043	XP_017177532|XP_006539726|NP_035285	4550	HGNC:9322	5536	NM_006247,NM_001204284	NP_006238,NP_001191213,XP_016882424
Slc38a2	234;718;2581;8612	1.5.3.2	0.2.6.2	0.6.0.8	0.0.5.5	MGI:1915010	6776	NM_175121|XM_006521300	NP_780330|XP_006521363	2313	HGNC:13448	5440	NM_001307936,NM_018976	NP_001294865,NP_061849
Cd63	168;719;5915;6161	1.1.2.6	0.6.0.5	0.0.6.5	0.0.5.5	MGI:995229	1251	NM_007653|NM_001282966|NM_001042580	NP_001269895|NP_001036045|NP_031679	3752	HGNC:1692	967	NM_001257389,NM_001257401,NM_001267698,NM_001257390,NM_001040034,NM_001257391,NM_001780,NM_001257400,NM_001257392	NP_001244319,NP_001244329,NP_001244330,NP_001244318,NP_001771,NP_001244320,NP_001254627,NP_001244321
Daglb	668;725;4996;7086	1.5.1.2	0.2.6.6	0.6.0.7	0.0.5.5	MGI:2442032	2318	XM_006504698|XM_006504700|NM_144915	XP_006504761|XP_006504763|NP_659164	3471	HGNC:28923	2219	NM_001142936,NM_139179	NP_001136408,NP_631918
Fkbp1b	712;726	1.5.0.2	0.6.4.5	0.6.0.5	0.0.5.5	MGI:133	1422	XM_006514974|XM_017314959|NM_016863	XP_017170448|XP_006515037|NP_058559	6838	HGNC:37	2281	NM_054033,NM_004116,NM_001322964,NM_001322963	XP_016859083,NP_004107,XP_016859085,XP_016859084,NP_473374,NP_001309893,XP_011531001,NP_00

	;3948;;7369					6205					12				1309892,XP_016859082
Surf2	736;7337;;8494;;89622	1.5431	1.0848	0.2682	0.6102	0.102	MGI:98444	2093 1	XM_006497827|NM_013678	XP_006497890|NP_038706	8430	HGNC:11475	6835	NM_001278928,NM_017503	NP_001265857,NP_059973
Aptx	472;742;;2432;;4650	1.5377	1.1600	0.2698	0.6109	0.109	MGI:1913658	64081	NM_025545|XM_006538169|XM_006538167|NM_001025444|XM_006538166|XM_011250084|XM_006538171|XM_006538170|NM_001025445	XP_006538234|NP_001020616|XP_006538233|XP_011248386|XP_006538231|NP_001020615|XP_006538232|NP_079821|XP_006538230|XP_006538229	41634	HGNC:15984	5840	NM_175072,NM_017692,NM_001195248,NM_001195251,NM_001195252,NM_001195250,NM_175073,NM_001195254,NM_175069,NM_001195249	XP_011516240,XP_016870326,NP_001182183,NP_778239,NP_001182178,XP_016870322,XP_016870327,NP_778243,NP_001182180,XP_011516241,XP_006716855,XP_016870324,XP_006716854,NP_001182177,NP_001182181,NP_001182179,XP_016870323,XP_016870320,XP_016870325,XP_016870321
2810408M09Rik	509;7600;;2290;;4741	1.5186	1.1366	0.2758	0.6212	0.189	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Zc3hc1	343;761;;2732;;8	1.5176	1.2103	0.2761	0.6189	0.189	MGI:1916023	2326 79	XM_017321571|NM_172735|NM_001311086	XP_017177060|NP_001298015|NP_766323	32315	HGNC:29913	5153 0	NM_016478,NM_001282191,NM_001282190	NP_001269119,XP_011514591,XP_005250460,XP_011514592,NP_057562,XP_016867777,XP_016867776,NP_001269120,XP_011514590

Pak1ip1	290;2678;7783;9273;9359	1.5004	1.2545	0.2816	0.6281	0.611	MGI:1915333	6803	NM_026550	NP_080826	3957	HGNC:20882	5503	NM_017906	XP_011513023,XP_011513022,XP_005249261,NP_060376
Uhrf1	1821;7822;2987;8298	1.4959	1.3262	0.2830	0.6282	0.611	MGI:1338889	1810	NM_001111079|NM_010931|XM_006523800|NM_001111078|NM_001111080|XM_006523799	NP_035061|NP_001104550|XP_006523863|NP_001104549|XP_006523862|NP_001104548	7866	HGNC:12556	2912	NM_001290051,NM_001290050,NM_001048201,NM_001290052,NM_013282	NP_001041666,XP_011526244,NP_037414,NP_001276981,NP_001276979,NP_001276980
Ppp1cc	6553;7833;3533;6246	1.4949	1.0802	0.2835	0.6261	0.611	MGI:1048722	1904	XM_006530200|NM_013636	NP_038664|XP_006530263	13542	#N/A	#N/A	#N/A	#N/A
Atp7a	1334;7887;2072;8159	1.4909	1.3885	0.2849	0.6263	0.6263	MGI:994000	1197	NM_001109757|NM_009726	NP_001103227|NP_033856	35	HGNC:869	538	NM_000052,NM_001282224	NP_000043,NP_001269153
Usf1	163;	1.48	1.34	0.28	0.63	0.63	MGI:	22	NM_001305678|NM_009480|NM_001305676|NM_001305677	NP_001292607|NP_001292605|NP_033506|NP_001292606	314	HGNC	7391	NM_007122,NM_207005,NM_001276373	NP_996888,NP_001263302,NP_009053

	7;2772:6471	09	14	80	01	01	9542	78				26	:12593			
Shoc2	165;814:3540;8692	1.4642	1.3305	0.2940	0.6400	0.6372	MGI:1927197	563 92	XM_006527228|NM_019658|NM_001168505|XM_017318260|XM_011247299	XP_006527291|NP_001161977|XP_011245601|NP_062632|XP_017173749	719	HGNC:15454	80 36	NM_007373,NM_001324337,NM_001269039,NM_001324336	NP_001311265,XP_016872191,NP_001255968,NP_031399,NP_001311266,XP_016872193,XP_016872192
Tnfrsf1a	475;818;2405;2704	1.4603	1.1201	0.2954	0.6400	0.6372	MGI:1314884	2193 7	NM_011609	NP_035739	828	HGNC:11916	71 32	NM_001346091,NM_001065,NM_001346092	NP_001333020,NP_001333021,NP_001056
Dusp11	603;821;2889;4468	1.4574	1.0758	0.2965	0.6395	0.6372	MGI:1919352	721 02	NM_028099|XM_011241476|XM_017321754|XR_001785172	XP_017177243|XP_011239778|NP_082375	3183	HGNC:3066	84 46	NM_003584	NP_003575
Taf1	78;822;4926	1.4564	1.4835	0.2936	0.6372	0.6372	MGI:1336878	2707	NM_001290729|XM_006528052|XM_017318512|XM_006528051|XM_006528053|XM_017318514|XM_006528050|XM_017318516|XR_001782749|XM_017318513|XM_017318518|XM_017318515|XR_001781	XP_006528114|XP_006528116|XP_017174006|XP_017174005|XP_006528115|XP_006528113|XP_017174002|XP_017174003|NP_001277658|XP_017174004|XP	3794 2	HGNC:11535	68 72	NM_004606,NM_138923,NM_001286074	XP_005262352,XP_005262357,XP_006724745,NP_004597,NP_620278,XP_005262354,NP_001273003,XP_005262353

	;894343							2748|XM_017318517	_017174007|XP_017174001						
Acp1	335;835;6724;7164	1.1.3.16	1.14.17.82	0.0.64.42	0.0.64.05	MGI:878881	114311	XR_381176|NM_001110239|NM_021330	NP_001103709|NP_067305	38274	HGNC:122	52	NM_004300,NM_001040649,NM_007099,NM_177554	NP_001035739,NP_009030,NP_004291
Ras	621;839;3412;7396	1.14.03	1.06.21	0.03.31	0.64.45	0.64.05	MGI:981779	20130	XM_006540721|NM_009101	XP_006540784|NP_033127	4565	HGNC:10447	6237	NM_006270	NP_006261
Dagla	444;844;5603;92288	1.43.56	1.12.03	0.03.05	0.64.54	0.64.05	MGI:2677061	26900600	NM_198114|XM_017318213|XM_006527114	NP_932782|XP_017173702|XP_006527177	4468	HGNC:11665	747	NM_006133	NP_006124,XP_016873729,XP_016873728,XP_016873727
Kra4	724;847;2561;82366	1.43.28	1.03.23	0.03.06	0.64.47	0.64.05	MGI:1019044	16635	NM_010649|XM_006505646|NM_001252577	XP_006505709|NP_034779|NP_001239506	#N/A	#N/A	#N/A	#N/A	#N/A

Snx27	76 4; 85 1; 28 77; 40 15	1 . 4 2 9 1	1 . 0 2 1 6	0 . 0 3 0 7 5	0 . 0 6 4 4 8	0 . 0 6 4 0 5	MGI:1923992	767 42	XM_131051|NM_001082484|XM_006502258	XP_006502321|NP_001075953|NP_083997	127 97	HGNC:20073	81 60 9	NM_001330723,NM_030918	XP_016857906,NP_001317652,XP_005245567,XP_005245566,XP_011508326,NP_112180,XP_005245568,XP_011508328,XP_011508327
Ercc6l	54 6; 85 2; 89 51; 97 58	1 . 4 2 8 2	1 . 0 7 8 7	0 . 0 3 0 7 9	0 . 0 6 4 2 6	0 . 0 6 4 0 5	MGI:2654144	23 69 30	NM_146235	NP_666347	44 94 45	HGNC:20794	54 82 1	NM_001009954,NM_017669	NP_060139,NP_001009954
Golph3	34 8; 85 3; 22 51; 62 43	1 . 4 2 7 3	1 . 1 6 2 4	0 . 0 3 0 8 3	0 . 0 6 4 0 5	0 . 0 6 4 0 5	MGI:1913879	66 62 9	NM_025673|XM_006520143	XP_006520206|NP_079949	56 94 2	HGNC:15452	64 08 3	NM_022130	XP_016865176,NP_071413,XP_016865175
Gnb2l1	15 4; 85 8; 78 81; 92 65	1 . 4 2 2 7	1 . 3 2 4 0	0 . 0 3 1 0 3	0 . 0 6 4 1 7	0 . 0 6 4 1 7	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Antxr2	11 6; 86 4	1 . 4 1 7 2	1 . 3 8 0 2	0 . 0 3 1 2 4	0 . 0 6 4 3 2	0 . 0 6 4 3 2	MGI:191	71 91 4	NM_133738	NP_598499	43 23 6	HGNC:21	11 84 29	NM_001286781,NM_058172,NM_001286780,NM_001145794	XP_016863200,NP_001139266,NP_001273710,XP_011529889,NP_001273709,NP_477520

	;4238;9206						9164				732			
Ppap2a	590;881;8936;9185	1.4019	1.0518	0.3191	0.6540	0.6519	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Pik3ca	363;882;2967;9116	1.4010	1.1411	0.3195	0.6519	0.6519	MGI:1206581	18706	XM_006535410|XM_006535409|NM_008839	XP_006535473|NP_032865|XP_006535472	21249	HGNC:8975	5290	NM_006218	XP_011511196,NP_006209,XP_006713721
Nmt1	753;899;2269;2383	1.3861	1.0025	0.3261	0.6625	0.6611	MGI:102579	18107	NM_008707|XM_006532445	XP_006532508|NP_032733	69027	HGNC:7857	4836	NM_021079	NP_066565,XP_011523160
Bfsp2	670;901;5532;5	1.3843	1.0211	0.3269	0.6611	0.6611	MGI:1333828	107993	XM_356180	NP_001002896	20791	HGNC:1041	8419	NM_003571	XP_016862804,NP_003562

Ppp6c	7500;60;925;4694;8479	1.1.3638	1.4.9330	0.3.3657	0.6.7744	0.6.7744	MGI:1915107	6785 7	XM_006498256|XM_017319227|NM_024209	XP_006498319|XP_017174716|NP_077171	6827 3	HGNC:9323	5537	NM_001123369,NM_002721,NM_001123355	XP_011517149,NP_002712,NP_001116827,NP_001116841
Aldh18a1	9350;9400;8434;9248	1.3513	0.9512	0.3427	0.6868	0.6868	MGI:1888908	5645 4	NM_153554|NM_019698	NP_062672|NP_705782	2142	HGNC:9722	5832	NM_001323418,NM_001323412,NM_001323415,NM_001323413,NM_001323419,NM_001323414,NM_001323417,NM_001017423,NM_002860,NM_001323416	NP_001310345,NP_001310347,NP_001310344,NP_001017423,NP_001310348,NP_002851,NP_001310346,NP_001310342,NP_001310341,NP_001310343
Gprc5a	6410;9488;3056;4376	1.3447	1.0088	0.3460	0.6904	0.6904	MGI:1891250	2324 31	NM_181444|XM_006506038	XP_006506101|NP_852109	2961	HGNC:9836	9052	NM_003979	NP_003970
Tmem173	16293;8285;97533	1.3407	1.2725	0.3482	0.6918	0.6918	MGI:1919762	7251 2	NM_001289591|XM_128954|NM_001289592|XM_017317994	NP_001276521|NP_082537|NP_001276520|XP_017173483	1886 8	HGNC:27962	3400 61	NM_198282,NM_001301738	NP_938023,XP_011535941,XP_005268502,NP_001288667,XP_011535942
Lsg1	3259	1.312	1.135	0.370	0.69		MGI:1	2240	NM_178069|XR_001781813	NP_835170	5917	HGNC:1	5534 1	NM_018385	NP_060855,XP_016862285

	67;3184;8204	93	67	41	05	89	0723 6	92				2565 2			
Acly	425;9699;5096;6311	1.3277	1.0745	0.0354 8	0.0689	0.0689	MGI:1032511	1041 12	NM_001199296|NM_134037	NP_001186225|NP_598798	854	HGNC:115	47	NM_001303274,NM_001096,NM_198830,NM_001303275	XP_005257452,NP_001087,XP_016880177,NP_001290204,NP_942127,NP_001290203
Irgm1	7842;9822;2935;6095	1.3174	0.9616	0.0360 4	0.0706 8	0.0702 4	MGI:1075 67	1594 4	NM_008326|XM_006532305|XM_011248764	NP_032352|XP_006532368|XP_011247066	#N/A	#N/A	#N/A	#N/A	#N/A
Ccne1	362;9833;4443;5352	1.3167	1.0995	0.0360 8	0.0704 5	0.0702 4	MGI:883 16	1244 7	NM_007633	NP_031659	1445 2	HGNC:1589	898	NM_001322259,NM_001322261,NM_001238,NM_057182,NM_001322262	NP_001309191,NP_001229,NP_001309188,NP_001309190,XP_011525742
Csde1	451;9855;2517	1.3151	1.0571	0.0361 6	0.0703 0	0.0702 4	MGI:923 56	2296 3	NM_144901|NM_001310693|NM_001161854|XM_017319550|XM_006501397|XM_006501398|XM_006501399	XP_006501462|XP_017175039|NP_659150|NP_001155326|XP_006501461|NP_001297622|XP_006501460	5179	HGNC:2990 5	7812	NM_007158,NM_001242892,NM_001242891,NM_001007553,NM_001242893,NM_001130523	NP_001229822,NP_001007554,NP_001229820,NP_001229821,NP_001123995,NP_009089

	;8191														
Cdk14	493;988;2691;5186	1.3127	1.0395	0.3628	0.7024	0.7024	MGI:894318	18647	XM_017320708|XM_006503544|XM_006503547|NM_001310448|NM_011074	NP_035204|XP_017176197|XP_006503610|NP_001297377|XP_006503607	7888	HGNC:8883	5218	NM_001287135,NM_001287136,NM_012395,NM_001287137	NP_001274065,XP_016867809,NP_036527,NP_001274064,XP_005250496,NP_001274066,XP_005250493,XP_011514609,XP_016867810,XP_016867811,XP_011514608,XP_005250495
Cntln	258;1023;4161;7492	1.2859	1.1506	0.3785	0.7297	0.7291	MGI:2443104	338349	NM_175275|XM_006538031|XM_006538028|XM_011250056|XR_881069|XM_006538026|XM_006538029|NM_177385|XM_006538032|XM_006538027	NP_796359|NP_780484|XP_006538095|XP_006538091|XP_006538090|XP_006538094|XP_011248358|XP_006538089|XP_006538092	9805	HGNC:23432	54875	NM_001286985,NM_001114395,NM_017738,NM_001286984	XP_016870330,XP_016870331,XP_006716856,XP_011516243,XP_016870329,NP_060208,XP_016870328,NP_001273914,XP_016870332,XP_016870333,XP_016870335,XP_016870334,NP_001273913,XP_005251549,XP_016870336,NP_001107867
Eif2ak4	869;1026;8710;9827	1.2837	0.9285	0.3798	0.7291	0.7291	MGI:1353427	27103	XM_006499625|XM_006499626|XM_017318915|NM_013719|NM_001177806|XM_017318909|XM_006499627	XP_006499688|XP_017174398|XP_006499690|NP_038747|XP_006499689|NP_001171277|XP_017174404	40891	HGNC:19687	440275	NM_001013703	XP_011519901,XP_016877708,XP_005254449,XP_011519902,NP_001013725
Ctdspl2	69;1035;2062;7830	1.2770	1.4198	0.3838	0.7337	0.7306	MGI:1196405	329506	XM_283758|XR_001783138|XM_017319053|XM_011239627|XM_006499776|NM_001290992|NM_001290991|XR_374482	XP_006499839|NP_001277920|NP_001277921|NP_997615|XP_017174542|XP_011237929	32311	HGNC:26936	51496	NM_016396	XP_006720628,NP_057480,XP_011519967,XP_016877795,XP_016877796,XP_005254498

Ppp2r1a	3673;10377;38288;42155	1.2755	1.0763	0.0384732	0.0730624	0.0730624	MGI:1926334	5179	NM_016891	NP_058587	68559	HGNC:9302	55518	NM_014225	XP_016882418,NP_055040
Snx18	5838;10447;28355;67800	1.2703	0.9882	0.0387735	0.0730624	0.0730624	MGI:2137642	17062	NM_130796	NP_570614	14164	HGNC:19245	11257	NM_001102575,NM_052870,NM_001145427	XP_016864486,NP_001138899,NP_443102,NP_001096045
Rab21	5988;10455;47088;84677	1.2696	0.9833	0.0383820	0.0733306	0.0733306	MGI:8943088	21634	XM_006513537|NM_024454	NP_077774|XP_006513600	89911	HGNC:18263	23011	NM_014999	NP_055814
Tmem127	9638;10466;23577;32022	1.2689	0.9057	0.0388586	0.0730606	0.0730606	MGI:1916720	69470	NM_175145	NP_780354	98777	HGNC:26038	55654	NM_017849,NM_001193304,NM_032218	NP_060319,XP_016859941,NP_001180233,XP_016859940,XP_016859939
Nud	9566	1.2	0.9	0.0	0.7	0.7	MGI	7566	NM_029385|XM_006511845	NP_083661|XP_006511908	1266	HGN	131	NM_152395,NM_001171	NP_001165377,NP_001165376,NP_689608

t16	;10504:30455:;40288	660	053	9051	3117	3077	:19229366	86				17	C:26442	870	1905,NM_001171906
Got2	674;10538;;71833;;92644	1.26388	0.95988	0.39188	0.73307	0.73077	MGI:957922	14719	NM_010325	NP_034455		1572	HGNC:4433	2806	NM_002080,NM_001286220	NP_001273149,NP_002071
Pigw	265;10644;;22192;;22622	1.25588	1.13028	0.39688	0.73689	0.73689	MGI:1917575	7032	XM_006534159|NM_001077636|NM_027388	XP_006534222|NP_081664|NP_001071104		6243	HGNC:23213	2840	NM_178517,NM_001346754,NM_001346755	NP_001333684,NP_848612,XP_005257295,XP_011522948,NP_001333683
Dact3	735;10822;;66113;;75488	1.24309	0.93405	0.74096	0.74096	0.74096	MGI:3654828	6293	NM_001081655	NP_001075124		7734	HGNC:30745	1479	NM_145056,NM_001301046	NP_001287975,XP_016881823,XP_011524802,NP_659493,XP_011524801
Bcl2	518;10	1.23748	0.99288	0.40932	0.75337	0.75155	MGI:88	1204	NM_177410|NM_009741	NP_803129|NP_033871		527	HGNC:9	596	NM_000657,NM_000633	NP_000648,NP_000624,XP_011524437,XP_016881406

	90;76133;88444						138				90				
Hif1a	10563;10911;34377;36988	10.23674	0.8764	0.04096	0.07515	0.0715	MGI:1069118	1525 1	XM_017314961|NM_001313919|XM_006515478|NM_010431|NM_001313920	NP_034561|XP_006515541|XP_017170450|NP_001300849|NP_001300848	1171	HGNC:49100	309 1	NM_181054,NM_001243084,NM_001530	NP_001230013,NP_851397,NP_001521
Mmp14	81;10966;38688;87111	10.23333	0.9143	0.04120	0.07528	0.0728	MGI:1019000	1738 7	NM_008608	NP_032634	2104 0	HGNC:7160	43 23	NM_004995	NP_004986
Map3k4	10922;11083;36631;41900	10.22650	0.8659	0.04167	0.07602	0.0581	MGI:1346875	264 07	XM_006523329|XR_001782076|XR_001782077|NM_011948|XR_001782079|XR_001782078	NP_036078|XP_006523392	3134 6	HGNC:6856	42 16	NM_001301072,NM_001291958,NM_005922,NM_006724	XP_005267046,NP_006715,NP_001278887,XP_016866358,NP_001288001,NP_005913
Ppp3ca	361;110	1.22433	1.0538	0.04182	0.07581	0.0581	MGI:107	1905 5	XM_017319492|NM_001293622|NM_008913|XM_017319493	XP_017174982|XP_017174981|NP_001280551|NP_032939	5549 7	HGNC:93	55 30	NM_000944,NM_001130691,NM_001130692	NP_001124164,XP_016863854,NP_001124163,NP_000935

	9;26103;63933						164					14				
Zfp462	94;1114;6882;91933	1.2208409	0.8842057	0.4259305	0.7593	0.7593	MGI:1076900	246	XM_017320200|XM_006537918|XM_017320199|XM_011250033|XM_011250032|XM_011250031|XM_006537919|XM_011250035|XM_006537916|XM_006537915|XM_006537917|XM_011250036|NM_172867	XP_011248338|XP_006537979|XP_006537980|XP_011248333|XP_006537981|XP_011248334|XP_017175688|XP_006537978|NP_766455|XP_017175689|XP_011248337|XP_006537982|XP_011248335	414430	HGNC:21684	589	NM_021224,NM_001347997	XP_006717272,XP_006717275,XP_011517194,XP_006717274,NP_001334926,XP_016870488,NP_067047,XP_016870487,XP_016870486,XP_006717279,XP_006717281,XP_006717278,XP_016870485
Sharpin	64;1119;43871;80911	1.2175	1.4061	0.4232	0.7610	0.7605	MGI:1913331	1025	NM_025340|XR_383966|XM_011245399|XM_011245398|XM_006520263	XP_006520326|XP_011243701|NP_079616|XP_011243700	11918	HGNC:25321	8185	NM_030974	XP_016869377,XP_016869376,NP_112236	
Nfkb2	406;1124;21469	1.2141	1.0263	0.4259	0.7629	0.7605	MGI:1098000	1834	NM_019408|NM_001177370|NM_001177369|XM_006526743	NP_001170840|NP_001170841|NP_062281|XP_006526806	1873	HGNC:7795	4791	NM_001322934,NM_001322935,NM_001077494,NM_001261403,NM_002502,NM_001288724	NP_001275653,NP_002493,XP_011538132,XP_016871767,NP_001070962,XP_011538133,NP_001248332,NP_001309863,NP_001309864	
Hmg20b	608;1127;47	1.2121	0.9517	0.4272	0.7623	0.7605	MGI:1341190	1535	NM_001163166|NM_001163165|NM_010440|XM_006513248|XM_006513249	NP_001156638|NP_001156637|NP_034570|XP_006513311|XP_006513312	74949	HGNC:50002	1036	NM_006339	NP_006330,XP_016881633	

Mrpl42	23;75409321;1130;52599;59752	1.2101	0.0881	0.0428	0.0761	0.0605	MGI:1337744	6772	NM_026065|XM_006513979	XP_006514042|NP_080341	12106	HGNC:14493	2897	NM_172178,NM_172177,NM_014050	NP_751917,NP_054769
Casp9	2891;1138;3517;;97288	1.2048	1.0875	0.0432	0.0765	0.0605	MGI:1277950	1237	NM_001277932|NM_015733|XM_017319928	NP_056548|XP_017175417|NP_001264861	31024	HGNC:15111	842	NM_001229,NM_032996,NM_001278054	NP_001220,XP_011540575,XP_005246071,NP_127463,NP_001264983
Uap1	69;1139;73000;92133	1.2041	0.0923	0.0433	0.0763	0.0605	MGI:1334459	1076	NM_133806|NM_001305046|NM_001305045|XM_006496606|XM_006496607|XM_006496608	XP_006496671|NP_001291974|NP_001291975|XP_006496669|XP_006496670|NP_598567	23442	HGNC:12457	6675	NM_001324113,NM_001324114,NM_001324116,NM_003115,NM_001324115,NM_001324117	XP_011508215,NP_001311044,NP_001311043,XP_011508216,NP_003106,NP_001311042,NP_001311046,NP_001311045
Atxn10	2811;1141;54522;	1.2028	1.0920	0.0434	0.0762	0.0605	MGI:1859293	5413	NM_016843	NP_058539	40858	HGNC:10549	2581	NM_013236,NM_001167621	NP_037368,NP_001161093

	65413														
Shb	19;1142;66600;83599	1.2021	1.0667	0.043446	0.076005	0.07605	MGI:98294	23012 6	NM_001033306	NP_001028478	74458	HGNC:10838	6461	NM_003028	NP_003019
Cbr1	87;1149;47766;87144	1.19755	1.08400	0.043882	0.076388	0.07638	MGI:88284	1240 8	NM_007620	NP_031646	37524	HGNC:1548	873	NM_001286789,NM_001757	NP_001273718,NP_001748
Klhl7	111;1156;24246;46122	1.19291	0.084471	0.044171	0.076771	0.07670	MGI:1196453	5232 3	NM_001161800|XR_880834|XM_006535753|NM_026448	NP_080724|NP_001155272|XP_006535816	10317	HGNC:15646	5597 5	NM_001031710,NM_001172428,NM_018846	NP_001026880,XP_016867928,XP_006715820,NP_001165899,XP_016867929,XP_006715818,XP_016867930,XP_006715817,XP_006715816,XP_006715819,NP_061334
H2-D1	79;11559;85555;96	1.19101	1.34481	0.044330	0.076770	0.07670	MGI:95896	1496 4	NM_010380	NP_034510	12835 2	HGNC:49311	3105	NM_002116,NM_001242758	XP_005275388,NP_002107,NP_001229687,XP_016885777

Hsd17b7	32374;1179;3939;7729	1.1.1.270	1781	10239	04534	07815	0775	MGI:1330808	154	XM_011238758|XM_006496667|NM_010476|XM_017317108	XP_017172597|XP_011237060|XP_006496730|NP_034606	4072	HGNC:5215	514	NM_016371,NM_001304513,NM_001304512	NP_001291442,NP_057455,NP_001291441
Elp3	4801;1189;2308;5508	1.1.97.270	1718	9739	04585	07873	0775	MGI:1921445	741	NR_045599|NM_001253812|NM_028811	NP_083087|NP_001240741	7105	HGNC:20696	5514	NM_001284222,NM_001284225,NM_001284224,NM_001284226,NM_001284220,NM_018091	NP_001271154,NP_060561,XP_016869093,NP_001271149,NP_001271153,NP_001271151,XP_006716417,NP_001271155
Adss	6711;1193;;8862;;92699	1.1.1.220	1692	9133	04607	07880	0775	MGI:879488	1156	NM_007422|XR_001785476	NP_031448	875	HGNC:2922	159	NM_001126	XP_011542410,NP_001117
Mlkl	7331;1195;;2294;;48611	1.1.1.680	1897	9167	04616	07867	0775	MGI:1921818	745	XM_006531444|XM_006531443|NM_001310613|XM_356104|XM_006531442	NP_001297542|XP_006531507|NP_083281|XP_006531505|XP_006531506	77416	HGNC:26617	1972	NM_152649,NM_001142497	NP_001135969,XP_011521238,NP_689862,XP_005255891

9630033F20Rik	252;1198;2395;2515	1.1661	1.0954	0.046633	0.078655	0.0775	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Psme1	926;1202;2401;3666	1.16368	0.085884	0.046542	0.078722	0.0775	MGI:1096367	1.9186	NM_011189	NP_035319	4560	HGNC:9568	57.20	NM_001281529,NM_001281528,NM_006263,NM_176783	NP_001268458,NP_788955,NP_006254,NP_001268457				
Atf2	193;1203;2800;5438	1.16308	1.1478	0.046559	0.078522	0.0775	MGI:1093449	1.1909	NM_001284370|NM_001284372|NM_001025093|NM_001284374|NM_001284371|NM_001284373|NM_001284376|NM_001284369|NM_009715	NP_001271303|NP_001271301|NP_001271298|NP_001271300|NP_001271299|NP_033845|NP_001271302|NP_001020264|NP_001271305	3106.1	HGNC:784	13.86	NM_001256094,NM_001256093,NM_001256091,NM_001256090,NM_001256092,NM_001880	NP_001243021,NP_001243019,NP_001243020,NP_001871,NP_001243023,NP_001243022				
Pdpn	861;1205;2827;4046	1.16190	0.086699	0.047840	0.0775	MGI:1030988	1.4726	NM_001290822|NM_010329	NP_001277751|NP_034459	4729	HGNC:29602	10.63.0	NM_006474,NM_001006625,NM_001006624,NM_198389	NP_001006625,NP_938203,NP_001006626,NP_006465,XP_006710358					
Cd	107	1.1	0.18	0.047	0.07	MGI	125	NM_007659	NP_031685	682	HGN	98.3	NM_001170406,NM_001307847,NM_001130829,N	NP_001163877,NP_001307847,NP_001777,NP_001163					

k1	3;1208;27177;63855	59358	685	837	775	:8835 1	34				03	C:1722	M_0013209 18,NM_001 786,NM_00 1170407,N M_033379	878,NP_203698,X P_005270360
Net1	544;1220;2754;7168	1.1525	0.9416	0.4747	0.7912	0.775	MGI:1927138	563 49	NM_019671|NM_0 01047159	NP_001040624 |NP_062645	4283	HGNC:14592	1027 6	NM_001047 160,NM_00 5863	NP_001040625,NP _005854
Comm d1	239;1223;23564;74044	1.1507	0.0983	0.4764	0.7911	0.775	MGI:1094774	1784 6	XM_017314316|X M_006514563|NM _144514|XM_0065 14564	XP_006514626 |XP_01716980 5|XP_0065146 27|NP_653097	1760 4	HGNC:23024	15068 4	NM_152516 ,NM_00132 1781,NM_0 01321782	NP_001308710,XP _016858901,XP_0 11530861,NP_001 308711,NP_68972 9,XP_011530860
Prkd2	720;1226;25344;69644	1.1489	0.1893	0.4780	0.7909	0.775	MGI:2141917	1015 40	NM_178900|NM_0 01252458|XR_391 036|XM_00653944 4	NP_849231|NP _001239387|X P_006539507	9516	HGNC:17293	2586 5	NM_001079 880,NM_00 1079882,N M_0010798 81,NM_016 457	XP_005258773,NP _001073349,NP_0 01073350,NP_001 073351,NP_05754 1
Ppp1r	183;1	1.1 4	1.1 5	0.4 7	0.7 8	0.7 7	MGI:1	52 04 0	XM_006524619|X M_006524616|XM_ 006524618|XM_00 6524617|NM_0011 63818	XP_006524679 |XP_00652468 1|XP_0065246 80|NP_001157	203 3	HGNC:	55 14	NM_002714	NP_002705,XP_01 1513024,XP_0067 15193,XP_016866 484

10	227:320303:891227328	83	13	85	89	75	289273			290|XP_006524682		92844			
Kras	78:1228:72933:76744	1.1476	0.18759	0.0479791	0.078669	0.07775	MGI:966680	1653	XM_006506918|XM_006506919|NM_021284	NP_067259|XP_006506982|XP_006506981	37900	HGNC:64007	3845	NM_004985,NM_033360	XP_011518955,NP_203524,NP_004976,XP_016874782,XP_006719132,XP_016874781
Calm2	407:1229:380443:72433	1.14700	0.19923	0.0478496	0.07775	0.07775	MGI:1032500	12314	NM_007589|XM_006523539	NP_031615|XP_006523602	116117	#N/A	#N/A	#N/A	#N/A
Sgip1	702:1230:692:82422	1.14643	0.18943	0.0480401	0.078029	0.07775	MGI:1920344	73094	XR_376365|XR_376364|XR_376361|XR_376370|XR_376362|XM_017320403|XR_376366|NM_001285860|XM_017320402|XR_001784209|XM_006503427|NM_001285859|XR_376363|XR_376360|XR_867892|XM_017320404|NM_001285852|XR_376359|XR_376369|XR_001784208|NM_144906|XM_017320401|NM_001285862|XR_376368|XR_001784206|XR_001784207|XM_006503429|XM_006503428|XM_017320400|XM_006503430	NP_001272789|XP_017175891|XP_006503493|XP_017175889|NP_001272788|XP_006503490|XP_017175890|XP_017175893|NP_001272781|XP_006503492|XP_006503491|NP_659155|NP_001272791|XP_017175892	13001	HGNC:25412	84251	NM_001350217,NM_032291,NM_001308203,NM_001350218	XP_016858021,XP_016858016,XP_016858010,XP_016858014,XP_016858002,XP_016858018,XP_006711035,NP_115667,XP_005271325,XP_016858011,XP_016857994,XP_016858008,XP_016858020,XP_016858012,XP_016858022,NP_001337146,XP_016857998,XP_006711037,XP_006711030,XP_011540593,XP_006711032,XP_006711036,XP_016858017,XP_016858003,XP_016858025,XP_016858023,XP_016858007,XP_016858019,XP_011540594,XP_006711034,XP_0168

														58015,XP_011540595,XP_016857995,XP_005271321,NP_001337147,XP_016858006,XP_016858026,XP_006711024,XP_016857997,XP_016858009,XP_016858001,XP_016858005,XP_016858004,XP_006711029,NP_001295132,XP_016858000,XP_016858013,XP_005271327,XP_016857999,XP_016857996,XP_016858024
Tpr	113;1234;3929;8668	1.1.1440	0.8.205	0.4.821	0.7.834	0.7.775	MGI:1922066	1089	NM_133780|XM_006529065	NP_598541|XP_006529128	3753	HGNC:12017	715	NM_003292	NP_003283
Gatad2b	928;1239;3896;42144	1.1.1410	0.8.472	0.4.848	0.7.850	0.7.775	MGI:2443225	2295422	XM_006501361|XM_006501360|NM_139304|XM_006501359	NP_647465|XP_006501423|XP_006501422|XP_006501424	3248 4	HGNC:30778	57459	NM_020699	NP_065750,XP_005245421
Acvr2b	274;1240;21699;5489	1.1.1404	1.0.658	0.4.853	0.7.830	0.7.775	MGI:879122	1148 1	NM_001313757|XM_006511926|XR_379846|NM_007397	NP_031423|NP_001300686|XP_006511989	863	HGNC:174	93	NM_001106	NP_001097,XP_016863004,XP_016863005,XP_016863003,XP_005265640

Pgp	446;1241;;3201;;87155	1.1398	0.9715	0.4859	0.7812	0.775	MGI:1914328	6708	NM_025954	NP_080230	5513	HGNC:8909	2838 71	NM_001042371	NP_001035830
Ogt	577;1243;;7524;;80344	1.1386	0.9241	0.4870	0.7801	0.775	MGI:1339639	1081555	NM_139144|NM_001290535|XM_011247503|XM_006527736	XP_006527799|NP_001277464|NP_631883|XP_011245805	9675	HGNC:8127	8473	NM_181672,NM_181673,NM_003605	NP_858059,NP_858058,XP_016885396,XP_016885397
Cdk16	2002;1244;;2663;;37122	1.1380	1.1260	0.4875	0.7783	0.775	MGI:975516	1855 5	NM_001310456|XM_017318425|NM_011049|XM_017318424|XM_006527570	XP_017173913|XP_017173914|NP_001297385|NP_035179|XP_006527633	7878	HGNC:8749	5127	NM_033018,NM_001170460,NM_006201	XP_011542222,NP_148978,XP_011542230,XP_011542223,XP_011542224,XP_011542229,NP_006192,XP_016885059,XP_011542225,XP_016885062,NP_001163931,XP_011542228,XP_016885061,XP_011542227,XP_011542226,XP_016885058,XP_016885060
Rapgef4	8466;1246;;3091;;31400	1.1368	0.8593	0.8877	0.7775	0.775	MGI:1917723	5650 8	NM_001204165|XM_011239711|XM_017319138|NM_019688|NM_001204167|XM_006499938|XM_017319139|NM_001204166	NP_062662|XP_017174627|XP_006500001|XP_017174628|XP_011238013|NP_001191095|NP_001191096|NP_001191094	4451	HGNC:16626	1069	NM_001282900,NM_007023,NM_001282899,NM_001282901,NM_001100397	NP_001093867,XP_011508807,NP_001269830,XP_016858686,XP_016858685,NP_001269829,XP_005246303,NP_008954,XP_006712268,NP_001269828
Aq	612	1.11	0.9	0.4	0.7	0.7	MGI	118	NM_007472	NP_031498	680	HGN	358	NM_198098,NM_001185062,NM_0	NP_932766,NP_001171990,NP_001171989,NP_001316

p1	;125 0;4270 ;5178	344	117	9107	785	785	:1032 01	26				51	C:633	01329872,NM_001185061,NM_000385,NM_001185060	801,NP_001171991
Sufu	396; 1256; 2990 ;7356	1.1309	0.1989 44	0.4944 10	0.7881 0	0.7810	MGI: 1345 643	240 69	NM_001025391|NM_015752	NP_056567|NP_001020562	926 2	HGNC: 16466	516 84	NM_016169,NM_001178133	XP_016871812,NP_057253,NP_001171604,XP_011538160,XP_011538166,XP_011538163,XP_011538165,XP_011538162
Akt2	114 0; 1274 ;2650 0; 9804	1.1 2003	0.8 0078	0.5 0445	0.7 9433	0.7 9433	MGI: 1048 74	116 52	NM_007434|NM_001331109|NM_001110208|XM_006539478|XM_011250418|XM_006539481|XM_006539483|XM_006539482|XM_006539480|XM_006539477|NM_001331108	XP_006539545|XP_011248720|NP_001103678|NP_031460|XP_006539541|NP_001318038|XP_006539546|XP_006539540|NP_001318037|XP_006539543|XP_006539544	4877 3	HGNC: 392	208	NM_001330511,NM_001243027,NM_001243028,NM_001626	NP_001229957,XP_011524920,XP_011524922,XP_011524918,XP_016881959,NP_001317440,XP_011524924,XP_016881960,NP_001617,XP_011524917,XP_011524916,NP_001229956,XP_011524921
Bgalt1	228 ;1280 ;2393 ;6955	1.1 1699	0.1 0907	0.5 7965	0.7 9047	0.7 947	MGI: 957 05	145 95	XM_006537620|XR_001784093|NM_022305	XP_006537683|NP_071641	2037 8	HGNC: 924	268 3	NM_001497	NP_001488,XP_005251497
Hk1	924 ;1	1.1 13	0.1 83	0.5 70	0.7 79	0.7 79	MGI: 9	152 75	NM_001146100|XM_006513247|XM_006513242|XM_006513246|XM_006513245|XM_006513	XP_006513309|XP_006513307|NP_034568|XP_006513308|XP_00651330	1005	HGNC:	309 8	NM_000188,NM_033496,NM_033497,NM_001322365,NM	NP_001309295,XP_005269794,NP_000179,NP_001309296,NP_277031,NP_277033,NP_277

	281:3556;8107	63	55	82	47	47	6103		244|NM_010438|XM_006513243	5|XP_006513306|NP_001139572|XP_006513310	30	4922		_001322364,NM_001322367,NM_001322366,NM_033498,NM_033500	032,XP_011538034,NP_001309294,NP_001309293,NP_277035
Slc1a5	7151;1285;3149;8210	1.1140	0.8750	0.5106	0.7956	0.7955	MGI:1053005	2051 4	XR_391053|XM_006539695|XR_391052|NM_009201	NP_033227|XP_006539758	2155	HGNC:10943	651 0	NM_005628,NM_001145145,NM_001145144	NP_001138617,NP_005619,XP_005259224,NP_001138616
Ptpn9	589;1289;2940;5495	1.1117	0.9070	0.5129	0.7964	0.7955	MGI:1928376	562 94	NM_019651	NP_062625	2121	HGNC:9661	578 0	NM_002833	NP_002824
Bdnf	1214;1291;4558;5290	1.1105	0.7948	0.5140	0.7955	0.7955	MGI:881445	1206 4	NM_001285422|NM_001285417|NM_001285420|NM_001285416|NM_001048142|NM_001316310|NM_001285418|NM_001285421|NM_001285419|NM_001048141|NM_001048139|NM_007540	NP_001041606|NP_001272346|NP_031566|NP_001272350|NP_001272351|NP_001272348|NP_001041604|NP_001303239|NP_001041607|NP_001272345|NP_001272349|NP_001272347	7245	HGNC:1033	627	NM_001143807,NM_001143811,NM_001143814,NM_170732,NM_170733,NM_001143808,NM_001143810,NM_001143806,NM_170731,NM_001143809,NM_001143816,NM_001143813,NM_001143805,NM_001709,NM_001143812,NM_170734,NM_001143815,NM_170735	NP_001137279,NP_733931,XP_011518582,NP_733929,NP_001137277,NP_001137278,NP_001137285,NP_001137284,NP_001700,NP_001137280,NP_733928,NP_001137288,NP_001137281,NP_001137286,NP_733930,NP_733927,NP_001137283,NP_001137282

Swap70	12902:12961:27011:57833	1.1078559	0.0.5169.7972	0.0.7972	MGI:129839047	2094	NM_009302|XM_017322086	XP_017177575|NP_033328	7557	HGNC:17070	2307 5	NM_015055,NM_001297714	NP_055870,NP_001284643,XP_005252887
Smarcad1	89502:13051:80882:82466	1.1026	0.0.5220	0.0.8025	0.0.813	MGI:954553	1390	NM_001253392|XM_006505512|XM_006505513|XM_011241205|XM_132597|XR_001785096|XM_006505510|XM_006505509	NP_031984|XP_006505575|XP_006505573|XP_006505576|NP_001240321|XP_006505572|XP_011239507	5301	HGNC:18398	5691 6	NM_020159,NM_001254949,NM_001128429,NM_001128430	NP_064544,NP_001121901,NP_001241878,XP_016863953,NP_001121902,XP_016863952,XP_016863954
Mink1	10663:13101:51771:57143	1.0998	0.0.5249	0.0.8042	0.0.813	MGI:1355329	5093 2	NM_001045964|XM_017314646|XM_017314645|NM_176893|XM_006533679|XM_006533677|XM_006533678|NM_001045959|XM_006533681|XR_388490|XM_006533682|NM_016713	NP_795712|XP_017170134|NP_001039424|XP_006533745|XP_006533740|XP_006533742|XP_017170135|XP_006533741|XP_006533744|NP_057922|NP_001039429	5676 2	HGNC:17565	5048 8	NM_015716,NM_001321236,NM_153827,NM_170663,NM_001024937	XP_011522208,XP_016880195,XP_016880193,XP_006721595,NP_001308165,NP_722549,NP_733763,XP_006721594,NP_056531,XP_016880197,XP_006721599,XP_016880194,NP_001020108,XP_016880196
Ppp1r35	21013:13162:62544	1.0981 1	1.0.5266	0.0.8040	0.0.813	MGI:1922853	6987 1	XM_006504615|NM_027242	XP_006504678|NP_081518	1233 7	HGNC:28320	2219 0 8	NM_145030,NM_001346938	NP_659467,NP_001333867,XP_011514216

Ngf	1273;1314;5785;;75311	1.0978255	0.0.5.2.7.1	0.0.8.0.2.1	0.0.8.0.1.3	MGI:973211	180.49	NM_001112698|NM_013609|XM_006501108	XP_006501171|NP_001106168|NP_038637	1876	HGNC:7808	48.03	NM_002506	NP_002497,XP_011539820,XP_006710726
Adck1	1282;1316;2527;;47000	1.0.7.8.1.1.0964	0.0.5.2.8.3	0.0.8.0.1.3	0.0.8.0.1.3	MGI:1919363	72.113	XM_006516248|XM_006516246|NM_028105|XM_017315209|NM_001277297|XM_006516252|XM_006516251|XM_006516245|NM_001277296	XP_006516315|XP_006516309|NP_001264225|XP_006516311|NP_001264226|XP_017170698|XP_006516314|NP_082381|XP_006516308	6493	HGNC:19038	57.143	NM_020421,NM_001142545	NP_001136017,XP_011535290,XP_005267943,XP_005267942,NP_065154,XP_016876966,XP_011535287,XP_011535289,XP_016876964,XP_016876963,XP_016876965
Polr3d	709;1320;30396;;3639	1.0.9.4.2.0.8.6.6.5	0.0.5.3.0.6	0.0.8.0.2.1	0.0.8.0.2.1	MGI:1914315	670.65	NM_001164082|NM_025945|XM_006519438	NP_001157554|XP_006519501|NP_080221	1303	HGNC:1080	66.1	NM_001722	NP_001713
Aplp1	186;1326;34311;;70366	1.1.0.9.0.9.1.1.9.2	0.0.5.3.4.1	0.0.8.0.4.7	0.0.8.0.4.7	MGI:880466	118.03	XM_017321948|NM_007467	NP_031493|XP_017177437	6844 7	HGNC:597	33.3	NM_005166,NM_001024807	NP_005157,NP_001019978,XP_016882227,XP_016882226

Ptc7	117;1342;3339;7362	10.0784.0815.0815	54321557	MGI:2444593	32071717	NM_177242	NP_796216	6100	HGNC:30695	160760	NM_139283	NP_644812
Parva	618;1357;5903;7737	10.0873.0822.0845	55226442	MGI:1931144	57342	XM_006508051|NM_020606|XM_006508050	NP_065631|XP_006508114|XP_006508113	1007	HGNC:14652	5742	NM_018222	XP_005253072,NP_060692
Apc	214;1359;5161;76188	1.0729	1.0817	0.0.5533	0.0.8254	0.0.8245	MGI:880389	1178	XM_006525529|XM_006525533|XM_006525538|XM_017317804|NM_007462|XM_006525532|XM_006525531|XM_006525536|XM_006525534|XM_006525535|XM_006525539|XM_006525530	XP_006525594|XP_006525599|XP_006525595|XP_006525597|XP_006525602|XP_006525601|XP_006525596|XP_006525598|XP_006525592|XP_017173293|XP_006525593|NP_031488	309503	HGNC:583	324	NM_001127511,NM_000038,NM_001127510	NP_001120983,NP_000029,NP_001120982
Atp2c1	856;1361;2883;2992	10.0718	0.0824	0.0824	0.0824	MGI:1890088	2355744	XM_006511710|NM_001253831|NM_001253834|XM_006511712|XM_006511714|NM_175025|NM_001253836|XM_006511711	XP_006511777|XP_006511774|XP_006511775|NP_001240760|NP_001240765|NP_001240763|XP_006511773|NP_778190	566722	HGNC:13211	27032	NM_001001486,NM_001199182,NM_001199180,NM_001199183,NM_001001485,NM_001199185,NM_001199181,NM_014382,NM_001199179,NM_001001487,NM_001199184	XP_005247413,XP_011510988,NP_001186112,NP_001001487,NP_001186110,XP_005247412,XP_005247415,NP_001001485,XP_005247411,XP_016861653,NP_001186108,NP_001186114,NP_001186113,NP_001186111,NP_001186109,NP_001001486,NP_055197
Zf	11	1.1	0.0	0.0	MG	52	NM_144523	NP_653106	74	HG	90	NM_033414	NP_219482

p622	0;1364;3007;9415	0702	21	55	82	84	I:12892882	52			377	NC:30958	441			
Ly6c1	12;1371;5269;6707	1.0665	0.7730	0.5606	0.8281	0.8280	MGI:968882	170	XM_006520521|XM_001252058|NM_010741|NM_001252056|NM_001252055|NM_001252057	NP_001238986|NP_001238984|XP_006520584|NP_001238985|NP_001238987|NP_034871	#N/A	#N/A	#N/A	#N/A	#N/A	
Elp4	11;1377;2333;9154	1.0633	0.7827	0.5642	0.8307	0.8280	MGI:1925016	776	NM_023876	NP_076365	3243	HGNC:11771	266	NM_001288726,NM_001288725,NM_019040	NP_001275655,NP_061913,NP_001275654	
Cd9	731;1379;6940;8547	1.0622	0.8454	0.5654	0.8299	0.8280	MGI:883488	127	NM_007657	NP_031683	20420	HGNC:1709	928	NM_001769,NM_001330312	NP_001760,XP_011519342,NP_001317241,XP_005253871	
Ptp	122	1.07	0.58	0.8			MGI	192	XM_006512610|XM_006512609|XM_006512607|XM_00	XP_006512683|XP_006512682|XP_006512	556	HGN	57	NM_001291982,NM_001135648,N	NP_002835,XP_011534317,NP_001278911,NP_001278	

rk	2;1381;4645;8067	612	6936	6629	2800	:10331 0	72	6512612|XM_011243146|XM_006512614|XM_006512606|XM_011243145|XM_006512617|XM_006512615|XM_006512618|NM_008983|XM_006512613|XM_006512611|XM_017313850|XM_006512620|XM_006512608|XM_006512619|XM_011243144|XM_011243143	75|XP_006512670|XP_006512677|XP_006512681|XP_006512672|XP_017169339|XP_011241447|XP_006512671|XP_006512674|NP_033009|XP_006512673|XP_011241446|XP_006512678|XP_006512676|XP_011241445|XP_006512669|XP_006512680|XP_011241448	93	C:967 4	96	M_001291984,NM_001291981,NM_002844,NM_001291983	913,XP_011534323,NP_001278910,XP_016866635,XP_006715600,XP_011534318,XP_016866639,XP_011534316,XP_011534319,XP_016866638,NP_001278912,XP_016866637,XP_016866634,XP_016866636,XP_011534320,NP_001129120,XP_011534322
Kcnn4	129;1383;3108;6459	1.06017	1.1795	0.5678	0.8280	0.8280	MGI:1277957	1653 4	XR_391046|NM_001163510|NM_008433|XM_006539563	NP_001156982|XP_006539626|NP_032459	169 6	HGNC:6293	378 3	NM_002250	XP_011525240,XP_005258939,NP_002241,XP_005258940
Bdkrb1	693;1387;2767;4805	1.05802	0.8522	0.5702	0.8289	0.8289	MGI:881444	1206 1	NM_007539	NP_031565	570	HGNC:1029	623	NM_000710	NP_000701
Slc39a14	642;1395;7451;7523	1.05386	0.8633	0.5751	0.8334	0.8334	MGI:2384851	2130 53	XM_006518789|XM_006518787|XM_006518786|NM_001135151|XM_006518791|NM_144808|NM_001135152|XM_006518788	NP_001128624|XP_006518852|XP_006518849|NP_001128623|XP_006518851|XP_006518854|NP_659057|XP_006518850	1503 7	HGNC:20858	2351 6	NM_001351656,NM_001135153,NM_001351655,NM_001351658,NM_001351660,NM_001128431,NM_015359,NM_001351659,NM_001351657,NM_001135154	XP_011542780,XP_016868783,XP_006716386,XP_016868782,XP_005273522,NP_001338586,XP_016868784,NP_056174,XP_005273523,XP_006716387,NP_001128626,NP_001338587,NP_001338584,NP_001338588,NP_001121903,NP_001338585,NP_001128625,NP_001338589,XP_016868781
Mt	71	1..	0..	0..	0..	0..	MG	17	XM_017318416|XM_006527890|NM	XP_006527954|NP_064310|X	37	HG	45	NM_000252	XP_016885038,NP_000243,XP_0168

m1	3;1402;7804;9339	0 5 0 2	8 4 3 6	5 7 9 3	8 3 6 8	8 3 3 9	I:109452	7 7 2	_001164190|XM_006527891|NM_019926|NM_001164192|NM_001164191|NM_001164193	P_017173905|NP_001157665|XP_006527953|NP_001157662|NP_001157664|NP_001157663	2 7 9	N C : 7 4 4 8	3 4		85039,XP_016885040,XP_016885037,XP_016885036,XP_005274744,XP_011529473,XP_011529475,XP_011529474
S1pr1	2803;1404;4669;8885	1 1 . 0 4 9 2	1 0 1 5 9	0 5 8 0 4	0 8 3 5 7	0 8 3 3 9	MGI:1096355	1 3 6 0 9	NM_007901	NP_031927	1 0 7 1	H G N C : 3 1 6 5	1 9 0 1	NM_001320730,NM_001400	NP_001307659,NP_001391
Ppp3r1	1253;1407;2470;3454	1 . 0 4 7 6	0 7 5 9 4	0 5 8 2 2	0 8 3 5 6	0 8 3 3 9	MGI:1071772	1 9 0 5 8	NM_024459	NP_077779	6 8 0 9 9	H G N C : 9 3 1 7	5 5 3 4	NM_000945	NP_000936
Trap1	9273;1408;5701;8687	1 . 0 4 7 1	0 8 0 1 4	0 5 8 2 8	0 8 3 3 9	0 8 3 3 9	MGI:1915265	6 8 0 1 5	NM_026508|XR_001781856|XR_001781855	NP_080784	9 4 5 7	H G N C : 1 6 2 6 4	1 0 1 3 1	NM_016292,NM_001272049	NP_001258978,XP_011520647,NP_057376,XP_016878340
Exo	894;	1 . 0 3	0 8 0	0 5 9	0 8 4	0 8 4	MGI:	5 3 4	XM_006533734|XM_006533733|XM_006533736|XM_006533737|XM_006533795	XP_006533798|XP_006533799|XP_006533795|NP_001156	4 1 0	H G N C	2 3 2	NM_001145298,NM_001013861,NM_001145299,NM_015219,	NP_056034,NP_001013861,XP_006721851,XP_016879886,NP_00113877

c7	14:27:30:02;85:64	74	11	43	76	58	185:92:70	13	33735|XM_006533732|NM_001162872|NM_001347636|NM_016857	344|NP_058553|XP_006533797|XP_006533796|XP_006533800|NP_001334565	19	:23:21:4	65	NM_001013839,NM_001145297,NM_001282313	0,XP_011522873,NP_001138771,XP_006721850,NP_001138769,XP_006721852,XP_011522874,NP_001269243,XP_006721849,NP_001269242
Cyr61	11:64;142:8;69:24;90:37	1	10.0369	0.0763494	0.0845	0.0845	MGI:1860713	107	NM_010516	NP_034646	11	HGNC:2654	94	NM_001554	NP_001545
Tnfrsf1b	52:9;143:2;338:5;43:24	1	10.0349	0.0887	0.0597	0.0846	MGI:1314883	219:38	NM_011610	NP_035740	82	HGNC:11917	9	NM_001066	XP_016857700,XP_016857703,XP_016857702,XP_016857701,XP_011540365,XP_016857704,XP_011540362,NP_001057
Tsg101	10:86;143:4;350:9;738	1	10.0339	0.0771	0.0598	0.0845	MGI:1065811	208	XM_006540790|NM_021884|XM_006540789|XM_006540788|NM_001348088|NM_001348089|XR_391333	XP_006540853|XP_006540851|XP_006540852|NP_001335017|NP_001335018|NP_068684	458	HGNC:15971	72	NM_006292	NP_006283,XP_005253165
Etnk1	213:1	1	1.026	0.0600	0.0854	0.084	MGI:1	753:20	XM_006507012|XM_006507011|NM_029250	NP_083526|XP_006507074|XP_006507075	1024	HGNC:0	55	NM_001039481,NM_018638	XP_016875070,NP_061108,NP_001034570,XP_016875069,XP_005253477

	442:569;743;7	99	11	38	05	88	922570					24649			
Pank1	1324;1443;4488;4937	1.0749437	0.0604488	0.0848888	0.0848888	MGI:1922985	5735	XM_006527427|NM_001114339|NM_023792	NP_076281|NP_001107811|XP_006527490	5697	HGNC:8598	534	NM_148978,NM_148977,NM_138316	XP_016871826,NP_683878,XP_016871823,XP_016871825,XP_016871827,XP_016871824,NP_612189,XP_016871822,NP_683879
Rasa1	905;1446;3231;8247	1.0794794	0.0606464	0.0849490	0.0849490	MGI:978660	218397	NM_145452|XM_011244518	XP_011242820|NP_663427	2168	HGNC:98771	5921	NM_002890,NM_022650	XP_011541829,XP_011541827,NP_002881,NP_072179
Ppap2c	1201;1455;2482;2864	1.0752346	0.0612042	0.0854542	0.0854542	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Hpse	1360;1	1.0190	0.0735	0.0617795	0.0859578	MGI:13	15442	NM_152803	NP_690016	68528	HGNC:5	10855	NM_001199830,NM_001098540,NM_006665,NM_001166498	NP_001092010,NP_006656,NP_001159970,NP_001186759

	464;2576;5420						4312 4					164			
Stk3	1294;1465;5716;7854	1.0185	0.0741 0	0.0618 4	0.0857 8	0.0857 8	MGI:1928487	562 74	XM_006520119|XM_011245369|NM_019635|XM_006520120|XM_006520121|XM_011245368	XP_011243670|XP_006520184|XP_011243671|NP_062609|XP_006520182|XP_006520183	484 20	HGNC:11406	67 8	NM_006281,NM_001256313,NM_001256312	XP_011515554,XP_016869253,XP_016869246,XP_016869248,XP_016869249,XP_011515553,XP_016869251,NP_001243241,XP_016869252,XP_011515550,XP_016869254,XP_011515555,NP_006272,NP_001243242,XP_016869247,XP_016869250,XP_011515557,XP_016869245,XP_011515559,XP_011515560
Nipa2	2963;1476;3083;6963	1.0132	0.0986 9	0.0625 8	0.0865 5	0.0865 4	MGI:1913918	937 90	XM_006541324|NM_001256132|NM_001256133|NM_001256130|NM_023647|NM_001256131	NP_001243060|XP_006541387|NP_001243062|NP_001243061|NP_076136|NP_001243059	113 68	HGNC:17044	81 6 14	NM_001008894,NM_001008892,NM_001184889,NM_001184888,NM_001008860,NM_030922	XP_016878138,XP_016878140,XP_005272603,XP_011542179,XP_016878147,XP_006720428,NP_112184,XP_005272607,XP_016878150,XP_016878146,XP_016878149,XP_016878136,XP_005272604,XP_016878135,XP_011542181,XP_011542180,XP_016878151,XP_016878141,NP_001008860,XP_016878143,NP_001008892,XP_016878144,XP_006720430,XP_006720427,XP_016878137,XP_016878145,XP_016878142,NP_001171817,XP_016878134,XP_011542182,XP_006720429,NP_001008894,XP_005272610,XP_016878139,XP_016878152,NP_001171818,XP_005272609,XP_005272605,XP_016878148
Akap1	1309;1479	1.0117	0.0736 2	0.0627 6	0.0865 4	0.0865 4	MGI:1047	1164 0	NM_009648|XR_879507|XR_388330|NR_104310|NM_001042541	NP_001036006|NP_033778	311 165	HGNC:367	81 6 5	NM_139275,NM_001242902,NM_001242903,NM_003488	XP_005257764,NP_001229831,XP_016880680,XP_016880678,XP_005257766,XP_016880679,NP_003479,NP_001229832

	;21502;55200						29								
Cd68	1295;14866;57757;66688	1.00835800	0.073632000	0.086887	0.08656	MGI:3883422	1251	NM_001291058|NR_110993	NP_001277987	955	HGNC:16933	968	NM_001040059,NM_001251	NP_001035148,NP_001242	
Wnt6	878;14911;54199;79499	1.00595	0.078811	0.063526	0.087066	0.08656	MGI:3989600	224220	XM_006495887|XM_006495888|NM_009526|XM_006495889	XP_006495951|NP_033552|XP_006495950|XP_006495952	475	HGNC:12785	6	475	NM_006522	NP_006513
Aimp1	809;14922;40233;83222	1.00544	0.080006	0.063588	0.086888	0.08656	MGI:1027744	1372	NM_007926	NP_031952	3126	HGNC:10648	0	925	5	NM_001142415,NM_001142416,NM_004757	XP_016864324,NP_001135888,XP_016864325,NP_001135887,NP_004748
Uhmk1	13381;14933;	1.00503	0.073036	0.063640	0.086706	0.08656	MGI:3419	1658	NM_010633|XM_006496682	NP_034763|XP_006496745	7801	HGNC:19683	1	279	33	NM_001184763,NM_144624,NM_175866	NP_787062,NP_653225,NP_001171692

	625 6;631 5					08									
Lims1	1165;1497;2495;4081	1.003163	0.074639	0.086379	0.086556	MGI:1195263	1089	NM_001193303|XM_006513069|XM_006513070|XM_006513074|XM_006513073|XM_006513068|NM_201242|NM_026148|XM_006513072|NM_001346676|XM_006513071	XP_006513131|NP_001180232|XP_006513133|NP_080424|XP_006513136|XP_006513134|XP_006513135|XP_006513132|XP_006513137|NP_957694|NP_001333605	6842	HGNC:6616	39 87	NM_001193482,NM_001193488,NM_004987,NM_001193485,NM_001193483,NM_001193484	XP_016859585,XP_005264006,NP_001180417,XP_016859584,XP_005264003,NP_001180413,XP_005264008,XP_016859581,XP_016859580,XP_005264007,XP_016859582,NP_001180412,NP_001180411,NP_001180414,XP_005264005,NP_004978,XP_016859583
Ceacam1	3700;1498;5370;5690	1.003826	0.093962	0.086562	0.086556	MGI:1347245	2636 65	NM_001039187|NM_011926|NM_001039186|NM_001039185	NP_001034275|NP_036056|NP_001034274|NP_001034276	12863 0	HGNC:1814	63 4	NM_001024912,NM_001205344,NM_001184813,NM_001184816,NM_001712,NM_001184815	NP_001020083,NP_001192273,XP_011525508,NP_001171742,NP_001171744,NP_001171745,NP_001703
Rgma	1380;1504;4268;8903	0.99972 42	0.072434	0.086887	0.086556	MGI:2679262	2440 58	NM_177740|XM_006540902	XP_006540965|NP_808408	10626	HGNC:30308	56 96 3	NM_001166288,NM_001166287,NM_020211,NM_001166286,NM_001166283,NM_001166289	NP_064596,NP_001159759,NP_001159758,NP_001159761,NP_001159755,NP_001159760
Gng2	8293;1505;3	0.99937	0.079341	0.086711	0.086556	MGI:1027055	1470 2	NM_001038637|NM_001285909|NM_001285910|NM_001285911|NM_001285908|NM_010315	NP_001272839|NP_001272840|NP_001272838|NP_001033726|NP_034445|NP_001272837	40715	HGNC:44044	54 33 1	NM_001243774,NM_053064,NM_001243773	NP_444292,XP_011535148,XP_016876865,NP_001230702,XP_006720236,XP_016876866,NP_001230703

Ntsc	110:6836;3044;15081;43018;46188	0.99780	0.97400	0.64611	0.86711	0.86556	MGI:1354954	5077 3	NM_015807|XM_011249123	NP_056622|XP_011247425	8745	HGNC:17144	3083 3	NM_001252377,NM_014595	NP_055410,NP_001239306,XP_011523002
Acsl3	2995;15100;56099;86996	0.99669	0.97688	0.64733	0.86863	0.86556	MGI:1921455	7420 5	NM_001033606|XM_129894|NM_001136222	NP_083093|NP_001129694|NP_001028778	3278	HGNC:35700	2181	NM_004457,NM_203372	NP_976251,XP_016859073,NP_004448
Mpp5	11465;15122;83155;86000	0.99600	0.97449	0.64887	0.86556	0.86556	MGI:1927339	5621 7	NM_019579|XM_006516098|XM_006516097|XM_017315139	XP_006516160|XP_017170628|XP_006516161|NP_062525	9512	HGNC:18669	6439 8	NM_001256550,NM_022474	XP_005268060,NP_071919,XP_011535388,NP_001243479,XP_011535389
Camk1d	4365;15527;326	0.98889	0.99003	0.65911	0.87669	0.87200	MGI:2442190	2275 41	XM_006497473|XM_006497469|NM_001290376|NM_177343|XM_011238973|NM_001290374|XM_006497471|XM_006497470|NM_001290375	NP_001277305|NP_001277304|XP_006497533|XP_006497534|XP_006497532|XP_006497536|NP_001277303|NP_796317|XP_011237275	12185 8	HGNC:19341	5711 8	NM_001351032,NM_153498,NM_020397	XP_011517897,XP_016871927,NP_705718,XP_016871928,XP_006717544,NP_065130,XP_006717546,NP_001337961,XP_011517893,XP_011517896,XP_011517895,XP_006717545,XP_011517894

	5:40044															
Rgs12	53;15284;28462;62005	0.9885	0.8629	0.6598	0.8752	0.8720	MGI:1918979	717 29	XM_006504120|XM_006504123|NM_001163512|NM_173402|XM_006504126|XM_006504125|XM_006504124|XM_006504121|XM_006504122	NP_775578|XP_006504183|XP_006504185|XP_006504187|NP_001156984|XP_006504184|XP_006504188|XP_006504189|XP_006504186	2195	HGNC:9994	602	NM_198230,NM_002926,NM_198229,NM_198587,NM_198227,NM_198430,NM_198432	XP_006713970,XP_016864019,XP_016864022,NP_937872,NP_002917,XP_016864023,XP_011511845,XP_016864018,XP_016864021,NP_937870,XP_006713968,XP_006713969,XP_016864020
Prkag1	376;15294;34822;77944	0.9880	0.9279	0.6705	0.8736	0.8720	MGI:1084111	1902 82	XM_011245520|NM_016781	XP_011243822|NP_058061	99712	HGNC:9385	557 1	NM_001206710,NM_002733,NM_001206709,NM_212461	XP_011536864,XP_016875111,XP_005269077,XP_005269076,XP_006719562,NP_002724,XP_016875112,NP_001193639,NP_001193638
Il15	524;15302;32522;47333	0.9875	0.8658	0.6612	0.8720	0.8720	MGI:1030144	1616 8	XM_006530709|XM_011248314|NM_008357|XM_006530711|XM_006530705|XM_006530708|XM_006530712|XM_006530713|XM_006530714|XM_006530707|NM_001254747|XM_011248312|XM_006530706|XM_006530715|XM_011248313|XM_006530710	XP_006530770|XP_011246615|XP_006530769|XP_006530768|XP_006530771|XP_011246616|XP_006530773|NP_032383|XP_011246614|XP_006530776|XP_006530774|XP_006530775|XP_006530778|NP_001241676|XP_006530777|XP_006530772	487	HGNC:5977	360 0	NM_000585,NM_172175,NM_172174	NP_000576,NP_751915
Cdc25b	392;15388;31245	0.9838	0.9178	0.6644	0.8764	0.8757	MGI:9970101	1253 1	XR_374398|NM_001111075|NM_023117	NP_075606|NP_001104545	41451	HGNC:1726	994	NM_001287517,NM_021872,NM_212530,NM_001287516,NM_021874,NM_004358,NM_001287519,NM_001287524,NM_001287518,NM_021873,NM_001287522,N	NP_001274448,NP_001274451,NP_068659,NP_001274453,NP_001274447,NP_001274446,NP_068658,NP_004349,NP_001274449,NP_001274445

	388												M_001287520	
Nedd1	458;1544;4792;;7815	0.981172	0.881703	0.678789	0.857	0.857	MGI:972933	179 97	NM_008682|XM_006513334	XP_006513397|NP_032708	74 39	HGNC:7723	12 141	NM_152905,NM_001135176,NM_001135177,NM_001135175	XP_011536205,XP_011536208,NP_001128649,XP_005268701,NP_690869,XP_016874290,NP_001128647,XP_011536206,NP_001128648,XP_006719300,XP_016874291,XP_011536207
Ehmt1	503;1545;4577;;6919	0.980698	0.867114	0.877457	0.857	0.857	MGI:1924933	77 683	XM_017319336|XM_006498423|XM_006498432|XM_006498422|XM_017319335|XM_006498425|XM_006498429|XR_374136|XM_006498427|XM_006498426|XM_006498431|NM_001012518|XM_006498424|NM_172545|NM_001109687|XM_006498430|NM_001109686	XP_006498492|XP_006498495|XP_006498493|XP_006498488|XP_006498489|XP_017174824|XP_006498487|NP_001012536|NP_766133|NP_001103156|XP_017174825|NP_001103157|XP_006498486|XP_006498485|XP_006498494|XP_006498490	116 98	HGNC:24650	79 813	NM_001145527,NM_024757	XP_011517325,XP_016870625,XP_011517324,XP_005266167,XP_016870624,XP_011517328,XP_011517331,XP_011517330,XP_011517326,XP_011517329,XP_006717351,NP_001138999,XP_005266162,NP_079033,XP_016870623,XP_011517335,XP_016870626,XP_016870627,XP_011517323,XP_011517333,XP_011517332,XP_011517327
Rab5c	923;1546;6413;;8502	0.980202	0.767676	0.677157	0.857	0.857	MGI:1053006	193 445	NM_001305003|NM_024456	NP_001291932|NP_077776	555 33	HGNC:9785	58 78	NM_201434,NM_004583,NM_001252039	XP_011523392,NP_001238968,NP_004574,NP_958842,XP_011523393
Efna2	893;1570;8301;;83	0.969372	0.767281	0.688145	0.894	0.945	MGI:1027077	136 377	NM_007909	NP_031935	107 5	HGNC:32222	19 43	NM_001405	NP_001396,XP_016881938,XP_016881939

Lyn6e	0613;1575;2571;2820	0.9671	0.7083	0.6914	0.8962	0.8962	MGI:1065651	170169	NM_008529|NM_001164040|NM_001164036|NM_001164039|NM_001164038|NM_001164037	NP_001157510|NP_001157512|NP_001157511|NP_001157508|NP_001157509|NP_032555	56411	HGNC:6727	401	NM_001127213,NM_002346	NP_002337,NP_001120685
Tank	7891;1585;3311;3710	0.9626	0.7832	0.6984	0.9027	0.9020	MGI:1076766	213153	XM_017316913|NM_001164072|NM_001164071|XM_006499088|XM_011239415|NM_011529|XM_006499089|XR_866264|XM_006499087	XP_017172402|XP_006499152|NP_035659|XP_006499150|XP_011237717|XP_006499151|NP_001157544|NP_001157543	3081	HGNC:11562	1010	NM_133484,NM_001199135,NM_004180	XP_016858582,XP_016858583,XP_016858585,NP_004171,NP_001186064,XP_016858584,NP_597841,XP_016858586,XP_005246264
Nek6	1331;1587;3782;5316	0.9617	0.7093	0.6998	0.9020	0.9020	MGI:1891638	591216	NM_001159631|XM_006498209|XM_006498210|NM_021606	XP_006498273|NP_001153103|XP_006498272|NP_067619	49379	HGNC:7749	1078 3	NM_001166168,NM_001166171,NM_014397,NM_001166170,NM_001166169,NM_001145001,NM_001166167	NP_001138473,NP_055212,NP_001159640,NP_001159643,NP_001159641,NP_001159642,XP_016869706,XP_006716999,XP_005251721,NP_001159639
Wwc2	5973;1597;5215;777	0.9573	0.8275	0.7067	0.9083	0.9059	MGI:1261872	523557	NM_133791	NP_598552	32618	HGNC:24148	800 14	NM_024949	NP_079225,XP_011530571

Ugt1a9	69 15 94 ; 15 98 ; 55 43 ; ; 62 55 5	0 . 95 69	0 . 68 81	0 . 70 72	0 . 90 64	0 . 90 59	MGI:3576092	394434	NM_201644	NP_964006	133281	#N/A	54 57 5	NM_019075	NP_061948
Stk38l	97 8 ; 16 01 ; 85 32 ; ; 93 99 9	0 . 95 56	0 . 74 68	0 . 70 93	0 . 90 65	0 . 90 59	MGI:1922250	23 25 33	XM_017321560|XM_006507029|XR_001785124|XM_006507032|XM_006507034|XM_006507027|XM_006507031|NM_172734|NM_001346666|XM_006507033	XP_006507097|XP_006507090|XP_006507092|XP_017177049|XP_006507096|XP_006507095|NP_766322|XP_006507094|NP_001333595	562 99	HGNC:17848	23 01 2	NM_015000	XP_006719122,XP_016874525,XP_011518915,XP_005253399,XP_006719121,NP_055815
Glrx3	48 ; 16 04 ; ; 50 17 ; ; 70 83	0 . 95 43 43	1 . 33 59 59	0 . 71 14 14	0 . 90 67 67	0 . 90 59 59	MGI:1353653	309 26	XM_006507916|NM_023140|XR_001785568|NM_001348093	XP_006507979|NP_075629|NP_001335022	476 9	HGNC:15987	10 53 9	NM_001321980,NM_001199868,NM_006541	NP_001186797,NP_006532,NP_001308909,XP_016870963
Lrp8	427 ; 16 06 ; ; 75 89 ; ; 84 88	0 . 95 34 34	0 . 88 66 65	0 . 71 27 27	0 . 90 59 59	0 . 90 59 59	MGI:1340044	169 75	XM_011240463|NR_033496|XM_011240465|XM_011240462|XM_011240459|XM_011240454|XM_011240458|XM_011240466|NM_001080926|XM_011240457|XM_011240460|XM_011240464|XM_011240456|XM_011240467|XM_017320003|XM_011240461|XM_017320004|XM_011240455	XP_011238769|XP_011238766|XP_011238758|XP_011238757|XP_011238756|XP_017175492|XP_011238759|XP_011238763|XP_011238767|XP_011238764|XP_011238768|XP_017175493|XP_011238760|XP_011238761|NP_001074395|XP_011238765|XP_011238762	312 50	HGNC:6700	78 04	NM_033300,NM_004631,NM_017522,NM_001018054	XP_005271232,XP_005271230,XP_011540396,XP_005271231,XP_011540397,XP_011540398,NP_001018064,XP_016857757,NP_150643,XP_006710944,XP_006710945,NP_059992,NP_004622,XP_016857756,XP_016857755,XP_016857754

Zbtb1	39;16;26;57;35	0.9499	0.8994	0.7180	0.9100	0.9100	MGI:2442326	2685664	XM_006515898|XR_872712|XM_006515897|XR_381523|NM_178744|XM_006515895	XP_006515960|XP_006515961|NP_848859|XP_006515958	8974	HGNC:20259	2289 0	NM_014950,NM_001123329	XP_016876583,XP_016876584,NP_001116801,NP_055765,XP_011534870,XP_011534868,XP_005267467
Ppp1r13b	12;57;16;31;53;76;64;67	0.9426	0.7065	0.7304	0.9231	0.9185	MGI:1336199	2198 1	XM_127168|XM_006515797|XM_006515796	XP_006515859|NP_035755|XP_006515860	9090	HGNC:14950	2336 8	NM_015316	XP_016876607,XP_005267544,XP_016876606,XP_016876605,XP_011534895,NP_056131,XP_016876608
Chka	42;16;32;25;45;41;02	0.9422	0.8826	0.7310	0.9214	0.9185	MGI:1077760	1266 0	XM_017318049|NM_001271496|XM_017318050|NM_013490|XM_006531650|XR_388248|XM_017318048|XM_011248600|NR_073190|XM_011248599|XM_006531648|XM_006531646|XM_006531651|XM_006531649	NP_038518|XP_006531714|XP_006531709|XP_006531713|XP_006531712|XP_011246901|NP_001258425|XP_011246902|XP_017173537|XP_017173539|XP_006531711|XP_017173538	88575	HGNC:1937	1119	NM_212469,NM_001277	XP_016872637,NP_997634,XP_016872636,NP_001268
Abcc1	95;16;34;30;86;32;70	0.9413	0.7425	0.7325	0.9207	0.9185	MGI:1026776	1725 0	NM_008576|XR_001781794|XM_006521839|XM_017316888	NP_032602|XP_006521902|XP_017172377	13377 9	HGNC:51	4363	NM_019900,NM_019901,NM_004996,NM_019902,NM_019862,NM_019899,NM_019898	XP_016878729,XP_016878732,XP_016878730,XP_011520799,NP_004987,XP_016878731,XP_016878727,XP_016878728,XP_016878726,XP_011520800

Hgf	13;163;6;;7;3;1;6;;7;4;0;9	0.9405	0.6997	0.7338	0.9198	0.9185	MGI:960779	1523 4	NM_001289460|XM_131908|NM_001289458|NM_001289459|NM_001289461	NP_001276387|NP_001276389|NP_001276390|NP_034557|NP_001276388	503	HGNC:4893	3082	NM_001010933,NM_001010934,NM_000601,NM_001010931,NM_001010932	XP_011514417,XP_016867586,NP_001010933,NP_001010934,NP_001010932,NP_001010931,XP_016867587,XP_006716019,NP_000592
Tax1bp3	13;16;;3;9;5;8	0.9383	0.6961	0.7372	0.9215	0.9185	MGI:1923531	762 81	NM_029564	NP_083840	8749	HGNC:30684	3085 1	NM_014604,NM_001204698	NP_055419,NP_001191627
C30021F23Rik	91;16;;3;8;;5;6	0.9367	0.7478	0.7401	0.9226	0.9185	MGI:3612471	5460 49	NM_001024728	NP_001019899	#N/A	#N/A	#N/A	#N/A	#N/A
Slc7a11	12;17;;4;6;;2;3;1;;2;3;8	0.9362	0.7074	0.7408	0.9209	0.9185	MGI:1347355	2657 0	XM_017319590|XM_006500777|XM_006500776|XM_006500778|NM_011990	XP_006500841|NP_036120|XP_006500839|XP_006500840|XP_017175079	22684	HGNC:11059	2365 7	NM_014331	NP_055146,XP_011530104

Nek9	59;164;;3220;;4393	0.9358	0.8173	0.7414	0.9192	0.9185	MGI:2387995	2177188	NM_145138|XM_006515708	XP_006515771|NP_660120	132222	HGNC:18591	9175	NM_001329237,NM_033116,NM_001329238	NP_001316167,XP_005268265,NP_149107,XP_016877254,NP_001316166,XP_005268266
Lamtor3	1581;;1649;;26544;;74488	0.9350	0.6779	0.7429	0.9185	0.9185	MGI:1929467	5669292	NM_019920	NP_064304	1053939	HGNC:15606	8649	NM_021970,NM_001243736	NP_001230665,NP_068805
Iqgap1	578;;16588;;76074;;85544	0.9312	0.8201	0.7493	0.9239	0.9227	MGI:1352757	2987575	XR_001785567|XM_006540950|NM_016721|XR_391347	NP_057930|XP_006541013	7451414	HGNC:61110	8826	NM_003870	NP_003861
Peli1	14993;;16600;;35892;;61722	0.9304	0.6807	0.7507	0.9231	0.9227	MGI:1914495	6724545	NM_023324|XM_011243746	XP_011242048|NP_075813	2324343	HGNC:8827	57162	NM_020651	XP_011531298,XP_005264494,XP_011531299,NP_065702,XP_011531296,XP_016860009,XP_016860010

Irf5	62;163;763;7;8156	0.9291	0.8051	0.7529	0.9233	0.9227	MGI:1350924	270 56	XM_006505097|NM_001252382|XM_006505099|XM_006505095|XM_006505098|NM_001311083|NM_012057|XM_006505100	XP_006505163|XP_006505162|NP_036187|NP_001298012|XP_006505160|XP_006505058|XP_006505161|NP_001239311	808 8	HGNC:6120	363	NM_001098627,NM_001098629,NM_001242452,NM_001347928,NM_032643,NM_001098630	XP_006716037,XP_011514466,XP_011514465,XP_005250374,XP_011514460,XP_011514461,NP_001092100,NP_001229381,NP_001092099,XP_011514462,NP_001092097,NP_116032,XP_011514463,XP_011514464,NP_001334857
Xpc	634;165;;3329;;75277	0.9283	0.8025	0.7544	0.9227	0.9227	MGI:1035557	225 91	NM_009531	NP_033557	340 1	HGNC:12816	750 8	NM_001145769,NM_004628	XP_011532395,NP_004619
Slc4a11	1344;1670;;3394;;67388	0.9262	0.6904	0.7580	0.9247	0.9247	MGI:2138987	269 356	XM_006499607|XM_006499604|NM_001081162	NP_001074631|XP_006499670|XP_006499667	1293 1	HGNC:16438	839 59	NM_032034,NM_001174090,NM_001174089	XP_016883586,XP_005260913,XP_011527685,NP_114423,XP_011527686,XP_005260914,XP_016883585,XP_016883582,XP_016883583,NP_001167561,XP_016883584,XP_011527687,NP_001167560
Ctn	579;1673;;7855;;9648	0.9250	0.8167	0.7602	0.9248	0.9248	MGI:9969 95	130 43	XM_006508475|XM_006508474|XR_001785469|NM_007803|XM_006508473|NM_001252572	XP_006508536|NP_001239501|XP_006508538|NP_031829|XP_006508537	383 4	HGNC:33338	201 7	NM_005231,NM_138565,NM_001184740	XP_006718511,NP_001171669,NP_612632,XP_006718510,NP_005222,XP_016872801

lbtk	83;1677;64022;81866	0.923353	0.755532	0.763262	0.926060	0.926000	MGI:1918677	10837	XM_006510766|NM_001081282|XM_006510765	XP_006510829|XP_006510828|NP_001074751	34661	HGNC:17853	259 98	NM_015525,NM_001300906	NP_056340,NP_001287835,XP_006715516,XP_006715517
Dusp7	513;1684;38631;83144	0.920401	0.836185	0.768685	0.930000	0.930000	MGI:2387100	23558 4	XR_379763|NM_153459	NP_703189	14668	HGNC:30733	184 49	NM_001947	NP_001938
Rnpep	781;1697;41866;96887	0.915111	0.761181	0.778111	0.939111	0.931113	MGI:2384902	21561 5	XR_387158|NM_001159624|NM_145417	NP_663392|NP_001153096	10628	HGNC:10078	605 1	NM_001319183,NM_020216,NM_001319182,NM_001319184	XP_016857511,NP_001306113,NP_001306111,NP_064601,XP_005245478,NP_001306112
Dync1li1	1185;1698;24111;64700	0.914700	0.770089	0.778975	0.931313		MGI:2135610	23561 1	NM_146229	NP_666341	94033	HGNC:18745	514 43	NM_016141,NM_001329135	NP_001316064,NP_057225

Tdg	689;1704;7076;8591	0.91203	0.78034	0.94044	0.9313	MGI:1082477	2165	XM_006513577|NM_172552|NM_011561	NP_766140|XP_006513640|NP_035691	2415	HGNC:11700	696	NM_003211,NM_001008411	XP_011537017,XP_011537016,NP_003202,XP_005269182
Ano6	1181;1706;6857;9465	0.91158	0.69848	0.78487	0.9313	MGI:2145890	1057222	NM_001253813|XM_006520234|XM_006520233|XM_006520231|NM_175344|XM_006520232	XP_006520297|NP_001240742|XP_006520296|XP_006520295|NP_780553|XP_006520294	27888	HGNC:25240	196527	NM_001142679,NM_001025356,NM_001142678,NM_001204803,NM_001142680	NP_001136150,XP_005268764,NP_001191732,NP_001020527,NP_001136151,XP_005268763
Ulk3	1569;1707;6290;8020	0.91111	0.66167	0.78555	0.93813	MGI:1918992	7174 2	XR_379457|XR_001779013|XR_870766|XR_379456|XR_379459|XR_379458|NM_027895|XR_870767|XR_001779012	NP_082171	68482	HGNC:19703	2598 9	NM_001099436,NM_001284365,NM_001284364	XP_016877561,XP_016877560,XP_016877559,XP_005254346,XP_016877558,NP_001092906,NP_001271294,XP_016877557,NP_001271293
Irak4	3465;1708;4575;5456	0.91077	0.90552	0.78663	0.93613	MGI:2182474	2663 2	XM_011245645|NM_029926	XP_011243947|NP_084202	41109	HGNC:17967	5113 5	NM_001351343,NM_001351338,NM_001145257,NM_001351345,NM_001351339,NM_016123,NM_001114182,NM_001351340,NM_001145258,NM_001351344,NM_001351341,NM_001351342,NM_001145256	XP_016874880,NP_001338273,NP_001338268,XP_005269005,XP_006719503,XP_011536733,XP_006719506,NP_001338270,XP_005269002,XP_011536734,NP_001138730,XP_005269004,XP_005269006,XP_006719501,NP_001338269,NP_001138729,NP_001338272,NP_001338267,XP_006719504,XP_005269001,NP_001338274,NP_057207,NP_00

															1338271,XP_005269000,XP_011536735,XP_016874879,NP_001107654,XP_006719505,NP_001138728,XP_006719502
Gpr124	15183;170931;594131;743131	0.910103	0.66944	0.787871	0.93511	0.9313	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Rcan3	16885;171131;583165	0.909095	0.65955	0.788586	0.93445	0.9313	MGI:1858220	5390 2	XM_017320317|NM_022980	XP_017175806|NP_075356	838 8	HGNC:3042	11 23	NM_001251984,NM_001251978,NM_013441,NM_001251981,NM_001251980,NM_001251977,NM_001251979,NM_001251982,NM_001251983,NM_001251985	NP_001238914,NP_001238907,NP_001238912,NP_001238911,NP_001238908,NP_001238910,NP_038469,NP_001238913,NP_001238906,NP_001238909
Hectd1	91217127;678 8	0.90911	0.73339	0.789 4	0.93293	0.9313	MGI:2384768	2073 04	XM_011244050|XM_011244051|NM_144788|XM_011244049|XM_017315008	XP_011242351|XP_011242352|XP_017170497|XP_011242353|NP_659037	911 5	HGNC:20157	25 831	NM_015382	XP_016876637,XP_016876640,NP_056197,XP_016876641,XP_011534923,XP_005267559,XP_016876638,XP_011534921,XP_011534924,XP_016876639,XP_016876642
Fggy	14741;171354	0.90817	0.67161	0.790113	0.93133	0.9313	MGI:1922828	7557 8	XM_017320429|XM_011240635|XM_011240633|NM_001113412|XM_011240643|XM_131496|XM_006503472|XM_006503474|XR_001784213|XM_006503475|XM_011240639|XM_017320431|XM_011240645|XM_006503461|	XP_011238946|XP_017175919|XP_011238938|XP_006503537|XP_017175918|NP_001106883|XP_017175920|XP_006503531|XP_011238937|XP_006503538|XP_011238939|X	49533 5	HGNC:25610	55 27 7	NM_001350794,NM_001350792,NM_001350796,NM_001113411,NM_001350798,NM_001278224,NM_001244714,NM_001350793,NM_00	XP_011540038,XP_016857134,XP_016857155,NP_001337721,NP_001231643,XP_016857143,NP_001106882,XP_016857158,XP_016857157,XP_016857167,XP_016857153,NP_001337725,XP_016857136,NP_001337720,

	05;7644							XM_006503468|XM_017320432|XM_011240644|XM_006503470|XM_011240636|XM_017320430|XM_011240637|XM_006503476	P_011238947|NP_083623|XP_011238935|XP_011238941|XP_006503535|XP_006503524|XP_017175921|XP_006503539|XP_006503533|XP_011238945			1350799,NM_001350795,NM_001350791,NM_001350790,NM_001350797,NM_018291	XP_016857159,NP_001337728,XP_016857138,XP_016857165,XP_016857133,XP_016857166,XP_016857145,NP_001337719,NP_001337724,NP_060761,XP_011540037,XP_016857147,XP_016857137,XP_016857150,XP_011540032,XP_016857164,XP_011540033,XP_016857141,XP_016857132,XP_016857139,XP_016857168,XP_016857146,XP_016857142,XP_016857144,XP_016857135,XP_016857154,NP_001337726,NP_001265153,NP_001337723,XP_016857149,XP_016857163,NP_001337722,XP_016857161,XP_016857151,XP_016857148,XP_011540034,XP_011540035,XP_016857140,XP_016857156,XP_016857162,NP_001337727,XP_016857152,XP_016857160
Uck1	537;1718;3941;5916	0.907	0.821	0.7940	0.9335	0.935	MGI:1989044	224	XM_006497853|NM_011675	NP_035805|XP_006497916	790	HGNC:14859	835	NM_001318519,NM_001261450,NM_001135954,NM_001261451,NM_031432	NP_001305448,XP_005272281,NP_001129426,NP_001248380,NP_001248379,NP_113620
Jade1	1662;1727;5076;7537	0.903	0.657	0.8010	0.9394	0.934	MGI:1925835	2694	XM_006500784|NM_001130186|NM_172303|NM_001130184|NM_001130185	NP_001123657|NP_758507|NP_001123656|XP_006500847|NP_001123658	1816	HGNC:30027	799	NM_001287442,NM_024900,NM_001287441,NM_001287437,NM_199320,NM_001287440,NM_001287439,NM_001287443	NP_001274371,NP_001274370,NP_955352,XP_016864116,NP_001274366,NP_001274368,NP_079176,NP_001274369,XP_005263289,NP_001274372,XP_016864115

Asap2	960;1731;4525;;7131	0.901524	0.7224	0.804040	0.940404	0.940404	MGI:2685438	211914	XR_001780443|NM_001098168|XM_006515050|NM_001135192|XM_150333|XM_358146|XM_006515047|XM_006515048	NP_001091637|NP_001128664|NP_001004364|XP_006515113|XP_006515111|XP_006515110	288	HGNC:2721	853	NM_001135191,NM_003887	XP_006711964,XP_011508706,XP_006711961,NP_003878,XP_011508710,XP_011508707,XP_011508705,XP_011508709,XP_011508711,NP_001128663,XP_006711965,XP_011508708
Lppr2	1276;1737;;5022;;87311	0.898920	0.683084	0.804084	0.943232	0.943232	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Il6st	1277;1746;;6140;;74233	0.895561	0.681151	0.815148	0.948486	0.945454	MGI:9656560	161995	NM_010560	NP_034690	1645	HGNC:6021	3572	NM_002184,NM_175767,NM_001190981	XP_016864930,NP_001177910,XP_016864931,NP_786943,NP_002175
Arhgef1	9143;1753;;2270;;94793	0.892929	0.722554	0.820505	0.952454	0.945454	MGI:1353510	168001	XR_391047|NM_001130151|XM_006539565|XM_006539564|NM_001130153|NM_001130152|XM_017322003|NM_001130150|NM_008488	NP_001123622|NP_001123623|XP_006539628|XP_017177492|NP_001123624|XP_006539627|NP_032514|NP_001123625	3454	HGNC:6811	9138	NM_198977,NM_199002,NM_004706	XP_011525770,XP_005259443,NP_945353,NP_945328,XP_005259447,NP_004697

Tbl2	174;1755;2943;8874	0.089211	0.064833	0.082119	0.095155	0.094554	MGI:1351652	273-68	XM_006504432|NM_013763|XM_006504433	XP_006504496|NP_038791|XP_006504495	8260	HGNC:11586	266-08	NM_012453,NM_032988	XP_011514329,XP_006715986,NP_036585
Phlda1	147;1757;5986;7521	0.089133	1.006803	0.082333	0.095084	0.094554	MGI:1096880	216-64	NM_009344	NP_033370	7203	HGNC:89333	228-22	NM_007350	NP_031376
Il10rb	1095;1760;6503;8390	0.089021	0.069081	0.082557	0.095111	0.094554	MGI:1093880	161-55	XM_006522924|NM_008349	XP_006522987|NP_032375	523	HGNC:5965	358	NM_000628	NP_000619
Hmgb3	979;1767;4448;86155	0.088755	0.071260	0.083109	0.095409	0.094554	MGI:1098219	153-54	NM_001293624|XM_006527842|NM_008253|NM_001293623|NM_001293625	NP_001280552|NP_001280554|NP_032279|NP_001280553|XP_006527905	13426	#N/A	#N/A	#N/A	#N/A

Smap	11021;17709;8042	0.8863	0.6954	0.8334	0.9551	0.9454	MGI:1933549	839 97	XM_017316227|XM_006519735|XM_006519729|XM_017316229|XM_006519738|XM_006519733|XM_017316228|XM_006519726|XM_006519731|XM_006519734|XM_006519728|NM_001310445|XM_006519732|XM_006519730|NM_001347494|XM_006519725|XM_006519737|NM_032008|XM_006519736|XM_006519727	XP_006519793|XP_006519790|XP_006519792|XP_006519797|XP_006519796|XP_006519798|NP_114397|XP_006519801|XP_017171718|XP_006519789|XP_006519791|XP_006519794|XP_006519788|NP_001297374|XP_006519800|XP_017171716|NP_001334423|XP_017171717|XP_006519795|XP_006519799	31428	HGNC:16643	7871	NM_007159,NM_001311178,NM_001304421,NM_001311179,NM_001304422,NM_001304423,NM_001304420	XP_016862658,NP_001291351,XP_016862635,XP_016862648,XP_016862645,XP_016862647,XP_005265516,XP_016862655,XP_016862657,XP_016862659,XP_016862652,XP_005265514,XP_016862649,XP_016862640,XP_011532405,XP_005265528,XP_011532408,XP_005265525,NP_001298108,NP_009090,XP_005265518,XP_016862654,XP_005265522,XP_011532406,XP_016862653,XP_016862641,XP_005265527,XP_016862656,XP_016862646,XP_016862644,XP_005265524,XP_016862650,XP_006713389,XP_005265519,NP_001298107,XP_016862637,XP_016862651,XP_005265529,XP_005265515,XP_016862642,XP_005265517,NP_001291350,XP_005265521,XP_016862638,XP_011532407,XP_005265513,XP_016862643,NP_001291349,NP_001291352,XP_016862636,XP_016862639,XP_005265523
Clk4	14223;17773;33545;77700	0.8837	0.6629	0.8388	0.9589	0.9454	MGI:1098551	1275 0	XM_006532115|XM_011248708|XM_006532116|XM_006532111|XM_017314244|NM_001304744|XM_006532118|XM_006532114|XM_006532113|XM_011248709|NM_007714|XM_006532112|XM_017314243	XP_017169733|XP_017169732|XP_006532179|XP_006532176|NP_031740|XP_006532175|XP_011247010|XP_006532181|NP_001291673|XP_006532178|XP_006532177|XP_006532174|XP_011247011	56895	HGNC:13659	5739 6	NM_020666	NP_065717
Nos2	16711;17778;;2	0.8833	0.6471	0.8396	0.9574	0.9454	MGI:973611	1812 6	NM_001313922|XM_006532446|NM_001313921|NM_010927	XP_006532509|NP_001300850|NP_035057|NP_001300851	55473	HGNC:7873	4843	NM_153292,NM_000625	NP_000616,XP_011523162,XP_011523164,XP_011523161,XP_011523163

	4877:8780														
Ctdspl	3399;17799;24999;41455	0.8829	0.8953	0.8403	0.9559	0.9454	MGI:1916524	6927 4	XM_006512262|XM_006512263|NM_133710	NP_598471|XP_006512326|XP_006512325	4881	HGNC:16890	10217	NM_001008392,NM_005808	NP_001008393,NP_005799,XP_016861009,XP_016861008
Vac14	5581;17800;21391;21611	0.8825	0.8020	0.8411	0.9544	0.9454	MGI:2157980	23472 9	NM_146216|XR_001778432|XM_006530919|XM_006530918	XP_006530982|NP_666328|XP_006530981	6528	HGNC:25507	55697	NM_001351157,NM_018052	XP_016878931,XP_011521525,NP_060522,XP_011521527,XP_011521526,XP_005256098,XP_016878930,XP_005256095,NP_001338086
Map3k12	2833;17822;46088;83299	0.8818	0.9301	0.8427	0.9538	0.9454	MGI:1346881	26404	XR_001781538|NM_001163643|XM_017316624|XM_006521013|XR_001781537|NM_009582|XM_017316626|XM_017316625	XP_017172115|XP_017172114|XP_006521076|NP_001157115|XP_017172113|NP_033608	4592	HGNC:6851	77866	NM_001193511,NM_006301	XP_011537027,XP_016875445,NP_001180440,XP_005269197,XP_005269195,XP_006719651,NP_006292
Mdp1	8061;17833;55244	0.8814	0.7392	0.8434	0.9523	0.9454	MGI:1915131	67881	XM_017316173|NR_028316|NM_023397	NP_075886|XP_017171662	5846	HGNC:28781	14553	NM_001199821,NM_001199822,NM_138476	NP_612485,NP_001186751,NP_001186750

	;7152														
Rab43	849;17853;39477;82228	0.880806	0.730649	0.849155	0.945154	MGI:1917084	6983	NR_104478|NM_001039394|NR_104477|NM_133717	NP_001034483|NP_598478	43122	HGNC:19983	3912	12	NM_001204885,NM_001204886,NM_001204883,NM_198490,NM_001204887,NM_001204884,NM_001204888	NP_001191815,NP_001191816,NP_001191813,NP_001191814,NP_940892,NP_001191812,NP_001191817
Prpsap1	14097;17888;66366;93433	0.879595	0.661873	0.847373	0.951959	0.945454	MGI:1915013	67763	XM_181343|XM_011249196|XM_006534018|XM_006534017	NP_080640|XP_011247498|XP_006534080|XP_006534081	55687	HGNC:9466	5635		NM_001330503,NM_002766	NP_002757,XP_011523336,NP_001317432
Stau1	45443;17793;28103;31788	0.877776	0.837713	0.851340	0.954054	MGI:1338864	20853	XM_006499071|NM_001109905|NM_011490|NM_001291160|NM_001109906|XM_011239406|NR_111895|XM_006499072	XP_011237708|NP_035620|XP_006499135|NP_001278089|XP_006499134|NP_001103376|NP_001103375	33884	HGNC:11370	6780		NM_017452,NM_001322932,NM_001322931,NM_001319135,NM_001322929,NM_004602,NM_001322928,NM_001322933,NM_017454,NM_001322930,NM_001037328,NM_001322927,NM_017453,NM_001319134	NP_001309857,NP_001309858,NP_001309856,XP_006723928,NP_059347,NP_001309860,NP_059348,NP_001306064,NP_001309859,NP_001032405,NP_059346,NP_001306063,NP_001309861,XP_005260584,NP_004593,XP_011527317,NP_001309862,XP_016883517
Bcar1	3817;17943;36043;	0.877202	0.870021	0.852168	0.952654	0.945454	MGI:1080091	12927	NM_001198839|XM_011248299|NM_009954	XP_011246601|NP_001185768|NP_034084	76744	HGNC:9711	9564		NM_001170719,NM_001170715,NM_001170721,NM_001170716,NM_001170720,NM_001170717,NM_001170714,NM_014567,NM_001170718	XP_016879387,NP_001164192,NP_001164188,XP_016879388,NP_001164187,NP_055382,XP_005256316,XP_016879386,NP_001164190,XP_005256317,XP_011521777,NP_001164191,XP_005256315,NP_001164189,NP_001164186,NP_001164185

	70355														
Ckb	510;17795;40018;74188	0.8768	0.8154	0.85291	0.95114	0.9544	MGI:84407	1270 9	NM_021273	NP_067248	37530	HGNC:19911	1152	NM_001823	XP_016876440,NP_001814,XP_016876441
Pacs2	385;17797;48873;63799	0.8761	0.8674	0.85456	0.95056	0.9544	MGI:1924399	2178 93	XM_006515779|XM_006515773|XM_006515769|XM_006515774|XM_006515777|XM_006515772|XM_006515778|XR_001780448|NM_001081170|XR_381518|NM_001291444|XR_381519|XM_006515771|XM_006515770|NM_001291445	NP_001278374|XP_006515836|NP_001278373|XP_006515834|XP_006515833|XP_006515841|XP_006515840|XP_006515835|XP_006515837|NP_001074639|XP_006515832|XP_006515842	15016	HGNC:23794	2341	NM_001100913,NM_001243127,NM_015197	XP_016876601,XP_016876595,XP_016876600,XP_016876598,XP_006720153,NP_001230056,XP_016876596,XP_016876597,XP_016876594,XP_006720155,XP_006720154,XP_016876599,NP_056012,NP_001094383
Pdgfrb	795;17799;22088;39022	0.8753	0.8734	0.85622	0.95054	0.9544	MGI:975311	1859 6	XM_011246856|NM_008809|NM_001146268	NP_001139740|XP_011245158|NP_032835	19600	HGNC:8804	5159	NM_002609	XP_011535960,XP_011535961,NP_002600,XP_005268521
S100a4	722;18001;44593;93	0.8746	0.8753	0.85786	0.94966	0.9544	MGI:1330282	2019 8	XM_006501177|NM_011311|XM_006501178	XP_006501240|NP_035441|XP_006501241	79244	HGNC:10494	6275	NM_002961,NM_019554	NP_002952,NP_062427

Necap2	85996;18022;33599;77522	0.8742	0.7034	0.8586	0.9482	0.954	MGI:1913397	6617	XR_881436|XR_001784179|XR_390777|NM_025383|XR_001784178|XR_001784177	NP_079659	916	HGNC:25528	557	NM_001145277,NM_001145278,NM_018090	XP_011540069,NP_001138750,XP_016857210,NP_001138749,NP_060560
Mob1b	13391;18033;48633;69733	0.8738	0.6647	0.8594	0.9468	0.954	MGI:1915723	6847	XM_284098	NP_081011	6167	HGNC:29801	925	NM_001244767,NM_173468,NM_001244766	XP_005265766,XP_011530714,NP_775739,NP_001231696,XP_016864326,NP_001231695
Tfap4	7866;18044;33200;57411	0.8735	0.7392	0.8602	0.9454	0.954	MGI:1032389	8338383	NM_031182|XM_006522765|XM_017317166|XM_006522764|XM_006522766|XM_011246047|XM_006522762|XM_006522763	XP_006522826|XP_006522827|NP_112459|XP_011244349|XP_017172655|XP_006522829|XP_006522825|XP_006522828	24224	HGNC:11745	702	NM_003223	NP_003214,XP_011520935,XP_011520937
Nfkbia	84513;18077;58193;68600	0.8723	0.7272	0.8625	0.9456	0.956	MGI:1047411	18035	NM_010907	NP_035037	78633	HGNC:7797	4792	NM_020529	NP_065390

Nbn	903;1821;6176;8358	0.8671	0.7144	0.8734	0.9552	0.9547	MGI:1351625	2735 54	XM_006537971|NM_013752|XM_006537970	XP_006538033|XP_006538034|NP_038780	1858	HGNC:7652	4683	NM_001024688,NM_002485	NP_001019859,NP_002476,XP_016868951,XP_016868950,XP_016868949,XP_011515347,XP_011515348
42071	337;1823;2118;4405	0.8664	0.8882	0.8749	0.9547	0.9547	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Actn1	1509;1830;2476;52111	0.8638	0.6468	0.8805	0.9584	0.9573	MGI:2137706	109 711	NM_134156|NM_001346669|XM_006515384|XM_006515388|XM_006515389|XM_006515387|XM_006515386|XM_006515385|XM_006515390	XP_006515451|NP_001333598|XP_006515452|NP_598917|XP_006515450|XP_006515448|XP_006515453|XP_006515449|XP_006515447	5553	HGNC:163	87	NM_001130005,NM_001102,NM_001130004	XP_016877214,XP_016877210,XP_016877215,XP_016877216,NP_001123476,XP_011535567,XP_011535569,XP_016877209,NP_001093,NP_001123477,XP_011535568,XP_016877212,XP_016877211,XP_011535570,XP_016877217
Myo5a	576;1837;7375;7936	0.8613	0.7858	0.8858	0.9620	0.9573	MGI:1059776	179 18	XM_006510829|XM_006510830|XM_006510831|XM_006510834|XM_006510828|XM_006510832|NM_010864|XM_006510827	XP_006510890|XP_006510894|NP_034994|XP_006510891|XP_006510893|XP_006510892|XP_006510895|XP_006510897	2010 0	HGNC:7602	4644	NM_000259,NM_001142495	XP_011519912,XP_005254454,XP_011519908,XP_011519914,XP_016877716,NP_000250,NP_001135967,XP_011519911,XP_011519909,XP_011519913,XP_011519910

Mien1	1468;1838;5441;6735	0.8609	0.6481	0.8867	0.9606	0.9573	MGI:1913678	1037442	NM_025559	NP_079835	11969	HGNC:28230	84299	NM_001330206,NM_032339	XP_005257793,NP_115715,NP_001317135
Ppp1r3d	1822;1840;5817;5917	0.8602	0.6289	0.8884	0.9601	0.9573	MGI:1917664	2289664	XM_141580	NP_001078970	4547	HGNC:92944	5509	NM_006242	NP_006233
Syt11	2683;1843;6948;7436	0.8591	0.9296	0.8907	0.9604	0.9573	MGI:1859547	2295211	NM_018804|XM_006501350|XM_006501348	XP_006501411|NP_061274|XP_006501413	23120	HGNC:19239	23208	NM_152280	NP_689493,XP_016856248,XP_005245071
Gnai2	9753;1844;6863;8544	0.8587	0.6988	0.8916	0.9590	0.9573	MGI:957572	1467 8	NM_008138|XM_006511637	XP_006511700|NP_032164	55539	HGNC:43855	27711	NM_001282619,NM_001282620,NM_001282618,NM_002070,NM_001166425,NM_001282617	NP_001269546,NP_001269548,NP_002061,NP_001269547,NP_001159897,NP_001269549

Tspan6	17611;18466;50167;17170	0.8580	0.6303	0.8933	0.9586	0.9573	MGI:1926264	564	XM_017318578|NM_019656	NP_062630|XP_017174067	20700	HGNC:11858	71	05	NM_003270,NM_001278741,NM_001278740,NM_001278743,NM_001278742	NP_001265671,NP_003261,XP_011529320,NP_001265670,NP_001265669,NP_001265672
Trib2	11473;18476;34083;83600	0.8576	0.6757	0.8942	0.9573	0.9573	MGI:2145021	2174	XM_006515054|NM_144551|XM_006515055	XP_006515117|XP_006515118|NP_653134	41445	HGNC:30809	28	951	NM_021643	NP_067675
Ptpn6	10633;18511;32355;36122	0.8562	0.6852	0.8974	0.9585	0.9585	MGI:960555	151	NM_001077705|NM_013545	NP_001071173|NP_038573	56589	HGNC:9658	57	77	NM_002831,NM_080548,NM_080549	XP_006719057,NP_536858,XP_011519290,NP_002822,NP_536859
Idnk	11685;18556;25544;500	0.8544	0.6717	0.9015	0.9606	0.9606	MGI:1922981	7573	NM_198004|NM_001048060	NP_001041525|NP_932121	56665	HGNC:31367	41	438	NM_001190727,NM_001351535,NM_001001551,NM_001256915	XP_006717173,XP_016870211,XP_016870212,XP_006717174,XP_016870210,XP_016870208,XP_016870214,XP_016870213,NP_001001551,NP_001243844,NP_001338464,XP_016870209

Arrb2	90 14 82; 18 60; 74 85; 79 99	0. 85 30	0. 64 32	0. 90 49	0. 96 20	0. 96 20	MGI: 99 47 74	21 68 69	NM_001271358|XM_006532917|NM_001271359|NM_001271360|NM_145429	XP_006532980|NP_001258288|NP_001258287|NP_001258289|NP_663404	31 83	HGNC: 712	40 9	NM_001257328,NM_001257331,NM_001257330,NM_004313,NM_001330064,NM_199004,NM_001257329	NP_001244258,XP_016880134,NP_001316993,NP_945355,NP_001244260,XP_006721583,XP_011522160,NP_004304,NP_001244257,NP_001244259
Erp44	65 2; 18 63; 23 86; 77 06	0. 85 19	0. 75 95	0. 90 72	0. 96 22	0. 96 22	MGI: 19 23 54 9	76 29 9	NM_029572|XM_006538341	NP_083848|XP_006538404	12 63 8	HGNC: 18 31 1	23 07 1	NM_015051	NP_055866
Sit2	11 43 ; 18 73 ; 26 05 ; 53 40	0. 84 83	0. 67 15	0. 91 53	0. 96 85	0. 96 72	MGI: 13 15 20 5	20 56 3	XM_006503816|XM_006503814|XM_006503815|NM_001291227|NM_178804|XM_006503813|NR_111900|NM_001291228	NP_848919|XP_006503879|XP_006503877|XP_006503878|XP_006503876|NP_001278156|NP_001278157	35 16	HGNC: 1086	93 53	NM_001289136,NM_004787,NM_001289135	XP_006714049,XP_016864334,XP_011512211,NP_001276064,XP_005248268,XP_011512212,NP_004778,NP_001276065
Calm3	10 39 ; 18 74 ; 49 48 ; 86	0. 84 80	0. 68 43	0. 91 62	0. 96 72	0. 96 72	MGI: 10 32 49	12 31 5	NM_007590	NP_031616	11 61 17	#N/A	#N/A	#N/A	#N/A

Chic1	55 121 9; 188 9; 416 8;; 745 4	0. 842 7	0. 660 4	0. 928 4	0. 977 8	0. 977 8	MGI: 134 469 4	122 12	NM_009767|XM_006527760	NP_033897|XP_006527823	475 43	HGNC: 1934	533 44	NM_001039840,NM_001300884	XP_016885073,XP_016885071,NP_001287813,NP_001034929,XP_016885072
Vcam1	772; 189 3;; 271 8;; 284 2	0. 841 3	0. 726 0	0. 931 7	0. 979 1	0. 979 1	MGI: 989 26	223 29	NM_011693	NP_035823	838	HGNC: 12663	741 2	NM_001199834,NM_001078,NM_080682	NP_001186763,NP_542413,NP_001069
Fat1	208; 189 6;; 475 7;; 764 8	0. 840 2	0. 971 1	0. 934 4	0. 979 6	0. 979 6	MGI: 109 168	141 07	XM_006509270|XM_006509272|XM_017312564|XM_006509268|XR_001778405|XM_011242173|XM_006509274|XM_006509267|XM_006509276|XM_006509273|XM_006509271|XM_006509277|NM_001081286	XP_017168053|XP_006509335|XP_006509339|XP_006509330|XP_006509340|XP_006509331|XP_006509336|XP_011240475|XP_006509334|XP_006509333|XP_006509337|NP_001074755	663 02	HGNC: 3595	219 5	NM_005245	NP_005236,XP_005262892,XP_006714202,XP_005262891
Smek2	111 7; 190 3;; 258 0;; 32	0. 837 8	0. 669 3	0. 940 2	0. 983 4	0. 983 4	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

B3gat3	97128873611904:58784:84040	0.8361	0.6504	0.9445	0.9857	0.9850	MGI:1919977	727	NM_024256	NP_077218	565564	HGNC:923	26229	NM_001288721,NM_001288723,NM_001288722,NM_012200	NP_001275652,NP_001275651,NP_036332,NP_001275650
Lgr4	732:19104:19835:32922	0.8354	0.7318	0.9460	0.9850	0.9850	MGI:1891468	1075115	XM_355385	NP_766259	102266	HGNC:13299	55366	NM_001346432,NM_018490	NP_060960,NP_001333361
Mapk12	13153:19155:52456:52566	0.8336	0.6467	0.9503	0.9872	0.9872	MGI:1353438	298557	XM_006521060|XM_006521061|XM_006521059|XM_006521058|NM_013871	XP_006521123|NP_038899|XP_006521121|XP_006521124|XP_006521122	557055	HGNC:6874	63000	NM_001303252,NM_002969	NP_001290181,NP_002960
Slc38a1	120:19211:45322:59	0.8316	0.0803	0.9554	0.9902	0.9902	MGI:2145895	1057227	NM_134086|XM_006520235|NM_001166458|NM_001166456	NP_598847|XP_006520298|NP_001159928|NP_001159930	127445	HGNC:13447	81539	NM_001278388,NM_001077484,NM_001278387,NM_001278390,NM_001278389,NM_030674	NP_001265317,XP_016875479,NP_001070952,NP_109599,XP_011537089,NP_001265318,NP_001265316,XP_011537086,NP_001265319,XP_011537088

Pcdh18	53150202;19272;58833;64233	0.8295	0.6301	0.9604	0.9931	0.917	MGI:1920423	731	NM_130448|XM_006500789	NP_569715|XP_006500852	1089	HGNC:14268	5451	NM_019035,NM_001300828	NP_001287757,XP_006714302,NP_061908,XP_016863800
Lamtor1	25492;19288;69411;84391	0.82922	0.92533	0.96112	0.99177	0.9177	MGI:1913758	6658	NM_025605	NP_079881	9909	HGNC:26068	55004	NM_017907	NP_060377
Pvrl3	13293;19344;46822;85688	0.82711	0.64222	0.96622	0.99446	0.9917	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Hfe	12555;19336;52800;66	0.82665	0.64887	0.96779	0.99441	0.9917	MGI:1091911	1521	XM_011244284|XM_006516557|NM_010424|XM_006516556|NM_001347493	XP_011242586|NP_034554|NP_001334422|XP_006516620|XP_006516619	8830	HGNC:4886	307	NM_000410,NM_001300749,NM_139008,NM_139007,NM_139003,NM_139006,NM_139010,NM_139009,NM_139002,NM_139004,NM_139011,NM_139005	NP_620575,NP_620579,NP_620578,XP_011512845,NP_620572,NP_620576,NP_001287678,NP_620580,NP_000401,NP_620573,NP_620577

Flcn	90 24 42; 1937 ;; 3983 ;; 4910 0	0. 8261	0. 9335	0. 9687	0. 9927	0. 9917	MGI: 2442184	2168 05	NR_073164|XR_879567|NM_146018|NM_001271356|XM_011248905|NM_001271357	NP_001258285|NP_666130|XP_011247207|NP_001258286	1458 3	HGNC: 27310	20 163	NM_144606,NM_144997	XP_011522021,NP_659434,XP_016879795,XP_011522016,XP_011522023,XP_016879798,XP_016879794,XP_016879797,XP_016879793,XP_016879796,XP_011522018,NP_653207,XP_011522020
Dcakd	98 74; 1941 ;; 7718 ; 8016	0. 8248	0. 6800	0. 9720	0. 9939	0. 9917	MGI: 1915337	6808 087	XM_006534038|NM_026551	XP_006534101|NP_080827	5652	HGNC: 26238	79 877	NM_001321326,NM_024819,NM_001275583,XP_016880594,XP_016880591,XP_016880593,XP_016880592,NP_079095,XP_016880595,NP_001122103,NP_001275584,XP_011523564	NP_001308255,XP_005257745,NP_001275583,XP_016880594,XP_016880591,XP_016880593,XP_016880592,NP_079095,XP_016880595,NP_001122103,NP_001275584,XP_011523564
Steap3	71 1; 1944 ;; 3674 ;; 6577 7	0. 8237	0. 7308	0. 9746	0. 9943	0. 9917	MGI: 1915678	6842 88	XM_006529845|NM_133186|XM_006529846|NM_001085409	NP_573449|XP_006529908|XP_006529909|NP_001078878	1008 4	HGNC: 24592	55 240	NM_138637,NM_001008410,NM_018234,NM_182915	NP_001008410,XP_006712678,NP_060704,XP_006712677,NP_878919,NP_619543,XP_011509705
Kidins220	11 80; 1945 ;; 2866 ;; 5811 1	0. 8234	0. 6549	0. 9755	0. 9929	0. 9917	MGI: 1924730	7748 0	XM_006515256|XM_006515249|XM_006515251|XM_017315243|XM_006515253|NM_001081378|XM_006515259|XM_006515257|XM_006515252|XM_006515254|XM_006515258|XM_006515255|XM_006515250|XM_017315244|XM_006515260	XP_006515320|NP_001074847|XP_006515318|XP_006515316|XP_006515317|XP_006515323|XP_006515315|XP_017170733|XP_006515312|XP_006515322|XP_006515319|XP_006515313|XP_006515314|XP_017170732|XP_006515321	1425 4	HGNC: 29508	57 498	NM_020738,NM_001348732,NM_001348736,NM_001348739,NM_001348734,NM_001348745,NM_001348729,NM_001348742,NM_001348738,NM_001348741,NM_001348731,NM_001348740,NM_00134874	NP_001335663,NP_001335667,NP_001335660,NP_001335665,NP_001335668,NP_001335672,NP_001335658,NP_001335669,NP_001335674,NP_001335664,NP_001335661,NP_001335670,NP_065789,NP_001335671

														3,NM_001348735	
C1rl	1150;1946;5013;5906	0.823180	0.065800	0.976400	0.991700	0.991700	MGI:2660692	2323711	NM_181344	NP_851989	9559	HGNC:21265	5127 9	NM_001297640,NM_001297642,NM_001297643,NM_016546	NP_001284571,XP_016874889,XP_016874893,XP_016874886,XP_016874892,NP_001284569,XP_016874887,NP_057630,XP_016874891,NP_001284572,XP_016874890,XP_016874888
Mtss1	1458;1954;3277;4158	0.820400	0.062880	0.983200	0.996400	0.996400	MGI:2384818	2114011	XM_011245543|XM_017316532|XM_006520709|XM_011245546|XM_006520711|XM_006520707|XM_011245541|NM_144800|XM_011245548|XM_006520712|XM_011245542|XM_011245545|XM_006520714|XM_017316531|NM_001146180|XM_011245540|XM_011245544|XM_011245547|XM_006520717	XP_006520772|XP_017172021|XP_011243843|XP_011243848|XP_011243847|XP_006520775|XP_006520780|XP_006520770|XP_017172020|XP_011243850|NP_659049|XP_011243846|XP_011243844|XP_011243845|XP_011243842|XP_011243849|XP_006520774|XP_006520777|NP_001139652	8841	HGNC:20443	9781 8	NM_001282971,NM_014751,NM_001282974	XP_011515709,XP_006716764,XP_016869590,XP_016869585,XP_016869577,XP_016869584,XP_016869588,XP_006716768,NP_055566,NP_001269903,XP_005251170,XP_011515705,XP_016869587,XP_016869581,XP_016869579,XP_016869586,XP_006716763,XP_011515706,XP_016869575,XP_005251175,XP_016869578,XP_006716767,XP_016869582,XP_016869576,XP_016869589,XP_006716769,XP_016869583,NP_001269900,XP_005251168,XP_006716765,XP_006716766,XP_016869580
Ublcp1	1390;1957;7642;8373	0.819400	0.063320	0.985700	0.996700	0.996700	MGI:1933105	7956 0	XM_006534522|NM_024475	XP_006534585|NP_077795	16796	HGNC:28110	1345 10	NM_145049	NP_659486
Anxa1	1902;19	0.818110	0.060500	0.989200	0.998000	0.998000	MGI:968	1695 2	NM_010730	NP_034860	563	HGNC:5	301	NM_000700	XP_016870146,NP_000691,XP_011516911

	61;64411;94355					19					33				
Slc12a7	816;1967;21778;47711	0.081616	0.07046	0.994100	1.0009	0.089	MGI:1342283	204	NM_011390|XM_006517174|XM_006517175|XM_006517171|XM_006517172|XM_006517170|XM_006517173	XP_006517238|XP_006517237|XP_006517235|NP_035520|XP_006517236|XP_006517234|XP_006517233	2131	HGNC:10915	107	23	NM_006598	XP_005248288,NP_006589,XP_011512242,XP_011512243,XP_011512241,XP_016864448,XP_016864447
Lpar4	562;19669;25944;51111	0.081544	0.076722	0.995800	1.0009	0.089	MGI:1925384	781	NM_175271	NP_780480	3871	HGNC:44478	284	6	NM_001278000,NM_005296	XP_016884926,XP_006724702,XP_005262183,XP_016884927,NP_005287,NP_001264929
Slc38a6	1370;19704;47746;67677	0.081511	0.063267	0.999899	0.0998	0.089	MGI:3648156	625098	XM_017315148|XM_017315149|XR_001780471|XM_017315147|XM_006516123|XM_006516122|XR_001780472|XM_006516118|XR_381540|NM_001037717|XR_381537|XM_011244154	XP_006516186|XP_017170638|XP_011242456|XP_006516181|XP_006516185|NP_001032806|XP_017170636|XP_017170637	27550	HGNC:19863	145389		NM_153811,NM_001172702	XP_016876512,XP_016876515,XP_006720112,NP_722518,XP_006720113,XP_016876516,XP_016876509,XP_016876517,XP_016876514,XP_016876510,XP_011534771,XP_016876511,NP_001166173,XP_016876513
Myl1p	1083;197	0.081416	0.066192	0.999992	0.0992	0.092	MGI:2238803	2183	NM_153789	NP_722484	8309	HGNC:2111	2916		NM_013262	XP_016866278,NP_037394,XP_005249090,XP_005249089

3;3295;4637	271	55

Part II Genes depleted in wild type C57BL6 mice treated with GVAX against the TCRα KO mice without treatment as control

p-value=0 means <2.3371e-05, FDR=0 means <0.000707343597609

GeneSymbol	Ranksofpertubations	STARSScore	AveragScore	p-value	FDR	q-value	MouseMarkerID	MouseNCBIEntrezID	Mouse NCBI RefSeq Transcript ID	Mouse NCBI RefSeq Protein ID	HomologeneID	HGNCID	Human NCBI RefSeq Transcript ID	Human NCBI RefSeq Protein ID
Ptpn2	2;7;9;371	8.518879	5.708	0.0000	0.0000	0.0000	MGI:978006	19255	XM_006525723|NM_008977|XM_011246858|XM_011246859|NM_001127177	XP_011245161|NP_001120649|XP_006525786|NP_033003|XP_011245160	7497	HGNC:9650	57471	NM_080422,NM_001308287,NM_002828,NM_080423,NM_001207013	NP_001193942,NP_536347,NP_002819,XP_016881377,XP_011524007,XP_005258182,XP_016881374,XP_016881376,NP_536348,XP_005258181,XP_011524009,NP_001295216,XP_016881373,XP_011524008,XP_016881375
Irf1	6;14;17;74	8.507	5.931	0.0000	0.0000	0.0000	MGI:965902	16362	NM_008390|NM_001159393|NM_001159396	NP_001152865|NP_032416|NP_001152868	16581	HGNC:6116	3659	NM_002198	NP_002189,XP_011541681,XP_011541680
Ncstn	67;2;61;26	6.006616	3.526464	0.0000	0.0001	0.0011	MGI:1891917	59287	XM_006496952|XR_373613|XM_017321872|NM_021607	NP_067620|XP_017177361|XP_006497015	41029	HGNC:17090	2338 5	NM_001349729,NM_001290186,NM_015331,NM_001290184	XP_011507665,NP_056146,NP_001277115,NP_001277113,NP_001336658,XP_005245110

	5;31100					00					91				
Pcif1	179;20610;21025	53.44641	30.41301	00.00018	00.00018	MGI:2443858	228866	XM_011239494|NM_146129|XM_011239495	NP_666241|XP_011237797|XP_011237796	1134	HGNC:16200	63935	NM_022104	XP_011527282, XP_011527283, XP_016883503, XP_016883502, NP_071387
Xrn1	69;113;114;95744	53.2155	30.2975	00.0001	00.0033	MGI:891964	24127	XM_006511156|NM_011916|NM_001311130|XM_006511154|XR_001778898|XM_011242743|XM_006511155	NP_001298059|NP_036046|XP_006511219|XP_006511217|XP_011241045|XP_006511218	5894	HGNC:30654	5464	NM_001282859, NM_019001,NM_001282857,NM_001042604	XP_011511224, XP_011511221, NP_001269786, XP_016862131, NP_001269788, XP_006713736, XP_016862129, XP_011511222, NP_061874,XP_016862130
Adnp	86;87;438;49311	53.20628	30.2072	00.0001	00.0033	MGI:1338758	11538	NM_001310088|NM_009628|NM_001310086	NP_001297017|NP_033758|NP_001297015	7617	HGNC:15766	2334	NM_001282532, NM_001347511, NM_001282531, NM_015339,NM_181442	NP_852107,NP_001334440,XP_011527050,NP_056154,XP_016883248,NP_001269461,NP_001269460,XP_011527049,XP_016883246,XP_016883247
Cd274	111;141;370;55211	53.00999	30.2047	00.0002	00.0044	MGI:1926446	60533	NM_021893	NP_068693	8560	HGNC:17635	2912 6	NM_001267706, NM_014143,NM_001314029	NP_054862,NP_001300958,NP_001254635
Cd47	11;24;152;16	43.84242	30.6890	00.0052	00.0052	MGI:961617	16423	XM_006521806|XM_006521810|XR_384530|XM_006521809|XM_006521807|NM_010581|XM_006521808|XM_006521811|XR_384529	XP_006521872|XP_006521874|XP_006521871|XP_006521869|XP_006521870|XP_006521873|NP_034711	1346	HGNC:16882	961	NM_001777,NM_001025079,NM_001025080,NM_198793	XP_005247966, XP_005247965, NP_942088,NP_001768,XP_016863025

Setdb1	49 27; 85; 159; 3301	4. 7840	3. 3693	0. 0002	0. 0056	0. 0056	MGI: 1934229	8 4 5 0 5	NM_001163642| NM_018877|NM _001163641	NP_061365|NP_ 001157114|NP_ 001157113	3 2 1 5 7	HGNC: 10761	9 8 6 9	NM_001145415, NM_001243491, NM_012432	NP_036564,XP_ 016858442,NP_ 001230420,NP_ 001138887,XP_ 016858444,XP_ 016858443,XP_ 005245698
Gna11	94; 529; 586; 651	4. 7233	2. 7677	0. 0003	0. 0062	0. 0062	MGI: 957666	1 4 6 7 2	NM_010301	NP_034431	2 0 4 7 4	HGNC: 4379	2 7 6 7	NM_002067	NP_002058
Kdm5a	65; 129; 180; 1295	4. 6233	3. 1852	0. 0004	0. 0078	0. 0076	MGI: 2136980	2 1 4 8 9 9	XM_011241281| NM_145997|XR _001785118|XR _377436	XP_011239583| NP_666109	3 4 1 9	HGNC: 9886	5 9 2 7	NM_005056,NM _001042603	NP_001036068
Prmt7	107; 194; 367; 696	4. 6072	3. 0851	0. 0004	0. 0077	0. 0076	MGI: 2384879	2 1 4 5 7 2	NM_145404|XM _006530828	XP_006530891| NP_663379	1 0 3 8 2	HGNC: 25557	5 4 4 9 6	NM_001290018, NM_001184824, NM_001351143, NM_019023,NM _001351144	XP_016878785, XP_016878783, XP_011521423, XP_016878789, XP_011521415, XP_016878781, XP_016878797, XP_011521428, XP_011521430, XP_016878805, XP_016878804, XP_016878803, XP_016878787, XP_016878802, XP_016878791, XP_016878779, XP_016878788, XP_016878795, NP_001338073, XP_016878799, XP_011521414, XP_016878801, XP_011521426, XP_011521427, XP_016878794, XP_016878800, XP_016878786, XP_016878792, XP_011521433, NP_001171753,

														XP_011521418, NP_061896,NP_001276947,XP_011521417,XP_016878793,XP_016878782,XP_016878798,XP_016878780,XP_016878784,XP_016878790,NP_001338072,XP_016878796
Cebpg	48;351;532;703	4.5898	2.9216	0.0004	0.0076	0.0076	MGI:1049822	126 11	NM_009884	NP_034014	136 8	HGNC:18377	10 54	NM_001252296, NM_001806	NP_001797,NP_001239225
Crl1	66;589;694;722	4.5435	2.6844	0.0005	0.0084	0.0084	MGI:8851133	129 46	XM_006497226| XM_017314176| NM_013499|XM_011238928	XP_011237230| XP_017169665| NP_038527|XP_006497289	128 275	HGNC:23355	13 79	NM_175710	NP_783641
Cdk12	314;381;631;840	4.2805	2.5777	0.0009	0.0146	0.0146	MGI:1098802	69 131	XM_011249225| NM_001109628| NM_001109626| XM_006534108| XM_011249224| NM_026952|XM_011249226	NP_081228|XP_011247527|XP_006534171|XP_011247528|NP_001103098|XP_011247526|NP_001103096	128 632	HGNC:24224	51 755	NM_016507,NM_015083	XP_011523197, XP_011523203, XP_016880238, XP_011523202, XP_016880237, XP_011523196, XP_005257513, XP_005257515, XP_016880240, XP_011523207, XP_016880234, NP_057591,XP_011523201,XP_011523198,XP_016880235,XP_016880242,XP_011523194,XP_011523208,NP_055898,XP_016880233,XP_016880236,XP_011523209,XP_011523205,XP_016880241,XP_016880239,XP_011523204,XP_011523195,XP_011523199,XP_011523200
Gng12	18;75;	4.2299	3.2798	0.0010	0.0158	0.0158	MGI:13	147 01	NM_025278|NM_001177557|NM_001177556|NM_001177559|NM_001177560|NM	NP_001171028| NP_079554|NP_001171030|NP_001171029|NP_001171027|NP_	324 27	HGNC:1	55 97 0	NM_018841	XP_016857299, NP_061329,XP_016857298,XP_016857300

	244;672404					361711		_001177558|XM_006505542	001171031|XP_006505605		96663				
Tead1	106;338;619;905	4.15130	2.6874	0.0012	0.0180	0	MGI:1876	XM_006507564|NM_009346|XM_006507563|NM_001166585|XM_006507561|XM_011241723|XM_011241724|NM_001166584|XM_006507565|XM_006507562	XP_011240025|XP_011240026|XP_006507628|XP_006507626|XP_006507624|XP_006507627|NP_033372|NP_001160056|NP_001160057|XP_006507625	248	HGNC:11714	7003	NM_021961	NP_068780
Pon2	101;147;292;319;606	3.9980	2.7628	0.0017	0.0237	0	MGI:1066887	XM_006505122|NM_183308	XP_006505185|NP_899131	385	HGNC:9205	5445	NM_000305,NM_001018161	XP_016867846,XP_016867847,XP_005250510,NP_001018171,NP_000296
Gne	126;284;506;1009	3.96221	2.7229	0.0018	0.0247	6	MGI:1354951	XM_017320310|XM_006538074|NM_015828|NM_001190414|XM_006538073	XP_006538136|XP_006538137|NP_056643|XP_017175799|NP_001177343	396	HGNC:23657	10020	NM_005476,NM_001190388,NM_001190383,NM_001128227,NM_001190384	NP_005467,XP_016869657,XP_016869656,XP_005251391,NP_001177312,NP_001177313,NP_001121699,NP_001177317
Ppp2r1a	312;520;931;1019	3.9449	2.3070	0.0018	0.0246	0	MGI:1926334	NM_016891	NP_058587	6855	HGNC:9302	5518	NM_014225	XP_016882418,NP_055040
Unc	242;	3.940	2.45	0.00	0.02	0	MGI:	673	XM_006496221|NM_026123|XM_006496220|XM	XP_006496284|XP_006496286|NP_080399|XP_	639	HGNC	259	NM_001330353,NM_001330354,NM_014044	XP_006712466,NP_001317282,XP_005263970,XP_006712467,

50	256;315;730	03	27	20	61	61	191463	87	_006496222|XM_006496223	006496283|XP_006496285		:160446	72			NP_001317283, NP_054763
Ppp1cb	200;599;1012;1085	3.8.3.59	2.6.9.2	0.0.2.3	0.2.8.9	0.2.8.6	MGI:1048711	1904 6	NM_172707|XM_006503780	NP_766295|XP_006503843	37659	HGNC:9282	550 0	NM_206877,NM_206876,NM_002709		NP_002700,NP_996759
Tmem127	396;755;857;1087	3.8.3.27	2.0.6.6	0.0.2.3	0.2.8.6	0.2.8.6	MGI:1916720	6947 0	NM_175145	NP_780354	9877	HGNC:26038	556 54	NM_017849,NM_001193304,NM_032218		NP_060319,XP_016859941,NP_001180233,XP_016859940,XP_016859939
Igsf11	177;274;1142;1155	3.7.2.73	2.7.9.1	0.0.2.9	0.0.3.5	0.0.3.5	MGI:2383847 7	2076 83	NM_170599|XM_011245851|XM_006521892|XM_006521893	XP_011244153|NP_733548|XP_006521955|XP_006521956	1761 3	HGNC:16669	152 404	NM_152538,NM_001015887		NP_689751,XP_011510765,XP_011510769,XP_011510773,XP_011510766,XP_011510771,XP_011510772,XP_006713580,XP_011510770,XP_011510776,XP_011510764,NP_001015887,XP_016861279,XP_011510768,XP_016861278,XP_011510774,XP_011510767
Dnajc5	54;747;793;12	3.6.4.79	2.3.9.1.8	0.0.0.3.5	0.0.4.0.6	0.0.4.0.6	MGI:892995	1302	NR_073369|NM_001271584|NM_001271585|NM_016775|XM_011239923|XR_867108	NP_058055|NP_001258514|NP_001258513|XP_011238225	9631	HGNC:16235	803 31	NM_025219		XP_011527350,XP_011527351,NP_079495

Ptpn1	09 30 0; 38 2; 39 9; 19 34	3. 5 9 6 2	2. 3 6 6 0	0. 0 0 3 9	0. 0 4 4 2	0. 0 4 4 2	MGI: 97 80 5	19 24 6	NM_011201|XM_006498981	NP_035331|XP_006499044	21 19	HGNC: 96 42	57 70	NM_002827,NM_001278618	NP_001265547, NP_002818
Map2k3	40 6; 49 1; 96 5; ; 12 75	3. 5 5 5 6	2. 1 8 4 8	0. 0 0 4 4	0. 0 0 4 8	0. 0 4 2 1	MGI: 13 46 86 8	26 39 7	XM_006533368|NM_008928	NP_032954|XP_006533431	56 43 0	HGNC: 68 43	56 06	NM_145109,NM_001316332,NM_002756,NM_145110	NP_002747,NP_001303261,XP_005256780,XP_011522261,XP_011522260,XP_016880348,XP_016880347,NP_659731,XP_016880346
Maea	41 ; 29 6; 41 5; ; 41 70	3. 5 4 5 7	2. 5 4 1 7	0. 0 0 4 4	0. 0 0 4 6	0. 0 4 6 1	MGI: 18 91 74 8	59 00 3	XM_006504041|NM_021500	XP_006504104|NP_067475	42 98	HGNC: 13 73 11	10 29 6	NM_001297432,NM_001017405,NM_005882,NM_001297431,NM_001297433,NM_001297430	NP_005873,NP_001284361,XP_016863126,XP_006713912,XP_006713913,NP_001284362,XP_011511679,XP_011511678,NP_001284360,XP_016863125,NP_001284359,NP_001017405
Smg1	91 ; 28 1; 41 6; ; 35 82	3. 5 4 4 2 6	2. 4 4 2 1	0. 0 0 4 5	0. 0 4 6 1	0. 0 4 6 1	MGI: 19 19 74 2	23 37 89	XM_006507678|NM_001031814|XM_006507677	NP_001026984|XP_006507741|XP_006507740	56 69 7	HGNC: 30 04 5	23 04 9	NM_015092	XP_005255241,XP_011544072,NP_055907,XP_011544071,XP_005255239,XP_005255240,XP_016878555,XP_016878556
Chp1	35 ; 32 5; ; 45 3; ;	3. 4 3 3 3	2. 5 0 0 7	0. 0 0 5 8	0. 0 5 8 2	0. 0 5 8 2	MGI: 19 27 18 5	56 39 8	NM_019769	NP_062743	52 35	HGNC: 17 43 3	11 26 1	NM_007236	NP_009167,XP_016877368

Trim28	2512;277;293;460;;199696	3.4.4.1.3.6	2.4.1.0.9	0.0.0.6.0	0.0.5.9.5	0.0.5.9.5	MGI:1092774	2184 9	NM_011588	NP_035718	2117 5	HGNC:16384	1015 5	NM_005762	NP_005753
Ccnc	266;620;;1206;;141 88	3.2.0.0.0.0.3.7.0.9	0.0.0.0.0.0.6.2.5	0.0.0.0.0.0.6.6.6	0.0.0.0.0.0.6.3.3	0.0.0.0.0.0.6.2.1	MGI:1858199	5181 13	NM_001290422|NM_001290420|NM_001122982|NM_016746	NP_001277351|NP_001116454|NP_001277349|NP_058026	3803	HGNC:15811	892	NM_005190,NM_001013399	XP_006715657,NP_005181,XP_016866925,NP_001013417,XP_011534534
Atf4	31;193;;476;;969 92	3.3.6.9.8	2.6.4.3.9	0.0.0.6.6	0.0.6.2.1	0.0.6.2.1	MGI:880 96	1191 1	NM_001287180|NM_009716	NP_033846|NP_001274109	1266	HGNC:786	468	NM_001675,NM_182810	NP_001666,XP_016884296,NP_877962
Actr8	57;278;;487;;261 77	3.3.4.0.5	2.4.4.0.0	0.0.0.7.0	0.0.0.6.5	0.0.0.6.5	MGI:1860775	5624 9	XM_006519309|NM_027493	NP_081769|XP_006519372	1128 6	HGNC:14672	9397 3	NM_022899	XP_005265644,NP_075050,XP_011532551
H13	395;;610;;7	3.3.2.1.4	1.4.9.2	0.0.0.7.7	0.0.6.6.3	0.0.6.6.7	MGI:958 86	1495 0	NM_001159552|XR_374416|NM_001159553|NM_001159551|XR_001780858|NM_010376|XM_017315666|XM_006498783	NP_001153023|NP_001153025|NP_001153024|NP_034506|XP_017171155|XP_006498846	7749	HGNC:164	8150 2	NM_178580,NM_178581,NM_030789,NM_178582	NP_848697,NP_110416,NP_848695,NP_848696

	86;14599										35				
Siah1a	349;3571;4966;18055	3.3171	2.3256	0.0075	0.0667	0.0667	MGI:1080644	2043 7	NM_009172|XM_006530784	XP_006530847|NP_033198	2065 4	HGNC:10857	6477	NM_003031,NM_001006610	NP_003022,NP_001006611,XP_006721309,XP_011521581
Abl1	222;922;7333;71111	3.2912	2.7211	0.0080	0.0697	0.0697	MGI:8785 9	1135 0	NM_001112703|NM_001283045|NM_001283046|NM_009594|XM_006497621|NM_001283047	NP_001269976|NP_033724|NP_001269975|XP_006497684|NP_001269974|NP_001106174	3783	HGNC:76	25	NM_005157,NM_007313	NP_005148,NP_009297
Efr3a	7153;8611;15700;16288	3.1763	1.0116	0.0972	0.0972	MGI:1923990	7674 0	XM_006521529|XM_006521530|NM_133766	NP_598527|XP_006521593|XP_006521592	4422 2	HGNC:28970	2316 7	NM_015137,NM_001323554,NM_001323555,NM_001323556,NM_001323557,NM_001323553,NM_001323558	NP_001310482,NP_055952,NP_001310487,NP_001310483,NP_001310484,NP_001310485,NP_001310486
Rb1cc1	5103;5113;8455;16377	3.1214	2.0879	0.0198	0.0983	0.0983	MGI:1341850	1242 1	XM_011238339|XM_011238341|XM_011238340|NM_009826|XM_006495443|XM_011238338	XP_006495506|XP_011236641|XP_011236642|XP_011236640|NP_033956|XP_011236643	7659	HGNC:15574	9821	NM_014781,NM_001083617	NP_001077086,XP_011515947,XP_011515948,XP_016869597,XP_016869593,XP_011515945,XP_016869592,NP_055596,XP_016869594,XP_016869595,XP_016869601,XP_016869600,XP_011515951,XP_016869598,XP_016869599,XP_011515946,XP_016869596,XP_011515949
Nck	195	3.02	2.00	0.01	0.01	MGI	5081	XM_006499881|NM_016965|XM	XP_006499945|XP_006499944|	83	HGN	107	NM_205842,NM_013436	XP_006712264,NP_995314,NP_

ap1	;226;590;2228	9548	1251	0120	0110	:13553333	84	_006499882|NM_001290745	NP_058661|NP_001277674	84	C:7666	87			038464,XP_006712263
Acin1	39;467;593;2794	3.0889	2.0269	0.0127	0.1102	0.1100	MGI:1891824	56215	XM_006519299|XM_006519308|XM_006519298|NM_023190|NM_001085472|NM_001242606|NM_019567|NM_001242605|NM_001085473|XM_006519296|XM_006519301|XM_006519297|XM_006519300|XM_006519304	XP_006519364|XP_006519363|XP_006519361|NP_001229534|NP_075679|XP_006519360|XP_006519367|NP_062513|XP_006519359|NP_001229535|XP_006519362|NP_001078942|NP_001078941|XP_006519371	228453	HGNC:17066	229855	NM_001164817,NM_001164815,NM_001164814,NM_014977,NM_001164816	NP_001158289,NP_001158286,XP_011534872,NP_055792,XP_005267475,NP_001158288,XP_005267473,XP_005267472,XP_006720144,NP_001158287
Ywhaz	32;365;600;4165	3.0739	2.0041	0.0131	0.1100	0.1100	MGI:1094884	22631	XM_011245352|NM_011740|NM_001253806|NM_001253807|NM_001253805	NP_035870|XP_011243654|NP_001240736|NP_001240734|NP_001240735	565288	HGNC:12855	7534	NM_003406,NM_001135699,NM_001135700,NM_001135701,NM_145690,NM_001135702	NP_663723,XP_016869300,NP_001129171,XP_005251118,NP_001129174,NP_003397,NP_001129172,XP_011515592,XP_016869299,XP_005251120,XP_016869301,NP_001129173
Rbm26	64;123;304;7466	3.0417	2.3182	0.0140	0.1060	0.1051	MGI:1921463	74213	NM_134077	NP_598838	414668	HGNC:20327	6402	NM_022118,NM_001286632,NM_001286631,NM_018605	XP_016876189,NP_001273560,XP_016876184,XP_011533489,XP_016876192,XP_016876178,XP_016876181,XP_011533484,XP_011533483,XP_016876179,XP_006719920,XP_011533493,XP_016876177,XP_011533494,XP_011533492,XP_016876190,XP_016876185,XP_011533487,XP_005266554,XP_016876186,XP_016876182,XP_016876183,XP_011533495,XP_011533488,XP_016876188,XP_016876180,NP_001273561,NP_071401,XP_011533491,XP_011533482,XP_011533490,XP_

															011533497,XP_011533485,XP_005266548,XP_016876187,XP_011533486,XP_016876191,XP_011533481
Gpa1	16;263;617;2018	3.0.3.8.3	2.1.1.4.1	0.1.0.5.1	0.1.0.5.1	MGI:1202392	147311	XM_017316432|NM_010331	XP_017171921|NP_034461	37852	HGNC:4446	8733	NM_003801	NP_003792
Scrib	208;255;639;85177	2.9.9.3.7	2.1.9.7.0	0.1.1.5.7	0.1.1.4.7	0.1.1.4.7	MGI:2145950	1057812	NM_001310543|XR_875208|XM_017316354|NM_134089|XR_001781490|XM_017316355|XM_006520242|XM_006520239|XR_875207|NM_001310542|XM_006520238	XP_017171844|XP_006520305|XP_017171843|NP_598850|XP_006520302|XP_006520301|NP_001297472|NP_001297471	44228	HGNC:30377	2351 3	NM_015356,NM_182706	NP_056171,NP_874365
Socs1	44;341;648;20511	2.9.7.5.9	2.3.0.2.1	0.0.1.6.3	0.1.1.7.1	0.1.1.7.1	MGI:1354910	12703	NM_009896|NM_001271603	NP_001258532|NP_034026	2776	HGNC:19383	8651	NM_003745	NP_003736
Rnf19b	517;999;1528;17999	2.9.5.7.5	1.7.2.8.1	0.1.1.6.9	0.1.9.9.9	0.1.1.9.9	MGI:1922484	752344	NM_029219|XM_006503458	XP_006503521|NP_083495	34999	HGNC:26886	1275 4 4	NM_001300826,NM_001127361,NM_153341	NP_001120833,XP_006710419,NP_699172,NP_001287755,XP_006710420,XP_006710421
Zeb2	167;	2.9.2	2.1.7	0.1.1	0.1.2	0.1.2	MGI:	241	NM_015753|XM_017318063|NM_001289521|XM_017318065|XM	XP_006498106|XP_006498105|NP_056568|NP_001276450|XP_	8868	HGNC	9839	NM_001171653,NM_014795	NP_001165124,XP_016860904,XP_016860903,XP_011510534,

	260;673;5786	78	45	81	66	66	1344407	36	_017318061|XM_006498042|XM_011239102|XM_006498043	017173550|XP_017173552|XP_017173554|XP_011237404		:1488	1		NP_055610,XP_006712945,XP_006712944
Xpo6	23;1685;1795;1844	2.9146	1.6505	0.0186	0.1282	0.1282	MGI:2429950	74204	XM_017312342|XM_017312341|XM_006508250|XM_017312344|XM_017312345|NM_001311143|XM_017312343|NM_028816	NP_083092|NP_001298072|XP_017167833|XP_017167832|XP_017167831|XP_017167830|XP_006508313|XP_017167834	125444	HGNC:19733	2321	NM_001270940,NM_015171	XP_005255256,XP_005255255,NP_001257869,XP_005255254,NP_055986,XP_011544074
Cdc7	52;645;693;3177	2.8906	2.0074	0.0197	0.1338	0.1327	MGI:1309511	12545	NM_001271568|XM_017320634|NM_009863|XM_006534737|NM_001271567|NM_001271566	NP_001258495|NP_001258497|NP_033993|XP_006534800|XP_017176123|NP_001258496	3116 6	HGNC:1745	831 7	NM_003503,NM_001134419,NM_001134420	NP_001127891,XP_005271298,XP_016857915,XP_016857916,XP_005271301,XP_016857914,NP_001127892,NP_003494
Atg5	326;744;1035;1873	2.8875	1.9326	0.0199	0.1327	0.1327	MGI:1277186	11793	XM_017313783|NM_001314013|XM_017313782|XM_011243108|NM_053069	NP_001300942|XP_017169271|XP_017169272|NP_444299|XP_011241410	3566	HGNC:589	947 4	NM_001286111,NM_001286108,NM_004849,NM_001286106,NM_001286107	NP_001273037,NP_001273040,NP_001273035,NP_001273036,NP_004840
Zfyve27	212;548;1126;	2.8390	1.9988	0.0224	0.1448	0.1440	MGI:1919602	31974 0	NM_177319|NM_001164531	NP_796293|NP_001158003	16939	HGNC:26559	1181 3	NM_001174119,NM_001174121,NM_001002262,NM_001174120,NM_001174122,NM_001002261,NM_144588	XP_016871141,XP_005269566,XP_005269567,XP_016871133,XP_005269568,XP_016871144,XP_016871134,XP_016871136,XP_005269561,XP_005269562,XP_016871135,XP_016871140,NP_001002262,

	1926													XP_011537555, XP_016871139, XP_011537557, XP_016871137, NP_001167590, XP_005269560, NP_001167593, NP_653189,NP_001167591,XP_016871142,NP_001002261,XP_005269563,XP_011537554,XP_005269559,XP_016871143,XP_011537556,XP_016871138,XP_005269565,NP_001167592
Trim56	158;4889;7288;4341	2.2.8.2.8.0	1.9.7.3.0	0.0.2.2.5	0.0.1.4.4.0	0.0.1.4.4.0	MGI:2685298	38430 9	NM_201373|XM_011240883|XM_006504441	XP_006504504|NP_958761|XP_011239185	12812	HGNC:19028	81844	NM_030961	NP_112223,XP_011514891
Lsg1	110;1660;6431;7908	2.2.8.1.6.6	2.0.9.1.1	0.0.2.3.1	0.0.1.4.5.9	0.0.1.4.5.9	MGI:1072366	22409 2	NM_178069|XR_001781813	NP_835170	5917	HGNC:256652	55341	NM_018385	NP_060855,XP_016862285
Ube2n	5;164;3807;5083	2.2.7.9.5.5	2.0.7.4.4.8	0.0.2.4.4	0.0.1.5.1.4	0.0.1.5.1.4	MGI:1934835	93765	XM_006514344|NM_080560	NP_542127|XP_006514407	12840 6	HGNC:12492	7334	NM_003348	XP_011537021, XP_016875407, NP_003339
Arf1	28;1688;6	2.2.7.7.4.9	2.0.3.6.1.9	0.0.2.5.2	0.0.1.5.4.4	0.0.1.5.4.4	MGI:994	11840	NM_001130408|NM_007476	NP_031502|NP_001123880	13930	HGNC:652	375	NM_001024226, NM_001024227, NM_001024228, NM_001658	NP_001019399, NP_001019398, NP_001019397, XP_016856722, NP_001649

	822;979					31									
Rer1	859;1176;8700;6467	22.7353243	22.0267	00.1618	00.1618	MGI:1915080	678	NM_026395|XM_006539133|XM_006539131|XM_006539130|XM_006539132|XM_011250328	XP_011248630|XP_006539193|NP_080671|XP_006539196|XP_006539195|XP_006539194	548	HGNC:30309	11079	NM_007033	XP_005244770, XP_016855623, XP_016855620, XP_006710369, XP_011538845, XP_016855621, XP_016855624, XP_016855622, NP_008964,XP_011538844
Psen1	103;178;2374;28866	22.7255694	00.0271	00.1621	00.1621	MGI:1913590	663	NM_025498	NP_079774	11952	HGNC:30100	55851	NM_172341,NM_001281532	NP_001268461, NP_758844
Seph s1	109;485;810;31122	21.6982917	00.0281830	00.1670	00.1670	MGI:1923580	109079	XM_006497309|XM_017314904|NM_175400	XP_006497372|XP_017170393|NP_780609	56558	HGNC:19685	22929	NM_001195602, NM_012247,NM_001195604	XP_016871431, XP_016871432, XP_016871433, NP_001182531, NP_001182533, NP_036379,XP_016871434
Csde1	239;692;896;45055	21.5635560	00.0347	00.1947	00.1929	MGI:9235356	229663	NM_144901|NM_001310693|NM_001161854|XM_017319550|XM_006501397|XM_006501398|XM_006501399	XP_006501462|XP_017175039|NP_659150|NP_001155326|XP_006501461|NP_001297622|XP_006501460	5179	HGNC:29905	78122	NM_007158,NM_001242892,NM_001242891,NM_001007553,NM_001242893,NM_001130523	NP_001229822, NP_001007554, NP_001229820, NP_001229821, NP_001123995, NP_009089
Hmg	192	21.58	00.0	00.1	00.1	MGI	153	NM_001163166|NM_001163165|NM_010440|XM	NP_001156638|NP_001156637|NP_034570|XP_	749	HGN	103	NM_006339	NP_006330,XP_016881633

20b	;216;384;9309	6178	4735	9400	9299	:13411190	53	_006513248|XM_006513249	006513311|XP_006513312	49	C:5002	62			
Nup35	309;674;903;4185	2.5558	1.7048	0.0353	0.1929	0.1929	MGI:1916732	6948	NM_027091|NM_001190179	NP_081367|NP_001177108	4451	HGNC:29797	1294	NM_138285,NM_001287585,NM_001008544,NM_001287584	NP_612142,NP_001274513,XP_006712317,XP_011508878,XP_016858797,XP_011508879,NP_001274514
Mpdz	47;862;912;6665	2.5433	1.5802	0.0360	0.1945	0.1945	MGI:134489	1747	5 NM_001305284|XM_006537646|XM_006537643|NM_001305286|XM_006537644|XM_006537649|NM_010820|XM_006537650|XM_006537647|XM_011249940	XP_006537712|NP_034950|XP_006537706|XP_006537713|XP_006537707|XP_006537709|XP_011248242|NP_001292213|XP_006537710|NP_001292215	2841	HGNC:7208	8777	NM_001330637,NM_001261406,NM_003829,NM_001261407	XP_006716954,XP_016870746,XP_016870747,XP_016870744,XP_006716948,XP_005251679,XP_005251680,XP_016870741,XP_006716952,XP_016870742,NP_003820,XP_016870745,XP_006716951,XP_016870743,XP_006716949,XP_006716950,NP_001248335,NP_001248336,XP_016870748,NP_001317566
Inppl1	378;461;1047;6162	2.3700	1.7202	0.0494	0.2605	0.2583	MGI:133787	1633	NM_010567|NM_001122739|XM_017321991|XM_011241682|XM_006507392|XR_378218|XM_006507391	NP_001116211|XP_006507454|XP_006507455|XP_017177480|NP_034697|XP_011239984	1204	HGNC:6080	3636	NM_001567	XP_011543301,XP_016873162,NP_001558,XP_005274036,XP_005274035,XP_011543302
Smarca5	170;271;	2.3689	1.7767	0.0495	0.2583	0.2583	MGI:193562	9376	NM_053124	NP_444354	55764	HGNC:1111	8467	NM_003601	NP_003592

	2358;3575					129					01				
Mapkapk5	492;1010;1075;3689	2.3.4.3706	1.4.6.6	0.0.5.2.5	0.2.7.0.9	0.2.6.9.6	MGI:1331310	1715	NM_010765	NP_034895	69077	HGNC:6889	8550	NM_139078,NM_003668	XP_016875625, XP_016875627, XP_016875624, XP_016875623, XP_016875619, XP_016875615, NP_003659,NP_620777,XP_016875621,XP_016875626,XP_016875614,XP_016875616,XP_016875620,XP_016875617,XP_016875628,XP_016875622,XP_016875618
Rapgef2	270;397;1078;5170	2.3.3.3.5	1.7.9.3.1	0.0.5.2.9	0.2.6.9.6	0.2.6.9.6	MGI:2659071	7608 9	NM_001310536|XM_006502254|XM_006502250|XM_011240277|XM_006502252|NM_001099624|XM_011240276	XP_006502313|XP_006502317|XP_011238579|NP_001297465|XP_006502315|XP_011238578|NP_001093094	35477	HGNC:16854	9693	NM_001351727, NM_001351728, NM_001351725, NM_001351724, NM_014247,NM_001351726	XP_011530729, NP_001338654, XP_016864347, XP_005263417, XP_005263415, XP_006714483, XP_011530728, XP_005263416, XP_016864348, XP_016864346, XP_005263418, NP_055062,XP_016864345,XP_006714484,NP_001338656,XP_011530727,NP_001338653,NP_001338657,XP_006714485,NP_001338655
Ep300	288;2900;1603;90000	2.3.1.1.8	1.7.0.8.9	0.5.5.2	0.2.7.8.7	0.2.7.8.7	MGI:1276116	3285 72	XM_006521090|XM_006521091|XM_006521089|NM_177821	XP_006521152|NP_808489|XP_006521153|XP_006521154	1094	HGNC:3373	2033	NM_001429	NP_001420,XP_006724228
Ptpn21	802;1093;11	2.2.9.0.3	1.3.7.4.7	0.0.5.7.8	0.2.8.8.2	0.2.8.8.2	MGI:1344406	2400 0	XM_011244112|NM_001146199|NM_011877	XP_011242414|NP_001139671|NP_036007	5110	HGNC:9651	1109 9	NM_007039	XP_016876428, XP_011534670, XP_011534671, XP_005267344, NP_008970,XP_011534669,XP_006720074,XP_016876427

	16;8219														
Gpi1	82;993;1132;22714	2.2725	1.6903	0.0598	0.2950	0.2946	MGI:95797	147511	NM_008155	NP_032181	145	HGNC:44581	2821	NM_001329909, NM_001289789, NM_001329910, NM_001329911, NM_001289790, NM_000175,NM_001184722	NP_001171651, NP_001276718, XP_005258821, NP_001316838, XP_011525056, XP_006723211, NP_001276719, NP_001316839, NP_000166,NP_001316840
Nbn	4722;1134;11366;603838	2.26811	1.41913	0.0604	0.2948	0.2946	MGI:1351625	27354	XM_006537971|NM_013752|XM_006537970	XP_006538033|XP_006538034|NP_038780	1858	HGNC:7652	4683	NM_001024688, NM_002485	NP_001019859, NP_002476,XP_016868951,XP_016868950,XP_016868949,XP_011515347,XP_011515348
Atg12	3049;5914;11400;40311	2.26367	1.5166	0.0610	0.2946	0.2946	MGI:1914776	67526	XM_006526187|NM_026217	XP_006526250|NP_080493	37953	HGNC:588	9140	NM_001277783, NM_004707	NP_001264712, NP_004698
Dgke	445;594;11600;21433	2.24217	1.5877	0.0636	0.3041	0.3014	MGI:1889276	56077	XM_011249151|XR_001780032|XR_388496|NM_019505	NP_062378|XP_011247453	2705	HGNC:28522	8526	NM_003647	XP_016880733, XP_016880734, XP_011523697, XP_011523696, NP_003638,XP_011523698,XP_016880732

Stk35	401;6999;11644;60277	2.2378	1.5555	0.0641	0.0310	0.0314	MGI:1914583	6733	NM_183262|NM_001038635	NP_899085|NP_001033724	15441	HGNC:16254	1409 01	NM_080836	XP_011527476, NP_543026
Tnfrsf1a	668;7901;11666;45777	2.2356	1.4608	0.0644	0.0301	0.0314	MGI:1314884	2193 37	NM_011609	NP_035739	828	HGNC:11916	7132	NM_001346091, NM_001065,NM_001346092	NP_001333020, NP_001333021, NP_001056
Dyrk1a	58;4432;11735;44355	2.2282	1.9047	0.0653	0.0303	0.0303	MGI:1330299	1354 8	NM_007890|XM_011246095|NM_001347731|XM_011246094|NM_001113389|XM_011246098|XM_011246096|XM_011246099	XP_011244396|XP_011244401|XP_011244400|XP_011244398|NP_031916|XP_011244397|NP_001106860|NP_001334660	5576	HGNC:3091	1859	NM_130438,NM_130437,NM_130436,NM_001347723,NM_001347722,NM_001347721,NM_101395,NM_001396	NP_567824,XP_011527785,XP_006724039,NP_001387,XP_006724040,XP_011527784,NP_001334650,NP_001334652,XP_005260990,NP_569122,XP_006724042,XP_016883773,XP_016883774,XP_011527786,NP_569120, NP_001334651, XP_016883775, XP_006724041, XP_011527787
Gtpbp4	268;6531;11845;26355	2.2166	1.6190	0.0668	0.0306	0.0303	MGI:1916487	6923 7	XM_017315592|NM_027000	XP_017171081|NP_081276	7100	HGNC:21535	2356 0	NM_012341	NP_036473
Tln1	408;4734	2.2134	1.6524	0.0672	0.0305	0.0303	MGI:10	2189 4	NM_011602|XM_006537768|XM_006537770|XM_006537769	XP_006537832|NP_035732|XP_006537831|XP_006537833	21267	HGNC:1	7094	NM_006289	NP_006280

	1;1187;4632					9983 2					1845				
Dmap1	17;6811;1194;23144	2.2.0.6.1	1.6.6.4.1	0.0.6.8.1	0.0.3.0.3	0.0.3.0.1	MGI:1913483	663	XM_006503266|XM_006503268|XM_006503267|NM_023178	XP_006503330|XP_006503331|NP_075667|XP_006503329	413 11	HGNC:18291	559	NM_019100,NM_001034023,NM_001034024	XP_005271094, XP_005271096, XP_016857296, NP_001029196, XP_005271097, XP_011540086, XP_006710834, NP_061973,XP_011540087,XP_016857297,NP_001029195
Baz1b	1002;1108;1197;3839	2.2.3.0.6.8.7	1.3.1.9.6	0.0.3.0.3.0	0.0.3.0.3.0	MGI:1353499	2238 5	NM_011714|XM_011240880	NP_035844|XP_011239182	226 51	HGNC:9611	903 1	NM_032408,NM_023005	NP_115784,XP_016868262	
Ric8	21;3744;12044;5715	2.1.9.5.8	2.1.2.2.4	0.0.6.9.6	0.0.3.0.3.8	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
Smg7	335;336;2363	2.1.8.8.1	1.5.5.0.2	0.0.7.0.9	0.0.3.0.6.4	0.0.3.0.5.6	MGI:2682334	226 517	XM_017319981|XM_006529451|XM_006529452|XM_017319979|XM_017319978|NM_001160256|XM_006529450|NM_001005507|NM_001160257	XP_006529513|XP_006529514|NP_001005507|XP_017175468|NP_001153728|NP_001153729|XP_017175467|XP_017175470|XP_006529515	322 35	HGNC:16792	988 7	NM_001174061, NM_001350222, NM_001350219, NM_001350221, NM_001331007, NM_201568,NM_014837,NM_201569,NM_173156,NM_001350220	NP_001337150, NP_001167532, XP_016858455, XP_016858457, XP_005245710, XP_011508510, XP_016858456, XP_011508509, XP_011508512, NP_963863,XP_005245709,XP_006711741,NP_

	;5754													001337149,NP_963862,XP_006711739,NP_775179,XP_016858460,XP_016858459,NP_001317936,NP_001337151,NP_001337148,XP_005245706,XP_011508508,XP_011508511,XP_005245705,XP_011508507,XP_016858458
B4galt1	21;1016;1217;3299	2.1.1824	1.5.2.3.3	0.0.7.1.7	0.0.3.0.6.9	0.0.3.0.5.6	MGI:95705	14595	XM_006537620|XR_001784093|NM_022305	XP_006537683|NP_071641	2037	HGNC:924	2683	NM_001497	NP_001488,XP_005251497
Cdc42	830;9700;1219;38511	2.1.1804	1.3.6.5.0	0.0.7.2.0	0.0.3.0.5.6	0.0.3.0.5.6	MGI:1062111	1254	NM_009861|NM_001243769	NP_001230698|NP_033991	13723	#N/A	#N/A	#N/A	#N/A
Plxna1	313;662;1225;4001	2.1.1743	1.5.8.0.8	0.0.7.2.9	0.0.3.0.6.3	0.0.3.0.6.3	MGI:1076855	1844	NM_008881	NP_032907	5642	HGNC:9099	5361	NM_032242	XP_011511211,XP_011511210,NP_115618
Slc30a1	618;684;	2.1.1542	1.4.8.0.9	0.0.7.5.9	0.0.3.1.6.2	0.0.3.1.4.2	MGI:13455	22782	XM_006497158|NM_009579	NP_033605|XP_006497221	6681	HGNC:110	7779	NM_021194	NP_067017

	124;523;6					281				12					
Tsc2	20;350;2157;3866	2.1.16.53.39	0.0.0.37.61	0.3.1.44.2	0.3.1.44.2	MGI:1025488	224;284	XM_017317390|NM_001286714|XM_017317391|XM_017317393|XM_017317386|XM_017317385|XR_001782063|NM_001286720|XM_006524044|NM_001286718|XM_017317384|XM_017317388|NM_001286713|NM_001286716|XR_001782062|NM_001039363|NM_011647|XM_017317389|XM_017317392|XM_017317387|XM_006524040	XP_006524103|XP_017172874|XP_017172877|XP_017172873|NP_001273642|NP_001273647|XP_017172875|XP_017172879|NP_001273643|NP_035777|XP_006524107|XP_017172882|NP_001034452|NP_001273645|NP_001273649|XP_017172880|XP_017172876|XP_017172881|XP_017172878	462	HGNC:12363	72;429	NM_021056,NM_021055,NM_000548,NM_001318832,NM_001318831,NM_001077183,NM_001318827,NM_001318829,NM_001114382	NP_001107854,XP_011520941,XP_011520938,NP_001305761,XP_005255588,NP_001305760,XP_016879107,XP_011520940,XP_016879105,XP_005255586,NP_001305756,NP_000539,NP_001305758,XP_011520942,XP_011520939,NP_001070651,XP_016879106,XP_016879104
Dnm2	33;822;1257;4752	2.1.14.22.23	0.0.0.18.56	0.3.1.27.8	0.3.1.82.2	MGI:1095477	134;430	XM_006509984|XM_006509982|XM_006509975|XM_017313125|XM_006509981|NM_001253893|NM_001253894|XR_001778793|XM_006509973|XM_006509980|NM_001039520|XM_006509983|XM_006509979|NM_007871|XM_006509977|XM_017313127|XM_017313129|XM_017313126|XM_006509976|XM_006509978|XM_017313128|XM_006509974|XM_006509985	XP_017168615|XP_006510044|XP_006510039|XP_006510037|XP_017168617|XP_006510043|XP_006510047|XP_006510042|NP_001240823|XP_017168614|XP_017168618|NP_001034609|XP_006510036|XP_006510040|XP_017168616|NP_001240822|XP_006510045|XP_006510046|XP_006510041|XP_006510048|NP_031897|XP_006510038	908	HGNC:2974	17;785	NM_001190716,NM_004945,NM_001005360,NM_001005362,NM_001005361	NP_001005360,NP_001177645,NP_001005361,NP_004936,NP_001005362
Pea15a	47;359;4370;83644	2.1.19.32.96	0.0.0.07.95	0.3.2.29.21	0.3.2.21.1	MGI:1047999	186;111	XM_017319302|XM_006496702|NM_001329871|NM_011063|NM_001329869	XP_017174791|NP_035193|NP_001316800|XP_006496765|NP_001316798	788	HGNC:8822	86;82	NM_003768,NM_001297576,NM_001297578,NM_001297577	NP_001284505,NP_003759,NP_001284507,XP_006711662,NP_001284506
Ilk	245;36	2.1.15.25.7	0.0.0.08.08	0.3.2.03.54	0.3.2.23.3	MGI:1161202	162;11	XM_006507389|NM_001161724|NM_010562|XM_006507390	XP_006507452|NP_034692|XP_006507453|NP_001155196	331	HGNC:6	36;11	NM_001278441,NM_004517,NM_001014794,NM_001278442,NM_001014795	NP_001014795,NP_001265371,XP_005252962,NP_004508,XP_005252961,XP_016873161,XP_

	2;23006;24900					9526 7					040 0				011518367,NP_001014794,NP_001265370
Snai1	27 2;36 33;30 036;32 97	2.12 3458	1.15 8809	0.08 2223	0.32 2323	MGI:983330	2061 3	NM_011427	NP_035557	463	HGNC:11128	661 5	NM_005985	NP_005976	
Casp8	29 8;41 11;12 87;39 60	2.11 311	1.16 9710	0.08 2767	0.32 6767	MGI:1261423	123 70	NM_001277926|NM_009812|NM_001080126|XM_006495634	NP_001073595|XP_006495697|NP_033942|NP_001264855	765 7	HGNC:1509	84 1	NM_001080125,NM_033356,NM_033358,NM_001080124,NM_001228,NM_033355,NM_033357	XP_005246943,XP_005246950,XP_005246947,NP_203520,XP_006712853,XP_006712856,NP_001219,XP_005246944,XP_005246952,XP_005246949,XP_005246948,NP_203522,NP_203519,XP_006712852,XP_005246942,XP_005246951,XP_011510271,NP_001073594,NP_001073593,XP_005246946,XP_005246945	
Csnk1d	316;12 55;12 94;68 76	2.10 644	1.13 9140	0.08 3838	0.32 811	MGI:1355272 2	1043 118	NM_139059|XM_011248663|XM_011248662|NM_027874	XP_011246964|NP_082150|NP_620690|XP_011246965	748 41	HGNC:24522	145 3	NM_001893,NM_139062	XP_016879688,NP_620693,NP_001884,XP_005256393,XP_005256394	
Rasgrp3	234;37 5;3	2.09 6253	1.05 7557	0.08 5326	0.33 2636	MGI:3028 85	240 168	XM_140160|XM_006524273|NM_001166493|XM_006524271|XM_006524272	NP_997129|XP_006524336|NP_001159965|XP_006524334|XP_006524335	150 19	HGNC:145	25 780	NM_015376,NM_001349980,NM_001139488,NM_001349975,NM_001349977,NM_001349981,NM_001349976,NM_001349979,NM	XP_011531050,NP_001336906,XP_016859249,XP_005264303,NP_001336910,NP_056191,NP_001132960,XP_011531048,NP_001336905,XP_	

	57;9135					79					45		_001349978,NM_170672	016859252,XP_016859250,NP_001336909,NP_001336908,XP_016859248,NP_733772,NP_001336904,XP_011531049,NP_001336907,XP_016859251
Bdkrb1	86;12341;13122;37177	2.08930	1.2690	0.0870	0.3348	0.3348	MGI:881444	1201	NM_007539	NP_031565	570	HGNC:10299	623	NM_000710	NP_000701
Snx4	149;10779;13266;86266	2.0762	1.5201	0.0893	0.3409	0.3401	MGI:1916400	6915 0	NM_080557	NP_542124	36143	HGNC:11175	8723	NM_003794	XP_016862903, NP_003785
Pigu	182;6889;13313;36977	2.07155	1.6084	0.0902	0.3413	0.3401	MGI:3039607	22812	XM_006499333| NM_001004721	XP_006499396| NP_001004721	653	HGNC:15791	12886 9	NM_080476	XP_016883154, XP_016883153, NP_536724,XP_011526844
Adcy3	101;12633;13	2.06817	1.2413	0.0906	0.3401	0.3401	MGI:996775	1041111	NM_001159536| XM_006514932| XM_006514934| XM_006514933| NM_001159537| XM_006514935| NM_138305	XP_006514998| XP_006514997| XP_006514995| NP_612178|XP_006514996|NP_001153009|NP_001153008	278	HGNC:234	109	NM_004036,NM_001320613	NP_001307542, XP_011530794, XP_016858676, XP_011530792, XP_006711988, XP_016858675, XP_016858682, XP_016858677, XP_011530796, NP_004027,XP_016858678,XP_011530795,XP_

	34;2256														016858679,XP_011530793,XP_016858680,XP_011530791,XP_011530798,XP_016858681
Rictor	262;454;1339;;35200	2.0641	1.6702	0.0914	0.3403	0.3403	MGI:1926007	7857	XM_006520003|XM_006520004|NM_030168	XP_006520066|XP_006520067|NP_084444	3431	HGNC:28611	253260	NM_001285440,NM_152756,NM_001285439	NP_001272369,XP_016864801,XP_016864803,XP_016864802,XP_006714526,NP_689969,NP_001272368,XP_016864804,XP_011512308,XP_016864800,XP_011512307
Nipa2	557;808;1357;;50750	2.0476	1.4133	0.0947	0.3496	0.3474	MGI:1913918	9379	XM_006541324|NM_001256132|NM_001256133|NM_001256130|NM_023647|NM_001256131	NP_001243060|XP_006541387|NP_001243062|NP_001243061|NP_076136|NP_001243059	1136	HGNC:17044	81614	NM_001008894,NM_001008892,NM_001184889,NM_001184888,NM_001008860,NM_030922	XP_016878138,XP_016878140,XP_005272603,XP_011542179,XP_016878147,XP_006720428,NP_112184,XP_005272607,XP_016878150,XP_016878146,XP_016878149,XP_016878136,XP_005272604,XP_016878135,XP_011542181,XP_011542180,XP_016878151,XP_016878141,NP_001008860,XP_016878143,NP_001008892,XP_016878144,XP_006720430,XP_006720427,XP_016878137,XP_016878145,XP_016878142,NP_001171817,XP_016878134,XP_011542182,XP_006720429,NP_001008894,XP_005272610,XP_016878139,XP_016878152,NP_001171818,XP_005272609,XP_005272605,XP_016878148
Shoc2	165;398;2300	2.0466	1.6217	0.0949	0.3475	0.3474	MGI:1927197	5632	XM_006527228|NM_019658|NM_001168505|XM_017318260|XM_011247299	XP_006527291|NP_001161977|XP_011245601|NP_062632|XP_017173749	7219	HGNC:15454	80336	NM_007373,NM_001324337,NM_001269039,NM_001324336	NP_001311265,XP_016872191,NP_001255968,NP_031399,NP_001311266,XP_016872193,XP_016872192

	;9388														
Adrm1	183;4000;13677;95933	2.0.4.2.5	1.7.4.5.1	0.0.9.5.7	0.3.4.7.4	0.3.4.7.4	MGI:1929289	564	XM_006500680|NM_019822	NP_062796|XP_006500743	105	HGNC:15759	11047	NM_001281438,NM_007002,NM_001281437,NM_175573	XP_016883093,XP_005260314,XP_011526805,XP_016883092,NP_008933,NP_001268367,NP_783163,NP_001268366,XP_016883091,XP_016883096,XP_016883098,XP_016883095,XP_016883097,XP_016883099,XP_016883094
Selk	354;4002;13777;88322	2.0.3.8.3	1.6.5.2.9	0.0.9.6.6	0.3.4.8.2	0.3.4.8.2	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Ap2a1	609;8355;13822;43022	2.0.2.5.1	1.3.8.6.6	0.0.9.9.5	0.3.5.5.6	0.3.5.3.8	MGI:1019211	1171	NM_007458|XM_006540569|NM_001077264|XM_006540570	NP_001070732|NP_031484|XP_006540633|XP_006540632	68997	HGNC:561	160	NM_014203,NM_130787	NP_570603,XP_011524858,NP_055018,XP_011524859
Strn3	2002;4009;45211;46866	2.0.2.4.0	1.5.6.8.9	0.0.9.9.8	0.3.5.3.8	0.3.5.3.8	MGI:2151064	946	NM_001172098|XM_006516410|XM_006516412|XM_006516411|NM_052973	NP_001165569|XP_006516475|XP_006516474|XP_006516473|NP_443205	8207	HGNC:15720	29966	NM_014574,NM_001083893	XP_005267627,NP_055389,XP_005267626,NP_001077362

Satb2	85;21400;14099;25133	2.01210453677	0	0	0	3677	MGI:2679336	212	XM_006495827|XM_006495828|NM_139146|XM_017319630|XM_017319629|XM_011238467|XM_017319631	XP_006495890|XP_017175118|XP_017175120|XP_017175119|XP_006495891|NP_631885|XP_011236769	32249	HGNC:21637	234	NM_015265,NM_001172517,NM_001172509	NP_001165988,XP_011509142,XP_006712435,XP_016859145,NP_056080,XP_005246453,NP_001165980
Picalm	46;42863;56033;85644	1.98617079677	1	0	0	3767	MGI:2385902	234	NM_001252522|XM_006507604|XM_006507600|XM_006507596|XM_006507601|XM_006507599|XM_006507595|NM_001252520|NM_001252521|XM_006507605|XM_006507597|XM_006507598|XM_006507594|NM_001252524|NM_146194|NM_001252523|XM_006507602|XM_006507603	XP_006507657|NP_001239453|XP_006507666|XP_006507663|NP_666306|XP_006507664|XP_006507658|NP_001239451|NP_001239452|NP_001239450|XP_006507665|XP_006507667|XP_006507661|XP_006507668|XP_006507659|NP_001239449|XP_006507660|XP_006507662	11783	HGNC:15514	8301	NM_001008660,NM_001206946,NM_007166,NM_001206947	XP_005274389,XP_005274387,XP_006718763,XP_005274383,XP_005274385,XP_005274386,XP_016873871,NP_001193876,XP_016873875,XP_005274388,XP_016873877,XP_006718762,XP_005274393,XP_005274381,NP_001008660,XP_011543595,XP_005274392,XP_005274391,NP_009097,XP_016873872,XP_016873873,NP_001193875,XP_005274382,XP_016873874,XP_005274394,XP_005274397,XP_016873876,XP_005274384,XP_016873870,XP_005274379,XP_005274390,XP_005274380,XP_006718764
Pi4kb	49;10449;14400;53900	1.99374531061	1	0	0	3831	MGI:1334433	107650	NM_001293715|NM_001293716|NM_175356	NP_001280644|NP_780565|NP_001280645	67441	HGNC:8984	529 8	NM_001198775,NM_001198774,NM_001198773,NM_002651,NM_001330721	XP_016856980,NP_001185703,XP_011507937,XP_011507940,XP_005245321,XP_011507936,XP_016856979,XP_011507938,NP_001185702,XP_016856976,XP_016856978,NP_001185704,XP_011507939,XP_016856977,NP_002642,XP_016856981,XP_016856975,NP_001317650
Chmp3	205;43	1.96908	1	0	0	3846	MGI:19	667010	XM_006506481|XM_017321713|XM_006506480|XM_006506482|NM_025783	XP_006506543|NP_080059|XP_017177202|XP_006506544|XP_006506545	6368	HGNC:2	5162	NM_016079,NM_001005753,NM_001193517	NP_001005753,NP_057163,NP_001180446

	7;2050;8885					13950					9865				
Tsc1	59;11949;14555;23277	1.1928160	1.1013469	0.0038447	0.0038447	MGI:1929183	6430	XM_006498222|XM_011239142|NM_001289576|NM_022887|XM_006498221|XM_011239144|XM_006498223|XM_006498220|XM_011239143|NM_001289575	NP_001276504|XP_011237445|XP_011237444|NP_075025|NP_001276505|XP_006498286|XP_006498283|XP_011237446|XP_006498284|XP_006498285	314	HGNC:12362	724	NM_000368,NM_001008567,NM_001162426,NM_001162427	XP_011517281,XP_016870585,XP_016870586,XP_016870588,XP_016870587,XP_016870589,NP_001155898,XP_006717334,XP_016870590,NP_001155899,XP_005272268,NP_000359
Atp2c1	321;44122;23399	1.1961552	1.1041355	0.0038447	0.0038447	MGI:1889008	2355744	XM_006511710|NM_001253831|NM_001253834|XM_006511712|XM_006511714|NM_175025|NM_001253836|XM_006511711	XP_006511777|XP_006511774|XP_006511775|NP_001240760|NP_001240765|NP_001240763|XP_006511773|NP_778190	5667 2	HGNC:13211	2703 2	NM_001001486,NM_001199182,NM_001199180,NM_001199183,NM_001001485,NM_001199185,NM_001199181,NM_014382,NM_001199179,NM_001001487,NM_001199184	XP_005247413,XP_011510988,NP_001186112,NP_001001487,NP_001186110,XP_005247412,XP_005247415,NP_001001485,XP_005247411,XP_016861653,NP_001186108,NP_001186114,NP_001186113,NP_001186111,NP_001186109,NP_001001486,NP_055197
Ccnl2	275;444;27355;89800	1.1955928	1.1047215	0.0038699	0.0038699	MGI:1927119	5603 6	XM_011250305|XR_001784166|XM_017320328|XR_881434|NM_207678|XM_017320327|XR_001784165|XM_011250304	XP_017175817|XP_017175816|XP_011248607|NP_997561|XP_011248606	6947 7	HGNC:20570	816 69	NM_001320155,NM_001350497,NM_001039577,NM_001350498,NM_001350500,NM_030937,NM_001144867,NM_001350499,NM_001320153,NM_001144868	XP_016857909,NP_001337426,NP_112199,XP_011540518,XP_016857910,XP_011540521,NP_001337429,NP_001337427,XP_016857911,NP_001307084,NP_001307082,XP_016857912,NP_001337428,NP_001034666,XP_011540523
28104081M09R	232;46210	1.1923004	1.1049233	0.0041115	0.0041115	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

ik	;930101														
Impa1	120;6887;15111;89755	1.9155	1.6147	0.1252	0.4150	0.4150	MGI:1933158	5598	XM_006530077|NM_018864|NM_001310433|XM_006530078	NP_061352|NP_001297362|XP_006530140|XP_006530141	4043	HGNC:6050	3612	NM_001144879, NM_005536,NM_001144878	NP_001138351, NP_005527,NP_001138350
Pak2	343;7000;15200;92227	1.9082	1.4652	0.1270	0.4178	0.4178	MGI:1339984	2241	NM_177326|XM_006522072	XP_006522135|NP_796300	9971	HGNC:8591	5062	NM_002577	XP_011511172, NP_002568,XP_016861990
Ctnnb1	876;1365;15444;49344	1.8891	1.1765	0.1324	0.4326	0.4320	MGI:882767	1238	NM_001165902|NM_007614	NP_001159374|NP_031640	1434	HGNC:2514	1499	NM_001330729, NM_001904,NM_001098209,NM_001098210	XP_006713046, NP_001091680, XP_016861227, NP_001895,XP_006713047,XP_005264943,NP_001317658,XP_006713048,NP_001091679
Mfsd7b	783;4863;15877;;20288	1.8863	1.7508	0.1332	0.4320	0.4320	MGI:2444881	2684	NM_198025|NM_001313747|NM_001081259|XR_001784141	NP_001300676|NP_932142|NP_001074728	56661	HGNC:24682	2898	NM_014053	XP_011507750, XP_011507749, NP_054772,XP_011507748
Zb	47	1.	1.	0.	0.	0.	MG	26	XM_006515898|XR_872712|XM_	XP_006515960|XP_006515961|	89	HG	22	NM_014950,NM_001123329	XP_016876583, XP_016876584,

tb1	8;486;1988;4927	88129	32945	13433	43330	IL:24423266	8564	006515897|XR_381523|NM_178744|XM_006515895	NP_848859|XP_006515958	74	NC:20259	890			NP_001116801, NP_055765,XP_011534870,XP_011534868,XP_005267467
Gpr19	13053;15133;1588;74711	1.8548039	1.1042454	0.1455329	0.4529	MGI:2897373	147600	XM_006505544|XM_017321393|XM_006505543|XM_006505547|NM_008157|NR_074084|NR_072990|NM_001167696|XM_006505554|NM_001167695|XM_017321391|NM_001167700|XM_017321390|NM_001167694|XM_017321392|NM_001167697|XM_006505545|NM_001167699	XP_006505617|XP_017176879|XP_006505608|NP_001161167|NP_032183|NP_001161166|NP_001161168|XP_017176880|NP_001161171|XP_017176881|NP_001161172|XP_006505610|XP_006505606|XP_017176882|XP_006505607|NP_001161169	4476	HGNC:4473	28422	NM_006143	NP_006134,XP_016874705,XP_016874702,XP_016874704,XP_011518925,XP_011518927,XP_011518926,XP_016874701,XP_016874703
Pigw	18545;50246;17345;61800	1.8554216	1.8441	0.1452	0.4529	MGI:1917575	703250	XM_006534159|NM_001077636|NM_027388	XP_006534222|NP_081664|NP_001071104	6243	HGNC:23213	28409 8	NM_178517,NM_001346754,NM_001346755		NP_001333684, NP_848612,XP_005257295,XP_011522948,NP_001333683
Kcnn4	16985;50808;38046;80960	1.8448	1.5159	0.1457	0.4594	MGI:1277957	165340	XR_391046|NM_001163510|NM_008433|XM_006539563	NP_001156982|XP_006539626|NP_032459	1696	HGNC:62933	3783	NM_002250		XP_011525240, XP_005258939, NP_002241,XP_005258940
Hdac2	776;1255	1.8395	1.1944	0.1473	0.4612	MGI:109	151820	XM_017313806|XM_006512555|NM_008229	XP_006512618|XP_017169295|NP_032255	68187	HGNC:48	3066	NM_001527		NP_001518,XP_011534090,XP_016866288

	0;160856					7691					53				
Ppp1r14c	42;512;5307;8128	1.1.1.8384	0.1.4.3316	0.4.5.4772	0.4.5.4922	MGI:1923392	7614	XM_006512490|NM_133485|XM_006512489	NP_597844|XP_006512552|XP_006512553	1280	HGNC:14952	81706	NM_030949	NP_112211,XP_005267209
Tsg101	503;519;87016;95166	1.8272	1.2931	0.1.5.4	0.4.6.7.7	MGI:1065811	2208	XM_006540790|NM_021884|XM_006540789|XM_006540788|NM_001348088|NM_001348089|XR_391333	XP_006540853|XP_006540851|XP_006540852|NP_001335017|NP_001335018|NP_068684	4584	HGNC:15971	72511	NM_006292	NP_006283,XP_005253165
Apc	42;525;2205;92488	1.8178	1.7962	0.1.5.4.6	0.4.7.4.2	MGI:88039	1178	XM_006525529|XM_006525533|XM_006525538|XM_017317804|NM_007462|XM_006525532|XM_006525531|XM_006525536|XM_006525534|XM_006525535|XM_006525539|XM_006525530	XP_006525594|XP_006525599|XP_006525595|XP_006525597|XP_006525602|XP_006525601|XP_006525596|XP_006525598|XP_006525592|XP_017173293|XP_006525593|NP_031488	3095	HGNC:583	324	NM_001127511,NM_000038,NM_001127510	NP_001120983,NP_000029,NP_001120982
Ap3d1	257;526;17532;;	1.8162	1.5226	0.1.5.5.2	0.4.7.2.9	MGI:107734	1176	NM_007460|XR_001779423|XR_380349|XR_001779424	NP_031486	2926	HGNC:5668	8943	NM_001077523,NM_001261826,NM_003938	NP_003929,XP_016882911,NP_001248755,XP_006722995

	064														
Cdc25a	39;1024;1647;;37944	1.1.3.1.1.0.4.7.5.1.0.3	1	0	0	0	MGI:1031980	1253	XM_006511929|XM_006511930|NM_007658|XM_006511931	XP_006511992|NP_031684|XP_006511994|XP_006511993	135	HGNC:17255	993	NM_201567,NM_001789	NP_963861,XP_006713497,XP_006713498,XP_011532618,NP_001780
Atp5b	1169;1318;1677;;75644	1.7.8.4.4.2	1	0	0	0	MGI:1078011	1147	NM_016774	NP_058054	1273	HGNC:8300	5061	NM_001686	NP_001677
Khdrbs1	60;626;1679;;97700	1.7.8.7.0	1	0	0	0	MGI:893579	2018	XR_001784112|NR_045036|NM_011317|XR_376300	NP_035447	4781	HGNC:18116	10657	NM_001271878,NM_006559	NP_001258807,NP_006550
Rapgef4	101;1672;1684;;27233	1.7.8.3.4	1	0	0	0	MGI:1917723	5658	NM_001204165|XM_011239711|XM_017319138|NM_019688|NM_001204167|XM_006499938|XM_017319139|NM_001204166	NP_062662|XP_017174627|XP_006500001|XP_017174628|XP_011238013|NP_001191095|NP_001191096|NP_001191094	4451	HGNC:16626	1106	NM_001282900,NM_007023,NM_001282899,NM_001282901,NM_001100397	NP_001093867,XP_011508807,NP_001269830,XP_016858686,XP_016858685,NP_001269829,XP_005246303,NP_008954,XP_006712268,NP_001269828

Mcm3ap	50;109;1691;5147	1.7783	1.2578	0.1685	0.4967	0.4967	MGI:1930089	543 87	XM_006513894|NM_019434	XP_006513957|NP_062307	290 2	HGNC:6946	88 88	NM_003906	XP_005261261, XP_005261260, XP_005261262, NP_003897
Anxa4	73;118;1698;4098	1.7733	1.1920	0.1705	0.4993	0.4981	MGI:1880300	117 46	XM_011241158|XM_011241156|NM_001331120|NM_013471|XM_006505397|XM_006505398	XP_006505461|XP_011239460|XP_011239458|XP_006505460|NP_001318049|NP_038499	681 64	HGNC:542	30 07	NM_001320700, NM_001320702, NM_001320698, NM_001153	XP_016859432, NP_001307629, NP_001144,NP_001307627,NP_001307631,XP_016859433
963003 3F20Rik	459;15554;17028;55518	1.7705	1.1799	0.1716	0.4994	0.4981	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Cyld	145;562;4284;7224	1.7621	1.5062	0.1748	0.5405	0.4981	MGI:1921506	742 56	XM_006531416|XM_006531414|XM_006531419|XM_006531420|XM_011248524|NM_001276279|NM_001128170|XM_006531417|XM_011248523|NM_001128171|XM_006531415|XM_006531418|NM_173369|XM_011248525|XM_017312989	XP_006531480|XP_006531481|XP_011246827|XP_011246826|XP_006531479|XP_006531477|NP_001121643|NP_775545|XP_006531478|XP_006531482|NP_001121642|XP_011246825|NP_001263208|XP_006531483|XP_017168478	906 9	HGNC:2584	15 40	NM_001042355, NM_015247,NM_001042412	XP_016878466, NP_001035877, XP_005255869, XP_016878470, XP_016878469, XP_016878468, NP_001035814, NP_056062,XP_011521213,XP_006721212,XP_011521209,XP_016878467,XP_011521210
Pex3	12;83	1.75	1.11	0.17	0.54	0.49	MGI:	56 5	NM_001347361|XM_006512807|NM_019961|NM_001164195	XP_006512870|NP_064345|NP_001157667|NP_001334290	269 1	HGNC	85 04	NM_003630	NP_003621

	;1292;1717;5157	98	18	5646	8	1929646	35				:8858				
Vac14	118;1485;1721;43266	1.7570	1.3673	0.1767	0.504	0.4981	MGI:2157980	2347229	NM_146216|XR_001778432|XM_006530919|XM_006530918	XP_006530982|NP_666328|XP_006530981	6528	HGNC:25507	5569 7	NM_001351157, NM_018052	XP_016878931, XP_011521525, NP_060522,XP_011521527,XP_011521526,XP_005256098,XP_016878930,XP_005256095,NP_001338086
Rab23	558;567;3444;88055	1.7549	1.2382	0.1777	0.504	0.4981	MGI:9983833	1933 5	NM_008999|XM_006495802|NM_001159729|XM_006495801	XP_006495864|NP_001153201|NP_033025|XP_006495865	7503	HGNC:142663	5171 5	NM_016277,NM_001278668,NM_001278667,NM_183227,NM_001278666	NP_057361,NP_001265597,NP_899050,NP_001265595,NP_001265596
Uhrf1	197;591;1725;93700	1.7542	1.5331	0.1778	0.5014	0.4981	MGI:1338889	1811 40	NM_001111079|NM_010931|XM_006523800|NM_001111078|NM_001111080|XM_006523799	NP_035061|NP_001104550|XP_006523863|NP_001104549|XP_006523862|NP_001104548	7866	HGNC:12556	291 28	NM_001290051, NM_001290050, NM_001048201, NM_001290052, NM_013282	NP_001041666, XP_011526244, NP_037414,NP_001276981,NP_001276979,NP_001276980
Syt11	546;569;	1.7520	1.2406	0.1708	0.5008	0.4981	MGI:18559	2295 21	NM_018804|XM_006501350|XM_006501348	XP_006501411|NP_061274|XP_006501413	2312 20	HGNC:192	232 08	NM_152280	NP_689493,XP_016856248,XP_005245071

	6344;6519					547				39					
Lpar1	4904;7733;1729;8803	1.7514	1.3417	0.1788	0.4981	0.491	MGI:1084299	145	XM_011249930|XM_011249929|XM_011249935|XM_011249931|NM_172989|XM_011249928|NM_010336|NM_001290486|XM_011249934|XM_011249933|XM_011249932	XP_011248233|NP_034466|XP_011248235|XP_011248234|XP_011248237|NP_766577|XP_011248232|XP_011248236|NP_001277415|XP_011248230|XP_011248231	1072	HGNC:3166	1902	NM_001351409,NM_001351414,NM_001351403,NM_001351412,NM_001351402,NM_001351397,NM_001351415,NM_001351416,NM_001351404,NM_001351408,NM_001401,NM_001351398,NM_001351417,NM_001351405,NM_001351419,NM_001351418,NM_001351420,NM_001351413,NM_001351400,NM_001351407,NM_001351406,NM_001351401,NM_057159,NM_001351411,NM_001351410,NM_001351399	NP_001338342,NP_001338326,XP_016869888,XP_016869876,NP_001338332,XP_016869881,NP_001338340,NP_001338338,XP_016869892,NP_001338336,NP_001338347,XP_016869886,NP_001338346,XP_016869877,NP_001338341,XP_016869890,NP_001338331,XP_016869887,NP_001338327,NP_001338334,XP_016869878,NP_001338335,NP_001338337,NP_001338328,XP_016869873,NP_476500,XP_005251838,XP_016869889,NP_001338333,NP_001338348,XP_016869874,NP_001338345,XP_016869893,NP_001338343,NP_001338339,NP_001392,XP_016869885,XP_005251839,XP_016869896,NP_001338349,XP_016869895,XP_016869883,XP_016869894,XP_016869882,XP_016869880,NP_001338330,XP_016869884,XP_016869879,NP_001338344,XP_016869872,XP_016869891,NP_001338329,XP_016869875
Clptm1	3272;5722;3517;	1.7477	1.3347	0.1803	0.4991	0.491	MGI:1927155	5645	NM_019649|XM_006540227	NP_062623|XP_006540290	37464	HGNC:2087	129	NM_001294,NM_001282175,NM_001282176,NM_001199468	NP_001269104,NP_001269105,NP_001285

	6933													
Vps35	2093;5800;3915;;6527	1.7364	1.4182	0.1851	0.5092	0.5090	MGI:1890467	651114	NM_022997	NP_075373	621	HGNC:13487	5573	NM_018206	NP_060676,XP_005256102,XP_011521529
Atp6v0d1	5605;5832;;7181;;83199	1.7322	1.2262	0.1867	0.5105	0.5090	MGI:1201778	119172	NM_013477	NP_038505	3444	HGNC:13724	9114	NM_004691	NP_004682,XP_011521748,XP_011521747,XP_011521746
Mark3	5653;5843;;3431;;5438	1.7308	1.2239	0.1872	0.5090	0.5090	MGI:1341865	17169	XM_006515517|XM_006515511|XM_011244006|XM_006515518|NM_021516|NM_022801|XM_006515515|XM_006515513|XM_006515519|XM_006515514|XM_011244007|XM_006515512|XM_006515522	XP_006515580|XP_006515575|XP_006515581|XP_011242308|XP_006515578|XP_006515574|NP_067491|XP_006515582|XP_006515577|XP_006515585|XP_011242309|XP_006515576|NP_073712	5563	HGNC:6897	4140	NM_002376,NM_001128920,NM_001128918,NM_001128921,NM_001128919	NP_001122392,XP_016876782,XP_016876797,NP_001122393,XP_016876800,XP_005267699,XP_016876793,XP_016876789,XP_005267700,XP_016876787,XP_016876794,XP_016876784,XP_016876783,XP_016876788,XP_016876791,XP_016876795,XP_005267698,NP_001122390,XP_006720209,XP_016876799,XP_016876798,XP_016876796,NP_001122391,XP_016876790,XP_016876785,XP_016876780,XP_016876786,XP_016876792,NP_002367,XP_016876781,XP_011535071
Nsf	105;98	1.7244	1.4741	0.1898	0.5128	0.5128	MGI:10	18195	NM_008740	NP_032766	4502	HGNC:8	4905	NM_006178	NP_006169

	8;1768;3619					4560					0166			
Tox4	248;7188;1772;3024	1.1.1.4.7.2.1.7	0.0.0.1.5.1.2.9	0.0.0.1.9.2.2.9	0.0.0.5.1.2.2.9	MGI:1915389	26841	NM_023434	NP_075923	8889	HGNC:20161	9878	NM_014828,NM_001303523	NP_055643,NP_001290452
Mapkap1	746;1323;1787;4878	1.1.1.7.1.4.2.0	0.0.0.1.5.2.2.5	0.0.0.9.2.2.2.5	0.0.0.2.2.2.2.4	MGI:2443454	22774	XM_011239083|NM_177345|XM_017317446|XM_011239085|XM_006497975|XM_006497980|XM_011239084|XM_006497978|XM_017317443|XM_011239082|XM_006497983|NM_001290625|XM_006497982|NM_001290626	XP_011237386|NP_001277555|XP_006498046|XP_011237387|NP_796319|XP_006498045|XP_006498043|NP_001277554|XP_011237385|XP_011237384|XP_017172932|XP_006498041|XP_017172935|XP_006498038	1147	HGNC:1875	7910	NM_001006620,NM_024117,NM_001006619,NM_001006621,NM_001006617,NM_001006618	XP_016870616,XP_011517309,XP_011517311,XP_011517308,NP_001006618,XP_016870615,NP_001006622,XP_011517307,XP_011517310,NP_001006619,NP_001006621,NP_001006620,XP_011517312,NP_077022
Sh3bp5	756;1120;1792;4877	1.1.1.7.0.8.0.1	0.0.0.1.8.2.2.9	0.0.0.9.0.2.2.9	0.0.0.6.5.2.2.9	MGI:1344391	24056	NM_001347585|XM_006519015|NM_011894|XM_006519013	XP_006519078|NP_036024|XP_006519076|NP_001334514	23450	HGNC:10827	9467	NM_004844,NM_001018009	XP_016863012,XP_011532553,NP_001018009,XP_016863014,XP_011532555,XP_016863010,XP_016863013,NP_004835,XP_016863011
Nsfl1c	446;605;234	1.1.1.7.0.2.1.1	0.0.0.1.2.5.9.6	0.0.0.5.2.6.6.8	0.0.0.2.6.8.6.8	MGI:3042273	38649	NM_198326|NM_001291074	NP_938085|NP_001278003	41114	HGNC:15912	5596	NM_018839,NM_001206736,NM_016143,NM_182483	NP_061327,XP_011527607,XP_006723655,XP_011527603,XP_011527602,XP_016883445,XP_011527606,XP_006723657,NP_001193665,NP_057227,XP_011527604,XP_016

	9;4830														883446,XP_006723656,XP_016883447
Ikbkg	10203;13833;18111;23922	1.6954	1.0938	0.0222	0.0307	0.0307	MGI:1338074	161511	XM_006527851|XM_006527850|NM_178590|NM_001161421|XM_006527852|XM_006527849|NM_010547|XM_006527853|XM_006527848|XM_006527847|NM_001161423|XM_011247527|NM_001136067|NM_001161424|NM_001161422	NP_001154896|NP_001154894|XP_006527911|NP_001154893|XP_006527915|XP_006527914|XP_006527916|NP_001154895|XP_011245829|XP_006527912|NP_848705|XP_006527910|NP_034677|NP_001129539|XP_006527913	2698	HGNC:5961	857	NM_001321397,NM_003639,NM_001099856,NM_001099857,NM_001321396,NM_001145255	NP_001308326,NP_001093327,NP_003630,NP_001093326,NP_001308325,NP_001138727
Rangrf	54562;57688;93211	1.6796	1.2048	0.2009	0.5467	0.5455	MGI:1889073	577885	NM_021329|NM_001285441|NM_001285442|NM_001285443	NP_067304|NP_001272372|NP_001272371|NP_001272370	41138	HGNC:17679	2909	NM_001177801,NM_001330127,NM_001177802,NM_016492	NP_001171273,XP_005256675,NP_001171272,NP_057576,NP_001317056
Fam120a	89414791;18375;59911	1.6782	1.0849	0.2103	0.5455	0.5455	MGI:2446163	218236	XR_001780774|XR_001780775|NM_001033268|XR_001780776	NP_001028440	87522	HGNC:13247	2316	NM_001286722,NM_014612,NM_001286724,NM_001286723	NP_001273652,NP_001273653,XP_005251899,XP_011516715,NP_055427,XP_011516716,XP_011516718,NP_001273651,XP_011516714
Uck1	17463;63041;68	1.6693	1.4221	0.2145	0.5532	0.5532	MGI:9890404	222445	XM_006497853|NM_011675	NP_035805|XP_006497916	7990	HGNC:14859	8354	NM_001318519,NM_001261450,NM_001135954,NM_001261451,NM_031432	NP_001305448,XP_005272281,NP_001129426,NP_001248380,NP_001248379,NP_113620

Csk	60435;6326;24400;39966	1.6667	1.2396	0.2158	0.5534	0.5534	MGI:88537	129	XM_006510801|NM_007783|XM_006510802|XM_011242659|NM_001304761	NP_001291690|XP_006510865|XP_006510864|XP_011240961|NP_031809	55818	HGNC:2444	145	NM_004383,NM_001127190	XP_005254222,NP_004374,XP_016877414,NP_001120662
Akr1b3	3326;12288;18600;70399	1.6633	1.2422	0.2174	0.5544	0.5544	MGI:1353494	167	NM_009658	NP_033788	13374	HGNC:3811	231	NM_001628,NM_001346142	NP_001333071,NP_001619,XP_005250291
Dusp11	8186;16100;18699;37377	1.6575	1.0671	0.2201	0.5584	0.5584	MGI:1919352	7210 2	NM_028099|XM_011241476|XM_017321754|XR_001785172	XP_017177243|XP_011239778|NP_082375	31183	HGNC:3066	8446	NM_003584	NP_003575
Gpr125	735;13911;18888;53766	1.6453	1.1094	0.2261	0.5702	0.5700	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Pi	51	1.	1.	0.	0.	0.	MG	22	XM_006522037|NM_001001983|	NP_001001983|XP_006522097|	11	HG	52	NM_002650,NM_058004	XP_005261691,NP_477352,XP_

4kaa	5;725;;1892;;9524	64285	31653	22733	57000	57000	I:24485062	4020	XM_006522036|XM_006522034	XP_006522099|XP_006522100	171	NC:8983	97		011528530,XP_016884319,XP_011528528,XP_016884318,XP_005261692
lkbkap	407;844;;1914;;55384	1.62889	1.30074	0.23485	0.58576	0.58576	MGI:1914544	23023	NM_026079|XR_390319	NP_080355	269	HGNC:5959	8518	NM_003640,NM_001330749,NM_001318360	NP_001305289,XP_011517438,NP_003631,XP_016870727,XP_011517439,NP_001317678
Met	1461;1851;;1922;;43277	1.62392	0.97224	0.23748	0.58906	0.58356	MGI:96969	17295	XM_011241043|XM_006505002|NM_008591|XM_011241042	XP_011239345|XP_011239344|XP_006505065|NP_032617	206	HGNC:7029	4233	NM_001127500,NM_001324401,NM_000245,NM_001324402	NP_001120972,NP_001311330,XP_011514525,XP_006716053,NP_000236,NP_001311331
Racgap1	464;667;;5434;;81300	1.62032	1.20599	0.23792	0.58700	0.58356	MGI:1349423	2693 4	NM_012025|XM_011245647|NM_001253808|XM_006521020|XM_011245646|XM_006521019|NM_001253809	XP_011243949|NP_001240737|XP_006521082|XP_011243948|NP_036155|NP_001240738|XP_006521083	807 7	HGNC:9804	2912 7	NM_013277,NM_001320002,NM_001126103,NM_001319999,NM_001320006,NM_001126104,NM_001320000,NM_001320007,NM_001320005,NM_001320001,NM_001320004,NM_001320003	NP_001306930,NP_001306933,XP_016874714,NP_001119576,XP_016874716,XP_011536545,XP_006719422,NP_001306935,NP_001306928,XP_011536540,XP_016874709,NP_001306932,XP_016874710,NP_001306929,NP_001306931,NP_001119575,XP_016874711,XP_016874713,XP_016874715,NP_001306936,NP_001306934,XP_016874712,NP_037409

Atrn	608;6699;19556;43611	1.6208	1.3050	0.2392	0.5871	0.5836	MGI:1341628	119	XM_011239259|XM_006498606|NM_009730	NP_033860|XP_006498669|XP_011237561	225422	HGNC:885	845	NM_139321,NM_012070,NM_001207047,NM_139322,NM_001323332	NP_001193976,NP_647538,NP_001310261,NP_647537
Exo1	1823;1880;19293;35400	1.6196	0.9543	0.2396	0.5849	0.5836	MGI:1349427	2690	XM_006496863|XM_006496862|NM_012012	XP_006496926|XP_006496925|NP_036142	313522	HGNC:35111	916	NM_006027,NM_003686,NM_001319224,NM_130398	XP_011542625,XP_016858282,NP_006018,XP_011542624,XP_011542627,XP_006711903,NP_001306153,NP_569082,XP_011542623,NP_003677,XP_011542626
Pp2r3c	27;671;27346;34688	1.6184	1.3027	0.2404	0.5836	0.5836	MGI:1930009	5903	NM_021529|XR_381536	NP_067504	99155	HGNC:17485	5501	NM_001305155,NM_001305156,NM_017917	XP_016876878,NP_001292085,NP_001292084,XP_016876877,NP_060387,XP_005267839
Peli1	551;15778;19455;49844	1.6097	1.1005	0.2452	0.5922	0.5922	MGI:1914495	6724	NM_023324|XM_011243746	XP_011242048|NP_075813	23243	HGNC:8827	5716	NM_020651	XP_011531298,XP_005264494,XP_011531299,NP_065702,XP_011531296,XP_016860009,XP_016860010
Rpa	259;	1.5 7	1.2 9	0.2 5	0.6 2	0.6 2	MGI:	23 15	NM_001163461|NM_001289570|XM_006534897|NM_001289569|	NP_001276498|NP_001156934|XP_006534963|NP_001276499|	117	HGNC	798	NM_024813	XP_011540469,XP_016857852,XP_016857853,NP_079089,XP_

p2	706;2764;;8385	756	8611	1111	21411422	71	XM_006534902|NM_144911|XM_011249440|XM_006534901|XM_006534903|NM_001163462|XM_006534900	XP_006534965|XP_006534966|XP_006534960|XP_011247742|XP_006534964|NP_001156933|NP_659160	33	:2579 1	71			016857851,XP_005271280
Xylb	570;7111;4997;6069	1.5718	1.1429	0.2601	0.6216	0.6216	MGI:2142985	1024485	XM_006511908|XM_017313063|NM_001033209|XM_011242927|NM_001199568	NP_001186497|XP_017168552|NP_001028381|XP_011241229|XP_006511971	3746	HGNC:12839	9942	NM_001349179,NM_001349178,NM_001349180,NM_005108	XP_011532627,NP_001336109,XP_016863084,XP_016863089,XP_016863087,XP_016863085,XP_011532631,XP_011532630,XP_016863086,XP_011532632,XP_016863088,NP_005099,XP_011532629,NP_001336108,NP_001336107
Arpc2	577;7533;;2262;;2775	1.5260	1.1178	0.2738	0.6507	0.6507	MGI:1923959	7670 9	XM_006496317|XM_129773	XP_006496380|NP_083987	4187	HGNC:705	101 09	NM_152862,NM_005731	XP_016858604,XP_011508773,NP_690601,XP_016858603,XP_016858602,NP_005722
Pptc7	63;7577;;5026;;61422	1.5218	1.5616	0.2752	0.6508	0.6508	MGI:2444593	3207 17	NM_177242	NP_796216	6100	HGNC:30695	1607 60	NM_139283	NP_644812
Ppp1r2	518;770;;8113	1.5082	1.1282	0.2798	0.6581	0.6580	MGI:1914099	6684 9	NM_025800	NP_080076	4546	HGNC:9288	5504	NM_006241,NM_001291504,NM_001316325,NM_001291505	NP_001278434,XP_006713745,NP_006232,NP_001303254,NP_001278433

	;9492														
Atp7a	12;7744;43622;59822	1.1.1.504149	0.2.8.12	0.6.5.80	0.6.5.80	MGI:994000	1197	NM_001109757|NM_009726	NP_001103227|NP_033856	35	HGNC:8699	538	NM_000052,NM_001282224	NP_000043,NP_001269153	
Rcan1	762;7800;23899;89466	1.4.9.80565	0.2.8.32	0.6.5.93	0.6.5.93	MGI:1890564	5472	NM_019466|NM_001081549	NP_001075018|NP_062339	3251	HGNC:3040	1827	NM_001285389, NM_001285391, NM_203417,NM_001285392,NM_001285393,NM_203418,NM_001331016,NM_004414	NP_004405,XP_005260986,NP_001317945,NP_001272322,XP_016883771,NP_981962,NP_981963,XP_016883772,NP_001272320,XP_005260987,NP_001272318,NP_001272321	
Cdk1	377;804;89111;97900	1.4.7.3739	0.1.7.0315	0.6.7.5252	0.6.7.5252	MGI:883511	1254	NM_007659	NP_031685	68203	HGNC:1722	983	NM_001170406, NM_001130829, NM_001320918, NM_001786,NM_001170407,NM_033379	NP_001163877, NP_001307847, NP_001777,NP_001163878,NP_203698,XP_005270360	
Arfrp1	143;811;73177;90999	1.4.6.671	0.3.9.15	0.6.7.7.39	0.6.7.5.72	MGI:1923938	7668	NM_001165991|XR_867138|NR_028585|NM_001165995|XM_011239965|NM_029702|XR_867137|NM_001165992	NP_083978|NP_001159463|NP_001159467|XP_011238267|NP_001159464	2425	HGNC:662	1039	NM_001267549, NM_001267544, NM_001267546, NM_001267545, NM_001267548, NM_001134758, NM_003224,NM_001267547	NP_001254477, NP_001254475, NP_001254473, XP_016883065, NP_001254478, NP_001254476, XP_011526785, NP_001254474, NP_003215,NP_001128230,XP_011526784	

Irgm1	49813;36577;79477	1.4651	1.1138	0.29466	0.67566	0.67566	MGI:1075667	1594	NM_008326|XM_006532305|XM_011248764	NP_032352|XP_006532368|XP_011247066	#N/A	#N/A	#N/A	#N/A	#N/A
Zc3hc1	13782;12612;43833	1.4574	1.3656	0.29746	0.67866	0.67866	MGI:1916023	23279	XM_017321571|NM_172735|NM_001311086	XP_017177060|NP_001298015|NP_766323	32315	HGNC:29913	5153	NM_016478,NM_001282191,NM_001282190	NP_001269119,XP_011514591,XP_005250460,XP_011514592,NP_057562,XP_016867777,XP_016867776,NP_001269120,XP_011514590
Mrpl42	70824;56955;85477	1.4545	1.0469	0.29866	0.67777	0.67777	MGI:1333774	6720	NM_026065|XM_006513979	XP_006514042|NP_080341	12106	HGNC:14493	2897	NM_172178,NM_172177,NM_014050	NP_751917,NP_054769
Elp4	21342;40733;68244	1.4375	1.2649	0.30551	0.68922	0.68922	MGI:1925016	7766	NM_023876	NP_076365	32433	HGNC:11771	2661	NM_001288726,NM_001288725,NM_019040	NP_001275655,NP_061913,NP_001275654
Ercc6l	83865	1.4163	1.0014	0.31366	0.70492	0.70122	MGI:2656	23693	NM_146235	NP_666347	44945	HGNC:20	5482	NM_001009954,NM_017669	NP_060139,NP_001009954

	;214;398;414										;794				
Slc46a1	51;867;4485;5979	1.4145	1.0828	0.3143	0.7029	0.7012	MGI:1098733	5246	NM_026740	NP_081016	4693	HGNC:30521	113235	NM_001242366, NM_080669	XP_016879599, NP_001229295, NP_542400,XP_005277843
Golph3	474;869;6790;6848	1.4127	1.0967	0.3151	0.7012	0.7012	MGI:1913879	6629	NM_025673|XM_006520143	XP_006520206|NP_079949	5694	HGNC:154552	64083	NM_022130	XP_016865176, NP_071413,XP_016865175
Tmem123	872;873;2241;4690	1.4091	0.9907	0.3167	0.7014	0.7013	MGI:1919179	7129	NM_133739|XM_017313600	XP_017169089|NP_598500	1417	HGNC:301388	114908	NM_052932	NP_443164
Casp9	294;877;7983;9	1.4055	1.1844	0.3182	0.7013	0.7013	MGI:1277950	1237	NM_001277932|NM_015733|XM_017319928	NP_056548|XP_017175417|NP_001264861	3102	HGNC:15111	842	NM_001229,NM_032996,NM_001278054	NP_001220,XP_011540575,XP_005246071,NP_127463,NP_001264983

	212														
Tm7sf3	78;8899;59177;70366	1.3861	0.0993964	0.0327126	0.0716677	0.0716677	MGI:1914873	673	XM_132970|XM_011241630	XP_011239932|NP_080557	9560	HGNC:23049	517	NM_016551	NP_057635,XP_016874952,XP_016874953,XP_005253448,XP_011518993,XP_016874954,XP_011518992,XP_016874955
Haus7	772;9100;32537;70977	1.3766	0.0993937	0.0331232	0.0723096	0.0719696	MGI:1920988	738	NM_028633|NM_207104	NP_996987|NP_082909	12513	HGNC:32979	5559	NM_017518,NM_207106,NM_207107	NP_059988
Nfkb2	439;9133;24417;57733	1.3740	1.0.0916	0.0332525	0.0722296	0.0719696	MGI:1099800	1803 4	NM_019408|NM_001177370|NM_001177369|XM_006526743	NP_001170840|NP_001170841|NP_062281|XP_006526806	1873	HGNC:7795	479 1	NM_001322934,NM_001322935,NM_001077494,NM_001261403,NM_002502,NM_001288724	NP_001275653,NP_002493,XP_011538132,XP_016871767,NP_001070962,XP_011538133,NP_001248332,NP_001309863,NP_001309864
Anapc5	587;9144;42073;47632	1.3732	1.0.0384	0.0332929	0.0719696	0.0719696	MGI:1929722	590 08	NM_001289517|XM_006530429|NM_001289520|NM_001289518|XR_387575|NM_001289519|NM_021505|XM_017321048|NM_001042491	NP_001276446|NP_001276449|NP_001276448|NP_001035956|NP_067480|XP_006530492|NP_001276447|XP_017176537	4118	HGNC:15713	514 33	NM_016237,NM_001137559,NM_001330489	XP_005253957,XP_016874912,NP_001131031,XP_016874913,NP_001317418,NP_057321
Exo	542;	1.3636	1.0.0433	0.0372	0.0372	MGI:	534	XM_006533734|XM_006533733|XM_006533736|XM_006533737|	XP_006533798|XP_006533799|XP_006533795|NP_001156344|	410	HGNC	232	NM_001145298,NM_001145299,NM_015219,NM_001013839,NM	NP_056034,NP_001013861,XP_006721851,XP_016879886,NP_

c7	925;4057;8983	38	79	70	52	52	185927 0	13	XM_006533735|XM_006533732|NM_001162872|NM_001347636|NM_016857	NP_058553|XP_006533797|XP_006533796|XP_006533800|NP_001334565	19	:23214	65	_001145297,NM_001282313,NM_001282314	001138770,XP_011522873,NP_001138771,XP_006721850,NP_001138769,XP_006721852,XP_011522874,NP_001269243,XP_006721849,NP_001269242
Slc38a2	8893;9300;7829;9092	1.3596	0.9630	0.3390	0.7260	0.7260	MGI:1915010	677 60	NM_175121|XM_006521300	NP_780330|XP_006521363	2313 2	HGNC:13448	5440 7	NM_001307936,NM_018976	NP_001294865,NP_061849
Pyurf	559;9447;2670;2690	1.3456	1.0332	0.3460	0.7374	0.7331	MGI:1913709	664 59	NM_025574	NP_079850	4983 2	HGNC:44317	1E+08	NM_032906	NP_116295
Dolk	479;9448;2193;3406	1.3447	1.0608	0.3464	0.7349	0.7331	MGI:2677836	227 697	NM_177648	NP_808316	8940	HGNC:23406	22845	NM_014908	NP_055723
Ap3b1	133;9511;207	1.3423	1.3142	0.3475	0.7338	0.7331	MGI:1333879	174	NM_009680|XM_006517523|XR_001780749|XR_382728	XP_006517586|NP_033810	68125	HGNC:566	8546	NM_001271769,NM_003664	XP_005248675,NP_001258698,NP_003655,XP_016865490,XP_005248676

	2;6530																			
42071	2583;9548;23522;53977	1.1337488	1.1773388	0.0.7331	0.0.7331	0.0.7331	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Trib2	4193;9644;34844;42533	1.1331882	1.1079230	0.0.7353867	0.0.7364	0.0.7364	MGI:2145021	21741 0	XM_006515054|NM_144551|XM_006515055	XP_006515117|XP_006515118|NP_653134	4144 45	HGNC:30809	2895 1	NM_021643	NP_067675						
Igsf8	9077;9666;38700;51777	1.3301	0.9452	0.0.7353	0.0.7371	0.0.7364	MGI:2154090	1405 59	NM_080419	NP_536344	1416 3	HGNC:17813	931 85	NM_052868,NM_001320247,NM_001206665	XP_016858329, NP_001307176, XP_016858324, XP_011508461, NP_001193594, XP_016858327, XP_016858328, NP_443100,XP_016858326,XP_006711694,XP_016858325						
Pik3c3	2203;9699;19955;25488	1.3277	1.2035	0.0.7355	0.0.7364	0.0.7364	MGI:2445019	2253 26	NM_181414|XR_385985	NP_852079	1986	HGNC:8974	5289	NM_002647,NM_001308020	NP_001294949, NP_002638,XP_011524333						

Ecm1	66;9748;37722;55022	10.3238	0.9926	0.3576	0.7379	0.7379	MGI:1030600	136011	NM_001252653|XM_011240009|XM_011240008|NM_007899|XM_006500984|XM_017319450|XM_017319449|XM_006500985	XP_011238310|XP_017174938|NP_031925|XP_006501047|XP_011238311|XP_017174939|XP_006501048|NP_001239582	3260	HGNC:3153	1893	NM_004425,NM_022664,NM_001202858	NP_001189787,NP_004416,NP_073155
Ipmk	135;9800;69599;76066	1.3190	1.2995	0.3600	0.7396	0.7396	MGI:1916968	69718	XM_011243555|NM_001347191|XM_125641|XM_006514056	NP_081460|XP_006514119|NP_001334120|XP_011241857	76214	HGNC:20739	25343 0	NM_152230	XP_011537867,XP_016871502,NP_689416
Atrx	66;9955;21562;6511	1.3073	0.9083	0.3665	0.7495	0.4436	MGI:1030667	22589	XM_011247571|XM_011247563|XM_011247570|XR_878099|XM_011247565|XM_011247562|XR_001782745|XM_011247573|XM_011247564|XM_011247575|XM_011247568|XM_006527948|XM_011247574|XM_011247572|XM_011247569|XM_011247567|XM_011247560|NM_009530|XM_011247561|XM_011247566	XP_011245867|XP_011245871|XP_011245865|NP_033556|XP_011245863|XP_011245866|XP_011245872|XP_011245862|XP_011245874|XP_011245870|XP_011245877|XP_011245869|XP_011245875|XP_011245876|XP_011245868|XP_011245864|XP_011245873|XP_006528011	416	HGNC:886	5463	NM_000489,NM_138271,NM_138270	XP_005262211,XP_016885091,XP_016885098,XP_006724731,XP_016885099,XP_005262213,XP_016885092,NP_000480,XP_016885090,XP_016885095,NP_612114,XP_016885097,XP_005262212,XP_016885100,XP_006724729,XP_016885094,XP_016885096,XP_005262214,XP_005262210,XP_006724730,XP_016885093
Eif2ak4	456;9965;49855;93277	1.3065	1.3058	0.3668	0.7469	0.4436	MGI:1353427	27103	XM_006499625|XM_006499626|XM_017318915|NM_013719|NM_001177806|XM_017318909|XM_006499627	XP_006499688|XP_017174398|XP_006499690|NP_038747|XP_006499689|NP_001171277|XP_017174404	4089 1	HGNC:19687	4402 75	NM_001013703	XP_011519901,XP_016877708,XP_005254449,XP_011519902,NP_001013725
Nec	88;	1.33	1.33	0.33	0.77	0.77	MGI	6611	XR_881436|XR_001784179|XR_390777|NM_025	NP_079659	91	HGN	5557	NM_001145277,NM_001145278,NM_018090	XP_011540069,NP_001138750,XP_016857210,

ap2	9;2079;8047	0.5022	8.2276	6.7451	4.3436	:19139397	47	383|XR_001784178|XR_001784177			68	C:25528	07		NP_001138749, NP_060560
Kat2a	9;10000;30855;52227	1.3034	0.9195	0.3685	0.7436	0.7436	MGI:1343101	145	XM_017314273|NM_020004|NM_001038010|XM_017314270|XM_017314272|XM_017314271	XP_017169760|NP_001033099|NP_064388|XP_017169759|XP_017169761|XP_017169762	413433	HGNC:4201	2648	NM_021078	XP_006721880, XP_016879937, XP_006721881, NP_066564
Fkrp	54;10007;37463;37773	1.2981	1.0153	0.3715	0.7463	0.7463	MGI:2447586	243853	XM_006539928|XM_006539930|NM_173430|XM_011250562|XM_006539929	NP_775606|XP_006539991|XP_011248864|XP_006539993|XP_006539992	11513	HGNC:17997	79147	NM_024301,NM_001039885	XP_005259305, XP_011525609, NP_001034974, XP_011525608, XP_005259304, XP_016882786, XP_005259306, NP_077277
Slmap	225;10226;26911;51400	1.2867	1.1784	0.3778	0.7556	0.7568	MGI:1933549	839397	XM_017316227|XM_006519735|XM_006519729|XM_017316229|XM_006519738|XM_006519733|XM_017316228|XM_006519726|XM_006519731|XM_006519734|XM_006519728|NM_001310445|XM_006519732|XM_006519730|NM_001347494|XM_006519725|XM_006519737|NM_032008|XM_006519736|XM_006519727	XP_006519793|XP_006519790|XP_006519792|XP_006519797|XP_006519796|XP_006519798|NP_114397|XP_006519801|XP_017171718|XP_006519789|XP_006519791|XP_006519794|XP_006519788|NP_001297374|XP_006519800|XP_017171716|NP_001334423|XP_017171717|XP_006519795|XP_006519799	31428	HGNC:16643	78711	NM_007159,NM_001311178,NM_001304421,NM_001311179,NM_001304422,NM_001304423,NM_001304420	XP_016862658, NP_001291351, XP_016862635, XP_016862648, XP_016862645, XP_016862647, XP_005265516, XP_016862655, XP_016862657, XP_016862659, XP_016862652, XP_005265514, XP_016862649, XP_016862640, XP_011532405, XP_005265528, XP_011532408, XP_005265525, NP_001298108, NP_009090,XP_005265518,XP_016862654,XP_005265522,XP_011532406,XP_016862653,XP_016862641,XP_

														005265527,XP_016862656,XP_016862646,XP_016862644,XP_005265524,XP_016862650,XP_006713389,XP_005265519,NP_001298107,XP_016862637,XP_016862651,XP_005265529,XP_005265515,XP_016862642,XP_005265517,NP_001291350,XP_005265521,XP_016862638,XP_011532407,XP_005265513,XP_016862643,NP_001291349,NP_001291352,XP_016862636,XP_016862639,XP_005265523
Sharpin	38;1029;8387;8956	1.2814	1.0681	0.0381393	0.0759386	MGI:1913331	1061025	NM_025340|XR_383966|XM_011245399|XM_011245398|XM_006520263	XP_006520326|XP_011243701|NP_079616|XP_011243700	1191	HGNC:25321	818581	NM_030974	XP_016869377,XP_016869376,NP_112236
Sp3	38;1032;3323;9832	1.2792	1.0700	0.0382786	0.0758586	MGI:1277166	2068687	NM_001018042|NM_001098425	NP_001018052|NP_001091895	7952	HGNC:11208	66701	NM_001172712,NM_003111,NM_001017371	NP_001166183,NP_003102,NP_001017371
Rasa1	142;1064;52477	1.2558	1.2574	0.0397852	0.0785220	MGI:978600	2183977	NM_145452|XM_011244518	XP_011242820|NP_663427	2168	HGNC:9871	59211	NM_002890,NM_022650	XP_011541829,XP_011541827,NP_002881,NP_072179

	;78633															
Pi4k2b	146;10733;44588;73944	1.2494	1.2484	0.40211	0.79022	0.79022	MGI:1914323	673	XM_006504064|NM_028744|NM_025951	NP_083020|XP_006504127|NP_080227	3240	HGNC:18215	553	NM_018323	XP_005248232, NP_060793,XP_005248231
Hbegf	9088;10773;46088;70566	1.24663	0.90333	0.40339	0.79044	0.79044	MGI:960770	1520	NM_010415	NP_034545	1466	HGNC:30599	1839	NM_001945	NP_001936
Cdk20	70;10895;74833	1.23819	0.93895	0.40950	0.79801	0.79801	MGI:2145349	1052	XR_001780743|NM_053180|XR_001780740|XM_006517033|XR_001780742|XR_001780741	XP_006517096|NP_444410	8109	HGNC:21420	2352	NM_178432,NM_012119,NM_001170640,NM_001039803,NM_001170639	XP_016870050, XP_016870052, NP_001034892, XP_016870051, NP_848519,NP_036251,NP_001164110,XP_016870053,NP_001164111
Snx18	215;10973;28377;87	1.23266	1.16066	0.41033	0.80188	0.79061	MGI:2137642	1706	NM_130796	NP_570614	14164	HGNC:19245	1125	NM_001102575, NM_052870,NM_001145427	XP_016864486, NP_001138899, NP_443102,NP_001096045

Arfgef2	40613;10983;43422;76999	1.2319601	1.9604138	1.9479361	1.7961	MGI:2139354	993771	XM_011239875|XM_006500484|XM_006500483|NM_001085495	XP_006500546|XP_011238177|XP_006500547|NP_001078964	111880	HGNC:15853	10564	NM_006420	NP_006411,XP_005260309
Prkacb	68523;10005;43522;48811	1.2305	1.9404048	1.9480	1.7961	MGI:975594	18749	NM_001164198|NM_011100|NM_001164200|NM_001164199	NP_035230|NP_001157671|NP_001157670|NP_001157672	121718	HGNC:9381	55667	NM_182948,NM_001242862,NM_001242860,NM_001300915,NM_207578,NM_001300916,NM_001300917,NM_001242861,NM_001242858,NM_001242857,NM_002731,NM_001242859	XP_016857199,NP_891993,XP_016857207,XP_016857203,NP_001229786,NP_001287846,NP_001287845,NP_997461,XP_016857200,XP_005271075,XP_016857208,XP_016857201,XP_016857195,XP_016857206,NP_001229790,XP_016857202,NP_001229791,NP_002722,XP_016857196,NP_001229787,XP_016857205,NP_001229789,XP_016857209,XP_005271073,XP_005271072,XP_016857197,XP_005271076,XP_016857204,NP_001229788,XP_016857198,XP_005271074,XP_005271077,XP_006710821,NP_001287844
Pdgfc	100113;11022;28633;94866	1.2291	1.2802	1.5967	1.7961	MGI:1859631	54635	XM_006501712|XM_017319655|NM_019971	NP_064355|XP_006501775|XP_017175144	9423	HGNC:8801	56034	NM_016205	XP_011530426,NP_057289,XP_016863944,XP_016863945

Stk11	49;110;7106;8973	10.29.41.79.61	0.0.0.0.0	MGI:1341870	208	NR_126043|XM_006513443|XM_006513442|NM_011492|XM_006513439|NM_001301853|NM_001301854|XM_006513441	NP_001288782|XP_006513504|XP_006513506|NP_001288783|XP_006513505|XP_006513502|NP_035622	393	HGNC:11389	679 4	NM_000455	XP_005259674,NP_000446,XP_011526511,XP_005259675
Ppp1r12c	204;110;2126;8939	11.21.67.19.63	0.0.0.0.0	MGI:1924258	2307	XR_881691|XM_006539767|NM_029834|XR_391056|XM_011250502	XP_006539830|XP_011248804|NP_084110	75071	HGNC:14947	547 76	NM_017607,NM_001271618	NP_060077,NP_001258547,XP_005259070,XP_011525347
Elp3	97;118;3956;8511	11.23.42.80.98	0.0.0.0.0	MGI:1921445	7419 5	NR_045599|NM_001253812|NM_028811	NP_083087|NP_001240741	7105	HGNC:20696	551 40	NM_001284222,NM_001284225,NM_001284224,NM_001284226,NM_001284220,NM_018091	NP_001271154,NP_060561,XP_016869093,NP_001271149,NP_001271153,NP_001271151,XP_006716417,NP_001271155
Uhmk1	501;112;624;9948	10.29.42.80.98	0.0.0.0.0	MGI:1341908	1658 9	NM_010633|XM_006496682	NP_034763|XP_006496745	7801	HGNC:19683	127 33	NM_001184763,NM_144624,NM_175866	NP_787062,NP_653225,NP_001171692
Chkb	249;21	11.12	0.0.0.0.0	MGI:216	1260	NR_037154|NR_037153|NM_007692	NP_031718	887	HGNC:1120	1 0	NM_005198,NM_152253	NP_005189

	112;358;756;565	41	18	65	02	88	1328313	51			18	:1938		
Prkd2	497;113;0;418;1;463;7	1.210167	0.98642943	0.80238	0.7988	MGI:2141917	1015401	NM_178900|NM_001252458|XR_391036|XM_006539444	NP_849231|NP_001239387|XP_006539507	9516	HGNC:17293	2586 5	NM_001079880, NM_001079882, NM_001079881, NM_016457	XP_005258773, NP_001073349, NP_001073350, NP_001073351, NP_057541
Snx3	968;113;3;2357;;6425	1.208145	0.87430	0.80188	0.7988	MGI:1860188	541988	NM_017472	NP_059500	36144	HGNC:11174	8724	NM_152828,NM_001300928,NM_003795,NM_152827,NM_001300929	NP_001287858, NP_001287857, NP_690040,NP_003786
Bnc2	127;113;5;339;3;9612	1.220568	0.54361	0.80419	0.7988	MGI:2443805	242509	XM_017320209|NM_172870|XM_017320207|XM_017320203|XM_017320211|XM_017320213|XM_006537933|XM_017320208|XM_017320212|XM_006537940|XM_017320205|XM_017320214|XM_017320204|XM_017320206|XM_017320210	XP_017175696|XP_006538003|XP_017175700|XP_017175692|NP_766458|XP_017175703|XP_017175702|XP_017175697|XP_017175699|XP_017175693|XP_006537996|XP_017175695|XP_017175701|XP_017175694|XP_017175698	18243	HGNC:3098	54796	NM_001317940, NM_017637,NM_001317939	NP_001304868, XP_016870314, XP_016870305, NP_001304869, XP_011516236, XP_016870306, XP_016870307, XP_016870313, XP_011516226, XP_016870317, XP_016870316, XP_016870312, XP_016870310, XP_016870315, XP_016870308, NP_060107,XP_016870311,XP_016870318,XP_016870309
Itga5	306;11	1.205465	0.07328	0.79888	0.7988	MGI:96	16402	NM_001314041|NM_010577	NP_034707|NP_001300970	20508	HGNC:6	3678	NM_002205	NP_002196

	37;23233;;74166					604					141				
Etnk1	837;11535;70542;71122	1.19490	0.8940076	0.4410070	0.8107076	MGI:1922570	753 20	XM_006507012|XM_006507011|NM_029250	NP_083526|XP_006507074|XP_006507075	1024 0	HGNC:24649	55 00	NM_001039481, NM_018638	XP_016875070, NP_061108,NP_001034570,XP_016875069,XP_005253477
Gata3	285;11544;73211;98222	1.19422	1.0844 9	0.4412 76	0.8076 76	MGI:956663	1462	NM_008091|XM_006497355|XM_006497354	XP_006497418|XP_006497417|NP_032117	1550 0	HGNC:4172	26 25	NM_002051,NM_001002295	NP_002042,XP_005252500,NP_001002295,XP_005252499
Synj1	1055;11700;24333;66229	1.18539	0.8449 3	0.8199 2	0.8132	MGI:1354961	1040 115	XM_017316841|XM_017316838|XM_011246083|XM_006522846|XM_011246076|NM_001164483|XM_011246089|XM_017316840|XM_011246084|XM_011246078|XM_017316836|XM_011246082|XM_017316837|XM_011246077|XM_011246080|XM_006522837|XR_876128|XM_011246075|XM_011246088|XM_017316839|XM_011246081|NM_001045515|XM_011246087|XM_011246079|XM_011246085	XP_017172329|XP_011244380|XP_006522909|XP_011244377|XP_017172325|XP_011244387|XP_011244390|XP_011244378|XP_011244391|XP_011244383|XP_017172327|XP_011244379|XP_017172328|NP_001157955|XP_017172326|XP_011244389|XP_011244382|XP_006522900|XP_011244381|XP_011244386|NP_001038980|XP_017172330|XP_011244384|XP_011244385	4825 2	HGNC:1503	88 67	NM_003895,NM_001160302,NM_001160306,NM_203446	NP_001153778, NP_001153774, XP_016883991, XP_016883987, XP_016883983, XP_016883986, XP_016883989, XP_016883988, XP_016883993, XP_016883984, XP_016883990, NP_982271,XP_016883994,XP_016883985,XP_016883992,NP_003886

Plec	128;1171;3418;6453	1.1832	1.2427	0.044969	0.081669	0.08132	MGI:1277961	180	NM_201394|NM_001163542|NM_201392|NM_201390|NM_001164203|NM_201386|NM_001163540|NM_011117|NM_201387|NM_201388|NM_201393|NM_001163549|NM_201389|NM_201385|NM_201391	NP_958796|NP_958793|NP_958794|NP_958788|NP_001157021|NP_001157014|NP_958790|NP_035247|NP_958789|NP_958792|NP_958787|NP_001157675|NP_958791|NP_001157012|NP_958795	384	HGNC:9069	539	NM_201378,NM_201382,NM_000445,NM_201380,NM_201383,NM_201379,NM_201381,NM_201384	XP_006716653,XP_005251040,NP_958784,XP_005251036,XP_011515432,XP_005251037,XP_006716651,XP_006716652,NP_958780,XP_005251039,NP_958783,NP_000436,XP_005251033,XP_005251038,XP_011515434,XP_005251041,XP_011515433,XP_005251035,NP_958781,NP_958786,NP_958785,NP_958782
Eif2ak3	731;1172;2243;2845	1.18266	0.0905	0.045046	0.081466	0.08132	MGI:1341830	166	XM_011241202|XM_006505501|NM_010121|NM_001313918	XP_006505564|NP_034251|NP_001300847|XP_011239504	3557	HGNC:32555	9451	NM_004836,NM_001313915	XP_016860865,NP_004827,NP_001300844
Ppp1cc	555;1178;4036;5454	1.17871	0.095111	0.045341	0.081668	0.08132	MGI:1048722	1947	XM_006530200|NM_013636	NP_038664|XP_006530263	13542 3	#N/A	#N/A	#N/A	#N/A
Faf1	1057;1180;4955;7355	1.17775	0.084666	0.045444	0.081554	0.08132	MGI:1094199	1404	NM_007983	NP_032009	5120	HGNC:35778	1124	NM_131917,NM_007051	NP_008982,XP_016855625

Tpr	410;1181;8816;93755	1.1768	1058	0.4550	0.8132	0.8132	MGI:1922066	1089	NM_133780|XM_006529065	NP_598541|XP_006529128	37753	HGNC:12017	7175	NM_003292	NP_003283
Ehd2	380;1188;42116;96777	1.1724	1018	0.4587	0.8167	0.8154	MGI:2154274	25930	NM_153068|XM_011250582	NP_694708|XP_011248884	22825	HGNC:32433	30846	NM_014601	NP_055416
Ehmt1	736;1190;8809;8854	1.1711	1898	0.4598	0.8154	0.8154	MGI:1924933	7683	XM_017319336|XM_006498423|XM_006498432|XM_006498422|XM_017319335|XM_006498425|XM_006498429|XR_374136|XM_006498427|XM_006498426|XM_006498431|NM_001012518|XM_006498424|NM_172545|NM_001109687|XM_006498430|NM_001109686	XP_006498492|XP_006498495|XP_006498493|XP_006498488|XP_006498489|XP_017174824|XP_006498487|NP_001012536|NP_766133|NP_001103156|XP_017174825|NP_001103157|XP_006498486|XP_006498485|XP_006498494|XP_006498490	11698	HGNC:24650	79813	NM_001145527,NM_024757	XP_011517325,XP_016870625,XP_011517324,XP_005266167,XP_016870624,XP_011517328,XP_011517331,XP_011517330,XP_011517326,XP_011517329,XP_006717351,NP_001138999,XP_005266162,NP_079033,XP_016870623,XP_011517335,XP_016870626,XP_016870627,XP_011517323,XP_011517333,XP_011517332,XP_011517327
Arl4a	926;1198;29800;80	1.1661	8601	0.4638	0.8194	0.8186	MGI:1994337	1161	NM_001039515|NM_007487	NP_031513|NP_001034604	4194	HGNC:6955	1012	NM_001037164,NM_005738,NM_001195396,NM_212460	NP_997625,NP_001182325,NP_005729,NP_001032241

	68														
Anapc4	324;1202;5186;9813	1.1636	1.0445	0.4659	0.8199	0.8186	MGI:1098673	52206	NM_024213	NP_077175	40873	HGNC:19990	29945	NM_013367,NM_001286756	XP_005248216,NP_037499,NP_001273685,XP_011512140,XP_011512141,XP_016863627
Gdnf	563;1205;3001;3358	1.1618	0.9401	0.4674	0.8193	0.8186	MGI:107430	14573	NM_010275|NM_001301357|NM_001301332|NM_001301333	NP_001288262|NP_001288261|NP_001288286|NP_034405	433	HGNC:4232	2668	NM_199231,NM_199234,NM_001278098,NM_001190468,NM_000514,NM_001190469	XP_011512332,NP_954701,NP_001265027,XP_016864826,NP_001177398,NP_001177397,NP_000505
Dpysl2	775;1212;4049;7174	1.1574	0.8835	0.4713	0.8230	0.8186	MGI:1349763	12934	NM_009955|XM_006518508	XP_006518571|NP_034085	74392	HGNC:3014	1808	NM_001197293,NM_001386,NM_001244604	NP_001184222,NP_001231533,NP_001377
Smarcad1	417;1213;3754;6284	1.1568	0.9926	0.4718	0.8207	0.8186	MGI:95453	13990	NM_001253392|XM_006505512|XM_006505513|XM_011241205|XM_132597|XR_001785096|XM_006505510|XM_006505509	NP_031984|XP_006505575|XP_006505573|XP_006505576|NP_001240321|XP_006505572|XP_011239507	5301	HGNC:18398	56916	NM_020159,NM_001254949,NM_001128429,NM_001128430	NP_064544,NP_001121901,NP_001241878,XP_016863953,NP_001121902,XP_016863952,XP_016863954

Map2k4	412;1214;4375;9459	1.1562	0.1994626	0.0472486	0.0818486	0.0818686	MGI:1346869	2639	XM_011249033|XM_017314561|XM_006533370|NM_009157|NM_001316367|NM_001316369|NM_001316368	XP_011247335|XP_006533433|XP_017170050|NP_001303298|NP_001303296|NP_033183|NP_001303297	4815	HGNC:6844	6416	NM_003010,NM_001281435	XP_011522279,NP_001268364,XP_011522278,NP_003001,XP_005256810,XP_005256812
C2cd5	1068;1220;7286;8667	1.1525	0.1832756	0.0482100	0.0821100	MGI:1921991	7417	XM_017321802|XM_017321803|XM_006507007|XM_017321800|NM_029897|XM_017321804|XR_001785182|XM_017321797|XM_017321798|XM_017321801|XM_017321813|XM_006507009|XM_017321799|XM_017321806|XM_006507003|XM_017321812|NM_001109688|XM_017321810|XM_017321796|XM_017321809|XM_017321805|XM_017321807|XM_017321811|XM_017321808|NM_001286578|XR_001785180|XM_006506997|XR_001785181|NM_029081	XP_017177300|XP_017177287|XP_017177299|XP_017177289|XP_017177291|XP_017177298|XP_017177293|XP_017177294|XP_017177285|NP_083357|XP_006507060|NP_001273507|XP_017177292|XP_017177302|XP_017177297|XP_017177290|XP_017177295|XP_017177288|XP_017177286|XP_017177296|XP_017177301|NP_001103158|XP_006507066|XP_006507070|NP_084173|XP_006507072	8873	HGNC:29062	9847	NM_001286173,NM_001286175,NM_014802,NM_001286177,NM_001286174,NM_001286176	NP_001273104,XP_016875755,XP_016875756,XP_016875758,XP_005253595,XP_016875764,XP_016875767,XP_016875765,NP_001273102,NP_001273106,XP_016875753,XP_016875768,NP_001273103,XP_016875760,XP_016875762,XP_016875763,XP_016875766,NP_055617,XP_016875754,XP_005253596,XP_006719233,XP_016875759,XP_016875761,NP_001273105,XP_016875757
Psme1	267;1224;2057;4990	1.1501	0.1075877	0.0472715	0.0821414	MGI:1096367	1918	NM_011189	NP_035319	4560	HGNC:9568	5720	NM_001281529,NM_001281528,NM_006263,NM_176783	NP_001268458,NP_788955,NP_006254,NP_001268457
Pim2	283;1229;2	1.1470	0.1062707	0.0480202	0.0822714	MGI:1975887	1871	NM_138606	NP_613072	1709	HGNC:8987	11040	NM_006875	NP_006866

	643;536														
Sp100	38;1231;6204;9131	1.1408581	1.0.0.1	0.4.8.1	0.8.2.1	0.2.1.4	MGI:1095611	206841	NM_013673|XM_006529286|XM_006529281|NM_001313714|XM_006529282|NM_001313713|XM_017319443|XM_006529283|XM_006529288|XM_006529285|NM_001313712|XM_006529284|XM_006529280|XM_017319442|XM_011247950	XP_006529345|XP_006529346|NP_001300643|NP_001300641|XP_006529348|NP_038701|XP_017174932|NP_001300642|XP_006529349|XP_006529344|XP_006529351|XP_017174931|XP_011246252|XP_006529343|XP_006529347	867611	#N/A	#N/A	#N/A	#N/A
Mef2c	12;1237;4091;5864	1.1.1.2	0.8.4.1	0.4.8.1	0.2.4.2	0.0.0.1	MGI:994581	172602	XM_017315409|NM_001347572|NM_001347573|NM_001347569|NM_001170537|XM_011244495|XM_017315406|XM_006517126|NM_001347568|NM_001347581|XM_017315408|XM_017315407|XM_006517120|NM_001347567|NM_001347578|NM_001347580|NM_025282|XM_006517130|XM_011244492|NM_001347574|NM_001347577|XM_006517129|NM_001347579|XM_006517124|NM_001347576|XM_006517128|XM_006517132|NM_001347575|XM_017315410|NM_001347566|XM_006517121|NM_001347564|XM_006517122|XM_017315405|NM_001347571|XM_017315411|XM_006517123|XM_006517131|XM_006517127	XP_017170900|XP_006517187|NP_001334501|XP_017170898|XP_011242797|NP_001334500|NP_001334497|NP_001334503|NP_001334493|XP_006517190|NP_001334496|XP_017170895|XP_006517191|NP_001164008|NP_079558|NP_001334507|XP_006517189|XP_006517193|NP_001334498|NP_001334505|XP_006517186|NP_001334510|XP_017170896|XP_017170897|XP_017170894|NP_001334509|NP_001334495|XP_006517183|XP_006517185|XP_006517194|XP_006517184|XP_006517195|NP_001334506|NP_001334508|NP_001334502|NP_001334504|XP_006517192|XP_017170899|XP_011242794	310871	HGNC:6996	42;08	NM_001193347,NM_001131005,NM_002397,NM_001308002,NM_001193349,NM_001193350,NM_001193348	XP_011541698,NP_001180279,XP_016864968,XP_016864970,NP_001180277,XP_005248568,NP_001294931,XP_016864969,XP_011541703,NP_001124477,NP_001180278,XP_011541702,XP_016864965,XP_016864971,XP_016864964,XP_016864966,XP_006714688,NP_002388,XP_016864967,XP_006714682,NP_001180276,XP_016864972,XP_011541699
Plin2	890;12435;5	1.1.3.3	0.8.4.8	0.8.2.6	0.8.2.5	0.2.5.2	MGI:879201	115201	XM_006537557|XM_011249907|NM_007408	XP_011248209|XP_006537620|NP_031434	872	HGNC:2488	123	NM_001122	NP_001113,XP_016869748

	230;625														
Dnaja1	450;1249;4328;6965	1.1350	0.9675	0.0491.10	0.0828.7	0.0825.2	MGI:127012 9	155.02	NM_008298|NM_001164671|NM_001164672	NP_001158143|NP_032324|NP_001158144	5578	HGNC:5229	33.01	NM_001314039,NM_001539	NP_001530,NP_001300968
Hyal2	347;1253;4401;5600	1.1327	0.1015.6	0.0493.4	0.0829.7	0.0825.2	MGI:119634	155.87	XM_006511643|XM_006511644|NM_010489|XM_006511645	NP_034619|XP_006511706|XP_006511707|XP_006511708	776	HGNC:53211	86.92	NM_003773,NM_033158	XP_005265581,XP_005265582,NP_003764,NP_149348
Hsd17b7	1238;1254;5685;7185	1.1321	0.0803.1	0.0494.40	0.0827.6	0.0825.2	MGI:133080 8	154.90	XM_011238758|XM_006496667|NM_010476|XM_017317108	XP_017172597|XP_011237060|XP_006496730|NP_034606	4078	HGNC:52155	51.478	NM_016371,NM_001304513,NM_001304512	NP_001291442,NP_057455,NP_001291441
Acsl3	323;1256;382	1.1309	0.0287	0.0495.52	0.0826.65	0.0825.2	MGI:192145 5	742.05	NM_001033606|XM_129894|NM_001136222	NP_083093|NP_001129694|NP_001028778	3278	HGNC:3570	21.81	NM_004457,NM_203372	NP_976251,XP_016859073,NP_004448

5;8206															
Ptk2	839;12585;8934;9628	10.1852970	0.4962	0.8252	0.8252	MGI:954811	140383	XR_383981|XM_006520421|XM_006520418|XM_006520434|XM_011245452|XM_011245453|XM_006520426|XM_006520420|XM_006520423|XM_006520416|XM_006520425|XM_006520432|XM_006520428|XM_006520427|XM_017316429|XM_006520435|XM_006520431|XM_006520415|XM_006520424|XM_006520429|NM_007982|XM_006520430|XM_006520433|XM_006520422|XR_001781493|NM_001130409|XM_017316428	NP_032008|XP_006520491|XP_006520484|XP_006520490|XP_011243755|XP_017171918|XP_006520485|XP_006520478|XP_006520496|XP_006520495|NP_001123881|XP_006520487|XP_006520498|XP_006520479|XP_017171917|XP_006520497|XP_006520486|XP_006520488|XP_006520494|XP_006520481|XP_006520483|XP_011243754|XP_006520489|XP_006520493|XP_006520492	73143	HGNC:9611	57474	NM_001352733,NM_001352697,NM_001352716,NM_001352746,NM_001352738,NM_001352752,NM_001352706,NM_001352740,NM_001352747,NM_001352723,NM_001352735,NM_001352732,NM_001352709,NM_001352701,NM_153831,NM_001352703,NM_001352712,NM_001352737,NM_001352741,NM_001352717,NM_001199649,NM_001352707,NM_001316342,NM_001352743,NM_001352720,NM_001352695,NM_001352699,NM_001352718,NM_001352711,NM_001352694,NM_001352745,NM_001352704,NM_001352700,NM_001352751,NM_001352724,NM_001352736,NM_001352708,NM_001352748,NM_001352730,NM_001352734,NM_001352750,NM_001352714,NM_001352713,NM_001352727,NM_001352726,NM_001352710,NM_001352696,NM_001352728,NM_001352698,NM_001352744,NM_001352742,NM_001352705,NM_005607,NM_001352722,NM_001352749,NM_001352731,NM_001352719,NM_001352721,NM_001352729,NM_001352725,NM_001352739,NM_001352715,NM_001352702	XP_016869172,NP_001339624,XP_016869145,XP_016869164,XP_016869155,XP_006716671,NP_001339671,XP_016869165,NP_001339679,XP_016869173,XP_016869169,XP_016869148,XP_016869176,NP_001339680,XP_005251070,NP_001339650,NP_001339658,NP_001339672,XP_016869159,XP_016869153,XP_016869162,NP_001339668,NP_001339627,XP_016869150,XP_016869178,NP_001339642,NP_001339667,NP_001339654,NP_001339665,XP_016869163,XP_016869144,NP_001339656,NP_001339655,NP_001339651,NP_001339628,NP_001339633,XP_016869154,NP_001339681,NP_001339636,NP_001339631,NP_001339634,XP_016869167,NP_001339629,NP_001339666,XP_016869147,XP_016869177,XP_016869158,NP_001339669,XP_005251069,NP_001339647,NP_001339677,XP_016869175,XP_005251060,NP_001339659,NP_001339644,NP_001339662,NP_001339645,NP_001339635,XP_016869166,NP_001339661,NP_001303271,XP_016869156,NP_001339632,NP_001339639,NP_001339673,XP_016869142,NP_001339623,NP_001339678,NP_001339643,

															XP_016869141, NP_001339674, NP_001339649, NP_001339625, NP_001339653, NP_001339657, XP_011515496, NP_005598,XP_016869146,NP_001339630,NP_001186578,NP_001339638,NP_001339626,XP_016869151,NP_001339641,NP_001339660,XP_016869171,XP_016869161,NP_001339675,NP_001339646,XP_016869143,XP_016869179,NP_001339637,NP_001339663,XP_016869152,XP_016869168,XP_016869174,XP_006716673,NP_001339648,XP_006716672,NP_001339676,NP_001339664,XP_016869140,XP_016869149,XP_016869170,NP_001339652,NP_001339670,XP_016869160,NP_001339640,NP_722560,XP_016869157
Mesdc2	627;12664;53794;71644	1.1216	0.1903	0.4994	0.8275	0.8275	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Usp6nl	484;1271;2000;;56	1.1221	0.1947	0.5033	0.8309	0.8297	MGI:2138893	9890	XM_011238992|XM_006497570|XM_006497569|XM_006497568|XM_011238993|NM_001080548|NM_181399	NP_852064|XP_006497631|XP_011237295|XP_011237294|NP_001074017|XP_006497632|XP_006497633	6879	HGNC:16858	9712	NM_014688,NM_001080491	NP_055503,XP_011518064,XP_006717605,XP_011518065,NP_001073960,XP_016872461,XP_016872460,XP_016872462

Shb	08615;12733;57900;70788	1.1.19041	0.0.50447	0.0.82977	0.0.82977	MGI:98294	2301266	NM_001033306	NP_001028478	74458	HGNC:10838	64661	NM_003028	NP_003019
Ambra1	41815;12858;78588;97299	1.1.19708	0.0.51100	0.0.83755	0.0.83755	MGI:2443564	2283261	NM_172669|XM_006499252|NM_001080754|XM_006499253	XP_006499316|NP_766257|XP_006499315|NP_001074223	18204	HGNC:25990	55626	NM_001300731, NM_001267782, NM_017749,NM_001267783	XP_006718323, NP_001254712, XP_005253068, XP_016873497, XP_005253071, XP_005253066, NP_001287660, NP_001254711, XP_016873496, XP_006718322, NP_060219
Glrx3	45113;12933;41277;69711	1.1.10942	0.0.51555	0.0.84119	0.0.84119	MGI:1353653	3092616	XM_006507916|NM_023140|XR_001785568|NM_001348093	XP_006507979|NP_075629|NP_001335022	47699	HGNC:15987	10539	NM_001321980, NM_001199868, NM_006541	NP_001186797, NP_006532,NP_001308909,XP_016870963
Elin2	18812;12977;35588;98288	1.1.10712	1.1.25178	0.0.84225	0.0.84225	MGI:2387215	2443273	NM_153592|XM_006509116|XM_006509115|XM_006509114|XM_006509117	XP_006509179|NP_705820|XP_006509180|XP_006509177|XP_006509178	51933	HGNC:13556	11160	NM_001003791, NM_001003790, NM_007175	NP_001003791, NP_009106,XP_006716343,NP_001003790,XP_016868489,XP_005273449

Pstk	128;1306;5554;6455	10.1020	0.7833	0.5229	0.8478	0.8478	MGI:2685945	2145801	XM_006507557|XM_006507555|XM_006507556|NM_001039534	XP_006507620|XP_006507619|NP_001034623|XP_006507618	4516 7	HGNC:28578	1186 72	NM_153336	NP_699167,XP_016871129,XP_016871130
Adipor2	1091;1316;2678;5039	10.0964	0.8018	0.5288	0.8543	0.8502	MGI:9383830	6846 65	XM_011241448|XM_006506538|NM_197985	NP_932102|XP_006506601|XP_011239750	5611 9	HGNC:24041	7960 2	NM_024551	XP_011519326,XP_005253846,XP_006719081,NP_078827
Lin7c	536;1321;5990;6149	10.0936	0.9148	0.5316	0.8558	0.8502	MGI:1330839	22343 3	NM_011699	NP_035829	2264 9	HGNC:17789	5532 7	NM_018362	NP_060832
Pank2	979;1324;2069;6074	10.0920	0.8148	0.5333	0.8555	0.8502	MGI:1921700	7445 0	XR_001783192|XM_017319300|XM_017319299|XM_006500300|XR_001783191|XM_006500299|NM_153501|XM_017319298|XM_006500298	XP_017174787|XP_006500362|XP_006500361|NP_705721|XP_017174788|XP_006500363|XP_017174789	6512 6	HGNC:15894	8025	NM_024960,NM_153640,NM_153641,NM_001324191,NM_001324193,NM_153637,NM_153638,NM_001324192,NM_153639	NP_079236,XP_005260892,NP_705902,XP_016883568,XP_016883566,NP_001311121,XP_016883567,XP_005260893,NP_001311122,XP_011527666,XP_011527667,NP_001311120,NP_705904

Hspb1	10633;13288;39977;71977	10.0898	0.08020	0.53556	0.85611	0.85022	MGI:962400	1507	NM_013560	NP_038588	1180	HGNC:52466	3315	NM_001540	NP_001531
Ajuba	37763;13300;61655;77711	10.0886	0.09782	0.53567	0.85502	0.85022	MGI:1341886	16475	NM_010590	NP_034720	7789	HGNC:202550	8496	NM_032876,NM_001289097,NM_198086	NP_932352,NP_116265,NP_001276026
Prkag1	34833;41100;53411	10.0870	0.09233	0.53844	0.85462	0.85022	MGI:1084111	19082	XM_011245520|NM_016781	XP_011243822|NP_058061	99712	HGNC:9385	5571	NM_001206710,NM_002733,NM_001206709,NM_212461	XP_011536864,XP_016875111,XP_005269077,XP_005269076,XP_006719562,NP_002724,XP_016875112,NP_001193639,NP_001193638
Socs3	88633;13366;23411;36911	10.0853	0.08264	0.54004	0.85402	0.85022	MGI:1201791	12702	NM_007707|XM_011248707	NP_031733|XP_011247009	29411	HGNC:193991	9021	NM_003955	NP_003946

Grk6	81;137;223;267	10.0854022:1347078	00.0852:635	NM_011938|XM_006517252|NM_001286064|NM_001286063|NM_001112711|XM_006517251|NM_001286066|NM_001286065|NM_001038018	XP_006517315|NP_001106182|NP_001272993|NP_036068|NP_001272995|XP_006517314|NP_001272994|NP_001033107|NP_001272992	375:GNC:545	28	NM_002082,NM_001004106,NM_001004105	NP_002073,NP_001004105,XP_011532840,XP_006714921,XP_011532839,XP_006714922,NP_001004106
Lya6	126;133;173;265	10.0754022:1075275	00.0852:1045	NM_010738|NM_001271419|NM_001271446|NM_001271416|NM_001271418|NM_001271417	NP_001258346|NP_001258375|NP_034868|NP_001258345|NP_001258347|NP_001258348	#N/A	#N/A	#N/A	#N/A	#N/A
Ewsr1	74;134;290;411	10.0854022:1399600	00.0856:1030	NM_001283063|NM_007968|XM_017314255|NM_001283062|XM_006514508|NM_001283061|XM_006514512|XM_006514509|XR_001779874|XM_006514510|XM_006514511	NP_031994|NP_001269991|XP_006514573|NP_001269990|XP_006514574|XP_017169744|NP_001269992|XP_006514575|XP_006514572|XP_006514571	134632	#N/A	#N/A	#N/A	#N/A
Atp1b3	43;135;222;334	10.0761939:1077888	00.0856:1133	XM_011242658|XM_017313113|NM_007502|XM_017313112	NP_031528|XP_017168602|XP_011240960|XP_017168601	37510:GNC:806	483	NM_001679	NP_001670

Acvr2b	63;1354;4650;6401	10.0875561;0855611	MGI:879112	1148 1	NM_001313757|XM_006511926|XR_379846|NM_007397	NP_031423|NP_001300686|XP_006511989	863	HGNC:174	93	NM_001106	NP_001097,XP_016863004,XP_016863005,XP_016863003,XP_005265640
Prkra	72;1358;3888;8776	10.0734090;0855369	MGI:1343437 5	2392	XM_017318023|XM_011239517|XM_011239518|NM_011871	NP_036001|XP_011237820|XP_017173512|XP_011237819	2738	HGNC:9438	857 5	NM_001139518,NM_003690,NM_001139517,NM_001316362	XP_016860648,NP_001303291,XP_011510368,NP_001132989,XP_011510365,NP_003681,NP_001132990
Smek2	789;13742;29153;32422	10.0836249;0856855;0867 5	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Rpl5	166;1376;6242;68255	10.0638;10.1291;0856375;0867 5	MGI:1028 54	1E+08	XM_006534684|NM_016980	XP_006534747|NP_058676	11064 9	HGNC:10360	6125	NM_000969	NP_000960
Polr	1259	10.0576;10.0577;0877	MGI:	704	NM_029763	NP_084039	4722	HGNC	106	NM_001282526,NM_006466	XP_011527443,NP_006457,NP_001269455,XP_016883085

3f	;13889;;68422;;98611	70	35	16	68	08	1924086	08				:157633	21		
Ptpn6	829;13933;;24155;;32699	1.054915	0821541	0577475	0877508	0870808	MGI:960555	1517 0	NM_001077705|NM_013545	NP_001071173|NP_038573	56589	HGNC:96558	577	NM_002831,NM_080548,NM_080549	XP_006719057,NP_536858,XP_011519290,NP_002822,NP_536859
Slc39a14	946;13944;;48055;;52055	1.054440	0801046	0574655	0877508	0870808	MGI:2384851	2130 53	XM_006518789|XM_006518787|XM_006518786|NM_001135151|XM_006518791|NM_144808|NM_001135152|XM_006518788	NP_001128624|XP_006518852|XP_006518849|NP_001128623|XP_006518851|XP_006518854|NP_659057|XP_006518850	15037	HGNC:20858	23516	NM_001351656,NM_001135153,NM_001351655,NM_001351658,NM_001351660,NM_001128431,NM_015359,NM_001351659,NM_001351657,NM_001135154	XP_011542780,XP_016868783,XP_006716386,XP_016868782,XP_005273522,NP_001338586,XP_016868784,NP_056174,XP_005273523,XP_006716387,NP_001128626,NP_001338587,NP_001338584,NP_001338588,NP_001121903,NP_001338585,NP_001128625,NP_001338589,XP_016868781
Trim8	720;13977;;35721;;65211	1.052838	0843263	0577508	0877508	0870808	MGI:1933302	9367 9	NM_053100|XM_006527488	NP_444330|XP_006527551	12795	HGNC:15579	81603	NM_001345950,NM_030912	NP_001332879,NP_112174
Mkl	759;1	1.043	0858	0877	0877	0870808	MGI:1	7456 8	XM_006531444|XM_006531443|NM_001310613|XM_356104|XM_006531442	NP_001297542|XP_006531507|NP_083281|XP_006531505|XP_006531506	77416	HGNC:	1972	NM_152649,NM_001142497	NP_001135969,XP_011521238,NP_689862,XP_005255891

	4033;48044;57422	97	30	00	77	08	92181818				26617	59			
Ccne1	51;14044;20336;55066	10.0490122	00.0958067	00.0857	00.0870	8	MGI:8831616	147	NM_007633	NP_031659	14452	HGNC:1589	898	NM_001322259, NM_001322261, NM_001238,NM_057182,NM_001322262	NP_001309191, NP_001229,NP_001309188,NP_001309190,XP_011525742
Cd63	1174;14055;51122;78077	10.0487487	00.0768	00.0581	00.0737	08	MGI:9952959	125	NM_007653|NM_001282966|NM_001042580	NP_001269895|NP_001036045|NP_031679	37526	HGNC:1692	967	NM_001257389, NM_001257401, NM_001267698, NM_001257390, NM_001040034, NM_001257391, NM_001780,NM_001257400,NM_001257392	NP_001244319, NP_001244329, NP_001244330, NP_001244318, NP_001771,NP_001244320,NP_001254627,NP_001244321
Limk1	3844;14066;20099;71899	10.0481	00.0953	00.0581	00.0871	08	MGI:1045722	168	XM_006504396|NM_010717|NM_001305875|NR_131247	NP_001292804|XP_006504459|NP_034847	1738	HGNC:66133	398	NM_001204426, NM_002314,NM_016735	NP_002305,NP_001191355
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Cdk4	184;1421;2232;2316	1.1.1.0.0.0.0	0.4.9.5.8.8.8	5.0.6.1.0.7.5	0.3.3.5.5.0.8	MGI:88357	1256 7	XM_006513163|NM_009870	NP_034000|XP_006513226	554 29	HGNC:17773	10 19	NM_052984,NM_000075	NP_000066	
H2afy	918;1422;3635;9595	1.0.7.5.8.8.8	0.4.9.9.7.7.0	0.0.2.2.8.5.8	0.3.1.5.5.0.8	MGI:134939 2	2691 4	XR_382440|XM_006517257|XM_006517258|NM_012015|XR_001780784|XR_001780785|XR_001780786|NM_001159513|NM_001159514|NM_001159515	NP_001152986|NP_001152985|NP_001152987|XP_006517321|NP_036145|XP_006517320	359 8	HGNC:4740	95 55	NM_004893,NM_138609,NM_001040158,NM_138610	XP_011542037,XP_016865557,NP_613075,XP_005272191,XP_011542033,NP_004884,XP_011542036,XP_005272192,XP_016865558,XP_011542035,NP_001035248,XP_011542032,XP_005272189,NP_613258,XP_016865556,XP_011542031,XP_011542034	
Hfe	781;1423;4256;6222	1.0.8.5.8.7.0	0.3.2.9.7.6.8	0.3.3.2.7.5.8	0.4.3.3.7.0.8	MGI:109191	1516	XM_011244284|XM_006516557|NM_010424|XM_006516556|NM_001347493	XP_011242586|NP_034554|NP_001334422|XP_006516620|XP_006516619	883 30	HGNC:4886	30 77	NM_000410,NM_001300749,NM_139008,NM_139007,NM_139003,NM_139006,NM_139010,NM_139009,NM_139002,NM_139004,NM_139011,NM_139005	NP_620575,NP_620579,NP_620578,XP_011512845,NP_620572,NP_620576,NP_001287678,NP_620580,NP_000401,NP_620573,NP_620577	
Lpar4	571;1424;3	1.0.3.8.9	0.8.7.6.1	0.5.9.3.4	0.8.7.4.7	0.8.7.0.8	MGI:1925 3	781 34	NM_175271	NP_780480	387 1	HGNC:4478	28 46	NM_001278000,NM_005296	XP_016884926,XP_006724702,XP_005262183,XP_016884927,NP_005287,NP_001264929	

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T	1	1	0	0	0	0	M	2	NM_001142918|	NP_033359|XP_	7	H	6	NM_001198528,	XP_016872081,
c	2	.	.	.	.	.	G	1	NM_009333|XM	017173600|XP_	5	G	9	NM_001146285,	XP_005270146,
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									_001782576|NR	001318065|XP_					XP_005270137,
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									8121|XR_00178	006526958					
									2575|XM_00652						
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									8131|NM_00133						
									1140|XR_00178						

								2572|NM_00133 1148|NM_00133 1146							
Pak1ip1	48;1426;42000;45999	1.0379	0.0962	0.059406	0.087008	0.0878	MGI:1915333	6803	NM_026550	NP_080826	3957	HGNC:20882	5503	NM_017906	XP_011513023, XP_011513022, XP_005249261, NP_060376
Nmt1	962;14352;26522;57999	1.0334	0.0781	0.060303	0.087633	0.0873	MGI:1025579	1817	NM_008707|XM_006532445	XP_006532508| NP_032733	6902	HGNC:7857	4836	NM_021079	NP_066565,XP_011523160
Rc3h2	1346;14377;24511;30777	1.0324	0.0743	0.060153	0.087533	0.0873	MGI:2442789	3198	XM_006498124| NM_001290642| XM_130233	NP_001094061| XP_006498187| NP_001277571	2827	HGNC:21461	5454	NM_001100588, NM_018835	NP_001094058, NP_061323
Nek9	1252;14388;28777;40	1.0319	0.0751	0.060211	0.087333	0.0873	MGI:2387995	2177	NM_145138|XM_006515708	XP_006515771| NP_660120	13222	HGNC:18591	9175	NM_001329237, NM_033116,NM_001329238	NP_001316167, XP_005268265, NP_149107,XP_016877254,NP_001316166,XP_005268266

Cdc6	37 10 72; 14 46; 48 99;; 84 27	1 . 0 2 7 9	0 . 0 7 6 9	0 . 0 6 0 7	0 . 0 8 7 8	0 . 0 8 8 0	MGI:1345150	238 34	XM_017314546|XR_001780004|NM_001025779|XM_017314547|XR_879651|NM_011799	NP_001020950|XP_017170036|XP_017170035|NP_035929	681 72	HGNC:17444	99 0	NM_001254	XP_011523843,NP_001245,XP_011523844
Ip6k2	635; 145 0;; 508 0;; 797 9	1 . 0 2 5 9	0 . 0 8 5 1 0	0 . 0 6 0 9 7	0 . 0 8 7 8	0 . 0 8 7 8	MGI:1923750	765 00	XM_006511856|NM_029634|XM_006511853|XM_006511850|XM_006511851|XM_006511854|XM_006511852|XM_006511855	XP_006511917|XP_006511913|NP_083910|XP_006511916|XP_006511918|XP_006511915|XP_006511919|XP_006511914	569 29	HGNC:17313	51 447	NM_001005911,NM_001005913,NM_001005912,NM_001146178,NM_016291,NM_001005910,NM_001190317,NM_001005909,NM_001190316,NM_001146179	NP_001177246,XP_016862082,XP_011532118,XP_011532124,XP_011532119,NP_001139650,XP_016862073,XP_016862079,XP_011532120,XP_006713262,XP_006713264,NP_001005911,XP_016862076,XP_006713263,XP_016862081,NP_001177245,NP_001005910,XP_006713265,XP_016862078,XP_016862075,XP_016862077,XP_016862080,XP_011532125,NP_001139651,XP_016862074,NP_057375,XP_016862072,NP_001005909
Csrnp2	360; 147 5;; 234 8;; 301 99	1 . 0 1 3 6	0 . 0 9 4 9 0	0 . 0 6 2 5 6	0 . 0 8 9 8 7	0 . 0 8 9 8 7	MGI:2386852	207 785	NM_153407|XM_006520683	XP_006520746|NP_700456	327 443	HGNC:16006	81 566	NM_030809	XP_006719684,NP_110436,XP_016875480
Tollip	361; 148 2	1 . 0 1 0 2	0 . 0 9 4 6 8	0 . 0 6 3 0 1	0 . 0 9 0 2 5	0 . 0 9 0 2 5	MGI:1891	543 73	NM_001347562|XM_006508631|NM_023764	NP_076253|NP_001334491|XP_006508694	103 75	HGNC:164	54 472	NM_001318514,NM_001318515,NM_019009,NM_001318516,NM_001318512	NP_001305444,NP_001305443,XP_016873420,NP_001305445,NP_061882,NP_001305441

	;5738;8994					808					76				
Dnajc1	13;14873;55283;92668	1.0078828	0.0633241	0.0904141	0.0904118	MGI:1032668	134118	NM_001190817|XM_011238947|NM_007869|XR_865923	XP_011237249|NP_001177746|NP_031895	7293	HGNC:20090	6421 5	NM_022365	XP_016872025,NP_071760,XP_011517916	
Fnbp1	35;14933;43107;4807	1.0050	0.0946970	0.0906606	0.0906606	MGI:1096069	142691	XM_006497693|NM_001177649|XM_006497685|XM_006497690|XM_006497692|XM_017315551|XM_006497691|XM_017315554|XM_006497688|NM_019406|XM_006497686|XM_006497689|NM_001177650|XM_017315555|XM_006497695|XM_006497694|NM_001177648|XM_006497684|NM_001038700|XM_006497687|XR_374060	XP_006497755|NP_001171121|XP_006497750|XP_006497757|NP_001033789|XP_006497751|XP_006497756|XP_017171044|XP_006497752|NP_001171120|XP_006497758|XP_006497749|XP_017171043|XP_006497748|NP_062279|XP_006497754|NP_001171119|XP_006497753|XP_017171040|XP_006497747	10983	HGNC:17069	2304 8	NM_015033	XP_011516701,NP_055848,XP_016869980,XP_005251880,XP_005251885,XP_005251890,XP_016869976,XP_005251877,XP_016869981,XP_005251891,XP_005251872,XP_005251887,XP_011516702,XP_011516703,XP_016869977,XP_005251884,XP_016869982,XP_006717079,XP_005251878,XP_005251879,XP_011516704,XP_016869978,XP_005251883,XP_016869983,XP_016869979,XP_005251889,XP_005251881,XP_005251882,XP_005251886,XP_005251888	
Lnpep	860;14988;70000;73	1.0078964	0.0640108	0.0908 2	0.0908 2	MGI:2387123	240028	NM_172827	NP_766415	21148	HGNC:66556	4012	NM_175920,NM_005575	NP_005566,NP_787116	

Cd68	187;1504;3271;;74433	0.998186	0.981864	0.642	0.911111	0.911111	MGI:88342	1254	NM_001291058|NR_110993	NP_001277987	955	HGNC:16933	968	NM_001040059, NM_001251	NP_001035148, NP_001242
Vti1b	1266;1515;;52653;6385	0.994516	0.973116	0.651686	0.918587	0.915959	MGI:1855688	5361 2	NM_016800|XM_006516088|XM_011244143	XP_011242445|XP_006516151|NP_058080	38178	HGNC:17793	1049 0	NM_006370	NP_006361
Snap29	1141;1516;;33054;93400	0.994146	0.974466	0.652267	0.916759	0.915959	MGI:1914724	6747 4	NM_023348	NP_075837	3512	HGNC:11133	9342	NM_004782	NP_004773
Pfkfb1	649;1518;;26117;27	0.993101	0.983096	0.653656	0.915959	0.915959	MGI:1078166	1863 9	NM_008824|XM_011247791|XM_006528755|XM_006528756|XM_006528757	XP_006528820|XP_011246093|XP_006528819|XP_006528818|NP_032850	10565 4	HGNC:8872	5207	NM_001271805, NM_002625,NM_001271804	NP_002616,XP_016885066,NP_001258733,XP_016885065,NP_001258734,XP_016885067

Ptprj	7396;1523;5582;6322	0.976908	0.0.6568	0.0.9176	0.0.9176	MGI:1045774	1271	NM_008982|XM_006498994|NM_001135657|XM_006498992|XM_006498991|XM_006498993	XP_006499056|XP_006499057|XP_006499054|NP_001129129|NP_033008|XP_006499055	2130	HGNC:9673	579	NM_002843,NM_001098503	XP_016873572, XP_016873574, NP_002834,NP_001091973,XP_016873573
Sucig2	1380;1530;8549;8774	0.9875	0.7181	0.6614	0.9212	MGI:1306824	2091	NM_011507|XM_017321481|NM_001326558	NP_001313487|NP_035637|XP_017176970	2854	HGNC:11450	8801	NM_001177599, NM_003848	NP_003839,XP_016862909,XP_016862904,XP_016862905,XP_016862907,XP_016862908,NP_001171070,XP_016862906
Fig4	405;1535;8226;8829	0.98524	0.9124	0.6648	0.9229	MGI:2143585	1031	NM_133999	NP_598760	6713	HGNC:16873	9896	NM_014845	XP_016867082, XP_011534583, XP_016867081, NP_055660,XP_016867080
Itgb1	1332;1539;2963;82	0.98340	0.7200	0.6675	0.9239	MGI:96610	1641	XM_134403	NP_034708	2999	HGNC:6153	3688	NM_033668,NM_002211,NM_033666,NM_033667,NM_033669,NM_133376	NP_596867,NP_391988,NP_002202

Cd81	163;1540;5013;;98499	0.98293	0.94531	0.66810	0.92200	0.92110	MGI:1096398	1252	NM_133655	NP_598416	2091	HGNC:17011	975	NM_004356,NM_001297649	XP_011518794,XP_016874087,NP_001284578,NP_004347
Psd3	1497;1542;5452;6262	0.98207	0.97067	0.66941	0.92100	0.92100	MGI:1918215	2343533	NM_027626|XM_017312706|XM_006509621|NM_177698|XM_017312709|XM_017312711|NM_030263|XM_017312708|XM_006509611|XM_017312710|XM_017312704|XM_011242288|XM_006509619|XM_006509620|XM_017312700|XM_017312703|XM_017312701|XM_017312702|XM_017312707|XM_017312705	XP_017168192|XP_017168200|NP_081902|XP_017168195|XP_011240590|XP_006509674|NP_084539|XP_006509684|XP_017168196|XP_017168198|XP_017168199|NP_808366|XP_017168197|XP_017168189|XP_006509683|XP_006509682|XP_017168194|XP_017168190|XP_017168191|XP_017168193	872	HGNC:19093	2336	NM_206909,NM_015310	XP_011542769,XP_016868747,XP_011542771,XP_011542773,XP_016868748,NP_056125,XP_016868752,XP_011542775,XP_016868750,XP_016868749,NP_996792,XP_016868751,XP_016868754,XP_011542770,XP_016868753
Mink1	1368;1547;4304;;70500	0.97195	0.97152	0.67229	0.92211	0.92110	MGI:1355329	5093	NM_001045964|XM_017314646|XM_017314645|NM_176893|XM_006533679|XM_006533677|XM_006533678|NM_001045959|XM_006533681|XR_388490|XM_006533682|NM_016713	NP_795712|XP_017170134|NP_001039424|XP_006533745|XP_006533740|XP_006533742|XP_017170135|XP_006533741|XP_006533744|NP_057922|NP_001039429	5676	HGNC:17565	504	NM_015716,NM_001321236,NM_153827,NM_170663,NM_001024937	XP_011522208,XP_016880195,XP_016880193,XP_006721595,NP_001308165,NP_722549,NP_733763,XP_006721594,NP_056531,XP_016880197,XP_006721599,XP_016880194,NP_001020108,XP_016880196
Ccnb2	1363;1548;;22333;;2	0.97933	0.97153	0.67361	0.92111	0.92111	MGI:8831111	1242	NM_007630	NP_031656	74359	HGNC:15800	913	NM_004701	NP_004692

Lamtor3	570;761;1558;7518;9027	0.9747951;0.6804276;0.926626	MGI:1929467	562	NM_019920	NP_064304	1053	HGNC:15606	864	NM_021970,NM_001243736	NP_001230665, NP_068805
Ano8	1472;1560;5166;9781	0.9703438;0.6818688;0.926626	MGI:2687327	3820	XM_006509688|XM_017312873|XM_017312871|XM_006509690|XM_006509686|XM_017312872|NM_001164679	XP_017168360|XP_006509753|XP_006509751|XP_017168362|XP_006509749|XP_017168361|NP_001158151	12473	HGNC:29329	5719	NM_020959	NP_066010,XP_016882537
Aip	528;1565;6863;9809	0.9716964;0.6851851;0.926626	MGI:1096222	1163	XM_006531641|NM_001276284|XM_006531642|NM_016666	NP_001263213|XP_006531704|NP_057875|XP_006531705	2959	HGNC:3558	9049	NM_001302959, NM_001302960, NM_003977	NP_001289888, NP_003968,NP_001289889
Vamp5	882;1566;4852;88	0.9771100;0.6858566;0.926626	MGI:1858622	5362	NM_016872|NM_001080742	NP_058568|NP_001074211	4833	HGNC:12646	1079	NM_006634	NP_006625

Pacs2	34 153 2; 157 4; 458 0; 678 4	0. 9 6 9 6 7 5	0. 6 9 7 2	0. 6 9 1 3	0. 9 3 1 3	0. 9 2 7 6	MGI: 1924 399	217 893	XM_006515779| XM_006515773| XM_006515769| XM_006515774| XM_006515777| XM_006515772| XM_006515778| XR_001780448| NM_001081170| XR_381518|NM _001291444|XR _381519|XM_00 6515771|XM_00 6515770|NM_00 1291445	NP_001278374| XP_006515836| NP_001278373| XP_006515834| XP_006515833| XP_006515841| XP_006515840| XP_006515835| XP_006515837| NP_001074639| XP_006515832| XP_006515842	150 16	HGNC: 23794	234 21	NM_001100913, NM_001243127, NM_015197	XP_016876601, XP_016876595, XP_016876600, XP_016876598, XP_006720153, NP_001230056, XP_016876596, XP_016876597, XP_016876594, XP_006720155, XP_006720154, XP_016876599, NP_056012,NP_ 001094383
Fmn1	134 7; 157 5; 339 0; 782 2	0. 9 6 7 7 1	0. 7 1 0 1 6	0. 6 9 2 0 0	0. 9 2 9 5	0. 9 2 7 6	MGI: 1018 15	142 60	XM_006498750| NM_010230|XM _011239294|NM _001287818|XM _011239298|XM _011239295|NM _001285458|NM _001285459|NM _001287817|XM _017315533	NP_034360|XP_ 006498813|NP_ 001272388|XP_ 011237596|XP_ 011237600|XP_ 011237597|XP_ 017171022|NP_ 001272387|NP_ 001274746|NP_ 001274747	121 778	HGNC: 37688	342 184	NM_198500,NM _001277314,NM _001103184,NM _001277313	XP_011519808, NP_001264242, XP_016877624, NP_001264243, XP_016877621, XP_016877622, XP_011519807, XP_011519811, XP_011519813, XP_016877619, XP_016877623, XP_011519809, XP_011519806, NP_001096654, XP_016877620
Wbp11	155 ; 157 6; 557 ; 956 8	0. 9 6 6 6	1. 0 9 4 6	0. 6 9 2 6	0. 9 2 7 6	0. 9 2 7 6	MGI: 1891 823	603 211	XM_017321694| XM_017321693| NM_021714	XP_017177182| XP_017177183| NP_068360	134 037	HGNC: 16461	517 29	NM_016312	NP_057396
Slc26a11	106 ; 157 9; 282 0; 78	0. 9 6 5 3	0. 7 4 7 5	0. 6 9 4 6	0. 9 2 7 6	0. 9 2 7 6	MGI: 2444 589	268 512	XM_006533419| XM_006533421| XM_006533418| XM_006533420| NM_178743	XP_006533483| XP_006533481| XP_006533482| XP_006533484| NP_848858	136 85	HGNC: 14471	284 129	NM_001166349, NM_001166348, NM_001166347, NM_173626	XP_016879996, XP_006721896, XP_011522954, XP_016879995, NP_775897,XP_ 011522956,NP_ 001159819,XP_ 016879994,NP_ 001159821,XP_ 011522955,NP_ 001159820

Cdk13	7712703;15844;21466;;80866	0.9631	0.7155	0.6981	0.9295	0.9287	MGI:1916812	6952	NM_027118|XM_011244344|XM_006516767|XM_127221|XM_017315593|XM_006516766	NP_001074527|NP_081394|XP_017171082|XP_006516829|XP_006516830|XP_011242646	13507	HGNC:17333	862 1	NM_031267,NM_003718	NP_112557,XP_011513899,XP_016868240,NP_003709,XP_016868239
Bad	15855;15866;68288;72077	0.96222	0.69213	0.69967	0.92887	0.92877	MGI:1096330	12015	NM_001285453|NM_007522	NP_031548|NP_001272382	3189	HGNC:9366	572	NM_004322,NM_032989	NP_116784,NP_004313
Inpp5b	14577;15962;22988;89355	0.95778	0.69744	0.70666	0.93533	0.93535	MGI:1032557	1630	XM_006502809|XM_011240450|NM_008385|XM_006502805|XR_001784096|XM_006502804|XR_867812|NR_126474	XP_006502867|XP_011238752|NP_032411|XP_006502872|XP_006502868	69021	HGNC:6077	363 3	NM_005540,NM_001350227,NM_001350228,NM_001297434	XP_011539694,XP_006710684,NP_001337157,XP_016856695,XP_011539695,NP_005531,NP_001337156,XP_016856698,NP_001284363,XP_016856696,XP_016856697
Ctps	34259;15973;72130;;90	0.95738	0.93088	0.70733	0.93355	0.93355	MGI:1858304	5177	NM_016748|XM_006503225	XP_006503288|NP_058028	20446	HGNC:25199	150 3	NM_001301237,NM_001905	NP_001896,NP_001288166

Zcch9	44854;16066;24711;;31211	0.0.0.0.0.0	0.9761361	0.7139391	0.9391	MGI:1916335	690	XM_006517361|XM_006517363|NM_145453|XM_017315591|XM_006517362	XP_006517425|NP_663428|XP_006517424|XP_017171080|XP_006517426	129	HGNC:25424	840	NM_032280,NM_001131035,NM_001131036	NP_001124507,XP_005248673,NP_115656,NP_001124508
Slc44a2	70549;16166;24693;;75944	0.0.0.0.0.0	0.9794909	0.7720554	0.9422	MGI:1915932	682	XM_011242593|XM_006510575|XM_006510576|NM_001199186|NM_152808	XP_006510639|NP_690021|XP_011240895|XP_006510638|NP_001186115	1071	HGNC:17292	571	NM_001145056,NM_020428	XP_005260056,NP_001138528,NP_065161,XP_005260054
Golga7	43119;16119;23055;;91422	0.0.0.0.0.0	0.9481978	0.7227456	0.9422	MGI:1931029	5743	XM_006509179|NM_020585|NM_001042484	NP_001035949|XP_006509242|NP_065610	9385	HGNC:24876	5112	NM_001002296,NM_001174124,NM_016099	NP_001002296,NP_001167595,NP_057183
Chka	29545;16211;43200;;46233	0.0.0.0.0.0	0.9454469	0.7244045	0.9422	MGI:1077600	160	XM_017318049|NM_001271496|XM_017318050|NM_013490|XM_006531650|XR_388248|XM_017318048|XM_011248600|NR_073190|XM_011248599|XM_006531648|XM_006531646|XM_006531651|XM_006531649	NP_038518|XP_006531714|XP_006531709|XP_006531713|XP_006531712|XP_011246901|NP_001258425|XP_011246902|XP_017173537|XP_017173539|XP_006531711|XP_017173538	8857	HGNC:1937	119	NM_212469,NM_001277	XP_016872637,NP_997634,XP_016872636,NP_001268

Lims1	16094;16233;31944;63966	0.0.0.0.0.0	9468608	6815425	7259382	9432422	MGI:1952663	11029	NM_001193303|XM_006513069|XM_006513070|XM_006513074|XM_006513073|XM_006513068|NM_201242|NM_026148|XM_006513072|NM_001346676|XM_006513071	XP_006513131|NP_001180232|XP_006513133|NP_080424|XP_006513136|XP_006513134|XP_006513135|XP_006513132|XP_006513137|NP_957694|NP_001333605	68428	HGNC:6616	3987	NM_001193482,NM_001193488,NM_004987,NM_001193485,NM_001193483,NM_001193484	XP_016859585,XP_005264006,NP_001180417,XP_016859584,XP_005264003,NP_001180413,XP_005264008,XP_016859581,XP_016859580,XP_005264007,XP_016859582,NP_001180412,NP_001180411,NP_001180414,XP_005264005,NP_004978,XP_016859583
Jtb	7947;16266;63322;75233	0.0.0.0.0.0	9447337	7727638	9432422	9432422	MGI:1346082	23922	XM_181436	NP_996807	4870	HGNC:62001	10899	NM_006694	NP_006685
Psap1	9781;16277;80872;80922	0.0.0.0.0.0	9443	7411	7284	9422422	MGI:1915013	67763	XM_181343|XM_011249196|XM_006534018|XM_006534017	NP_080640|XP_011247498|XP_006534080|XP_006534081	55687	HGNC:9466	56355	NM_001330503,NM_002766	NP_002757,XP_011523336,NP_001317432
Isg20	4147;16311;39122;87955	0.0.0.0.0.0	9426	8869	7313	9432432	MGI:1928895	5744	XM_006541030|NM_001291220|NM_001113527|NM_020583|NM_001291221|XM_006541028|XM_006541026	XP_006541089|NP_001278149|XP_006541093|NP_065608|NP_001106999|XP_006541091|NP_001278150	31081	HGNC:6130	3669	NM_001303237,NM_001303234,NM_001303233,NM_002201,NM_001303236,NM_001303235	XP_005254956,NP_001290163,NP_001290162,NP_002192,XP_016877637,XP_006720551,NP_001290164,XP_016877636,NP_001290165,NP_001290166,XP_011519823

Cd14	10253;16400;24588;87155	0.9388	0.7316	0.7375	0.9485	0.9485	MGI:883185	12475	NM_009841	NP_033971	493	HGNC:16288	929	NM_001174105, NM_001040021, NM_001174104, NM_000591	NP_001035110, NP_000582,NP_001167576,NP_001167575
C1qbp	98253;16455;31422;56611	0.9367	0.7367	0.7411	0.9504	0.9489	MGI:1194505	12261	NM_007573	NP_031599	31023	HGNC:12433	708	NM_001212	NP_001203
Marf1	113953;16485;30523;43077	0.9354	0.7155	0.7434	0.9507	0.9489	MGI:2444505	22389	XM_006522019|XM_006522018|NM_001081154	XP_006522081|XP_006522082|NP_001074623	40967	HGNC:29562	9665	NM_014647,NM_001184998,NM_019081,NM_001184999	NP_001171928, NP_055462,XP_016879392,XP_016879391,XP_016879395,XP_016879393,NP_001171927,XP_016879389,XP_005255763,XP_005255761,XP_016879394,XP_005255764,XP_016879390
Relt	88753;16523;34892;73922	0.9337	0.7504	0.7461	0.9515	0.9489	MGI:2443773	32010 0	XM_006507935|XM_006507931|XM_006507934|NM_177073|XM_006507933|XM_006507940|XM_006507930|XM_006507939|XR_378249|XM_006507936|XM_006507932	XP_006508002|XP_006508003|XP_006507995|XP_006507999|NP_796047|XP_006507998|XP_006507993|XP_006507997|XP_006507994|XP_006507996	13151	HGNC:13764	8497	NM_152222,NM_032871	NP_689408,XP_005274413,XP_011543607,NP_116260,XP_006718777

Chrna1	13116557;46566;76557	0.9316	0.6960	0.7496	0.9532	0.9489	MGI:878485	1143 5	NM_007389	NP_031415	59	HGNC:19555	1134	NM_001039523, NM_000079	XP_016858746, NP_001034612, XP_016858745, NP_000070
Tmem150a	48165;28177;85577	0.9312	0.8532	0.7503	0.9516	0.9489	MGI:2385244	2320 86	NM_144916	NP_659165	16378	HGNC:24677	1293 03	NM_001031738, NM_153342	NP_001026908, XP_011530809, XP_016858796, XP_016858794, XP_011530810, XP_006711995, XP_006711993, XP_006711994, XP_016858795, XP_011530807
Acly	24160;34455;90996	0.9304	0.9864	0.7517	0.9506	0.9489	MGI:1032511	1041 12	NM_001199296| NM_134037	NP_001186225| NP_598798	854	HGNC:115	47	NM_001303274, NM_001096,NM_198830,NM_001303275	XP_005257452, NP_001087,XP_016880177,NP_001290204,NP_942127,NP_001290203
H2-Aa	14281;16611;39462;70622	0.92999	0.6856	0.7524	0.9489	0.9489	MGI:958955	1496 0	NM_010378	NP_034508	12382 0	HGNC:49422	3117	NM_002122	NP_002113,XP_006715142

Rb1	1260;1665;5731;9306	0.928391	0.669191	0.755353	0.949949	0.949944	MGI:97874	19645	XR_383150|XM_006518731|NM_009029	NP_033055|XP_006518794	272	HGNC:98844	59255	NM_000321	XP_011533473, NP_000312
Pkig	1059;1669;2884;9725	0.926610	0.772100	0.758313	0.951030	0.949944	MGI:1343086	18769	XM_006498927|NM_001039391|NM_011106|NM_001164053|XM_006498926|NM_001164055|NM_001277096|NM_001039390	NP_001034480|NP_001157527|NP_001157525|XP_006498989|NP_001034479|NP_001264025|NP_035236|XP_006498990	5133	HGNC:90199	11142	NM_181804,NM_001281444,NM_007066,NM_181805,NM_001281445	NP_001268373, XP_016883104, NP_861520,XP_016883103,NP_001268374,NP_008997,NP_861521,XP_016883105
Stau1	1299;1670;4177;52700	0.926224	0.694441	0.759114	0.949944	0.949944	MGI:1338864	20853	XM_006499071|NM_001109905|NM_011490|NM_001291160|NM_001109906|XM_011239406|NR_111895|XM_006499072	XP_011237708|NP_035620|XP_006499135|NP_001278089|XP_006499134|NP_001103376|NP_001103375	3384	HGNC:11370	67800	NM_017452,NM_001322932,NM_001322931,NM_001319135,NM_001322929,NM_004602,NM_001322928,NM_001322933,NM_017454,NM_001322930,NM_001037328,NM_001322927,NM_017453,NM_001319134	NP_001309857, NP_001309858, NP_001309856, XP_006723928, NP_059347,NP_001309860,NP_059348,NP_001306064,NP_001309859,NP_001032405,NP_059346,NP_001306063,NP_001309861,XP_005260584,NP_004593, XP_011527317, NP_001309862, XP_016883517
Il17ra	7691;1675;2618;90733	0.924411	0.768117	0.762713	0.951313	0.951313	MGI:1073999	16172	NM_008359|XM_006505618	NP_032385|XP_006505681	7378	HGNC:59855	23765	NM_014339,NM_001289905	NP_001276834, NP_055154

Dist	1464;1678;8709;9287	0.922994	0.067946	0.076491	0.095144	0.095144	MGI:1926170	7892 0	XM_006516392|NM_030225|XM_017315247	NP_084501|XP_006516455|XP_017170736	1456	HGNC:29111	1743	NM_001933,NM_001244883	NP_001231812,NP_001924
Smek1	820;1688;7601;9564	0.918852	0.775521	0.775721	0.957843	0.954343	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Pip4k2c	6569;1689;3031;8608	0.918447	0.791728	0.775728	0.956143	0.954343	MGI:2152214	11710	XM_006513120|XM_011243288|XM_017313768|NM_054097|XR_871695|XM_006513121|XM_011243289	XP_017169257|XP_006513183|NP_473438|XP_006513184|XP_011241591|XP_011241590	23484	HGNC:23786	7983 7	NM_001146259,NM_001146260,NM_024779,NM_001146258	NP_079055,NP_001139731,XP_011537049,XP_016875462,XP_005269209,NP_001139730,NP_001139732
Prkci	1611;1690;3123;3790	0.918807	0.677736	0.775436	0.954343	0.954343	MGI:992660	18759	NM_008857|XM_006535411	NP_032883|XP_006535474	37667	HGNC:94044	5584	NM_002740	XP_016862349,NP_002731

Crcp	33;169;6518;7739	0.9174	0.9175754	0.954454	MGI:1100818	1209	NM_007761	NP_031787	4058	HGNC:17888	27297	NM_014478,NM_001040648,NM_001040647,NM_001142414	NP_001035738, NP_001035737, NP_001135886, NP_055293
Rab22a	952;17003;29677;87033	0.9127	0.9783261	0.95944	MGI:1050722	1933 4	NM_024436|XM_017316603	NP_077756|XP_017172092	10782	HGNC:9764	5740 3	NM_020673	NP_065724
Prkd1	1441;17044;31700;64299	0.9123	0.6758400	0.95944	MGI:998799	1876 0	XR_001780428|XR_001780432|XM_011244017|XM_006515586|NM_008858|XR_001780429|XM_006515587|XM_006515590|XR_001780427|XR_001780430|XR_001780431|XM_006515591	XP_006515649|XP_011242319|NP_032884|XP_006515650|XP_006515654|XP_006515653	55680	HGNC:9407	5587	NM_001330069, NM_001348390, NM_002742	XP_005267916, XP_011535266, XP_016876950, NP_001335319, NP_001316998, XP_011535267, NP_002733,XP_016876951
Sdc4	1185;17199;33111;52888	0.9063	0.6958	0.7952	0.970 5	MGI:1349164	2097 1	NM_011521	NP_035651	31121	HGNC:10661	6385	NM_002999	NP_002990,XP_011527279

Ptpn23	103;1724;3966;6699	0.904313	0.719902	0.972523	0.972323	MGI:2144837	1048331	NM_001081043|XM_011242931	NP_001074512|XP_011241233	13570	HGNC:14406	2593	0	NM_001304482, NM_015466	NP_001291411, NP_056281,XP_005265088
Nifk	186;1728;23700;38885	0.902752	0.102522	0.802239	0.973239	MGI:1915199	679449	NM_026472	NP_080748	49862	HGNC:17838	84365		NM_032390	NP_115766
Nuak1	317;1731;25100;66627	0.901577	0.917745	0.804540	0.972323	MGI:1925226	779776	NM_001004363|XM_011243603	NP_001004363|XP_011241905	8896	HGNC:14311	9891		NM_014840	NP_055655
Plk4	427;1732;33098;64800	0.901103	0.860352	0.805223	0.972323	MGI:1017883	2073	NM_011495|XM_006500770|NR_045576|NM_173169|XM_011239968|XM_006500768	NP_775261|NP_035625|XP_006500833|XP_011238270|XP_006500831	7962	HGNC:11397	1073	3	NM_001190801, NM_014264,NM_001190799	XP_016863151, XP_016863152, NP_055079,XP_005262758,NP_001177728,NP_001177730
Ug	64	0.	0.	0.	0.	0.	MG	39	NM_201645	NP_964007	12	#N	54		NM_000463	NP_000454

t1a1	2;1737;3067;4728	8928588	7809143	9737	I:9898	4436				803 4	/A	658		
Erbb3	1595;1741;5286;8707	0.897 6	0.658 4	0.812 1	0.975 3	0.973 7	MGI:954111	13867	NM_010153	NP_034283	20457	HGNC:34331	2065	NM_001005915, NM_001982	NP_001005915, NP_001973
Gng10	1445;1742;7199;7236	0.897 2	0.667 9	0.812 8	0.973 7	0.973 7	MGI:1361669	1470 0	NM_025277	NP_079553	20874	HGNC:44022	2790	NM_001198664, NM_001017998	NP_001017998, NP_001185593
Gnas	1335;1746;2799;8992	0.895 6	0.675 9	0.815 8	0.974 7	0.974 7	MGI:957777	1468 3	XR_374413|XM_006498780|NM_010309|XM_006498777|NM_001077510|XR_374414|XM_006498778|NM_201617|NM_022000|NM_001310083|NR_003258|NM_001077507|XM_006498776|XM_006498779|NM_019690|NM_001310085|XM_017315658|NM_201616|NM_201618|XM_006498774	XP_017171147|XP_006498837|NP_001297014|NP_963910|NP_068840|NP_001070978|NP_062664|NP_963911|NP_034439|XP_006498841|NP_001070975|XP_006498839|XP_006498840|NP_963912|XP_006498842|XP_006498843|NP_001297012	5534	HGNC:4392	2778	NM_000516,NM_001309861,NM_001309842,NM_001309883,NM_016592,NM_001309840,NM_001077490,NM_001077489,NM_001077488,NM_080425,NM_080426	XP_016883308, XP_016883310, NP_001070956, XP_016883307, XP_016883306, NP_000507,XP_016883304,XP_016883309,NP_001296812,NP_536351,NP_057676,NP_536350, NP_001070957, XP_016883301, XP_016883303, NP_001296769, XP_016883302, XP_016883305, NP_001070958, NP_001296771, XP_016883311, NP_001296790

Otub1	16950;17500;28122;46511	0.894113	0.651389	0.975757	0.975757	MGI:2147616	1072160	NM_134150	NP_598911	9772	#N/A	#N/A	#N/A	#N/A	#N/A
Riok1	20325;17542;44226;44677	0.892525	0.100222	0.821968	0.976768	MGI:1918590	7134140	XR_001780817|NM_024242|XM_017315606|XR_382077	NP_077204|XP_017171095	6950	HGNC:18656	83732	NM_153005,NM_001348194,NM_031480	NP_694550,XP_011513235,NP_113668,XP_005249503,NP_001335123	
Nudt19	16361;17599;23377;79166	0.890606	0.652656	0.825687	0.978787	MGI:9420359	1109599	NM_033080|XR_391037	NP_149071	13211	HGNC:32036	390916	NM_001105570	XP_016882295,NP_001099040	
Tnk2	14511;17699;37148;64887	0.886767	0.662323	0.839851	0.985151	MGI:1858308	51789	XM_006522334|XM_006522337|XM_006522336|NM_016788|NM_001347185|NM_001289443|XM_006522333|NM_001110147|XM_006522339|XM_006522340|XM_006522332|XM_017317065|XM_006522335|XM_017317066|XM_006522343|XM_006522342|XM_006522344|XM_011245946|XM	NP_058068|XP_006522397|XP_006522408|XP_006522398|NP_001334114|NP_001103617|XP_006522403|XP_011244248|XP_006522400|XP_017172554|XP_006522405|XP_006522396|XP_006522395|XP_006522407|XP_006522402|XP_006522399|XP_006522401|XP_017172555|NP_	4224	HGNC:19297	10188	NM_005781,NM_001010938,NM_001308046	NP_005772,XP_005269332,NP_001294975,XP_016860999,XP_011510623,XP_005269331,XP_005269325,XP_011510622,XP_016860997,XP_011510620,NP_001010938,XP_005269327,XP_016860998,XP_011510619	

								_006522338|XM_006522345	001276372|XP_006522406						
Bmp2	151;1776;4359;;8490	0.8840	1.0587	0.8387	0.9891	0.9873	MGI:881777	121156	NM_007553|XM_006498619	NP_031579|XP_006498682	926	HGNC:10699	650	NM_001200	XP_011527625, NP_001191
Spp12a	1211;1777;22800;;39800	0.8837	0.6817	0.8395	0.9874	0.9873	MGI:1913802	665552	XM_017319183|XM_017319184|XM_011239737|XM_017319182|XM_017319181|XM_011239735|XM_017319180|NM_023220	XP_017174673|XP_011238037|XP_017174669|XP_017174671|XP_011238039|XP_017174672|XP_017174670|NP_075709	36411	HGNC:30227	8488	NM_032802	XP_016878170, XP_016878169, NP_116191,XP_005254779
Ifitm3	10311;1782;62299;;88722	0.8818	0.7023	0.8434	0.9894	0.9873	MGI:1913391	661411	NM_025378	NP_079654	136199	HGNC:54144	10410	NM_021034	NP_066362
Mpp6	1286;1783;56933;;69	0.8814	0.6732	0.8439	0.9875	0.9873	MGI:1927340	565254	NM_001164733|NM_001164734|NM_019939	NP_001158206|NP_064323|NP_001158205	22976	HGNC:18167	5167 8	NM_016447,NM_001303037	NP_001289966, XP_016867805, XP_016867804, XP_005249832, XP_011513727, XP_006715802, XP_016867806, XP_006715803, XP_006715801, NP_057531

Ulbp1	91832;17891;40002;43711	0.8791	0.7330	0.8485	0.9903	0.9873	MGI:1925027	777	NM_029975|XM_006512492	NP_084251|XP_006512555	108274	HGNC:14893	803	NM_025218,NM_001317089	NP_001304018, XP_016866811, NP_079494
Ube2v1	13097;35064;49466	0.8761	0.8519	0.8547	0.9949	0.9873	MGI:1913839	6589	NM_023230|XM_006500014|NM_001311131|NM_001311146	NP_001298060|NP_075719|XP_006500077|NP_001298075	81888	HGNC:12494	735	NM_199144,NM_001257399,NM_021988,NM_001257395,NM_001257393,NM_001282578,NM_001257397,NM_001282576,NM_022442,NM_001282579,NM_001257394,NM_001282580,NM_001282577,NM_001257396,NM_001257398,NM_001282575,NM_001032288	NP_001244325, NP_001269506, NP_001269504, NP_001244328, NP_001244327, NP_001244324, NP_001244322, NP_001027459, NP_001269509, NP_001269507, NP_001269505, NP_954595,NP_001244326,NP_001269508,NP_068823,NP_001244323,NP_071887
Zdhhc17	16833;18033;57513;84533	0.8738	0.6418	0.8593	0.9978	0.9873	MGI:2445110	32015	XM_006513762|XM_006513761|NM_172554	NP_766142|XP_006513824|XP_006513825	56324	HGNC:18412	2339	NM_015336	XP_016874584, XP_016874582, XP_005268807, XP_016874580, NP_056151,XP_016874583,XP_016874581,XP_011536385
Rgs12	13604;18044;49933;57	0.8763	0.6276	0.8660	0.9961	0.9873	MGI:1918979	7179	XM_006504120|XM_006504123|NM_001163512|NM_173402|XM_006504126|XM_006504125|XM_006504124|XM_006504121|XM_006504122	NP_775578|XP_006504183|XP_006504185|XP_006504187|NP_001156984|XP_006504184|XP_006504188|XP_006504189|XP_006504186	21955	HGNC:9994	602	NM_198230,NM_002926,NM_198229,NM_198587,NM_198227,NM_198430,NM_198432	XP_006713970, XP_016864019, XP_016864022, NP_937872,NP_002917,XP_016864023,XP_011511845,XP_016864018,XP_016864021,NP_937870,XP_006713968,XP_006713969,XP_016864020

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Fam126a	95;1807;6884;9582	0.870823	0.8625	0.9963	0.9873	MGI:2149839	8462	NM_001310471|NM_053090|XM_011249798|XM_006535822|XM_017321188	NP_444320|NP_001297400|XP_017176677|XP_006535885|XP_011248100	5715	HGNC:24587	846	NM_032581	XP_011513892, XP_011513891, XP_005249951, NP_115970,XP_005249952
Ap2m1	51;1808;3492;75611	0.872017	0.8632	0.9947	0.9873	MGI:1298405	1173	NM_009679|NM_001302970	NP_001289899|NP_033809	3000	HGNC:5644	1173	NM_001311198, NM_004068,NM_001025205	NP_001298127, NP_004059,NP_001020376
B3gat3	452;1809;4474;74777	0.871649	0.8640	0.9931	0.9873	MGI:1919977	7277	NM_024256	NP_077218	56554	HGNC:9233	26229	NM_001288721, NM_001288723, NM_001288722, NM_012200	NP_001275652, NP_001275651, NP_036332,NP_001275650
Fscn1	1291;1810;39366;86199	0.871276	0.8648	0.9915	0.9873	MGI:1352745	1408	NM_007984	NP_032010	481644	HGNC:11148	6624	NM_003088	NP_003079

Taok2	66418183;67211;94111	0.8676831	0.8764611	0.8991623	0.9873	MGI:1915919	381921	NM_001163775|NM_001163774|XR_001785580|XR_001785578|XR_001785579	NP_001157246|NP_001157247	74531	HGNC:16835	934	NM_016151,NM_001252043,NM_004783	XP_011544286,XP_011544285,NP_004774,XP_011544288,NP_057235,XP_011544284,NP_001238972,XP_011544287
Zfp462	15191;18211;26283;59233	0.8664771	0.8736	0.8996	0.9873	MGI:1076900	24166	XM_017320200|XM_006537918|XM_017320199|XM_011250033|XM_011250032|XM_011250031|XM_006537919|XM_011250035|XM_006537916|XM_006537915|XM_006537917|XM_011250036|NM_172867	XP_011248338|XP_006537979|XP_006537980|XP_011248333|XP_006537981|XP_011248334|XP_017175688|XP_006537978|NP_766455|XP_017175689|XP_011248337|XP_006537982|XP_011248335	41430	HGNC:21684	58499	NM_021224,NM_001347997	XP_006717272,XP_006717275,XP_011517194,XP_006717274,NP_001334926,XP_016870488,NP_067047,XP_016870487,XP_016870486,XP_006717279,XP_006717281,XP_006717278,XP_016870485
Itga6	16255;18243;39384;45344	0.8646091	0.8761	0.9983	0.9873	MGI:964605	16403	XM_017315707|XM_011239309|NM_001277970|NM_008397|XM_011239308	NP_001264899|XP_011237610|XP_017171196|NP_032423|XP_011237611	20091	HGNC:61422	365 5	NM_001079818,NM_000210,NM_001316306	XP_016859496,XP_006712573,XP_016859494,NP_001303235,XP_016859495,XP_006712574,NP_001073286,NP_000201,XP_016859497
Cyr61	14191;18266;45577;82399	0.8653	0.8778	0.9963	0.9873	MGI:886133	16007	NM_010516	NP_034646	11941	HGNC:26544	34911	NM_001554	NP_001545

Nt5c3	17748;18288;23455;91033	0.8646	0.6330	0.8794	0.9956	0.9873	MGI:1927186	107569	XM_006505273|NM_026004|NM_001252374|XM_006505276|XM_006505272|XM_011241111|XM_006505275|XM_006505274	NP_001239303|XP_006505339|XP_006505337|XP_006505338|NP_080280|XP_011239413|XP_006505336|XP_006505335	9534	HGNC:17820	512511	NM_001166118,NM_001002010,NM_016489,NM_001002009	NP_001002010,XP_011513711,NP_001002009,NP_001159590,NP_057573
Ttyh2	93482;18299;30966;72199	0.8642	0.8708	0.8802	0.9941	0.9873	MGI:2157091	11716 0	NM_053273	NP_444503	41882	HGNC:13877	94015	NM_001330453,NM_032646,NM_052869	NP_443101,NP_116035,NP_001317382,XP_005257881
Cdk16	76583;18311;45027;74844	0.8635	0.7386	0.8817	0.9933	0.9873	MGI:975116	185 55	NM_001310456|XM_017318425|NM_011049|XM_017318424|XM_006527570	XP_017173913|XP_017173914|NP_001297385|NP_035179|XP_006527633	7878	HGNC:8749	512 7	NM_033018,NM_001170460,NM_006201	XP_011542222,NP_148978,XP_011542230,XP_011542223,XP_011542224,XP_011542229,NP_006192,XP_016885059,XP_011542225,XP_016885062,NP_001163931,XP_011542228,XP_016885061,XP_011542227,XP_011542226,XP_016885058,XP_016885060
Ccny	99018;18333;90477;95522	0.8627	0.6986	0.8833	0.9926	0.9873	MGI:1915224	67974	NM_026484|XM_017317976|XM_017317975|XM_017317974	XP_017173464|XP_017173465|NP_080760|XP_017173463	12219	HGNC:23354	219771	NM_001282854,NM_001282852,NM_181698,NM_001282853,NM_145012	XP_011517671,XP_011517663,NP_001269783,XP_016871330,XP_016871329,XP_011517667,XP_011517664,NP_001269781,XP_011517666,NP_859049,NP_659449,XP_011517660,XP_011517670,XP_011517659,XP_016871328,XP_006717455,XP_011517665,XP_011517662,NP_001269782,XP_011

														517668,XP_011517669
Gprc5a	13;18;1834;2351;;31000	0.8624	0.6541	0.8841	0.9910	0.973	MGI:1891250	2324311	NM_181444|XM_006506038	XP_006506101|NP_852109	2961	HGNC:9836	9052	NM_003979	NP_003970
Rad50	1534;1835;;650967667	0.86200	0.6443	0.8849	0.9895	0.973	MGI:1092292	19360	NM_009012	NP_033038	38092	HGNC:98116	10111	NM_133482,NM_005732	NP_005723
Cbr1	1500;1836;;61250;;63900	0.86163	0.6463	0.8857	0.9880	0.973	MGI:882844	12408	NM_007620	NP_031646	37524	HGNC:15488	873	NM_001286789,NM_001757	NP_001273718,NP_001748
Ppp2r5a	893;1838;;41888;;69	0.8609	0.7130	0.8873	0.9873	0.973	MGI:2384479	22684	NM_144880	NP_659129	55961	HGNC:93099	5525	NM_001199756,NM_006243	NP_006234,NP_001186685

	93														
Bcar1	945;1845;4689;6962	0.8587032	0.8923	0.9912	0.905	MGI:1080911	1279	NM_001198839|XM_011248299|NM_009954	XP_011246601|NP_001185768|NP_034084	767	HGNC:971	954	NM_001170719,NM_001170715,NM_001170721,NM_001170716,NM_001170720,NM_001170717,NM_001170714,NM_014567,NM_001170718	XP_016879387,NP_001164192,NP_001164188,XP_016879388,NP_001164187,NP_055382,XP_005256316,XP_016879386,NP_001164190,XP_005256317,XP_011521777,NP_001164191,XP_005256315,NP_001164189,NP_001164186,NP_001164185
Gab2	841;1849;5870;7255	0.8569	0.8963	0.9925	0.905	MGI:1333854	1439	NM_010248|NM_001162477	NP_034378|NP_001155949	69067	HGNC:14458	9846	NM_080491,NM_012296	NP_536739,XP_011543710,XP_006718816,NP_036428
Dip2a	1618;1850;6820;9819	0.8566	0.8971	0.9909	0.905	MGI:2385920	6451	NM_001081419|XM_006513940|XM_006513939|XR_001779571|XM_006513941	XP_006514003|NP_001074888|XP_006514002|XP_006514004	41012	HGNC:17217	2311	NM_206891,NM_206889,NM_206890,NM_001146114,NM_015151,NM_001146115,NM_001146116	XP_011527794,NP_001139587,XP_016883783,XP_016883781,XP_016883784,XP_016883786,XP_016883785,XP_016883791,XP_016883780,XP_016883792,NP_001139588,XP_016883794,XP_016883789,XP_011527804,XP_016883793,XP_016883782,NP_996774,XP_016883790,NP_996772,XP_016883788,NP_055966,XP_011527803,NP_996773,XP_016883787
Nras	637;1855;5673;	0.8548	0.7640	0.9909	0.905	MGI:97376	1816	XM_006501119|XM_006501118|XM_006501120|XM_006501122|NM_010937|XM_006501123|XM_006501121	XP_006501186|XP_006501182|XP_006501181|XP_006501183|NP_035067|XP_006501185|XP_006501184	55661	HGNC:7989	4893	NM_002524	NP_002515

H2-D1	8687;11856;23193;23833	0.8544	0.0970	0.0901	0.9913	0.9905	MGI:95896	1496	NM_010380	NP_034510	12835	HGNC:49311	3105	NM_002116,NM_001242758	XP_005275388,NP_002107,NP_001229687,XP_016885777
Tirap	17941;18611;45144;54933	0.8526	0.0622	0.0905	0.9933	0.9905	MGI:2152213	11749	NM_054096|NM_001177847|NM_001177845|NM_001177846	NP_001171318|NP_473437|NP_001171317|NP_001171316	14285	HGNC:17192	11609	NM_052887,NM_148910,NM_001039661,NM_001318777,NM_001318776	XP_005271456,NP_683708,NP_001034750,XP_016872651,NP_001305706,XP_016872650,XP_011540878,NP_001305705
Kidins220	7481;18622;58791;92833	0.8532	0.0906	0.0919	0.9905	MGI:1924730	77480	XM_006515256|XM_006515249|XM_006515251|XM_017315243|XM_006515253|NM_001081378|XM_006515259|XM_006515257|XM_006515252|XM_006515254|XM_006515258|XM_006515255|XM_006515250|XM_017315244|XM_006515260	XP_006515320|NP_001074847|XP_006515318|XP_006515316|XP_006515317|XP_006515323|XP_006515315|XP_017170733|XP_006515312|XP_006515322|XP_006515319|XP_006515313|XP_006515314|XP_017170732|XP_006515321	14254	HGNC:29508	57498	NM_020738,NM_001348732,NM_001348736,NM_001348739,NM_001348734,NM_001348745,NM_001348729,NM_001348742,NM_001348738,NM_001348741,NM_001348731,NM_001348740,NM_001348743,NM_001348735	NP_001335663,NP_001335667,NP_001335660,NP_001335665,NP_001335668,NP_001335672,NP_001335658,NP_001335669,NP_001335674,NP_001335664,NP_001335661,NP_001335670,NP_065789,NP_001335671
Sgce	14319;18633;47107;7	0.8519	0.0640	0.0907	0.9905	MGI:1329042	20392	XM_006505024|XM_006505021|NM_001130188|NM_001130189|NM_001130190|NM_001130191|XM_006505019|XM_006505020|XM_006505023|NM_011360|XM_011241051|XM_006505022	NP_001123660|XP_006505086|XP_006505087|NP_035490|XP_006505084|NP_001123662|XP_006505085|XP_006505082|XP_006505083|NP_001123663|NP_001123661|XP_011239353	31205	HGNC:10808	89108	NM_001346715,NM_001346717,NM_003919,NM_001346719,NM_001346720,NM_001099400,NM_001346713,NM_001301139,NM_001099401	NP_003910,NP_001333644,NP_001333642,XP_011514965,NP_001333648,XP_016868257,NP_001092870,XP_016868255,XP_016868256,NP_001288068,XP_011514968,XP_011514969,XP_016868258,XP_005250734,NP_001092871,XP_016868259,XP_

	636													016868253,XP_005250732,XP_016868254,XP_016868252,XP_011514971,XP_011514967,XP_011514966,NP_001333646,NP_001333649
B2m	641;1872;4167;8290	0.848708	0.760849	0.914961	0.995939	0.995939	MGI:881127	1210	NM_009735	NP_033865	287	HGNC:914	567	NM_004048	NP_004039,XP_005254606
Clk4	1503;1874;2481;3695	0.848403	0.639316	0.916454	0.995439	0.995439	MGI:1098551	1270	XM_006532115|XM_011248708|XM_006532116|XM_006532111|XM_017314244|NM_001304744|XM_006532118|XM_006532114|XM_006532113|XM_011248709|NM_007714|XM_006532112|XM_017314243	XP_017169733|XP_017169732|XP_006532179|XP_006532176|NP_031740|XP_006532175|XP_011247010|XP_006532181|NP_001291673|XP_006532178|XP_006532177|XP_006532174|XP_011247011	56895	HGNC:136559	573956	NM_020666	NP_065717
Serinc1	1310;1875;8166;8254	0.847676	0.654173	0.917339	0.993939	0.993939	MGI:1926228	5642	NM_019760	NP_062734	41334	HGNC:134464	575155	NM_020755	NP_065806
Rab5b	864;1878;5	0.846505	0.710998	0.919842	0.994242	0.994242	MGI:1059388	1934	XM_006513384|NM_177411	XP_006513447|NP_803130	104027	HGNC:97884	5869	NM_002868,NM_001252037,NM_001252036	XP_005269109,NP_001238965,NP_001238966,NP_002859,XP_005269108

	191;595														
Sla2	1322;1882;6730;7359	0.845	0.651	0.923	0.995	0.995	MGI:1925049	779	NM_029983|XM_011239846|XM_011239845|XM_006500405	XP_011238148|NP_084259|XP_011238147|XP_006500468	499	HGNC:17329	89	NM_032214,NM_175077	NP_115590,XP_016883587,NP_778252
Nudt6	1600;1886;3995;6707	0.843	0.631	0.926	0.996	0.995	MGI:2387618	229	XM_006535459|XM_017319540|XM_011249670|NM_001291044|XM_011249672|XM_006535463|XM_006535460|XM_011249671|XM_017319539|NM_153561|XM_011249676|XM_011249674|XM_011249675|XM_006535462	XP_017175029|XP_011247977|XP_011247974|XP_006535526|XP_006535522|XP_006535523|XP_011247973|XP_011247978|NP_001277973|XP_017175028|XP_011247972|NP_705789|XP_006535525|XP_011247976	3142	HGNC:8053	116	NM_198041,NM_007083	NP_009014,NP_932158
Adcy7	1733;1890;6702;8621	0.842	0.623	0.929	0.997	0.995	MGI:1028911	1151	XM_011248281|XR_878769|XM_011248278|NM_001109756|NM_007406|NM_001037723|XM_006530580|XM_011248277|XM_011248282|XM_011248280|NM_001037724|XM_011248279|XR_878770|XM_011248283	XP_006530643|XP_011246579|XP_011246583|XP_011246580|NP_001032812|NP_001032813|XP_011246585|NP_031432|XP_011246582|NP_001103226|XP_011246581|XP_011246584	866	HGNC:238	113	NM_001286057,NM_001114	XP_011521140,XP_011521142,XP_016878386,XP_016878388,XP_016878387,NP_001272986,XP_011521144,XP_011521141,XP_016878384,XP_016878385,XP_011521137,XP_011521138,NP_001105,XP_011521139
Rala	1048;1891;	0.842	0.680	0.930	0.996	0.995	MGI:1927244	5604	NM_019491	NP_062364	3942	HGNC:98399	5898	NM_005402	XP_011513769,NP_005393,XP_006715825,XP_011513768

	32173;81977						43								
Pkia	1364;1895;6153;85144	0.8406	0.6459	0.9936	0.9973	0.9958	MGI:1047477	1867	NM_008862|XM_006530056	NP_032888|XP_006530119	7473	HGNC:9017	559	NM_181839,NM_006823	NP_006814,XP_016869109,NP_862822,XP_016869110,XP_016869111
Exoc2	1121;1896;32233;70288	0.8402	0.6700	0.9344	0.9958	0.9958	MGI:1913732	6648	XM_017315564|NM_025588|XM_011244327|XM_006516726|XM_011244328|XM_017315565|XM_011244326	XP_011242628|XP_017171053|NP_079864|XP_011242630|XP_011242629|XP_017171054|XP_006516789	10122	HGNC:24968	5570	NM_018303	XP_016866515,NP_060773,XP_016866509,XP_016866508,XP_016866513,XP_016866511,XP_016866510,XP_016866514,XP_016866512,XP_016866507
Fam21	1301;19025;65533;70599	0.8381	0.6502	0.9939	0.9877	0.9972	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Rps6ka3	507;1903;	0.8378	0.7969	0.9401	0.9972	0.9972	MGI:1045	1065	XM_017318355|NM_148945|XM_017318354|XM_017318353|XM_006528687|XM_006528688|XM_006528686|NM_001346675	XP_017173844|XP_006528751|NP_683747|XP_017173842|NP_001333604|XP_006528749|XP_006528750|XP_017173843	37940	HGNC:104	6197	NM_004586	XP_016885202,XP_011543865,XP_005274630,XP_006724570,XP_011543861,XP_011543864,XP_011543863,XP_011543859,XP_016885208,

	27240;6940					57				32				XP_016885204, XP_011543862, XP_016885206, XP_016885207, XP_011543858, NP_004577,XP_005274634,XP_016885203,XP_011543857,XP_011543860,XP_016885205
Pin1	55;19122;29811;50855	0.83470	1.24770	0.94760	1.00000	1.00000	MGI:1346036	2398	NM_023371	NP_075860	4531	HGNC:8988	5300	NM_006221	XP_011526370, NP_006212
Jam3	897;19133;27866;43588	0.83430	0.66990	0.94855	1.00000	1.00000	MGI:1933825	8396	NM_023277	NP_075766	11338	HGNC:15532	8370	NM_032801,NM_001205329	NP_116190,NP_001192258
Bptf	14911;19115;56822;97800	0.83329	0.63250	0.95001	1.00000	1.00000	MGI:2444008	20716 5	XM_006532690|XM_006532687|XM_006532684|XM_006532676|XM_006532682|XM_006532688|XM_006532689|XM_017314399|XM_006532678|XM_006532675|XM_006532677|XM_006532685|XM_006532679|NM_176850|XM_006532681|XM_006532683|XM_006532680|XM_006532686|XM_006532691	XP_006532740|XP_006532747|XP_006532753|XP_006532743|XP_006532751|XP_006532744|XP_006532745|XP_006532754|XP_006532752|XP_006532748|XP_006532742|XP_006532750|XP_006532739|NP_789820|XP_017169888|XP_006532741|XP_006532738|XP_006532749|XP_006532746	11439 7	HGNC:3581	21816	NM_004459,NM_182641	XP_005257207, XP_011522826, XP_011522824, XP_011522823, XP_011522828, XP_005257212, XP_005257213, XP_005257215, XP_005257218, XP_011522822, XP_016879843, NP_872579,XP_005257208,XP_005257211,NP_004450,XP_005257210,XP_005257217,XP_005257216,XP_011522825,XP_005257214,XP_005257209,XP_016879842,XP_011522827
Tes	15733;1	0.83230	0.62700	0.95340	1.00000	1.00000	MGI:10	2175 3	NM_207176	NP_997059	41051	HGNC:1	26136	NM_015641,NM_152829	XP_005250315, NP_690042,NP_056456

	9 1 9 ; 4 9 1 3 ; ; 8 1 1 2					5 0 8 1					4 6 2 0				
Pip5k1a	7 3 2 ; 1 9 2 8 ; ; 2 6 5 8 ; ; 3 6 2 4	0 . 8 2 9 2	0 . 7 2 8 7	0 . 9 6 1 0	1 . 0 0 0 0	1 . 0 0 0 0	MGI:1079291	18720	XM_017319485|NM_001293707|NM_008847|XR_375499|XR_375498	XP_017174974|NP_001280636|NP_032873	9 3 4 9 2	HGNC:8994	8 3 9 4	NM_001135637, NM_001330689, NM_001135636, NM_001135638, NM_003557	XP_011508348, XP_005245585, NP_001129110, XP_005245582, XP_016857929, NP_003548,XP_011508345,XP_016857930,XP_006711630,XP_006711626,XP_016857928,NP_001317618,XP_005245584,XP_006711631,XP_011508347,XP_005245587,XP_006711627,XP_011508350,XP_005245588,NP_001129109,NP_001129108,XP_005245589,XP_011508351
Snx27	3 0 5 ; 1 9 3 1 ; ; 2 0 5 8 ; ; 4 5 7 3	0 . 8 2 8 2	0 . 8 8 8 5	0 . 9 6 3 6	1 . 0 0 0 0	1 . 0 0 0 0	MGI:1923992	76742	XM_131051|NM_001082484|XM_006502258	XP_006502321|NP_001075953|NP_083997	1 2 7 9 7	HGNC:20073	8 1 6 0 9	NM_001330723, NM_030918	XP_016857906, NP_001317652, XP_005245567, XP_005245566, XP_011508326, NP_112180,XP_005245568,XP_011508328,XP_011508327
Akt2	1 7 1 5 ; 1 9 3 5 ; 6 0 4 0 ; 6 4 3 0	0 . 8 2 6 8	0 . 6 6 6 7	0 . 9 6 7 1	1 . 0 0 0 0	1 . 0 0 0 0	MGI:1048774	11652	NM_007434|NM_001331109|NM_001110208|XM_006539478|XM_011250418|XM_006539481|XM_006539483|XM_006539482|XM_006539480|XM_006539477|NM_001331108	XP_006539545|XP_011248720|NP_001103678|NP_031460|XP_006539541|NP_001318038|XP_006539546|XP_006539540|NP_001318037|XP_006539543|XP_006539544	4 8 7 3	HGNC:392	2 0 8	NM_001330511, NM_001243027, NM_001243028, NM_001626	NP_001229957, XP_011524920, XP_011524922, XP_011524918, XP_016881959, NP_001317440, XP_011524924, XP_016881960, NP_001617,XP_011524917,XP_011524916,NP_001229956,XP_011524921
Ra	1 0	0 .	0 .	0 .	1 .	1 .	MG	69	NR_104478|NM_001039394|NR	NP_001034483|NP_598478	4 3	HG	3 3	NM_001204885, NM_001204886,	NP_001191815, NP_001191816,

b43	82;19362;32611;75866	82679	96800	00000	I:191708	834	_104477|NM_133717			122	NC:19983	912	NM_001204883, NM_198490,NM_001204887,NM_001204884,NM_001204888	NP_001191813, NP_001191814, NP_940892,NP_001191812,NP_001191817
Dtnbp1	175;19373;25733;41844	0.8261	0.9994	0.9688	0.0000	MGI:2137586	9424 5	XM_006516984|NM_025772	NP_080048|XP_006517047	12037	HGNC:17328	84062	NM_001271667, NM_001271668, NM_183040,NM_032122,NM_001271669	NP_001258596, NP_898861,NP_001258597,XP_016866837,NP_115498,XP_011513238,NP_001258598,XP_005249504,XP_011513239,XP_016866838
Ncs1	154;19422;37700;55300	0.8244	0.0249	0.9730	0.0000	MGI:109166	14299	XR_866007|NM_019681|XR_866008	NP_062655	5719	HGNC:39533	2341 3	NM_001128826, NM_014286	NP_055101,NP_001122298
Eya3	442;19444;42733;75700	0.8237	0.8152	0.9746	0.0000	MGI:109339	14050	NM_010166|NM_211357|XM_006538540|NM_210071|XM_006538537|XM_006538538	XP_006538601|NP_997592|NP_034296|XP_006538600|XP_006538603|NP_997596	1508	HGNC:35211	2140	NM_001282562, NM_172098,NM_001282560,NM_001282561,NM_001990	XP_011539306, NP_001269489, XP_016856142, XP_016856144, NP_001269490, XP_016856147, NP_001981,XP_016856148,XP_016856143,NP_001269491,XP_011539305,XP_006710512,XP_016856145,XP_016856146,XP_016856141,XP_011539303,XP_011539301
Mna	1918	0.8 2	0.6 0	0.9 7	1.0 0	1.0 0	MGI:	174	NM_008612|XM_011244008|XM_006515526	XP_006515589|NP_032638|XP_011242310	1821	HGNC	4331	NM_001177963, NM_002431	XP_005267744, XP_016876822, XP_005267745, XP_016876821,

t1	;19473;92933;98333	27	68	73	000	000	10620	207				:7181			XP_016876823, NP_002422,NP_001171434
lqgap3	19098;19483;39311;74200	0.82244	0.60700	0.97810	1.00000	1.00000	MGI:3028642	40471	NM_001033484|XM_006501643	NP_001028656|XP_006501706	2640	HGNC:20669	1	NM_178229	XP_011507503, XP_016855806, XP_016855807, NP_839943,XP_011507502,XP_011507500
Mapk6	93;19493;29133;48844	0.82211	0.68611	0.97890	1.00000	1.00000	MGI:1354946	50772	NM_027418|NM_015806|XM_011242767	NP_081694|XP_011241069|NP_056621	5568	HGNC:6879	5	NM_002748	NP_002739,XP_005254595,XP_011520084,XP_005254596,XP_005254594
Ect2	79;19503;27783;79377	0.82117	0.71198	0.97900	1.00000	1.00000	MGI:952881	13605	NM_001177625|XM_006535385|XM_006535386|NM_007900|NM_001177626	NP_001171096|XP_006535448|NP_001171097|XP_006535449|NP_031926	7298	HGNC:3155	1	NM_001349102, NM_001349100, NM_001349099, NM_001258315, NM_001349101, NM_001258316, NM_001349097, NM_001349104, NM_001349096, NM_001349103, NM_001349094, NM_018098,NM_001349098,NM_001349095	XP_011510817, XP_016861327, NP_060568,XP_016861325,NP_001245244,XP_011510816,XP_016861320,NP_001336032,XP_006713587,NP_001336030,XP_006713586,NP_001336026,XP_016861324,NP_001336028,XP_011510818,NP_001336023,NP_001336031,NP_001336024,NP_001336025,NP_001336027,XP_016861321,NP_001336029,XP_016861326,XP_

														005247233,NP_001245245,NP_001336033,XP_016861319,XP_016861322,XP_016861323
Map3k15	125;1957;2410;25334	0.81944	1.06557	0.985566	1.0000	1.0000	MGI:2448588	2706720	NM_001163085	NP_001156557	5040 1	HGNC:31689	3898400	NM_001001671	XP_011543809, XP_011543812, XP_011543813, NP_001001671, XP_011543810, XP_016885000
Arf6	1820;1959;26599;35766	0.818187	0.60882	0.987373	1.0000	1.0000	MGI:994355	1184545	NM_007481	NP_031507	1256	HGNC:6599	3823	NM_001663	NP_001654
Tfpi	1298;1960;24493;30166	0.818406	0.648806	0.988100	1.0000	1.0000	MGI:1095418	2178	XM_006499146|NM_001177319|XM_006499149|XM_006499147|NM_011576|XM_006499150|XM_006499148|XM_006499145|NM_001177320	XP_006499212|XP_006499208|XP_006499209|NP_001170790|XP_006499211|XP_006499213|NP_001170791|XP_006499210|NP_035706	4579	HGNC:11760	70355	NM_001329240,NM_006287,NM_001329239,NM_001318941,NM_001329241,NM_001032281	XP_006712783, XP_005246875, XP_011510010, NP_001027452, XP_005246876, NP_001316170, NP_001305870, XP_011510009, XP_011510011, NP_001316168, NP_001316169, NP_006278
Ccnd2	850;1961;23500	0.818111	0.699100	0.989000	1.0000	1.0000	MGI:883144	1244 4	NM_009829|XM_006505460|XM_006505459	XP_006505523|XP_006505522|NP_033959	37525	HGNC:15833	8940	NM_001759	NP_001750

	;7685													
Tfpt	10268;19677;93255;97344	0.8161	0.6701	0.99400	1.0000	1.0000	MGI:1916964	6971 4	NM_001290381|NM_023524	NP_076013|NP_001277310	8349	HGNC:13630	2984 4	NM_001321792, NM_013342	NP_037474,NP_001308721,XP_005278318
Ugt1a9	16744;19682;26855;41733	0.8157	0.6132	0.99480	1.0000	1.0000	MGI:3576092	3944 34	NM_201644	NP_964006	13328 1	#N/A	5454 575	NM_019075	NP_061948
Akap1	8369;19699;25699;;26233	0.8154	0.7004	0.99570	1.0000	1.0000	MGI:1047299	1164 0	NM_009648|XR_879507|XR_388330|NR_104310|NM_001042541	NP_001036006|NP_033778	31165	HGNC:367	8165	NM_139275,NM_001242902,NM_001242903,NM_003488	XP_005257764, NP_001229831, XP_016880680, XP_016880678, XP_005257766, XP_016880679, NP_003479,NP_001229832
Efna2	14771;19711;62788	0.8147	0.6244	0.99740	1.0000	1.0000	MGI:1027077	1363 7	NM_007909	NP_031935	1075	HGNC:32222	1943	NM_001405	NP_001396,XP_016881938,XP_016881939

;9110															
Adck5	18	0.8	0.6	0.9	0.0	1.0	MGI:2	26	NR_073123|NM_172960	NP_766548	34	HGNC:21738	20	NM_174922	XP_011515209, NP_777582,XP_011515212,XP_016868663,XP_006716590,XP_011515211
	48;19	1.4	0.5	0.8	0.0	1.0	6792	82			37		05		
	72;62	4.4	0.3	3.0	0.0	1.0	74	2			8		4		
70;64															
05															
Sbf2	84	0.8	0.6	0.9	0.0	1.0	MGI:1	31	XM_011241830|XR_001785572|XM_006507926|NM_177324|XM_006507924|XM_006507925|XM_006507927	NP_796298|XP_006507987|XP_006507988|XP_006507989|XP_011240132|XP_006507990	41	HGNC:2135	81	NM_030962	XP_005253211, XP_011518698, XP_011518696, XP_016873864, XP_016873865, XP_005253212, XP_011518697, NP_112224,XP_016873866,XP_016873861,XP_016873863,XP_016873862
	43;19	1.4	0.9	9.9	0.0	1.0	9213	34			81		84		
	73;71	1.4	0.1	1.0	0.0	1.0	831				10		6		
10;90															
34															
Acvr1b	16	0.8	0.6	0.0	0.0	1.0	MGI:1	14	NM_007395	NP_031421	20	HGNC:172	91	NM_020328,NM_004302,NM_020327	XP_011537269, XP_011537268, XP_016875690, NP_064733,NP_004293,NP_064732,XP_016875688,XP_016875689
	13;19	1.3	0.1	0.0	0.0	1.0	3389	79			09				
	74;41	3.7	0.5	0.0	0.0	1.0	44				06				
40;42															
20															

Part III Genes depleted in TCRα KO mice without treatment against the *in vitro* control

p-value=0 means <3.7344e-05, FDR=0 means <0.0006

p-value=0 means <4.6679238942e-06, FDR=0 means <0.000523974457124

Genes	Ranks	STARS	Average	p-val	FDR	q-val	Mouse	Mouse	Mouse NCBI RefSeq Transcript ID	Mouse NCBI RefSeq Protein ID	Homol	HGNC	Human	Human NCBI RefSeq Transcript ID	Human NCBI RefSeq Protein ID

ymbol	ofpeturbations	Score	geScore	ue	ue	MarkerID	NCBIEntrezID			ogeneID	ID	NCBIEntrezID		
Arf1	1;16;10;77	8.43177	6.46552	0.000000	0.000000	MGI:994310	11840	NM_001130408|NM_007476	NP_031502|NP_001123880	133930	HGNC:652	375	NM_001024226, NM_001024227, NM_001024228, NM_001658	NP_001019399, NP_001019398, NP_001019397, XP_016856722, NP_001649
Adrbk1	20;35;56;91	8.141415	5.12500	0.000000	0.000000	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Pdxk	54;65;69;129	7.553531	4.66510	0.000000	0.000000	MGI:1351869	216134	NM_172134	NP_742146	27331	HGNC:88199	8566	NM_001331030, NM_021941,NM_003681	XP_011528064, NP_003672,XP_005261252,NP_001317959,XP_016883973,XP_005261253,XP_011528063,XP_005261255,XP_016883972,XP_011528062,XP_011528060,XP_005261256
Yipf3	40;46;48;137	7.430738	4.86380	0.000000	0.000000	MGI:1062800	280064	XM_017317498|NM_145353|XM_006524377	XP_006524440|NP_663328|XP_017172987	9117	HGNC:210223	25844	NM_015388	NP_056203,XP_005249047,XP_011512760,XP_005249046
Nckap1	7;17;157;192	6.844461	4.73610	0.000000	0.000044	MGI:1355333	508084	XM_006499881|NM_016965|XM_006499882|NM_001290745	XP_006499945|XP_006499944|NP_058661|NP_001277674	8384	HGNC:7666	10787	NM_205842,NM_013436	XP_006712264, NP_995314,NP_038464,XP_006712263
Clpt	51;1	6.18	3.92	0.000	0.000	MGI:	564	NM_019649|XM_006540227	NP_062623|XP_006540290	374	HGNC	1209	NM_001294,NM_001282175,NM_001282176,NM_001199468	NP_001269104, NP_001269105, NP_001285

m1	11;171;280	900	500	0007	07	1927155	57				64	:2087			
Tm2d1	29;62;68;1449	5.8866	3.6963	0.0000	0.0012	0.0012	MGI:2137022	9404	XM_006503494|NM_053157	XP_006503557|NP_444387	1292	HGNC:24142	8394	NM_032027	NP_114416
Prkra	13;39;74;1061	5.7767	3.7909	0.0000	0.0013	0.0013	MGI:1344375	2392	XM_017318023|XM_011239517|XM_011239518|NM_011871	NP_036001|XP_011237820|XP_017173512|XP_011237819	2738	HGNC:9438	8575	NM_001139518,NM_003690,NM_001139517,NM_001316362	XP_016860648,NP_001303291,XP_011510368,NP_001132989,XP_011510365,NP_003681,NP_001132990
Arpc2	33;79;84;4129	5.6120	3.6375	0.0000	0.0019	0.0019	MGI:1923959	7670	XM_006496317|XM_129773	XP_006496380|NP_083987	4187	HGNC:7055	1010	NM_152862,NM_005731	XP_016858604,XP_011508773,NP_690601,XP_016858603,XP_016858602,NP_005722
Crk	63;73;99;6766	5.3986	3.7871	0.0001	0.0029	0.0029	MGI:8850	128	XM_006532125|XM_006532124|NM_133656|NM_001277221|NM_001277219	XP_006532188|NP_001264148|NP_001264150|NP_598417|XP_006532187	8185	HGNC:2362	1398	NM_016823,NM_005206	NP_005197,NP_058431
Yipf4	27;209;308;463	5.3153	3.4495	0.0001	0.0029	0.0029	MGI:1915114	6784	NM_026417	NP_080693	3265	HGNC:28145	8427	NM_032312	XP_011531427,NP_115688,XP_005264656

Itgb1	83;277;396;478	5.2599	3.1751	0.0001	0.0030	0.0030	MGI:96610	1641 2	XM_134403	NP_034708	22999	HGNC:6153	368 8	NM_033668,NM_002211,NM_033666,NM_033667,NM_033669,NM_133376	NP_596867,NP_391988,NP_002202
Scyl1	102;252;317;653	4.7180	3.1094	0.0003	0.0098	0.0098	MGI:1931787	7891	NM_023912|XM_006531856|XM_006531857|XR_388273	XP_006531919|XP_006531920|NP_076401	69477	HGNC:14372	5741 0	NM_020680,NM_001048218	NP_065731,XP_016873519,XP_016873521,XP_016873518,XP_005274178,XP_005274177,XP_016873522,NP_001041683,XP_016873520,XP_005274175
Ptk2	2;167;593;681	4.64501	3.4014 4	0.0012 3	0.0123	0.0123	MGI:95481	1408 3	XR_383981|XM_006520421|XM_006520418|XM_006520434|XM_011245452|XM_011245453|XM_006520426|XM_006520420|XM_006520423|XM_006520416|XM_006520425|XM_006520432|XM_006520428|XM_006520427|XM_017316429|XM_006520435|XM_006520431|XM_006520415|XM_006520424|XM_006520429|NM_007982|XM_006520430|XM_006520433|XM_006520422|XR_001781493|NM_001130409|XM_017316428	NP_032008|XP_006520491|XP_006520484|XP_006520490|XP_011243755|XP_017171918|XP_006520485|XP_006520478|XP_006520496|XP_006520495|NP_001123881|XP_006520487|XP_006520498|XP_006520479|XP_017171917|XP_006520497|XP_006520486|XP_006520488|XP_006520494|XP_006520481|XP_006520483|XP_011243754|XP_006520489|XP_006520493|XP_006520492	7314	HGNC:9611	5747	NM_001352733,NM_001352697,NM_001352716,NM_001352746,NM_001352738,NM_001352752,NM_001352706,NM_001352740,NM_001352747,NM_001352723,NM_001352735,NM_001352732,NM_001352709,NM_001352701,NM_153831,NM_001352703,NM_001352712,NM_001352737,NM_001352741,NM_001352717,NM_001199649,NM_001352707,NM_001316342,NM_001352743,NM_001352720,NM_001352695,NM_001352699,NM_001352718,NM_001352711,NM_001352694,NM_001352745,NM_001352704,NM_001352700,NM_001352751,NM_001352724,NM_001352736,NM_001352708,NM_001352748,NM_001352730,NM_001352734,NM_001352750,NM_001352714,NM_001352713,NM_001352727,NM_001352726,NM_001352710,NM_	XP_016869172,NP_001339624,XP_016869145,XP_016869164,XP_016869155,XP_006716671,NP_001339671,XP_016869165,NP_001339679,XP_016869173,XP_016869169,XP_016869148,XP_016869176,NP_001339680,XP_005251070,NP_001339650,NP_001339658,NP_001339672,XP_016869159,XP_016869153,XP_016869162,NP_001339668,NP_001339627,XP_016869150,XP_016869178,NP_001339642,NP_001339667,NP_001339654,NP_001339665,XP_016869163,XP_016869144,NP_001339656,NP_001339655,NP_001339651,NP_001339628,NP_001339633,XP_016869154,NP_001339681,NP_001339636,NP_001339631,NP_001339634,XP_016869167,NP_001339629,NP_001339666,XP_016869147,XP_016869177,

													_001352696,NM_001352728,NM_001352698,NM_001352744,NM_001352742,NM_001352705,NM_005607,NM_001352722,NM_001352749,NM_001352731,NM_001352719,NM_001352721,NM_001352729,NM_001352725,NM_001352739,NM_001352715,NM_001352702	XP_016869158, NP_001339669, XP_005251069, NP_001339647, NP_001339677, XP_016869175, XP_005251060, NP_001339659, NP_001339644, NP_001339662, NP_001339645, NP_001339635, XP_016869166, NP_001339661, NP_001303271, XP_016869156, NP_001339632, NP_001339639, NP_001339673, XP_016869142, NP_001339623, NP_001339678, NP_001339643, XP_016869141, NP_001339674, NP_001339649, NP_001339625, NP_001339653, NP_001339657, XP_011515496, NP_005598,XP_016869146,NP_001339630,NP_001186578,NP_001339638,NP_001339626,XP_016869151,NP_001339641,NP_001339660,XP_016869171,XP_016869161,NP_001339675,NP_001339646,XP_016869143,XP_016869179,NP_001339637,NP_001339663,XP_016869152,XP_016869168,XP_016869174,XP_006716673,NP_001339648,XP_006716672,NP_001339676,NP_001339664,XP_016869140,XP_016869149,XP_016869170,NP_001339652,NP_001339670,XP_016869160,NP_001339640,NP_722560,XP_016869157
Trapc4	81;124;201;	4.4805	3.0324	0.0.0505	0.0.1500	0.1.1500	MGI:1926211	6049	NM_021789|XM_017313498	XP_017168987|NP_068561	10545	HGNC:19943	5139	NM_001318490, NM_001318494, NM_001318489, NM_001318488, NM_001318492, NM_016146,NM_001318486	NP_001305417, NP_001305419, NP_001305423, NP_001305418, NP_001305421, NP_057230,NP_001305415

	57011														
Arfrp1	5;25;62669;94222	4.4170	3.5505	0.0006	0.0153	0.0153	MGI:1923938	768	NM_001165991|XR_867138|NR_028585|NM_001165995|XM_011239965|NM_029702|XR_867137|NM_001165992	NP_083978|NP_001159463|NP_001159467|XP_011238267|NP_001159464	2425	HGNC:662	1039	NM_001267549, NM_001267544, NM_001267546, NM_001267545, NM_001267548, NM_001134758, NM_003224,NM_001267547	NP_001254477, NP_001254475, NP_001254473, XP_016883065, NP_001254478, NP_001254476, XP_011526785, NP_001254474, NP_003215,NP_001128230,XP_011526784
Bcar1	8;215;222;17455	4.3152044	3.1000006	0.0001557	0.0001556	0.0001556	MGI:1080091	1279	NM_001198839|XM_011248299|NM_009954	XP_011246601|NP_001185768|NP_034084	7674	HGNC:971	9564	NM_001170719, NM_001170715, NM_001170721, NM_001170716, NM_001170720, NM_001170717, NM_001170714, NM_014567,NM_001170718	XP_016879387, NP_001164192, NP_001164188, XP_016879388, NP_001164187, NP_055382,XP_005256316,XP_016879386,NP_001164190,XP_005256317,XP_011521777,NP_001164191,XP_005256315,NP_001164189,NP_001164186,NP_001164185
Hscb	88;469;720;814	4.3351	2.6368	0.0005	0.0001556	0.0001556	MGI:2141135	1090	XR_001784585|NM_153571|XM_017320582|XM_006534694	XP_006534757|XP_017176071|NP_705799	13945	HGNC:28913	150274	NM_001318314, NM_001318316, NM_172002,NM_001318315	XP_016884108, XP_016884109, NP_001305243, NP_741999,NP_001305244,NP_001305245,XP_005261416
Dgke	170;230;312;825	4.3119	2.9792	0.0005	0.0001559	0.0001559	MGI:1888927	5607	XM_011249151|XR_001780032|XR_388496|NM_019505	NP_062378|XP_011247453	2705	HGNC:2852	8526	NM_003647	XP_016880733, XP_016880734, XP_011523697, XP_011523696, NP_003638,XP_011523698,XP_016880732
Esyt2	172;236;306;	3.9337	2.5374	0.0001	0.0003	0.0003	MGI:1261845	5263	XM_011244139|XM_006516072|XM_017315129|XM_006516075|XM_017315130|XR_001780465|XM_017315131|NM_028731|XR_001780464|XR_001780466|XM_017315128|XR_001780467	XP_006516135|XP_017170618|XP_017170617|XP_006516138|XP_017170619|NP_083007|XP_011242441|XP_017170620	3269	HGNC:2221	5748	NM_020728	NP_065779

	560909														
Ap3d1	37;27878;31521121	3.9.40.3	2.6.4.0	0.0.1.9	0.0.3.7	0.0.3.8	MGI:1077734	117176	NM_007460|XR_001779423|XR_380349|XR_001779424	NP_031486	2926	HGNC:5668	894 3	NM_001077523, NM_001261826, NM_003938	NP_003929,XP_016882911,NP_001248755,XP_006722995
Cdc25b	131;147;449;1139	3.7.5.1.5	2.8.4.4.4	0.0.0.2.6	0.0.5.1.4	0.0.4.8.2	MGI:9970701	125311	XR_374398|NM_001111075|NM_023117	NP_075606|NP_001104545	41451	HGNC:1726	994	NM_001287517, NM_021872,NM_212530,NM_001287516,NM_021874,NM_004358,NM_001287519,NM_001287524,NM_001287518,NM_021873,NM_001287522,NM_001287520	NP_001274448, NP_001274451, NP_068659,NP_001274453,NP_001274447,NP_001274446,NP_068658,NP_004349,NP_001274449,NP_001274445
Cyth3	261;674;805;1141	3.7.4.8.5	2.6.8.6	0.0.2.7	0.0.5.0	0.0.4.8.2	MGI:1335107	191159	NM_011182|XM_017320729|NM_001163548	NP_001157020|XP_017176218|NP_035312	316	HGNC:9504	926 5	NM_004227	NP_004218
Pkn2	150;354;355;2777	3.7.4.6.4	2.3.7.5.6	0.0.2.7	0.0.4.8.2	0.0.4.8.2	MGI:1092111	109333	NM_178654	NP_848769	2054	HGNC:9406	555 86	NM_001320707, NM_001320708, NM_006256,NM_001320709	NP_001307637, XP_016857271, NP_006247,XP_016857272,NP_001307636,NP_001307638,XP_011540074
Pik3cb	153;159;	3.6.4.7.9	2.6.5.2.2	0.0.0.3.3	0.0.5.6.9	0.0.5.6.9	MGI:1922	477 69	XM_011242830|NM_029094|XM_011242829|XM_006511520	XP_011241132|XP_006511583|NP_083370|XP_011241131	21250	HGNC:89	529 1	NM_001256045, NM_006219	XP_005247587, XP_011511197, XP_011511198, NP_006210,XP_016862109,XP_016862108,NP_001242974,XP_

	682;1209					019					76				016862110,XP_006713722
Hk2	196;377;711;1246	3.5955	2.4179	0.0038	0.0628	0.0625	MGI:1315197	1527	NM_013820|XM_017321401	XP_017176890|NP_038848	3727	HGNC:4923	309	NM_000189	NP_000180,XP_011531109,XP_016859434,XP_005264337
Mark3	14;207;408;2474	3.5675	2.8042	0.0040	0.0636	0.0625	MGI:1341865	1719	XM_006515517|XM_006515511|XM_011244006|XM_006515518|NM_021516|NM_022801|XM_006515515|XM_006515513|XM_006515519|XM_006515514|XM_011244007|XM_006515512|XM_006515522	XP_006515580|XP_006515575|XP_006515581|XP_011242308|XP_006515578|NP_067491|XP_006515582|XP_006515577|XP_006515585|XP_011242309|XP_006515576|NP_073712	5565	HGNC:6897	410	NM_002376,NM_001128920,NM_001128918,NM_001128921,NM_001128919	NP_001122392,XP_016876782,XP_016876797,NP_001122393,XP_016876800,XP_005267699,XP_016876793,XP_016876789,XP_005267700,XP_016876787,XP_016876794,XP_016876784,XP_016876783,XP_016876788,XP_016876791,XP_016876795,XP_005267698,NP_001122390,XP_006720209,XP_016876799,XP_016876798,XP_016876796,NP_001122391,XP_016876790,XP_016876785,XP_016876780,XP_016876786,XP_016876792,NP_002367,XP_016876781,XP_011535071
Bcap31	834;1178;1235;1272	3.5597	1.8722	0.0040	0.0625	0.0625	MGI:1350933	2706	XM_011247600|NM_001313698|NM_012060|XM_006528048	XP_006528111|NP_036190|NP_001300627|XP_011245902	3809	HGNC:1669	1034	NM_005745,NM_001139441,NM_001256447,NM_001139457	NP_001132913,NP_005736,NP_001243376,NP_001132929
Ap	15	3.	2.	0.	0.	0.	MG	11	NM_009680|XM_006517523|XR	XP_006517586|NP_033810	68	HG	85	NM_001271769,NM_003664	XP_005248675,NP_001258698,

3b1	4;342;527;1359	44407	52053	00799	07799	I:13387	774	_001780749|XR_382728		125	NC:566	46		NP_003655,XP_016865490,XP_005248676
Vdac1	760;890;1131;1405	3.38669	1.9176	0.00622	0.0892	0.083	MGI:1069119	233	XM_017314500|NM_011694	NP_035824|XP_017169989	10724	HGNC:12669	7416	NM_003374	XP_016865311,NP_003365,XP_016865312,XP_005272132,XP_016865310
Nsfl1c	125;412;845;1422	3.3660	2.3338	0.00065	0.0910	0.083	MGI:3042273	3864	NM_198326|NM_001291074	NP_938085|NP_001278003	41114	HGNC:15912	5596	NM_018839,NM_001206736,NM_016143,NM_182483	NP_061327,XP_011527607,XP_006723655,XP_011527603,XP_011527602,XP_016883445,XP_011527606,XP_006723657,NP_001193665,NP_057227,XP_011527604,XP_016883446,XP_006723656,XP_016883447
Cdk8	242;753;959;1423	3.3648	2.1029	0.00065	0.0883	0.083	MGI:1196224	2640	XM_006504836|XM_006504839|XM_006504835|NM_153599|XM_006504840|XM_006504838	XP_006504902|XP_006504899|NP_705827|XP_006504903|XP_006504901|XP_006504898	55565	HGNC:1779	1024	NM_001346501,NM_001318368,NM_001260	XP_016875807,XP_011533167,XP_016875806,XP_011533166,XP_005266273,NP_001333430,NP_001251,NP_001305297
Racgap1	225;325;1105	3.2698	2.2146	0.0081	0.1076	0.076	MGI:1349423	2693	NM_012025|XM_011245647|NM_001253808|XM_006521020|XM_011245646|XM_006521019|NM_001253809	XP_011243949|NP_001240737|XP_006521082|XP_011243948|NP_036155|NP_001240738|XP_006521083	80774	HGNC:98044	2917	NM_013277,NM_001320002,NM_001126103,NM_001319999,NM_001320006,NM_001126104,NM_001320000,NM_001320007,NM_001320005,NM_001320001,NM_001320004,NM_001320003	NP_001306930,NP_001306933,XP_016874714,NP_001119576,XP_016874716,XP_011536545,XP_006719422,NP_001306935,NP_001306928,XP_011536540,XP_016874709,NP_001306932,

	;150;3													XP_016874710, NP_001306929, NP_001306931, NP_001119575, XP_016874711, XP_016874713, XP_016874715, NP_001306936, NP_001306934, XP_016874712, NP_037409
Hif1a	296;567;1484;1582	3.1.1.8	1.9.5.8	0.0.1.1	0.0.2.2	0.0.8.3	MGI:1069188	152;511	XM_017314961|NM_001313919|XM_006515478|NM_010431|NM_001313920	NP_034561|XP_006515541|XP_017170450|NP_001300849|NP_001300848	117;11	HGNC:4910	30;91	NM_181054,NM_001243084,NM_001530	NP_001230013, NP_851397,NP_001521
Prkce	330;413;646;1612	3.1.4.8.2	2.6.5.5	0.0.1.0.9	0.0.1.3.5.9	0.0.1.3.3.4	MGI:975999	187;554	XM_017317328|NM_011104|XM_006523833	XP_006523896|XP_017172817|NP_035234	48;343	HGNC:9401	55;581	NM_005400	XP_016859980, XP_011531282, XP_016859979, XP_016859978, XP_016859977, XP_006712113, XP_011531283, XP_005264488, XP_016859976, NP_005391,XP_005264485,XP_016859975,XP_011531277,XP_011531285,XP_011531284,XP_011531280,XP_011531273,XP_016859981
Zpr1	61;109;469;5;832;6	3.1.4.5.4	2.3.8.0.3	0.0.1.1.0	0.0.1.3.3.4	0.0.1.3.3.4	MGI:1330262	226;887	NM_011752	NP_035882	290;00	HGNC:13051	88;82	NM_003904,NM_001317086	NP_001304015, NP_003895
Cyth2	713;885;1054;	3.1.3.1.0	1.8.2.0	0.0.1.1.3	0.0.1.3.3.5	0.0.1.3.3.5	MGI:1334255	191;58	NM_011181|NM_001112701|XR_001785493	NP_035311|NP_001106171	32;116	HGNC:9502	92;66	NM_004228,NM_017457	XP_006723535, NP_004219,NP_059431,XP_006723536

	16288														
Inpp1	59;13120;14200;16766	3.08074	10.17012705	0.14571	0.14571	MGI:1048481	16329	XM_011238441|NM_008384|XM_011238442	XP_011236743|NP_032410|XP_011236744	165	HGNC:6071	36281	NM_002194,NM_001128928	NP_001122400,XP_005246589,NP_002185
Vmp1	100;121;536;8732	3.05588	2.23070	0.13517	0.15171	MGI:1923159	75909	XM_006534403|XM_006534402|NM_029478	XP_006534465|NP_083754|XP_006534466	2368	HGNC:29559	81671	NM_030938,NM_001329398,NM_001329395,NM_001329401,NM_001329400,NM_001329399,NM_001329397,NM_001329396,NM_001329402,NM_001329394	NP_001316326,NP_001316327,NP_001316324,NP_001316331,NP_112200,NP_001316323,NP_001316330,NP_001316328,NP_001316325,NP_001316329
Ssfa2	386;908;1606;17084	3.04777	10.07812139	0.14571	0.15171	MGI:1917849	70599	NM_080558|XM_006500165|XR_001783177	XP_006500228|NP_542125	4912	HGNC:11319	67441	NM_001287505,NM_001130445,NM_006751,NM_001287503,NM_001287504	NP_001123917,XP_011510005,XP_016860271,XP_011510004,NP_001274433,XP_011510003,NP_001274434,NP_001274432,XP_005246869,XP_005246870,NP_006742
Fkbp1a	124;583;13693;17366	3.01994	20.02549	0.01547	0.15772	MGI:954541	14225	NM_001302079|NM_001302077|NM_008019|NM_001302078|XM_011239292|NM_001302080|XM_017315525|NR_126058	XP_017171014|NP_032045|NP_001289008|NP_001289006|XP_011237594|NP_001289007|NP_001289009	10513	HGNC:37111	22801	NM_054014,NM_001199786,NM_000801	NP_463460,NP_001186715,NP_000792
St	37	2.	10.	0.	0.	MG	20	XM_006499071|NM_001109905|	XP_011237708|NP_035620|XP_	33	HG	67	NM_017452,NM_001322932,NM	NP_001309857,NP_001309858,

au1	3;1315;1388;1833	92507	2818801	0188811	1881	I:1338864	853	NM_011490|NM_001291160|NM_001109906|XM_011239406|NR_111895|XM_006499072	006499135|NP_001278089|XP_006499134|NP_001103376|NP_001103375	84	NC:11370	80	_001322931,NM_001319135,NM_001322929,NM_004602,NM_001322928,NM_001322933,NM_017454,NM_001322930,NM_001037328,NM_001322927,NM_017453,NM_001319134	NP_001309856,XP_006723928,NP_059347,NP_001309860,NP_059348,NP_001306064,NP_001309859,NP_001032405,NP_059346,NP_001306063,NP_001309861,XP_005260584,NP_004593,XP_011527317,NP_001309862,XP_016883517
Fam120a	1820;5001;1081;;19366	2.8300	2.0432	0.0221	0.2259	0.2259	MGI:2446163	2182	XR_001780774|XR_001780775|NM_001033268|XR_001780776	NP_001028440	8752	HGNC:13247	2319	6	NM_001286722,NM_014612,NM_001286724,NM_001286723	NP_001273652,NP_001273653,XP_005251899,XP_011516715,NP_055427,XP_011516716,XP_011516718,NP_001273651,XP_011516714
Mfsd7b	2133;2999;7800;;25396	2.7406	2.0397	0.0259	0.2581	0.2535	MGI:2444881	2268	NM_198025|NM_001313747|NM_001081259|XR_001784141	NP_001300676|NP_932142|NP_001074728	56661	HGNC:24682	2898	2	NM_014053	XP_011507750,XP_011507749,NP_054772,XP_011507748
Tead1	2846;6599;7833;;73663	2.7358	1.7819	0.0260	0.2538	0.2535	MGI:1018766	2176	XM_006507564|NM_009346|XM_006507563|NM_001166585|XM_006507561|XM_011241723|XM_011241724|NM_001166584|XM_006507565|XM_006507562	XP_011240025|XP_011240026|XP_006507628|XP_006507626|XP_006507624|XP_006507627|NP_033372|NP_001160056|NP_001160057|XP_006507625	2418	HGNC:11714	7003		NM_021961	NP_068780
Clp1	43;1178;366	2.7256	2.2451	0.0265	0.2535	0.2535	MGI:2138989	9898	NM_133840	NP_598601	4975	HGNC:16999	1097	8	NM_001142597,NM_006831	NP_006822,NP_001136069

	1;400					68									
Shoc2	295;297;801;4159	27.0770	19.8669	0.027245	0.025445	MGI:1927197	563	XM_006527228|NM_019658|NM_001168505|XM_017318260|XM_011247299	XP_006527291|NP_001161977|XP_011245601|NP_062632|XP_017173749	721	HGNC:15454	803	NM_007373,NM_001324337,NM_001269039,NM_001324336	NP_001311265,XP_016872191,NP_001255968,NP_031399,NP_001311266,XP_016872193,XP_016872192
Esyt1	247;448;854;9322	26.2611	18.6911	0.031	0.02851	MGI:1344426	2394	NM_011843	NP_035973	4079	HGNC:29534	2344	NM_001184796,NM_015292	NP_056107,NP_001171725
Orc1	58;205;1886;98422	26.0549	19.6229	0.032399	0.028997	MGI:1328337	1839	XM_011240469|NM_011015	NP_035145|XP_011238771	3121	HGNC:8487	4998	NM_004153,NM_001190819,NM_001190818	NP_004144,XP_011539829,XP_016856877,NP_001177747,NP_001177748,XP_016856878
Uck2	41;208;2874;4094	25.9300	21.8900	0.032997	0.028997	MGI:1931744	8091	NM_030724|XM_006497040|XM_017312968	NP_109649|XP_017168457|XP_006497103	40850	HGNC:12562	7371	NM_012474	NP_036606,XP_011508272,XP_016857725
Zmynd	243;2	25.536	19.603	0.0311	0.0311	MGI:1	665	XM_006516507|XR_001780796|NM_001347470|NM_144516|XM_017315569|XM	XP_006516569|NP_001186070|NP_001334401|NP_001334402|XP_017171058|	4828	HGNC:	1077	NM_212479,NM_006624,NM_001202468,NM_001202465,NM_001202464,NM_00	NP_001316986,XP_005252416,XP_016871078,NP_997644,XP_016871080,NP_

11	89;921;7822	09	16	66	62	62	9137555		_006516505|NM_001199141|XM_006516494|XM_006516501|NM_001347477|XM_017315566|XM_006516497|XM_006516498|XM_006516503|NM_001347474|NM_001347471|XM_017315570|XM_017315568|XM_006516504|XM_017315567|NM_001347472|XM_006516493|NM_001347480|XM_006516500|XM_006516506|NM_001347473|NM_001347476|XM_006516491|NM_001347481|XM_006516502|NM_001347479|XM_006516492|XM_006516496|XM_006516499	NP_653099|XP_006516563|XP_006516562|XP_006516567|XP_017171059|NP_001334399|NP_001334405|XP_017171057|XP_006516564|XP_006516560|NP_001334406|XP_006516566|XP_017171055|XP_006516556|NP_001334410|XP_006516570|NP_001334408|XP_006516554|NP_001334403|XP_006516557|XP_017171056|XP_006516559|XP_006516568|XP_006516555|XP_006516565|NP_001334409|NP_001334400|XP_006516561	1696	1330057,NM_001202466,NM_001202467	001189394,XP_006717439,XP_016871079,NP_006615,NP_001189397,XP_005252418,NP_001189393,XP_016871077,XP_016871082,NP_001189396,XP_005252419,XP_016871081,XP_016871076,XP_016871083,NP_001189395
Vamp2	64;529;944;27666	2.49987	1.96887	0.03876	0.32715	0.3215	MGI:1313277	2318	NM_009497	NP_033523	7591	HGNC:12643	6844	NM_001330125,NM_014232	NP_001317054,NP_055047,XP_005256832
Cd47	407;686;950;25099	2.49199	1.64596	0.03926	0.32615	0.3215	MGI:961617	1642 3	XM_006521806|XM_006521810|XR_384530|XM_006521809|XM_006521807|NM_010581|XM_006521808|XM_006521811|XR_384529	XP_006521872|XP_006521874|XP_006521871|XP_006521869|XP_006521870|XP_006521873|NP_034711	1346	HGNC:16822	961	NM_001777,NM_001025079,NM_001025080,NM_198793	XP_005247966,XP_005247965,NP_942088,NP_001768,XP_016863025
Jtb	42;774;953;41855	2.48802	1.92202	0.03945	0.32115	0.3215	MGI:1346082	2392 2	XM_181436	NP_996807	4870	HGNC:62001	10899	NM_006694	NP_006685

Usp6nl	87;244;1080;3392	2.4576	2.0844	0.0419	0.3357	0.3357	MGI:2138893	9910	XM_011238992|XM_006497570|XM_006497569|XM_006497568|XM_011238993|NM_001080548|NM_181399	NP_852064|XP_006497631|XP_011237295|XP_011237294|NP_001074017|XP_006497632|XP_006497633	689	HGNC:16858	971 2	NM_014688,NM_001080491	NP_055503,XP_011518064,XP_006717605,XP_011518065,NP_001073960,XP_016872461,XP_016872460,XP_016872462
Smyd3	186;256;5343;;87511	2.4170	1.7823	0.0455	0.3556	0.3556	MGI:1916976	6972 6	XM_017312213|XM_011238864|XM_017312211|NM_027188|XM_006496982|XM_011238865	XP_006497045|XP_017167702|XP_011237166|XP_011237167|XP_017167700|NP_081464	41491	HGNC:15513	64754	NM_001167740,NM_022743	XP_011542561,NP_001161212,XP_011542556,XP_011542559,XP_016857584,XP_011542555,XP_011542560,XP_011542562,XP_011542563,NP_073580,XP_016857583
Rps6ka3	800;847;1043;;38611	2.3748	1.4690	0.0487	0.3772	0.3772	MGI:1045571	1106 51	XM_017318355|NM_148945|XM_017318354|XM_017318353|XM_006528687|XM_006528688|XM_006528686|NM_001346675	XP_017173844|XP_006528751|NP_683747|XP_017173842|NP_001333604|XP_006528749|XP_006528750|XP_017173843	37940	HGNC:10432	6197	NM_004586	XP_016885202,XP_011543865,XP_005274630,XP_006724570,XP_011543861,XP_011543864,XP_011543863,XP_011543859,XP_016885208,XP_016885204,XP_011543862,XP_016885206,XP_016885207,XP_011543858,NP_004577,XP_005274634,XP_016885203,XP_011543857,XP_011543860,XP_016885205
Polr3d	36;375;1058;;59533	2.3569	2.0980	0.0503	0.3828	0.3773	MGI:1914315	6706 5	NM_001164082|NM_025945|XM_006519438	NP_001157554|XP_006519501|NP_080221	1303	HGNC:10800	661	NM_001722	NP_001713
Riok2	139;277	2.3565	1.8122	0.0504	0.3773	0.3773	MGI:1967045	NM_025934	NP_080210	67760	HGNC:1	55781	NM_001159749,NM_018343	NP_001153221,NP_060813,XP_016865117	

	5;43584;97288					14295				8999				
C1qbp	64093;10729;91311	2.34054	1.4684	0.05209	0.03829	0.03829	MGI:1194505	12261	NM_007573	NP_031599	31023	HGNC:12443	708	NM_001212	NP_001203
Mien1	11930;31864;72177	2.27761	1.8051	0.05858	0.04257	0.04246	MGI:1913678	10374 2	NM_025559	NP_079835	11969	HGNC:28230	84299	NM_001330206, NM_032339	XP_005257793, NP_115715,NP_001317135
Unc50	47304;18054;26544	2.27213	1.8933	0.05966	0.04466	0.04466	MGI:1914637	67387	XM_006496221|NM_026123|XM_006496220|XM_006496222|XM_006496223	XP_006496284|XP_006496286|NP_080399|XP_006496283|XP_006496285	6391	HGNC:16046	25972	NM_001330353, NM_001330354, NM_014044	XP_006712466, NP_001317282, XP_005263970, XP_006712467, NP_001317283, NP_054763
Akt2	28713;11377;11675;	2.23416	1.4710	0.06402	0.04503	0.04464	MGI:104874	11652	NM_007434|NM_001331109|NM_001110208|XM_006539478|XM_011250418|XM_006539481|XM_006539483|XM_006539482|XM_006539480|XM_006539477|NM_001331108	XP_006539545|XP_011248720|NP_001103678|NP_031460|XP_006539541|NP_001318038|XP_006539546|XP_006539540|NP_001318037|XP_006539543|XP_006539544	48773	HGNC:392	208	NM_001330511, NM_001243027, NM_001243028, NM_001626	NP_001229957, XP_011524920, XP_011524922, XP_011524918, XP_016881959, NP_001317440, XP_011524924, XP_016881960, NP_001617,XP_011524917,XP_011524916,NP_001229956,XP_011524921

	8936														
Fas	52;3199;7109;8112	2.2316	1.9574	0.0646	0.0446	0.0446	MGI:954844	1410 2	XM_011247141|NM_007987|NM_001146708	NP_001140180|NP_032013|XP_011245443	27	HGNC:11920	35 5	NM_152876,NM_152873,NM_152874,NM_152875,NM_001320619,NM_152872,NM_152871,NM_000043,NM_152877	XP_011538066,XP_011538068,NP_000034,NP_001307548,NP_690610,XP_011538069,XP_006717882,XP_011538067,NP_690611
Sesn3	10193;11025;11845;57933	2.2166	1.3239	0.0665	0.0452	0.0452	MGI:1922997	7574 7	NM_030261	NP_084537	14386	HGNC:23060	14 3686	NM_001271594,NM_144665	XP_011540916,NP_001258523,NP_653266
Riok1	72;3355;7440;82888	2.1906	1.8676	0.0703	0.0471	0.0471	MGI:1918590	7134 0	XR_001780817|NM_024242|XM_017315606|XR_382077	NP_077204|XP_017171095	6950 0	HGNC:18656	83732	NM_153005,NM_001348194,NM_031480	NP_694550,XP_011513235,NP_113668,XP_005249503,NP_001335123
Mnat1	26;3477;46822;55066	2.1611	2.0709	0.0746	0.0492	0.0892	MGI:1062007	1742 0	NM_008612|XM_011244008|XM_006515526	XP_006515589|NP_032638|XP_011242310	1821 0	HGNC:7181	43 31	NM_001177963,NM_002431	XP_005267744,XP_016876822,XP_005267745,XP_016876821,XP_016876823,NP_002422,NP_001171434
Arid	5403;	2.145	1.457	0.048	0.048		MGI:	937	XM_006539327|XM_006539325|XM_006539326|NM_001080819	XP_006539390|NP_001074288|XP_006539389|XP_006539388	212	HGNC	82 89	NM_018450,NM_139135,NM_006015	NP_624361,NP_006006

1a	797;1242;4519	721	52	92	1935147	60				16	:11110					
Clec2d	348;1173;1264;5037	2.13540	1.4050	0.0786	0.5039	0.5039	MGI:2135589	93694	XM_006506805|NM_053109	XP_006506868|NP_444339	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Adss	263;361;4193;5784	2.12800	1.5678	0.0800	0.5058	0.5058	MGI:879488	1156	NM_007422|XR_001785476	NP_031448	875	HGNC:2922	1559	NM_001126	XP_011542410,NP_001117	
Vamp4	522;1165;1284;74600	2.11160	1.3495	0.0819	0.5108	0.5108	MGI:1858730	5330	XM_006496936|XM_006496934|XM_006496935|NM_001347125|NM_016796	XP_006496997|NP_001334054|XP_006496999|XP_006496998|NP_058076	37847	HGNC:12645	8674	NM_003762,NM_001185127,NM_201994	XP_016858202,NP_001172056,NP_003753	
Ccl5	910;1075;	2.10733	1.3049	0.0835	0.5134	0.5134	MGI:982662	2030	NM_013653	NP_038681	2244	HGNC:1062	6352	NM_001278736,NM_002985	NP_002976,NP_001265665	

	12933;32022										32				
Crcp	3449;3779;13555;68999	2.0.8.7.4	1.6.7.7.8	0.0.8.7.0	0.0.5.2.7.7	0.5.2.7.7	MGI:1100818	1290 9	NM_007761	NP_031787	40587	HGNC:17888	2729 7	NM_014478,NM_001040648,NM_001040647,NM_001142414	NP_001035738, NP_001035737, NP_001135886, NP_055293
Efnb2	1683;3833;22377;89422	2.0.7.8.6	1.6.3.4.0	0.0.8.8.5	0.0.5.3.0.1	0.5.3.0.1	MGI:1050 97	1364 2	NM_010111|XM_011242036|XM_006508694	XP_011240338|XP_006508757|NP_034241	3019	HGNC:32277	1948	NM_004093	XP_016875895, NP_004084
Hs1bp3	5412;8488;13422;52466	2.0.6.1.4	1.4.0.8.4	0.0.9.1.7	0.0.5.4.1.6	0.5.3.2.5	MGI:1913 2244	5824 0	XM_006515161|NM_021429	XP_006515224|NP_067404	10980	HGNC:24979	6434 2	NM_022460	XP_016860185, XP_016860186, XP_016860190, NP_071905,XP_016860189,XP_016860188,XP_016860187
1810043G02Rik	11283;13177;13433;	2.0.6.0.4	1.2.8.1.1	0.0.9.1.8	0.0.5.3.5.1	0.5.3.2.5	MGI:1915 134	6784	XM_006514009|NM_026431|XM_006514008	XP_006514071|XP_006514072|NP_080707	3619	HGNC:1260	755	NM_001271440, NM_001271442, NM_004928,NM_001271441	XP_016883959, NP_001258371, NP_004919,XP_006724114,XP_016883960,XP_016883961,NP_001258370,XP_006724116,NP_001258369

Smarcc1	7330 8 4 6 ; 1 2 5 4 ; 1 3 4 8 ; 4 0 7 3	2.0558	1.2565	0.0925	0.5325	0.5325	MGI:1203524	2058	NM_009211	NP_033237	6829	HGNC:11104	6599	NM_003074	NP_003065,XP_011532336
Xpo6	6030;13011;13711;20488	2.0350	1.2780	0.0966	0.5491	0.5491	MGI:2429950	74204	XM_017312342|XM_017312341|XM_006508250|XM_017312344|XM_017312345|NM_001311143|XM_017312343|NM_028816	NP_083092|NP_001298072|XP_017167833|XP_017167832|XP_017167831|XP_017167830|XP_006508313|XP_017167834	12544	HGNC:19733	2321 4	NM_001270940,NM_015171	XP_005255256,XP_005255255,NP_001257869,XP_005255254,NP_055986,XP_011544074
Sik2	2144;8839;13891;21099	2.0189	1.5166	0.1000	0.5613	0.5540	MGI:2445031	23534 4	NM_178710|XR_379116|XM_017313332|XM_006510266|XM_006510267	XP_006510329|NP_848825|XP_006510330|XP_017168821	22875	HGNC:21680	2323 5	NM_015191	XP_016872906,NP_056006,XP_016872907
Nt5c3	7714;8911;14000;58766	2.0092	1.3378	0.1022	0.5665	0.5540	MGI:1927186	10756 9	XM_006505273|NM_026004|NM_001252374|XM_006505276|XM_006505272|XM_011241111|XM_006505275|XM_006505274	NP_001239303|XP_006505339|XP_006505337|XP_006505338|NP_080280|XP_011239413|XP_006505336|XP_006505335	9534	HGNC:17820	5125 1	NM_001166118,NM_001002010,NM_016489,NM_001002009	NP_001002010,XP_011513711,NP_001002009,NP_001159590,NP_057573

Ect2	23;623;1402;9346	2.7.11.1	0058126	0010216	0056160	0055400	MGI:95281	1605	NM_001177625|XM_006535385|XM_006535386|NM_007900|NM_001177626	NP_001171096|XP_006535448|NP_001171097|XP_006535449|NP_031926	7298	HGNC:31555	1894	NM_001349102,NM_001349100,NM_001349099,NM_001258315,NM_001349101,NM_001258316,NM_001349097,NM_001349104,NM_001349096,NM_001349103,NM_001349094,NM_018098,NM_001349098,NM_001349095	XP_011510817,XP_016861327,NP_060568,XP_016861325,NP_001245244,XP_011510816,XP_016861320,NP_001336032,XP_006713587,NP_001336030,XP_006713586,NP_001336026,XP_016861324,NP_001336028,XP_011510818,NP_001336023,NP_001336031,NP_001336024,NP_001336025,NP_001336027,XP_016861321,NP_001336029,XP_016861326,XP_005247233,NP_001245245,NP_001336033,XP_016861319,XP_016861322,XP_016861323
Hdac2	43;1381;1404;3161	2.3.1.48	0057937	0010330	0055700	0055400	MGI:1097691	1518	XM_017313806|XM_006512555|NM_008229	XP_006512618|XP_017169295|NP_032255	6818	HGNC:4853	3066	NM_001527	NP_001518,XP_011534090,XP_016866288
Pgam5	152;423;2901;8093	1.9.1.96	1.6.1.34	0010500	0056133	0055400	MGI:1919792	7254	XM_132261|NM_001163538	NP_001157010|NP_082549	14597	HGNC:28763	1921111	NM_138575,NM_001170544,NM_001170543	NP_612642,NP_001164014,NP_001164015
Ccnd3	60;424;3326	1.9.4.1	1.8.1.1	0010554	0055667	0055400	MGI:883115	1445	NM_001081636|XM_011246262|XM_006523552|NM_001081635|XM_006523553|NM_007632	XP_006523616|XP_011244564|NP_001075104|NP_031658|XP_006523615|NP_001075105	20419	HGNC:1585	896	NM_001760,NM_001287434,NM_001287427,NM_001136125,NM_001136017,NM_001136126	XP_011513273,NP_001129597,NP_001129489,NP_001274356,NP_001274363,XP_011513274,NP_001129598,NP_001751

	;5417													
Hmg20b	14;4283;16755;4666	1.9863	1.6764	0.1072	0.5594	0.5540	MGI:1341190	153	NM_001163166|NM_001163165|NM_010440|XM_006513248|XM_006513249	NP_001156638|NP_001156637|NP_034570|XP_006513311|XP_006513312	7494	HGNC:5002	1062	NM_006339	NP_006330,XP_016881633
Dok	399;4299;7396;8360	1.9843	1.4147	0.1076	0.5552	0.5540	MGI:2677836	2769	NM_177648	NP_808316	8940	HGNC:23406	22845	NM_014908	NP_055723
Rab3gap2	155;431;1450;5708	1.9805	1.7231	0.1086	0.5540	0.5540	MGI:1916043	9873	XM_006497216|NM_001163754	NP_001157226|XP_006497279	40842	HGNC:17168	25782	NM_012414	NP_036546
Clic4	200;441;3167;5356	1.9615	1.5397	0.1130	0.5703	0.5703	MGI:1352754	2976	NM_013885	NP_038913	8490	HGNC:13518	25932	NM_013943	NP_039234

Src	630;1280;1466;8121	1.9524965	1.2491149	0.1573373	0.5733	MGI:983977	207779	XM_006499063|NM_001025395|XM_011239404|XM_006499065|XM_011239403|NM_009271|XM_006499066|XM_011239402	XP_011237704|XP_011237706|XP_006499128|XP_011237705|XP_006499129|XP_006499126|NP_033297|NP_001020566	21120	HGNC:11283	6714	NM_198291,NM_005417	XP_016883516,NP_005408,XP_016883515,XP_016883513,XP_011527315,NP_938033,XP_016883514
Adck2	390;1384;1485;37844	1.9368341	1.2811902	0.1587247	0.5847	MGI:1889336	57869	XM_006506425|NM_178873	XP_006506488|NP_849204	491103	HGNC:190339	90956	NM_052853	XP_006716233,NP_443085,XP_011514977
Ctn	1228;1256;1504;89400	1.9212121	1.1761231	0.1206087	0.5847	MGI:996955	13043	XM_006508475|XM_006508474|XR_001785469|NM_007803|XM_006508473|NM_001252572	XP_006508536|NP_001239501|XP_006508538|NP_031829|XP_006508537	38342	HGNC:33338	2017	NM_005231,NM_138565,NM_001184740	XP_006718511,NP_001171669,NP_612632,XP_006718510,NP_005222,XP_016872801
Cnep1r1	45;4657;2205;71200	1.9177	1.8131440	0.1598486	0.5847	MGI:1921981	38203	XM_011248421|XM_011248420|XM_356102	XP_011246723|XP_011246722|NP_083350	14472	HGNC:26759	25591	NM_001281789,NM_153261	NP_001268718,NP_694993
Unc	579;	1.9110	1.2012	0.1559	0.58	MGI:74	107	NM_029770|XM_006513028	NP_084046|XP_006513091	325	HGNC	2196	NM_001244889,NM_170744	NP_734465,NP_001231818,XP_016871324,XP_

5b	149303;151303;300011	391	501	711	477	894703	499			38:12568	99			011537755,XP_016871323
Golt1b	313;11177;15177;33166	1.1.107	2.0.1.1.1.1.0	0.1.2.5.5.6	0.5.3.6	0.5.8.4.7	MGI:1914214	66964	XM_011241596|NM_025872|XM_011241597|XM_006506981|XR_869553	NP_080148|XP_011239899|XP_011239898|XP_006507044	4102	HGNC:20175	5102 6	NM_016072	NP_057156,XP_016874873
Lman2	260;4733;41273;49900	1.1.9.4.5.7.8.0.3.6.7.9	0.1.2.7.8	0.5.9.8.0	0.5.8.4.7	MGI:1914140	66890	NM_025828	NP_080104	4962	HGNC:16986	10960	NM_006816	NP_006807
Prpf4b	114;7706;15299;64499	1.1.9.0.1.0	1.5.8.4.5	0.1.2.8.6	0.5.9.5.1	0.5.8.4.7	MGI:109584	1913 4	XM_017315427|XM_017315436|XM_017315437|XM_017315434|XM_017315430|XM_017315432|XM_006516583|XM_017315433|XM_017315429|XM_017315435|NM_013830|XM_017315441|XM_006516582|XM_017315440|XM_006516584|XM_017315426|XM_017315428|XM_017315425|XM_017315439|XM_017315431|XM_017315438	XP_017170924|XP_017170925|XP_017170923|XP_017170914|XP_017170926|XP_017170915|XP_017170920|XP_006516645|XP_017170922|XP_017170927|XP_017170930|XP_006516646|XP_017170919|XP_006516647|XP_017170918|XP_017170921|XP_017170917|XP_017170916|XP_017170929|XP_017170928|NP_038858	13408 5	HGNC:17346	8899	NM_176800,NM_003913	XP_016866920,XP_016866901,XP_016866904,XP_016866902,XP_016866910,XP_016866913,XP_016866914,XP_016866903,XP_016866906,XP_016866905,XP_016866907,XP_016866916,XP_016866912,XP_016866915,XP_011513272,XP_016866924,XP_016866918,XP_016866921,XP_016866899,XP_016866908,XP_016866911,XP_016866917,XP_016866909,NP_003904,XP_016866900,XP_016866922,XP_016866923,XP_016866919

Kiz	472;510;1531;630 4	1.8994	1.5077	0.1291	0.5915	0.5847	MGI:2684960	2287 30	XM_006499300|XM_130476|XM_006499298|XM_011239478|XM_006499299	XP_011237780|NP_001028470|XP_006499361|XP_006499362|XP_006499363	10219	HGNC:15865	5585 7	NM_001163022,NM_001163023,NM_001276389,NM_001352434,NM_018474,NM_001352435,NM_001352436	NP_001263318,XP_016883441,XP_016883440,XP_011527598,NP_060944,NP_001156495,XP_016883443,XP_011527599,XP_011527601,NP_001339364,NP_001339363,XP_011527600,NP_001156494,NP_001339365,XP_016883442
Slc30a5	234;1047;1538;2375	1.8938	1.4055	0.1305	0.5920	0.5847	MGI:1916298	6904 8	XR_382742|XM_011244695|NM_022885	XP_011242997|NP_075023	41503	HGNC:190889	6492 4	NM_001251969,NM_022902,NM_024055	NP_076960,XP_006714735,XP_016865238,NP_075053,NP_001238898,XP_005248626
Ptpn1	97;922;1553;3157	1.8820	1.5556	0.1341	0.6019	0.5847	MGI:978005	1924 6	NM_011201|XM_006498981	NP_035331|XP_006499044	2119	HGNC:96422	5770	NM_002827,NM_001278618	NP_001265547,NP_002818
Camkk2	1179;1349;1554;8592	1.8812	1.1487	0.1344	0.5975	0.5847	MGI:2444812	2075 65	XM_006530233|XM_006530236|XM_006530235|XM_006530232|NM_145358|XM_006530230|XM_017320763|XM_006530234|NM_001199676|XM_006530231	XP_006530295|XP_006530293|NP_663333|XP_006530294|XP_017176252|XP_006530298|XP_006530296|XP_006530297|XP_006530299|NP_001186605	327 556	HGNC:1470	1064 5	NM_001270486,NM_153499,NM_006549,NM_172214,NM_153500,NM_172216,NM_172226,NM_172215,NM_001270485	XP_016874184,XP_016874187,XP_016874197,XP_016874194,NP_001257415,XP_011536065,XP_011536066,XP_016874186,NP_757365,NP_006540,NP_705720,NP_757364,XP_016874191,XP_016874192,XP_016874188,XP_005253880,NP_757380,XP_016874183,XP_016874189,XP_016874196,XP_016874195,XP_016874193,NP_757363,XP_016874190,XP_005253879,XP_016

														874198,XP_005253881,XP_016874185,NP_705719,NP_001257414
Fig4	14;4911;2856;5028	1.8728	1.5673	0.1368	0.6023	0.5847	MGI:2143585	1019	NM_133999	NP_598760	6713	HGNC:16873	9896	NM_014845	XP_016867082, XP_011534583, XP_016867081, NP_055660,XP_016867080
Cd44	460;9886;1566;3241	1.8718	1.3260	0.1371	0.5977	0.5847	MGI:883838	1205	NM_001177787|NM_001177786|XM_006498645|NM_001177785|XM_006498647|XM_006498646|NM_009851|NM_001039151|XM_006498648|XM_006498649|NM_001039150	NP_001171257|XP_006498711|NP_001171256|NP_001034240|XP_006498712|NP_001171258|NP_001034239|XP_006498710|XP_006498709|NP_033981|XP_006498708	508	HGNC:16811	960	NM_001001391, NM_001202556, NM_001001392, NM_001202557, NM_001202555, NM_000610,NM_001001389,NM_001001390	NP_001001389, XP_011518784, XP_005253296, NP_001189484, XP_005253288, XP_016874073, XP_016874074, XP_011518790, XP_011518786, NP_001189486, XP_005253292, NP_001001391, XP_005253290, XP_011518788, XP_006718451, XP_005253295, XP_011518787, XP_011518791, XP_005253297, NP_001189485, XP_011518785, XP_006718453, XP_016874072, NP_001001392, XP_011518789, NP_000601,XP_005253291,XP_005253289,NP_001001390
Chkb	181;1273;1575;3498	1.8648	1.3815	0.1392	0.6010	0.5847	MGI:1328313	1651	NR_037154|NR_037153|NM_007692	NP_031718	88718	HGNC:19338	1120	NM_005198,NM_152253	NP_005189
Cdc42s	394;4959	1.8547	1.3540	0.1409	0.6025	0.5847	MGI:118	5791	NM_001038708|NM_172395	NP_765983|NP_001033797	23209	HGNC:1	5682	NM_020239,NM_001038707	XP_016857336, NP_001033796, NP_064624

e1	9;4316;5732					8951 0				7719				
Stat6	545;933;1586;4063	1.8563	1.3145	0.1418	0.0608	0.0847	MGI:103034	2852	NM_009284|XR_001779497	NP_033310	2373	HGNC:11368	678	NM_001178080, NM_001178078, NM_001178079, NM_001178081, NM_003153	XP_006719638, XP_011537009, XP_011537006, NP_001171549, NP_003144,XP_011537007,XP_011537011,NP_001171551,NP_001171552,XP_011537005,NP_001171550,XP_011537008,XP_011537010
Arf6	968;1536;1587;2642	1.8555	1.1271	0.1423	0.5970	0.0847	MGI:994355	11845	NM_007481	NP_031507	1256	HGNC:6559	3842	NM_001663	NP_001654
Cd320	378;1018;1590;9513	1.8532	1.3362	0.1428	0.5939	0.0847	MGI:1860083	54219	NM_001305169|NM_019421	NP_062294|NP_001292098	9573	HGNC:16692	5129 3	NM_016579,NM_001165895	NP_057663,NP_001159367
Smarca5	417;504;925	1.8513	1.3399	0.1435	0.5912	0.0847	MGI:1935129	93762	NM_053124	NP_444354	5576 4	HGNC:11101	8467	NM_003601	NP_003592

	0;9664														
Apc	176;1479;1593;9693	1.8509	1.3443	0.1437	0.5864	0.5847	MGI:88039	117	XM_006525529|XM_006525533|XM_006525538|XM_017317804|NM_007462|XM_006525532|XM_006525531|XM_006525536|XM_006525534|XM_006525535|XM_006525539|XM_006525530	XP_006525594|XP_006525599|XP_006525595|XP_006525597|XP_006525602|XP_006525601|XP_006525596|XP_006525598|XP_006525592|XP_017173293|XP_006525593|NP_031488	309;50	HGNC:583	32	NM_001127511,NM_000038,NM_001127510	NP_001120983,NP_000029,NP_001120982
Slc20a2	458;506;702;7249	1.8481	1.3207	0.1445	0.5847	0.5847	MGI:978511	2051 6	XM_006509043|NM_011394|XM_006509044	XP_006509107|XP_006509106|NP_035524	685;531	HGNC:10947	65;75	NM_001257181,NM_006749,NM_001257180	XP_016869241,XP_016869238,NP_001244109,XP_016869239,XP_005273670,XP_006716454,XP_005273672,NP_006740,NP_001244110,XP_016869240,XP_016869237,XP_006716453
Ptpn21	496;515;2135;4901	1.8336	1.2988	0.1491	0.5979	0.5929	MGI:1344406	2400	XM_011244112|NM_001146199|NM_011877	XP_011242414|NP_001139671|NP_036007	510	HGNC:9651	110;99	NM_007039	XP_016876428,XP_011534670,XP_011534671,XP_005267344,NP_008970,XP_011534669,XP_006720074,XP_016876427
Epha2	608;744;1623;2650	1.8282	1.3517	0.1509	0.5998	0.5929	MGI:952778	1383 6	XM_006538528|NM_010139	XP_006538591|NP_034269	209;29	HGNC:33866	196;9	NM_001329090,NM_004431	XP_016856026,XP_016856025,NP_001316019,XP_016856023,NP_004422,XP_016856024

Lat2	52;116;122;1625;;6408	1.8261615	1.2615116	0.1596525	0.5929	0.529	MGI:1926479	567433	XM_006504452|XM_006504451|XM_006504455|NM_020044|NM_022964|XM_006504456|XM_006504453|XM_006504450	XP_006504518|XP_006504513|XP_006504516|NP_075253|XP_006504514|NP_064428|XP_006504519|XP_006504515	1129	HGNC:12749	7462	NM_032464,NM_014146,NM_032463	XP_011514860,NP_115852,NP_115853,NP_054865
Picalm	140;520;838;5242	1.8245572	1.8545129	0.1592529	0.559	0.59	MGI:2385902	2343489	NM_001252522|XM_006507604|XM_006507600|XM_006507596|XM_006507601|XM_006507599|XM_006507595|NM_001252520|NM_001252521|XM_006507605|XM_006507597|XM_006507598|XM_006507594|NM_001252524|NM_146194|NM_001252523|XM_006507602|XM_006507603	XP_006507657|NP_001239453|XP_006507666|XP_006507663|NP_666306|XP_006507664|XP_006507658|NP_001239451|NP_001239452|NP_001239450|XP_006507665|XP_006507667|XP_006507661|XP_006507668|XP_006507659|NP_001239449|XP_006507660|XP_006507662	1178	HGNC:15514	8301	NM_001008660,NM_001206946,NM_007166,NM_001206947	XP_005274389,XP_005274387,XP_006718763,XP_005274383,XP_005274385,XP_005274386,XP_016873871,NP_001193876,XP_016873875,XP_005274388,XP_016873877,XP_006718762,XP_005274393,XP_005274381,NP_001008660,XP_011543595,XP_005274392,XP_005274391,NP_009097,XP_016873872,XP_016873873,NP_001193875,XP_005274382,XP_016873874,XP_005274394,XP_005274397,XP_016873876,XP_005274384,XP_016873870,XP_005274379,XP_005274390,XP_005274380,XP_006718764
Hras	188;1435;1639;;21111	1.8831631	1.1559547	0.1598988	0.5988	0.588	MGI:962224	154611	XR_389950|XM_006536159|NM_001130444|XR_389951|XR_389952|NM_001130443|NM_008284	XP_006536222|NP_001123915|NP_001123916|NP_032310	558901	HGNC:51773	3265	NM_176795,NM_001318054,NM_005343,NM_001130442	NP_001304983,NP_005334,NP_789765,NP_001123914
Pacsi	158;;1	1.7951719	1.0516187	0.1621084	0.6188	0.618	MGI:18	807018	NM_001289678|XM_006500427|NM_028733|XM_006500424|XM_006500428|XM_006500425|NM	NP_001276606|NP_083009|XP_006500490|NP_001276607|XP_006500488|NP_112019|XP_006	41117	HGNC:38	2976 3	NM_016223,NM_001184975,NM_001184974	NP_001171903,NP_057307,NP_001171904

n3	637;1667;4549					9141 0		_030880|NM_001289677	500491|XP_006500487		572				
Tnip2	13133;15555;16700;29255	1.79355	1.0765	0.16255	0.6184	0.6184	MGI:2386643	2311 30	NM_139064	NP_620703	1151 5	HGNC:19118	791 55	NM_024309,NM_001161527,NM_001292016	NP_077285,NP_001278945,NP_001154999
Rock2	57;12771;16799;81699	1.7870	1.5177	0.16251	0.6229	0.6229	MGI:1079266	1987 8	XM_006515020|NM_009072|XM_006515019	XP_006515083|XP_006515082|NP_033098	2101 0	HGNC:10252	947 5	NM_004850,NM_001321643	XP_005246247,NP_004841,XP_016860867,XP_011508719,XP_016860868,NP_001308572
Rhoa	514;10883;16966;62155	1.77447	1.2549	0.16940	0.6340	0.6340	MGI:1096342	1184 8	NM_016802|NM_001313962|NM_001313961	NP_001300891|NP_001300890|NP_058082	6898 6	HGNC:667	387	NM_001313947,NM_001313941,NM_001313943,NM_001313944,NM_001313946,NM_001313945,NM_001664	NP_001300874,NP_001300872,NP_001300870,NP_001655,NP_001300875,NP_001300873,NP_001300876
Mb21d1	48259;	1.76655	1.2705	0.17265	0.6405	0.6396	MGI:2442 42	2147 63	NR_125721|XM_006511006|NM_173386	NP_775562|XP_006511069	5138 4	HGNC:2133	115 004	NM_138441	XP_016865721,NP_612450

	5288;9321					2611					67				
Spry4	4677;5611;34911;88999	1.7636	1.2749	0.1738	0.6396	0.6396	MGI:1345144	2406	NM_011898	NP_036028	8042	HGNC:15533	8184	NM_001293289, NM_001293290, NM_030964,NM_001127496	NP_001120968, XP_011535987, NP_112226,NP_001280219,NP_001280218,XP_016865399
Vim	962;11941;17311;90466	1.7500	1.1538	0.1791	0.6539	0.6467	MGI:98932	2235 2	NM_011701	NP_035831	2538	HGNC:12692	7431	NM_003380	NP_003371,XP_006717563
Arf5	1153;8533;17341;22600	1.7479	1.5074	0.1798	0.6512	0.6467	MGI:994344	1184 4	NM_007480	NP_031506	129625	HGNC:658	381	NM_001662	NP_001653
Tbl2	1945;6277;17375	1.7458	1.5164	0.1807	0.6492	0.6467	MGI:1351652	2736 8	XM_006504432|NM_013763|XM_006504433	XP_006504496|NP_038791|XP_006504495	8260	HGNC:11586	2660 8	NM_012453,NM_032988	XP_011514329, XP_006715986, NP_036585

Tspan4	6820;13944;14477;17405;76055	11.7432157	10.1815	00.6467	00.6467	MGI:1928097	6540	XM_006536224|NM_001252588|NM_053082	XP_006536287|NP_001239517|NP_444312	245	HGNC:11859	71061	NM_001025238,NM_001025234,NM_001025237,NM_001025239,NM_003271,NM_001025236,NM_001025235	NP_001020406,XP_011518641,NP_001020407,XP_011518640,XP_011518638,NP_001020405,XP_011518642,XP_011518639,NP_001020408,XP_011518643,NP_003262,XP_005253159,XP_005253161,NP_001020409,NP_001020410
Catspe r2	10293;13707;17500;27466	11.7309684	10.1844	00.6519	00.6499	MGI:2387404	2167 0	XM_017316898|XM_006499083|XM_017316895|XM_011239414|NM_153075|XM_006499085|XM_006499081|XM_011239413|XM_006499084|XM_006499080|XM_006499082	XP_006499144|XP_006499145|XP_011237716|XP_006499143|NP_694715|XP_006499148|XP_017172387|XP_006499146|XP_011237715|XP_017172384|XP_006499147	774 23	HGNC:18810	11755	NM_001282310,NM_001282309,NM_054020,NM_172095,NM_172097	XP_016877393,NP_001269238,NP_742093,NP_473361,NP_001269239
Hmgcs1	30;5811;8156;85711	11.7832857	10.1853	00.6499	00.6499	MGI:1075922	2087 15	XM_006517578|NM_001291439|NM_145942	XP_006517641|NP_001278368|NP_666054	1609	HGNC:5007	31557	NM_002130,NM_001324222,NM_001324223,NM_001098272,NM_001324224,NM_001324219,NM_001330663,NM_001324220	NP_001311152,NP_001311151,NP_002121,NP_001091742,NP_001311148,XP_011512338,XP_016864901,NP_001317592,NP_001311153,NP_001311149
Pkcsh	15;6062;24066;94288	11.7906122	10.1969	00.6889	00.6891	MGI:1078777	1908 9	XM_006510095|XM_006510096|NM_008925|NM_001293650|NM_001293651	NP_001280579|XP_006510158|XP_006510159|NP_001280580|NP_032951	2056	HGNC:9411	55589	NM_001289102,NM_002743,NM_001001329,NM_001289104,NM_001289103	XP_016882466,XP_011526434,NP_001276031,NP_002734,XP_011526432,NP_001001329,NP_001276032,NP_001276033,XP_011526433

Sfn	143 2; 166 5; 181 2; 909 1	1 6 9 4 8	1 0 2 1 2	0 2 0 2 5	0 6 9 9 5	0 6 9 2 3	MGI: 1891 831	559 48	NM_018754	NP_061224	447 5	HGNC: 10773	28 10	NM_006142	NP_006133
Comm d1	648; 1800 ; 181 5; 406 1	1 6 9 2 8	1 0 7 9 0	0 2 0 3 3	0 6 9 6 6	0 6 9 2 3	MGI: 1094 744	17 846	XM_017314316| XM_006514563| NM_144514|XM _006514564	XP_006514626| XP_017169805| XP_006514627| NP_653097	176 04	HGNC: 23024	15 06 84	NM_152516,NM _001321781,NM _001321782	NP_001308710, XP_016858901, XP_011530861, NP_001308711, NP_689729,XP_ 011530860
Arrb2	395; 612 ; 532 1; 811 18	1 6 9 2 7	1 2 7 0 8	0 2 0 3 5	0 6 9 2 3	0 6 9 2 3	MGI: 994 74	21 686 9	NM_001271358| XM_006532917| NM_001271359| NM_001271360| NM_145429	XP_006532980| NP_001258288| NP_001258287| NP_001258289| NP_663404	318 3	HGNC: 712	40 9	NM_001257328, NM_001257331, NM_001257330, NM_004313,NM _001330064,NM _199004,NM_00 1257329	NP_001244258, XP_016880134, NP_001316993, NP_945355,NP_ 001244260,XP_ 006721583,XP_ 011522160,NP_ 004304,NP_001 244257,NP_001 244259
Shpk	730 ; 157 2; 183 0; 598 3	1 6 8 2 8	1 0 9 3 5	0 2 0 7 9	0 7 0 1 8	0 7 0 1 8	MGI: 1921 887	74 637	XM_006534380| XM_017314814| NM_029031	XP_017170303| NP_083307|XP_ 006534443	831 9	HGNC: 14922	23 729	NM_013276	NP_037408
Hmg	259	1 6	1 3	0 2	0 7	0 7	MGI	668	XM_006511368| NM_025812	XP_006511431| NP_080088	323	HGN	10 3	NM_001304504, NM_001304505, NM_018200	NP_060670,NP_ 001291434,XP_

2a	;6222;4725;8226	7966	4665	0020	0020	:1914117	67			99	C:5001	63			011519460,NP_001291433
Hipk2	103;1778;18465;57944	1.6724	1.0261	0.2127	0.7073	MGI:1315872	158	NM_001136065|XR_001785097|XM_006505602|NM_010433|NM_001294144|XM_006505603|NM_001294143	NP_001281072|NP_001129537|XP_006505665|XP_006505666|NP_034563|NP_001281073	6876	HGNC:14402	2896	NM_001113239,NM_022740	NP_073577,XP_006715998,XP_016867558,XP_011514382,XP_011514380,XP_011514383,XP_011514379,NP_001106710,XP_011514381
Lsp1	3003;6355;57394;68900	1.6291	1.0173	0.1775	0.7175	MGI:9683285	169	NM_001271523|XM_006508496|NM_001271510|XM_006508494|NM_001271509|XM_006508495|NM_001271508|NM_001136071|NM_019391	NP_001129543|NP_001258438|NP_001258437|XP_006508559|NP_062264|XP_006508557|NP_001258452|NP_001258439|XP_006508558	1750	HGNC:6707	4046	NM_002339,NM_001013253,NM_001013254,NM_001013255,NM_001289005,NM_001242932	NP_001013273,NP_001229861,NP_001275934,NP_001013272,NP_001013271,NP_002330
Hdac3	365;6399;45855;89600	1.6578	1.2685	0.2199	0.7207	MGI:1343091	1583	NM_010411|XR_385976	NP_034541	48250	HGNC:48544	8841	NM_003883	XP_011535999,NP_003874
Cul5	534;6452;	1.6502	1.1932	0.2237	0.7259	MGI:1922	757	XM_017313680|NM_001161618|NM_027807	NP_082083|XP_017169169|NP_001155090	2597	HGNC:225	806 5	NM_003478	XP_016873854,XP_011541315,NP_003469,XP_016873852,XP_016873853,XP_005271739

	761 7;8 958					967					56				
Dbnd2	285;647;2067;6587	1.6411772247259	1.3117	0.2247	0.7259	0.7259	MGI:1065622	528 40	XM_006499895|NM_001048228|NM_026797|NM_001048229|NM_001048227	NP_001041693|NP_001041692|XP_006499958|NP_081073|NP_001041694	1276	HGNC:15881	55 61	NM_018478,NM_001048224,NM_001048221,NM_001197139,NM_001048225,NM_001048223,NM_001197140,NM_001048222,NM_001048226	NP_001041691,NP_001184068,NP_001041690,NP_001184069,NP_001041687,NP_060948,NP_001041688,NP_001041689,NP_001041686
Htt	494;18022;18922;70666	1.6428	1.0942	0.2271	0.7282	0.7282	MGI:960067	151 194	XM_017320683|XM_132009|XR_376798|XM_006503744	XP_017176172|NP_034544|XP_006503807	1593	HGNC:48511	30 64	NM_002111	NP_002102
Dbf4	23;1170;19085;65996	1.6327	1.6167	0.2327	0.7410	0.7300	MGI:1351328	272 14	NM_013726|XM_011240670|NM_001190717	NP_038754|XP_011238972|NP_001177646	4089 2	HGNC:17364	10 926	NM_006716,NM_001318061,NM_001318060,NM_001318062	NP_001304990,NP_001304989,NP_006707,NP_001304991
Tanc1	33;1662;6321;6	1.6292	1.2719	0.2346	0.7418	0.7300	MGI:1914110	668 60	XM_017319202|XM_017319201|XM_017319205|XM_006500034|XM_006500036|XM_006500040|XM_017319203|XM_006500035|NM_001290659|XM_017319200|XM_017319204|XM_006500037|XM_130249|XM_006500039	XP_006500103|XP_006500098|XP_017174691|NP_001277588|XP_006500102|XP_017174694|XP_006500099|XP_006500097|XP_017174692|XP_017174689|XP_017174693|NP_938036|XP_006500100|XP_017174690	1894 6	HGNC:29364	85 461	NM_001350062,NM_033394,NM_001350064,NM_001350065,NM_001145909,NM_001350063	NP_001336991,XP_016860633,NP_001336993,XP_016860641,NP_203752,XP_016860647,XP_006712873,XP_016860631,XP_016860645,NP_001336994,XP_016860637,XP_011510364,XP_006712877,XP_016860644,NP_

	540													001336992,XP_011510350,XP_011510357,XP_016860646,XP_011510361,XP_011510353,NP_001139381,XP_016860643,XP_006712875,XP_016860630,XP_016860640,XP_016860634,XP_016860642,XP_016860632,XP_005246975,XP_011510360,XP_011510355,XP_016860639,XP_016860636,XP_016860638,XP_016860635
Cav2	763;6630;5058;8029	1.6280	1.5748	0.2352	0.7386	0.7300	MGI:1075571	130	NM_001277756|NM_016900	NP_001264685|NP_058596	942	HGNC:1528	858	NM_001206748,NM_001206747,NM_001233,NM_198212	NP_001193677,NP_001224,NP_937855,NP_001193676
Eif	737;8967;19211;94477	1.6246	1.2128	0.2369	0.7386	0.7300	MGI:1093777	1316	NM_007924	NP_031950	4762	HGNC:23114	8178	NM_006532	NP_006523,XP_016882824,XP_016882825,XP_016882826,XP_011526632
Stk38	489;6666;63308582	1.6244	1.1968	0.2371	0.7430	0.7300	MGI:2442572	1054	XM_011246232|XR_385254|XM_017317192|XM_017317193|XM_011246233|XM_006523385|XM_006523386|XM_017317194|NM_134115	XP_017172681|XP_006523448|XP_006523449|NP_598876|XP_011244535|XP_011244534|XP_017172682|XP_017172683	5603	HGNC:17847	1132	NM_001305102,NM_007271	XP_006715051,NP_009202,NP_001292031,XP_016865715,XP_006715052
Pde	858;	1.6	1.0	0.2	0.7	0.7	MGI:	242	NM_153422|XM_006501481	XP_006501544|NP_700471	842	HGNC	8654	NM_001083,NM_033430,NM_033437	XP_016864280,NP_236914,NP_001074,NP_246273

5a	163;1922;4441	39	35	74	00	00	26514999	02				:8784			
C1qb	238;6700;41322;93300	1.6196	1.3336	0.23397	0.7321	0.7321	MGI:88224	1260	NM_009777	NP_033907	418	HGNC:1242	713	NM_000491	XP_011540361, NP_000482
Prkcd	454;11911;19391;21033	1.6134	1.1935	0.24330	0.7373	0.7345	MGI:975998	1753	XM_006518697| XM_006518695| NM_001310682| NM_011103|XM_017315918|XM_006518698	XP_006518758| XP_017171407| XP_006518760| XP_006518761| NP_001297611| NP_035233	55963	HGNC:9399	5580	NM_006254,NM_001316327,NM_212539	XP_006713320, NP_997704,NP_006245,XP_006713322,XP_016862345,XP_016862344,NP_001303256
Mfsd5	288;18801;19411;27082	1.6122	1.1432	0.24337	0.7345	0.7345	MGI:2145901	1060 73	NM_134100	NP_598861	695117	HGNC:28156	8497 5	NM_001170790, NM_032889	NP_001164261, XP_005269255, XP_005269254, NP_116278
Ano6	650;19455	1.6085	1.0333	0.24557	0.7354	0.7354	MGI:21455	1057 22	NM_001253813| XM_006520234| XM_006520233| XM_006520231| NM_175344|XM_006520232	XP_006520297| NP_001240742| XP_006520296| XP_006520295| NP_780553|XP_006520294	27888	HGNC:2552	1965 27	NM_001142679, NM_001025356, NM_001142678, NM_001204803, NM_001142680	NP_001136150, XP_005268764, NP_001191732, NP_001020527, NP_001136151, XP_005268763

	;1947;52022					890					40				
Serinc3	832;16907;19588;88322	1.6017	1.0355	0.0249417	0.0741763	MGI:1349457	269433	XM_006499616|NM_012032	XP_006499679|NP_036162	38230	HGNC:11699	105 5	NM_198941,NM_006811	NP_945179,NP_006802,XP_016883090
Csk	508;8887;19613;87533	1.5999	1.2506	0.2503	0.0739	MGI:88537	1298 8	XM_006510801|NM_007783|XM_006510802|XM_011242659|NM_001304761	NP_001291690|XP_006510865|XP_006510864|XP_011240961|NP_031809	55818	HGNC:2444	1445	NM_004383,NM_001127190	XP_005254222,NP_004374,XP_016877414,NP_001120662
Rgs20	17555;19422;19643;22433	1.5981	0.9415	0.2511	0.0738	MGI:192986	5817 5	XM_006495553|NM_001177795|NM_021374|XM_011238400|NM_001290372|XM_011238401|XM_006495554	XP_011236702|NP_001277301|XP_006495617|NP_067349|NP_001171266|XP_006495616|XP_011236703	2745	HGNC:14600	8601	NM_001286674,NM_001286673,NM_001286675,NM_003702,NM_170587	NP_001273602,NP_001273604,NP_733466,XP_011515924,NP_001273603,NP_003693
Isg20	865;18288;19	1.5938	1.0111	0.2537	0.0739	MGI:192895	5744 4	XM_006541030|NM_001291220|NM_001113527|NM_020583|NM_001291221|XM_006541028|XM_006541026	XP_006541089|NP_001278149|XP_006541093|NP_065608|NP_001106999|XP_006541091|NP_001278150	31081	HGNC:6130	3669	NM_001303237,NM_001303234,NM_001303233,NM_002201,NM_001303236,NM_001303235	XP_005254956,NP_001290163,NP_001290162,NP_002192,XP_016877637,XP_006720551,NP_001290164,XP_016877636,NP_001290165,NP_001290166,XP_011519823

	71;6509														
Ccnd1	32;1552;19724;97744	1.5932	1.1645	0.25422	0.75363	0.75363	MGI:88313	1243	NM_007631|XM_011241977	XP_011240279|NP_031657	134	HGNC:1582	595	NM_053056	NP_444284
Fgd4	71;7144;4244;4356	1.5685	1.5595	0.2614	0.75233	0.75233	MGI:2183747	2240114	NM_001301817|XM_006522027|XM_006522025|XM_006522024|NM_139232|XM_006522029|XM_006522023|XR_875778|NM_001301818|XM_011245874	XP_011244176|XP_006522087|XP_006522092|NP_631978|XP_006522090|NP_001288747|XP_006522088|NP_001288746|XP_006522086	2672	HGNC:19125	1512	NM_001304484,NM_001304480,NM_139241,NM_001330373,NM_001304481,NM_001330374,NM_001304483	XP_016874294,NP_001317302,NP_001291410,XP_011518860,NP_001291413,XP_011518859,XP_016874292,XP_011518857,NP_001291409,XP_011518858,XP_005253361,NP_640334,XP_005253364,XP_011518856,NP_001291412,XP_005253365,XP_005253366,XP_011518861,XP_016874293,NP_001317303,XP_005253367
Mtmr4	709;724;2706;4706	1.55733	1.09881	0.26467	0.75667	0.75667	MGI:2180699	17074 9	XM_011248780|XM_006532383|XM_006532384|NM_133215|XM_006532385	XP_006532448|XP_006532447|NP_573478|XP_011247082|XP_006532446	3440	HGNC:7452	9110	NM_004687	XP_005257841,XP_005257843,XP_005257842,XP_006722231,XP_011523762,NP_004678
Casp9	430;741;6116	1.5388	1.1778	0.26997	0.76705	0.76705	MGI:1277950	1237 1	NM_001277932|NM_015733|XM_017319928	NP_056548|XP_017175417|NP_001264861	3102 4	HGNC:1511 1	842	NM_001229,NM_032996,NM_001278054	NP_001220,XP_011540575,XP_005246071,NP_127463,NP_001264983

	;7175													
Rhog	3233;7446;20023;26244	1.5334	1.2300	0.2714	0.7665	0.7625	MGI:192837 0	5621 2	NM_019566	NP_062512	6819 6	HGNC:6722	391	NM_001665	XP_005252973, XP_016873208, NP_001656
Stk11	589;7511;9080;91500	1.5281	1.1152	0.2731	0.7665	0.7625	MGI:134187 0	2086 9	NR_126043|XM_006513443|XM_006513442|NM_011492|XM_006513439|NM_001301853|NM_001301854|XM_006513441	NP_001288782| XP_006513504| XP_006513506| NP_001288783| XP_006513505| XP_006513502| NP_035622	393	HGNC:11389	6794	NM_000455	XP_005259674, NP_000446,XP_011526511,XP_005259675
Prkaa1	22;7520;4097;92900	1.5270	1.7899	0.2735	0.7627	0.7625	MGI:214595 5	1057 87	XM_017316356| XM_006519953| XM_011245321| XM_139298	XP_011243623| XP_006520016| XP_017171845| NP_001013385	4959 0	HGNC:9376	562	NM_006251,NM_206907	XP_016865114, XP_016865113, NP_006242,XP_006714545,NP_996790
Aplp1	594;7557;20866;64744	1.5210 8	1.1010 6	0.2751	0.7625	0.7625	MGI:880 46	1180 3	XM_017321948| NM_007467	NP_031493|XP_017177437	6844 7	HGNC:597	333	NM_005166,NM_001024807	NP_005157,NP_001019978,XP_016882227,XP_016882226
Sma	407	1.14	1.11	0.2	0.7	0.7	MGI	669	XM_006535797| XR_389749|XM_006535798|XM_	NP_080167|XP_006535861|XP_006535860|XP_	23	HGN	66	NM_003078,NM_001003802,NM_001003801	NP_001003802, NP_001003801, NP_003069,XP_

rcd3	;7822;20544;71811	9568340	8806	7500	:19142433	93	017321074|NM_025891|XM_006535799|XM_006535796	006535862|XP_006535859|XP_017176563	14	C:11108	04			016868045,XP_011514823
Fam129b	544;7888;30711;56355	1.1489992	1.1102	0.2855	0.7815	0.7750	MGI:2442910	2277373	NM_146119	NP_666231	11269	HGNC:25282	64855	NM_022833,NM_001035534	NP_001030611,NP_073744,XP_005252192,XP_011517227
Csnk1g2	616;7791;64833;76533	1.4868	1.0868	0.2864	0.7794	0.7750	MGI:1920014	1032360	NM_001159591|XR_001779401|NM_134002|XM_006513010|XM_006513011|XR_380333	XP_006513073|NP_598763|XP_006513074|NP_001153063	10045	HGNC:24555	14555	NM_001319	XP_005259557,NP_001310,XP_005259555,XP_016881787,XP_005259556,XP_005259558,XP_016881786
Sphk2	351;7922;35066;74266	1.4858	1.1900	0.2869	0.7759	0.7750	MGI:1861380	5663260	NM_001172561|XM_006541013|XM_006541012|NM_203280|NM_020011	NP_001166032|NP_975009|NP_064395|XP_006541076|XP_006541075	32456	HGNC:18859	56848	NM_001204160,NM_020126,NM_001204158,NM_001204159,NM_001243876	XP_011525435,XP_016882499,NP_001191088,XP_006723355,NP_001230805,XP_011525436,XP_016882497,XP_016882498,NP_064511,NP_001191087,NP_001191089
Tmem219	450;7963;64	1.4819	1.1409	0.2883	0.7750	0.7750	MGI:1915959	6874212	XM_006508155|XM_006508158|NM_026827|XM_006508156|XM_133813|XM_006508157	XP_006508220|XP_006508221|NP_081103|NP_082665|XP_006508219|XP_006508218	19263	HGNC:25201	12446	NM_001083613,NM_194280	XP_005255180,NP_001077082,NP_919256

	23;7288					92								
Lims1	803;819;3254;8498	1.4593	1.0287	0.2963	0.7918	0.7918	MGI:1195263	110829	NM_001193303|XM_006513069|XM_006513070|XM_006513074|XM_006513073|XM_006513068|NM_201242|NM_026148|XM_006513072|NM_001346676|XM_006513071	XP_006513131|NP_001180232|XP_006513133|NP_080424|XP_006513136|XP_006513134|XP_006513135|XP_006513132|XP_006513137|NP_957694|NP_001333605	6842 8	HGNC:6616	3987	NM_001193482, NM_001193488, NM_004987,NM_001193485,NM_001193483,NM_001193484	XP_016859585, XP_005264006, NP_001180417, XP_016859584, XP_005264003, NP_001180413, XP_005264008, XP_016859581, XP_016859580, XP_005264007, XP_016859582, NP_001180412, NP_001180411, NP_001180414, XP_005264005, NP_004978,XP_016859583
Mul1	2273;8273;5884;5968	1.4516	1.2599	0.2991	0.7947	0.7947	MGI:1915600	683550	XM_006539134|NM_026689	NP_080965|XP_006539197	11576	HGNC:257622	7959 4	NM_024544	XP_011540439, NP_078820
Sirt2	563;849;2922;8964	1.4310	1.0746	0.3070	0.8109	0.8076	MGI:1927664	643883	NM_022432|XM_017312217|NM_001122766|NM_001122765|XM_017312216|XM_017312215|XM_017312214	NP_071877|NP_001116237|XP_017167706|XP_017167703|XP_017167705|NP_001116238|XP_017167704	40823	HGNC:108866	2293 3	NM_001193286, NM_030593,NM_012237	NP_001180215, XP_011524957, XP_006723174, XP_011524956, NP_085096,XP_016881989,NP_036369
Cdc37	332;857;2732;9802	1.4236	1.1697	0.3100	0.8104	0.8076	MGI:1095311	125359	XM_006509967|NM_016742	XP_006510030|NP_058022	38268	HGNC:17355	1140	NM_007065	NP_008996,XP_011525954

Abi1	2985;2592;3262	1.4219	1.1899	0.3108	0.8113	0.8076	MGI:104913	113	NM_007380|NM_001331044|XM_006497620|XM_006497617|NM_001331043|XM_006497619|NM_145994|NM_001077192|NM_001077190|NM_001331045|NM_001077193|XM_006497618	XP_006497682|XP_006497681|NP_001317972|NP_001070658|XP_006497683|NP_031406|NP_001070660|NP_001317974|XP_006497680|NP_001317973|NP_666106|NP_001070661	3805 3	HGNC:11320	100 6	NM_001178116, NM_001178123, NM_001348031, NM_001012750, NM_001348030, NM_001178119, NM_001348034, NM_005470,NM_001348033,NM_001348029,NM_001178124,NM_001178125,NM_001348032,NM_001178122,NM_001178120,NM_001012751,NM_001012752,NM_001178121	NP_001171587, NP_001171590, XP_006717422, NP_001334961, NP_001012769, XP_005252390, NP_001171594, NP_001334959, XP_006717423, NP_001334960, NP_001171593, XP_006717424, NP_001171592, NP_001171591, NP_001334958, NP_001334962, XP_016870947, XP_016870948, NP_001171596, NP_005461,XP_005252389,NP_001012770,XP_011517591,NP_001171595,NP_001012768,NP_001334963
Aurkb	158;8600;4367;4892	1.4208	1.3178	0.3112	0.8076	0.8076	MGI:1071688	2087 7	XM_181344|XM_006532725	XP_006532788|NP_035626	55807	HGNC:11390	92 1 2	NM_001313954, NM_001256834, NM_001313951, NM_001313950, NM_001313952, NM_004217,NM_001284526,NM_001313955,NM_001313953	NP_001271455, NP_001300881, XP_016880798, NP_001300880, NP_001300884, XP_011522372, XP_016880797, XP_016880800, NP_001300879, NP_001300882, NP_004208,NP_001243763,XP_016880799,XP_016880796,XP_011522374,NP_001300883
Scarb1	543;8749;6491;97466	1.4082	1.0697	0.3164	0.8118	0.8077	MGI:893578	2077 8	XM_017320764|NM_016741|NM_001205082|NM_001205083	NP_001192011|NP_058021|NP_001192012|XP_017176253	21132	HGNC:16644	94 9	NM_005505,NM_001082959	NP_005496,NP_001076428
Pnpla2	665;8753;6498;69	1.4073	1.0338	0.3168	0.8082	0.8077	MGI:1914103	668 53	NM_001163689|NR_028142|NM_025802	NP_080078|NP_001157161	10687	HGNC:308022	57 1 04	NM_020376	XP_006718328, XP_016873517, NP_065109,XP_006718329

Azi2	214980;879;28002;47577	1	1	0	0	0	MGI:1351332	272157	XM_006512147|NM_013727|NM_001286508|NM_001048146|NM_001286507|XM_011242976|XM_006512149|XR_001778916|XM_006512148	XP_006512210|XP_006512211|XP_011241278|NP_001041611|XP_006512212|NP_038755|NP_001273436|NP_001273437	844443	HGNC:24002	643434	NM_001134433,NM_001271650,NM_022461,NM_001134432	XP_005265449,NP_001127904,XP_011532312,XP_011532311,NP_071906,NP_001258579,NP_001127905,XP_011532313
Gata3	268;8965;27622;79100	1	1	0	0	0	MGI:956633	144622	NM_008091|XM_006497355|XM_006497354	XP_006497418|XP_006497417|NP_032117	155050	HGNC:41722	262545	NM_002051,NM_001002295	NP_002042,XP_005252500,NP_001002295,XP_005252499
Pcdh19	535;90445;54722	1	1	0	0	0	MGI:2685563	279653	XM_006528558|XM_006528559|NM_001105246|XM_006528556|XM_006528557|XM_205287	XP_006528620|NP_001098716|XP_006528621|XP_006528619|XP_006528622|NP_001098715	189166	HGNC:14270	575226	NM_001105243,NM_001184880,NM_020766	NP_065817,NP_001098713,NP_001171809,XP_011529299
Fzd2	661;91223;63535	1	1	0	0	0	MGI:1885133	57265	NM_020510	NP_065256	203777	HGNC:4040	253535	NM_001466	NP_001457
Ppa2	799;9	1	0	0	0	0	MGI:1	74776	NM_146141|XM_006502217|XM_006502216|NM_001293641	NP_666253|NP_001280570|XP_006502280|XP_006502279	13422	HGNC:	270688	NM_176866,NM_001034193,NM_001034191,NM_001034192,NM_006903,NM_17	NP_789843,NP_789842,NP_789845,NP_008834

	14;30033;;97900	32	65	17	28	57	92020626				44	28883	6867,NM_176869	
Capn2	2865;9155;;38444;;40644	1.37233	1.173320	0.3381922	0.8115	0.857	MGI:882644	12334	NM_009794	NP_033924	1326	HGNC:14779	824	NM_001146068, NM_001748	NP_001739,XP_011542588,NP_001139540
Mdfic	657;9166;;42677;;79133	1.37150	1.10180	0.3325	0.8157	0.857	MGI:1046111	16543	XM_017321412| NM_175088	NP_780297|XP_017176901	1804	HGNC:28870	2996	NM_001166345, NM_001166346, NM_199072	NP_001159818, NP_951038,NP_001159817
Ccnc	404;9322;;51083;;63255	1.35802	1.09923	0.33889	0.8271	0.871	MGI:1858199	51813	NM_001290422| NM_001290420| NM_001122982| NM_016746	NP_001277351| NP_001116454| NP_001277349| NP_058026	3803	HGNC:15811	892	NM_005190,NM_001013399	XP_006715657, NP_005181,XP_016866925,NP_001013417,XP_011534534
Smg1	80;9499;;57655;;	1.34399	1.4219	0.346201	0.8401	0.841	MGI:1917422	23789	XM_006507678| NM_001031814| XM_006507677	NP_001026984| XP_006507741| XP_006507740	5669 7	HGNC:30045	2309	NM_015092	XP_005255241, XP_011544072, NP_055907,XP_011544071,XP_005255239,XP_005255240,XP_016878555,XP_016878556

	9633													
Jag1	4791;9655;4527;;9344	1.1.0.3.8.4.4	3310	0539	0.5.3.5.2.2.4.4	MGI:1095416	1649	NM_013822|XM_011239312	NP_038850|XP_011237614	180	HGNC:6188	182	NM_000214	XP_016883196, NP_000205
Pard6a	7863;9766;5509;;6131	1.3.2.2.2	0.9.6.3.6	0.3.5.7.5	0.8.5.8.4.4.4	MGI:1927223	5651 3	NM_019695|NM_001047435|NM_001286344|NM_001286345|NM_001047436	NP_001040901|NP_062669|NP_001273274|NP_001273273|NP_001040900	9661	HGNC:15943	5085 5	NM_016948,NM_001037281	XP_011521397, XP_016878750, XP_011521398, NP_058644,NP_001032358,XP_005256034
Ptprk	9063;9777;7587;;9173	1.3.2.1.4	0.9.4.1.0	0.3.5.7.9	0.8.5.4.8	0.4.4.4	MGI:1033 10	1972	XM_006512610|XM_006512609|XM_006512607|XM_006512612|XM_011243146|XM_006512614|XM_006512606|XM_011243145|XM_006512617|XM_006512615|XM_006512618|NM_008983|XM_006512613|XM_006512611|XM_017313850|XM_006512620|XM_006512608|XM_006512619|XM_011243144|XM_011243143	XP_006512683|XP_006512682|XP_006512675|XP_006512670|XP_006512677|XP_006512681|XP_006512672|XP_017169339|XP_011241447|XP_006512671|XP_006512674|NP_033009|XP_006512673|XP_011241446|XP_006512678|XP_006512676|XP_011241445|XP_006512669|XP_006512680|XP_011241448	5569 3	HGNC:9674	5796	NM_001291982, NM_001135648, NM_001291984, NM_001291981, NM_002844,NM_001291983	NP_002835,XP_011534317,NP_001278911,NP_001278913,XP_011534323,NP_001278910,XP_016866635,XP_006715600,XP_011534318,XP_016866639,XP_011534316,XP_011534319,XP_016866638,NP_001278912,XP_016866637,XP_016866634,XP_016866636,XP_011534320,NP_001129120,XP_011534322
Gpsm1	5543;9784;5494;;6863	1.3.2.0.6	1.0.2.2.3	0.3.5.8.4	0.8.5.1.4.4.4	MGI:1915089	6783 9	NM_153410|NM_001199147|NM_001199146|XM_006498255|XM_017319226|XM_006498253	NP_700459|NP_001186076|XP_017174715|XP_006498316|XP_006498318|NP_001186075	1698 7	HGNC:17858	2600 8 6	NM_001145639, NM_001200003, NM_015597,NM_001145638	NP_001139111, XP_016870087, NP_001139110, XP_016870088, NP_001186932, NP_056412,XP_011516800

Rab32	352;9779;;30955;;53844	1.3198	1.1065	0.35888	0.84478	0.8444	MGI:1915094	6784	NM_026405	NP_080681	38233	HGNC:9772	1098	NM_006834	NP_006825
Lsg1	21;19800;;20966;;73477	1.3199	1.1696	0.35922	0.84444	0.8444	MGI:1072366	2240922	NM_178069|XR_001781813	NP_835170	5917	HGNC:25652	55341	NM_018385	NP_060855,XP_016862285
Bcl3	3289;9945;;56988;;67566	1.3081	1.1143	0.36520	0.85400	0.8540	MGI:881440	12051	XM_006539487|NM_033601	XP_006539550|NP_291079	81738	HGNC:998	602	NM_005178	XP_016882599,NP_005169,XP_011525500,XP_011525499,XP_016882598,XP_011525502
Nt5m	66;10033;;40199;;56889	1.3011	1.4413	0.36913	0.85586	0.8564	MGI:1917127	10385	NM_134029|XR_388314|XM_006531931|XR_001779853	XP_006531994|NP_598790	10622	HGNC:15769	56953	NM_020201	XP_011522265,XP_011522268,XP_005256791,XP_011522267,XP_005256794,XP_005256790,NP_064586,XP_011522266,XP_005256789,XP_011522269,XP_016880368,XP_005256788,XP_011522264
Sesn1	838;10005	1.2994	0.37001	0.85644	0.8564	MGI:2155	1407	NM_001162908|NM_001013370	NP_001013388|NP_001156380	8697	HGNC:2155	27244	NM_001199933,NM_014454,NM_001199934	NP_001186863,NP_055269,NP_001186862

	;49211;69155					278				95					
Cog3	101;10147;64887;90366	1.2927	1.3471	0.3741	0.8614	0.8580	MGI:2450151	338337	XM_011245092|XM_006519148|NM_177381	XP_006519211|XP_011243394|NP_796355	5854	HGNC:18619	8354	NM_001204476,NM_031431	XP_011533569,NP_113619,XP_011533568,XP_016876279
Pi4k2b	725;10155;45588;88766	1.2920	0.9617	0.3745	0.8580	0.8580	MGI:1914323	670733	XM_006504064|NM_028744|NM_025951	NP_083020|XP_006504127|NP_080227	32405	HGNC:18215	5530	NM_018323	XP_005248232,NP_060793,XP_005248231
Bag5	392;10523;82366;83811	1.2645	1.0582	0.3910	0.8866	0.8723	MGI:1917619	70369	XM_127149|XM_006516217|NM_001324480|NM_001324481|XM_017315180|NM_001324482	NP_001311410|XP_006516280|NP_001311409|NP_081680|XP_017170669|NP_001311411	3584	HGNC:941	9529	NM_004873,NM_001015048,NM_001015049	NP_001015048,NP_001015049,NP_004864
Snx3	524;10556;36	1.2616	1.0028	0.3928	0.8863	0.8723	MGI:1860188	5419 8	NM_017472	NP_059500	36144	HGNC:11174	8724	NM_152828,NM_001300928,NM_003795,NM_152827,NM_001300929	NP_001287858,NP_001287857,NP_690040,NP_003786

	14;9658														
Tln1	34;10057;22333;37400	1.26091	1.56331	0.39333	0.88299	0.87233	MGI:1099832	2194	NM_011602|XM_006537768|XM_006537770|XM_006537769	XP_006537832|NP_035732|XP_006537831|XP_006537833	2267	HGNC:11845	7094	NM_006289	NP_006280
Dyrk1a	436;10063;27566;91988	1.25651	1.03411	0.39611	0.88449	0.87233	MGI:1330299	1548	NM_007890|XM_011246095|NM_001347731|XM_011246094|NM_001113389|XM_011246098|XM_011246096|XM_011246099	XP_011244396|XP_011244401|XP_011244400|XP_011244398|NP_031916|XP_011244397|NP_001106860|NP_001334660	5576	HGNC:3091	1859	NM_130438,NM_130437,NM_130436,NM_001347723,NM_001347722,NM_001347721,NM_101395,NM_001396	NP_567824,XP_011527785,XP_006724039,NP_001387,XP_006724040,XP_011527784,NP_001334650,NP_001334652,XP_005260990,NP_569122,XP_006724042,XP_016883773,XP_016883774,XP_011527786,NP_569120,NP_001334651,XP_016883775,XP_006724041,XP_011527787
Fkbp15	975;10064;46255;57866	1.25583	0.89973	0.39655	0.88144	0.87233	MGI:2444782	3385	XM_006538033|XM_006538034|NM_001045528	XP_006538097|XP_006538096|NP_001038993	28743	HGNC:23397	2307	NM_015258	XP_006717081,XP_016870041,XP_006717082,NP_056073
Lrig2	67;10071;30487;87	1.25081	1.41309	0.39945	0.88455	0.87233	MGI:2443718	2694	XM_017319602|XM_006501544|XM_194114|NM_001310698	XP_017175091|NP_001297627|NP_001020238|XP_006501607	8882	HGNC:20889	9860	NM_014813,NM_001312686	NP_055628,XP_016858441,XP_005271426,NP_001299615

	97														
Sp100	270;1074;2149;9183	1.2487	1.1229	0.4012	0.8830	0.8723	MGI:109561	20684	NM_013673|XM_006529286|XM_006529281|NM_001313714|XM_006529282|NM_001313713|XM_017319443|XM_006529283|XM_006529288|XM_006529285|NM_001313712|XM_006529284|XM_006529280|XM_017319442|XM_011247950	XP_006529345|XP_006529346|NP_001300643|NP_001300641|XP_006529348|NP_038701|XP_017174932|NP_001300642|XP_006529349|XP_006529344|XP_006529351|XP_017174931|XP_011246252|XP_006529343|XP_006529347	86761	#N/A	#N/A	#N/A	#N/A
Axin2	655;1077;2528;9157	1.2466	0.9561	0.4025	0.8817	0.8723	MGI:1270862	12006	XM_006532058|NM_015732|XM_006532057|XM_006532059|XM_006532060	XP_006532120|XP_006532121|XP_006532122|NP_056547|XP_006532123	3420	HGNC:904	8313	NM_004655	XP_011523621, XP_016880683, XP_016880682, NP_004646,XP_011523623,XP_016880681,XP_011523622
Arl13b	1055;1078;2755;3133	1.2459	0.8811	0.4030	0.8784	0.8723	MGI:1915396	68146	XM_006522503|NM_026577|XM_006522504|XM_006522505	XP_006522568|XP_006522566|XP_006522567|NP_080853	18820	HGNC:25419	200894	NM_182896,NM_001174151,NM_001321328,NM_001174150,NM_144996	NP_001167621, XP_011510835, XP_006713595, XP_016861342, XP_011510834, XP_011510836, NP_878899,NP_659433,XP_011510837,NP_001167622,NP_001308257
Abcc4	468;1083;2208;2493	1.2423	1.0139	0.4053	0.8791	0.8723	MGI:2443111	239273	XR_874344|NM_001163675|XM_006519010|NM_001033336|NM_001163676	NP_001157147|XP_006519073|NP_001157148|NP_001028508	74563	HGNC:55	10257	NM_001105515, NM_001301829, NM_001301830, NM_005845	NP_001288758, XP_016875809, NP_005836,NP_001288759,NP_001098985,XP_016875808,XP_005254082,XP_016875810,XP_016875811

Hcfc2	27;10887;61087;77711	1.2395	1.1541	0.0407	0.0878	0.0723	MGI:1915183	679 3	XR_001779585|XM_006514013|XM_011243544|NM_001081218|XM_011243545|XM_006514011|XM_006514010	XP_011241846|XP_011241847|XP_006514076|XP_006514073|XP_006514074|NP_001074687	8337	HGNC:24972	2991 5	NM_013320	XP_016874731, XP_016874730, NP_037452
Csnk1d	8383;10900;63677;71021	1.2374	0.2120	0.0408	0.0776	0.0723	MGI:1352722	1043 1 8	NM_139059|XM_011248663|XM_011248662|NM_027874	XP_011246964|NP_082150|NP_620690|XP_011246965	7484 1	HGNC:24522	1453	NM_001893,NM_139062	XP_016879688, NP_620693,NP_001884,XP_005256393,XP_005256394
Car9	675;10911;23960;57541	1.2367	0.2346	0.0409	0.0744	0.0723	MGI:2447188	2309 9	NM_139305|XM_006537831	NP_647466|XP_006537894	2032 5	HGNC:13833	768	NM_001216	NP_001207
Lamp2	483;10966;37399;63651	1.2333	1.2003	0.0411	0.0754	0.0723	MGI:967488	1678 4	NM_010685|XR_001782739|NM_001017959|NM_001290485	NP_001277414|NP_001017959|NP_034815	7809	HGNC:6501	3920	NM_001122606, NM_013995,NM_002294	NP_002285,NP_054701,NP_001116078
Spp	108	1.28	0.0448	0.0848	0.0848	0.0723	MGI	732	XR_380447|XM_006514214|XM_011243585|XM_	XP_006514277|XP_006514278|XP_006514274|	106	HGN	569	NM_152988,NM_001077238	NP_001070706, XP_016882507, XP_011526440,

I2b	6;110;594;882	277	680	152	752	731	:1920468	18	006514209|XM_017314120|XM_006514210|XM_006514213|XR_001779612|XM_006514211|NM_175195|XM_006514212|XM_006514215|XM_017314121|XM_017314119	XP_006514272|XP_017169608|XP_006514276|NP_780404|XP_017169610|XP_006514275|XP_006514273|XP_017169609|XP_011241887	05	C:30627	28		NP_694533,XP_011526442,XP_016882508,XP_016882506,XP_011526441,XP_016882505
Maea	161;1106;8165;;91922	1.2264	1.2166	0.4161	0.8731	0.8731	MGI:1891748	59003	XM_006504041|NM_021500	XP_006504104|NP_067475	4298	HGNC:13731	1096	NM_001297432,NM_001017405,NM_005882,NM_001297431,NM_001297433,NM_001297430	NP_005873,NP_001284361,XP_016863126,XP_006713912,XP_006713913,NP_001284362,XP_011511679,XP_011511678,NP_001284360,XP_016863125,NP_001284359,NP_001017405
Vasp	701;1118;2288;;52000	1.2182	0.9304	0.4221	0.8814	0.8782	MGI:1092668	22323	NM_001282022|NM_001282021|NM_009499|NR_104069	NP_001268951|NP_033525|NP_001268950	7592	HGNC:12652	7408	NM_003370,NM_001008736	NP_003361,XP_016882689,XP_005259257,XP_005259256
Vezt	894;1119;3715;;6165	1.2175	0.8911	0.4226	0.8784	0.8782	MGI:2143698	21508	NM_172538|NM_001304572|NM_001304575|NM_001304720	NP_001291501|NP_001291649|NP_766126|NP_001291504	9739	HGNC:18258	55591	NM_001352095,NM_001352118,NM_001352111,NM_001352098,NM_001352089,NM_001352099,NM_001352103,NM_001352106,NM_001352117,NM_017599,NM_001352119,NM_001352116,NM_001352088,NM_001352097,NM_001352110,NM_001352115,NM_001352109,NM_001352091,NM_001352105,NM_001352094,NM_001352092,NM_001352104,NM_001352114,NM_	NP_001339025,XP_006719542,NP_001339041,XP_011536849,NP_001339042,NP_001339024,XP_016875093,XP_011536851,NP_001339046,XP_006719541,XP_011536853,NP_001339018,XP_016875081,XP_006719540,XP_006719549,XP_016875091,NP_001339045,XP_016875080,NP_001339033,XP_016875079,NP_001339030,NP_001339027,NP_001339040,

													_001352113,NM_001352101,NM_001352096,NM_001352112,NM_001352100,NM_001352107,NM_001352108,NM_001352102,NM_001352090,NM_001352093	NP_001339038, XP_016875084, NP_001339044, NP_001339023, XP_011536845, NP_001339026, NP_001339043, XP_016875085, XP_011536847, NP_001339021, XP_011536854, NP_001339019, XP_006719548, NP_001339017, XP_016875087, XP_011536848, XP_006719545, XP_016875077, XP_006719544, XP_011536852, NP_001339034, XP_006719543, NP_001339031, XP_016875075, XP_006719553, XP_016875083, XP_016875090, XP_011536850, NP_001339020, XP_016875086, XP_016875078, NP_001339048, NP_001339022, XP_016875076, NP_001339036, XP_016875088, XP_016875094, NP_001339032, NP_001339039, XP_011536846, XP_006719547, NP_001339029, NP_001339035, NP_001339047, XP_006719546, NP_001339028, XP_016875089, XP_016875082, XP_011536855, NP_060069,XP_016875092,NP_001339037
Bbs2	94;1148;1232;4842;5148	1.2132244	1.3232	0.4878	0.8782	0.8782	MGI:2135267	6738	NM_026116|XM_006531304|XR_001778463	NP_080392|XP_006531367	1222	HGNC:967	583	NM_031885	NP_114091,XP_005256137
Rabac1	381;1148	1.2048	1.0337	0.4318	0.8892	0.8796	MGI:12	1470	NM_010261	NP_034391	3818 2	HGNC:9	1056 7	NM_006423	NP_006414

	38;245;376					0169					794				
Gtf2h2	401;1143;4355;6619	1.2014	1.0243	0.4343	0.8904	0.8796	MGI:1345669	238	XM_006517660|NM_022011|XR_873756|XR_873758|XM_006517662|XR_873759	NP_071294|XP_006517723|XP_006517725	119	HGNC:4656	296	NM_001515	XP_016864895, XP_016864894, XP_016864892, NP_001506,XP_016864893
Ctps	538;1144;4542;6786	1.2008	0.9677	0.4347	0.8872	0.8796	MGI:1858304	517977	NM_016748|XM_006503225	XP_006503288|NP_058028	20446	HGNC:25199	1503	NM_001301237, NM_001905	NP_001896,NP_001288166
Nudt4	164;1152;3210;57666	1.1955	0.1974	0.4386	0.8911	0.8796	MGI:1918457	7127077	NM_027722|XM_006514116	XP_006514179|NP_081998	41726	HGNC:80511	1163	NM_019094,NM_199040,NM_001301024,NM_001301023,NM_001301022	XP_011536097, XP_011536098, NP_001287951, XP_011536096, NP_001287952, NP_001287953, NP_950241,NP_061967
Spry2	767;1153;	1.1949	0.1903	0.4392	0.8822	0.8796	MGI:1345111	240644	XM_006519016|NM_011897	XP_006519079|NP_036027	42667	HGNC:1112	1025 3	NM_001318536, NM_001318537, NM_001318538, NM_005842	NP_001305466, NP_001305465, NP_001305467, NP_005833

	43180;79911						38				70				
Psd	123;115;42764;43155	1.1936	1.2562	0.4403	0.8864	0.896	MGI:1920978	7372	XM_006527389|XM_006527390|XM_006527391|XM_011247377|XR_386518|XM_006527388|XM_006527393|NM_001347454|XM_011247376|XM_006527386|NM_028627	XP_006527454|XP_011245678|NP_001334383|XP_011245679|XP_006527451|XP_006527456|XP_006527452|XP_006527449|XP_006527453|NP_082903	3115	HGNC:9507	56 62	NM_002779,NM_001270965,NM_001270966	NP_002770,XP_016871922,NP_001257894,NP_001257895,XP_011538271,XP_011538270,XP_016871923
Fzd1	78;11577;88892	1.1923	0.1899	0.4412	0.8843	0.8796	MGI:1196625	1436 2	NM_021457	NP_067432	20750	HGNC:40388	83 21	NM_003505	NP_003496
Ras	416;11581;77133;95588	1.1916	0.1005	0.4417	0.8814	0.8796	MGI:9817979	20130	XM_006540721|NM_009101	XP_006540784|NP_033127	4565	HGNC:10447	62 37	NM_006270	NP_006261
Ilk	343;11660;2477	1.1903	1.0467	0.4427	0.8796	0.896	MGI:1195267	16202	XM_006507389|NM_001161724|NM_010562|XM_006507390	XP_006507452|NP_034692|XP_006507453|NP_001155196	3318	HGNC:60400	36 11	NM_001278441,NM_004517,NM_001014794,NM_001278442,NM_001014795	NP_001014795,NP_001265371,XP_005252962,NP_004508,XP_005252961,XP_016873161,XP_011518367,NP_001014794,NP_001265370

	0;3998														
Rhoj	224;1168;2350;4117	1.1851	1.1286	0.44683	0.88837	0.88311	MGI:1931551	80837	NM_023275	NP_075764	56894	HGNC:688	57381	NM_020663	NP_065714,XP_006720277,XP_011535295
Prkdc	24;1171;7805;8938	1.1832	1.1599	0.44885	0.88311	0.88311	MGI:1047779	19090	XM_017316892|XM_006521861|NM_011159|XM_011245841|XM_011245842	XP_011244144|XP_011244143|XP_006521924|NP_035289|XP_017172381	50377	HGNC:9413	55911	NM_006904,NM_001081640	NP_008835,NP_001075109
Shisa5	329;1175;3539;8774	1.18007	1.10000	0.45005	0.88832	0.88832	MGI:1915044	66940	XM_006512213|XM_006512216|XM_006512218|XM_006512212|NM_025858|NM_001284332|NM_026381|XM_006512217|XM_006512219|XM_006512215	XP_006512276|XP_006512279|XP_006512282|XP_006512281|XP_006512280|XP_006512275|NP_080657|NP_001271261|NP_080134|XP_006512278	133951	HGNC:30376	51246	NM_001272065,NM_001272068,NM_016479,NM_001272082,NM_001272083,NM_001272066,NM_001272067	NP_001258994,NP_001259012,XP_005265262,NP_001258997,NP_001258995,XP_011532098,XP_006713251,NP_057563,NP_001258996,NP_001259011
Rapgef2	456;1180;5259;80	1.17752	0.19862	0.45229	0.88442	0.88442	MGI:2659071	76089	NM_001310536|XM_006502254|XM_006502250|XM_011240277|XM_006502252|NM_001099624|XM_011240276	XP_006502313|XP_006502317|XP_011238579|NP_001297465|XP_006502315|XP_011238578|NP_001093094	35477	HGNC:16854	96903	NM_001351727,NM_001351728,NM_001351725,NM_001351724,NM_014247,NM_001351726	XP_011530729,NP_001338654,XP_016864347,XP_005263417,XP_005263415,XP_006714483,XP_011530728,XP_005263416,XP_016864348,XP_016864346,XP_005263418,NP_055062,XP_016864345,XP_006714484,NP_001338656,XP_011530727,NP_

	23													001338653,NP_001338657,XP_006714485,NP_001338655
Trap	45;119;345;426	1.19848113	0.0.4.8.9.1	0.0.8.9.1	0.0.9.1	MGI:2153272	106831	XM_006504790|XM_006504786|XM_006504789|XR_377189|XM_006504787|XM_006504794|XM_006504782|XM_017320576|XM_017320577|XM_006504788|XM_006504785|XM_011240999|XM_006504795|XM_017320578|XM_006504793|NM_001081362|XM_006504783|XM_006504792|XM_006504784|XM_017320575|XR_377190|XM_006504781	XP_006504855|XP_006504851|XP_017176064|XP_006504847|XP_006504844|XP_006504848|XP_006504846|XP_006504850|NP_001074831|XP_006504845|XP_017176066|XP_006504849|XP_011239301|XP_006504852|XP_006504856|XP_006504853|XP_006504858|XP_017176065|XP_017176067|XP_006504857	392	HGNC:1234	8295	NM_001244580,NM_003496	NP_001231509,NP_003487
Lin7c	43;119;204;671	1.1.1.1	0.0.0.0	0.0.0.0	0.0.0.0	MGI:133083	223439	NM_011699	NP_035829	22649	HGNC:17789	55327	NM_018362	NP_060832
Aptx	63;120;362;752	1.1.1.1	0.0.0.0	0.0.0.0	0.0.0.0	MGI:191365	6408	NM_025545|XM_006538169|XM_006538167|NM_001025444|XM_006538168|XM_006538166|XM_011250084|XM_006538171|XM_006538170|NM_001025445	XP_006538234|NP_001020616|XP_006538233|XP_011248386|XP_006538231|NP_001020615|XP_006538232|NP_079821|XP_006538230|XP_006538229	41634	HGNC:15984	54840	NM_175072,NM_017692,NM_001195248,NM_001195251,NM_001195252,NM_001195250,NM_175073,NM_001195254,NM_175069,NM_001195249	XP_011516240,XP_016870326,NP_001182183,NP_778239,NP_001182178,XP_016870322,XP_016870327,NP_778243,NP_001182180,XP_011516241,XP_006716855,XP_016870324,XP_006716854,NP_001182177,NP_001182181,NP_001182179,XP_016870323,XP_016870320,XP_016870325,XP_016870321
Rasgrp3	896;120;745	1.1.1.1	0.0.4.6.6.0	0.0.8.9.7.2	0.0.9.4.6.5	MGI:3028579	2401683	XM_140160|XM_006524273|NM_001166493|XM_006524271|XM_006524272	NP_997129|XP_006524336|NP_001159965|XP_006524334|XP_006524335	15019	HGNC:14545	25780	NM_015376,NM_001349980,NM_001139488,NM_001349975,NM_001349977,NM_001349981,NM_001349976,NM_001349979,NM_001349978,NM_170672	XP_011531050,NP_001336906,XP_016859249,XP_005264303,NP_001336910,NP_056191,NP_001132960,XP_011531048,NP_001336905,XP_016859252,XP_016859250,NP_

	68;9795													001336909,NP_001336908,XP_016859248,NP_733772,NP_001336904,XP_011531049,NP_001336907,XP_016859251
Gstp1	228;1211;41122;58277	1.1.1.1580	1.1.1.1144	0.4.6.9.3	0.8.9.6.7	0.8.9.4.5	MGI:95865	1487	NM_013541	NP_038569	660	HGNC:4638	2950	NM_000852	NP_000843
Rgma	10122;12166;53362;63122	1.1.5.5.0	0.8.4.1.5	0.4.7.2.0	0.8.9.8.0	0.8.9.4.5	MGI:2679262	24058	NM_177740|XM_006540902	XP_006540965|NP_808408	10626	HGNC:303038	5693	NM_001166288,NM_001166287,NM_020211,NM_001166286,NM_001166283,NM_001166289	NP_064596,NP_001159759,NP_001159758,NP_001159761,NP_001159755,NP_001159760
Sox9	9291;12180;30200;31622	1.1.5.3.7	0.8.5.3.4	0.4.7.3.1	0.8.9.6.2	0.8.9.4.5	MGI:983711	20682	NM_011448	NP_035578	294	HGNC:11204	662	NM_000346	NP_000337
Fkrp	735;12300;53331	1.1.4.6.4	0.8.6.6	0.4.7.9.5	0.9.0.4.5	0.8.9.4.5	MGI:2447586	24385	XM_006539928|XM_006539930|NM_173430|XM_011250562|XM_006539929	NP_775606|XP_006539991|XP_011248864|XP_006539993|XP_006539992	1153	HGNC:17997	7914	NM_024301,NM_001039885	XP_005259305,XP_011525609,NP_001034974,XP_011525608,XP_005259304,XP_016882786,XP_005259306,NP_077277

	4;7930														
Ak1	726;12333;65977;66588	1.1488478	0.0.48.49.80.38.94.45	MGI:872977	116	NM_001198791|NM_021515|XM_006497624|NM_001198790|XM_017315020|NM_001198792	XP_006497687|NP_001185719|XP_017170509|NP_001185720|NP_067490|NP_001185721	20135	HGNC:361	203	NM_001318121,NM_000476,NM_001318122	NP_001305050,XP_016869916,NP_001305051,XP_016869917,NP_000467
Phactr1	634;12340;20311;72054	1.1414040	0.0.49.48.01.16.09.45	MGI:2659021	2189 4	XM_006516911|XM_006516907|XM_006516905|XM_017315484|NM_001005740|XM_017315483|XM_017315482|XM_011244395|XM_006516906|NM_001302635|NM_001005748|NM_001302636	XP_017170971|NP_001289565|NP_001005740|XP_006516974|NP_001005748|XP_011242697|NP_001289564|XP_006516969|XP_006516968|XP_006516970|XP_017170972|XP_017170973	33597	HGNC:20990	22192	NM_001322312,NM_001322309,NM_001322308,NM_030948,NM_001322310,NM_001322311,NM_001322313,NM_001242648,NM_001322314	XP_016865956,XP_016865953,XP_016865947,NP_001309238,XP_016865948,XP_016865954,XP_016865951,XP_016865950,NP_001309237,NP_001229577,XP_016865955,XP_016865941,NP_001309241,XP_016865943,XP_016865945,XP_005248991,NP_001309242,NP_001309243,XP_016865958,NP_001309240,NP_001309239,XP_016865952,XP_016865946,XP_016865949,XP_016865944,NP_112210
Dnajb4	617;12338;43541;87011	1.1941683	0.0.49.48.01.38.94.45	MGI:191428 5	67035	XM_006501920|XM_006501921|NM_025926|NM_027287	XP_006501983|NP_080202|NP_081563|XP_006501984	10061 0	HGNC:14886	11 0 8 0	NM_007034,NM_001317101,NM_001317102,NM_001317100,NM_001317099,NM_001317103	NP_001304032,NP_008965,NP_001304030,NP_001304029,NP_001304031,NP_001304028
Csnk2a2	591;12323	1.1421 0	0.0.48.49.88.86.94.45	MGI:885	130 0	XM_006530641|NM_009974|XM_006530642|XM_017312556|XM_006530643	XP_006530706|XP_006530705|XP_017168045|XP_006530704|NP_034104	20444	HGNC:24	14 5 9	NM_001896	NP_001887,XP_016878434,XP_005255858,XP_005255857

	9;3383;5440					47				59				
Vcl	95;1241;2744;32266	1.1385	1.1283	0.0485	0.0896	0.0894	MGI:98927	2330	XM_006518922|NM_009502	NP_033528|XP_006518985	7594	HGNC:12665	74144	NM_014000,NM_003373	NP_054706,NP_003364
Ccny	10324;12455;37977;77222	1.1374	0.0830	0.0487	0.0897	0.0894	MGI:1915224	67974	NM_026484|XM_017317976|XM_017317975|XM_017317974	XP_017173464|XP_017173465|NP_080760|XP_017173463	12219	HGNC:23354	21977	NM_001282854, NM_001282852, NM_181698,NM_001282853,NM_145012	XP_011517671, XP_011517663, NP_001269783, XP_016871330, XP_016871329, XP_011517667, XP_011517664, NP_001269781, XP_011517666, NP_859049,NP_659449,XP_011517660,XP_011517670,XP_011517659,XP_016871328,XP_006717455,XP_011517665,XP_011517662,NP_001269782,XP_011517668,XP_011517669
Adrm1	557;12485;45511;84688	1.1356	0.0928	0.0489	0.0896	0.0894	MGI:1929289	5643	XM_006500680|NM_019822	NP_062796|XP_006500743	10513	HGNC:15759	11047	NM_001281438, NM_007002,NM_001281437,NM_175573	XP_016883093, XP_005260314, XP_011526805, XP_016883092, NP_008933,NP_001268367,NP_783163,NP_001268366,XP_016883091,XP_016883096,XP_016883098,XP_016883095,XP_016883097,XP_016883099,XP_016883094
Trip10	8511;12252	1.1336	0.0849	0.0897	0.0894	5	MGI:2146	1062	NM_134125|XM_006523401|XM_006523400|NM_001242390|NM_001242391|NM_001242389	NP_001229318|NP_001229320|NP_001229319|XP_006523464|NP_598886|XP_006523463	99728	HGNC:123	932	NM_004240,NM_001288963,NM_001288962	NP_001275891, XP_005259740, NP_001275892, XP_006723003, NP_004231

	;8696;90299					901					04				
Itpr2	36;12533;49327;54377	1.1327	1.1007	0.04921	0.08945	0.08945	MGI:3994188	1643	XM_017321411|XM_006507026|NM_019923|NM_010586	NP_034716|XP_017176900|XP_006507089|NP_064307	3753	HGNC:6181	309	NM_002223	XP_016874756, XP_016874758, XP_016874757, NP_002214,XP_016874755
Pcyox1	1206;12688;27355;87199	1.12382	1.1802	0.05003	0.09059	0.09005	MGI:1914131	6681	XM_006506486|NM_025823	NP_080099|XP_006506549	9458	HGNC:20588	5144	NM_016297	NP_057381
Vamp5	1039;12669;25888;69566	1.12321	1.8219	0.05008	0.09031	0.09005	MGI:1858622	5362	NM_016872|NM_001080742	NP_058568|NP_001074211	4833	HGNC:12646	10791	NM_006634	NP_006625
Emp3	723;12705;	1.1227	1.8775	0.05014	0.09005	0.09005	MGI:1097	1373	NM_001146346|NM_010129	NP_001139818|NP_034259	1090	HGNC:33355	2014	NM_001313905, NM_001425	NP_001300834, XP_011524907, NP_001416

	29						29								
	14;3737														
Dtnbp1	577;1276;2886;9389	1.1944	0.1049	0.9032	0.9005	MGI:2137586	9424 5	XM_006516984|NM_025772	NP_080048|XP_006517047	1203 7	HGNC:17328	84062	NM_001271667, NM_001271668, NM_183040,NM_032122,NM_001271669	NP_001258596, NP_898861,NP_001258597,XP_016866837,NP_115498,XP_011513238,NP_001258598,XP_005249504,XP_011513239,XP_016866838	
Nmt1	620;1285;5460;9491	1.1140	0.1892	0.5101	0.9089	0.9005	MGI:1025779	181 07	NM_008707|XM_006532445	XP_006532508|NP_032733	69027	HGNC:78557	4836	NM_021079	NP_066565,XP_011523160
Rgs10	486;1286;4078;7576	1.1342	0.9424	0.5107	0.9063	0.9005	MGI:1915115	678 65	NM_026418|XM_006508139|XM_006508140|XM_017312270	XP_017167759|NP_080694|XP_006508203|XP_006508202	3771 0	HGNC:9992	601	NM_001005339, NM_002925	NP_001005339, XP_016871981, XP_016871982, NP_002916
Best1	619;1287;234	1.1289	0.1895	0.5101	0.9037	0.9005	MGI:1346332	241 15	XM_129203	NP_036043	3789 5	HGNC:12703	7439	NM_001300786, NM_001300787, NM_001139443, NM_004183	XP_005274276, XP_016873717, NP_001132915, XP_005274273, XP_011543535, XP_016873719, XP_011543532, NP_001287716, XP_005274278, NP_004174,NP_001287715,XP_005274272,XP_

	3;4609													011543531,XP_016873718,XP_005274267
Ctdnep1	9701;12889;34922;35277	1.1.1.117	0.8.1.160	0.5.1.124	0.9.0.222	0.0.0.5	MGI:1914431	671 to 811	NM_026017	NP_080293	9100	HGNC:19085	23 to 399	NM_015343,NM_001143775	NP_056158,NP_001137247
Slc33a1	3163;12911;28300;73544	1.1.1.105	0.2.1.028	0.5.1.234	0.9.0.005	0.0.0.5	MGI:1332247	114 to 116	XM_017319441|NM_001331067|NM_015728|NM_001272035	XP_017174930|NP_001258964|NP_001317996|NP_056543	3476	HGNC:95	91 to 97	NM_001190992,NM_004733	XP_011511613,XP_016862953,NP_001177921,XP_016862952,NP_004724,XP_016862951
Ccni	7343;13033;37822;67022	1.1.1.037	0.8.6.055	0.5.2.033	0.9.0.090	0.0.0.69	MGI:1341077	124 to 153	XM_006534736|NM_017367	XP_006534799|NP_059063	4979	HGNC:1595	10 to 83	NM_001348134,NM_001348138,NM_001348136,NM_001348137,NM_001348135,NM_001348140,NM_001348132,NM_001348139,NM_001348133,NM_006835	NP_006826,XP_011529857,NP_001335064,NP_001335066,NP_001335063,NP_001335069,NP_001335065,NP_001335068,NP_001335061,NP_001335067,NP_001335062
Tmem50b	3973;13093;54276	1.1.1.033	0.9.7.337	0.5.2.337	0.9.1.144	0.0.0.69	MGI:1925225	775 to 975	NM_030018	NP_084294	21234	HGNC:12800	757	NM_006134	NP_006125,XP_011528048

Smarcc2	7800;1616;1316;3741;;5271	1.0964	1.1454	0.0527	0.0914	0.0909	MGI:1915344	6804	XM_006514024|NM_001114097|XM_006514022|NM_198160|XM_006514020|NM_001114096|XM_006514023|XM_006514021	NP_937803|XP_006514083|XP_006514086|XP_006514087|XP_006514084|XP_006514085|NP_001107569|NP_001107568	2312	HGNC:11105	6601	NM_139067,NM_001330288,NM_001130420,NM_003075	XP_016875374,NP_003066,NP_001317217,XP_016875375,NP_620706,XP_005269160,XP_005269158,XP_005269159,XP_005269161,XP_016875376,NP_001123892,XP_016875373,XP_011536995
Gcc1	8761;1320;2912;4822	1.0942	0.0832	0.0530	0.0915	0.0909	MGI:1921625	7437	NM_028900	NP_083176	11567	HGNC:19095	7957	NM_024523	NP_078799
Tm7sf3	3681;1325;2261;;58000	1.0914	0.0983	0.0532	0.0916	0.0909	MGI:1914873	6762	XM_132970|XM_011241630	XP_011239932|NP_080557	9560	HGNC:23049	5176	NM_016551	NP_057635,XP_016874952,XP_016874953,XP_005253448,XP_011518993,XP_016874954,XP_011518992,XP_016874955
Atn1	10301;1329;;48955;;800	1.0892	0.0806	0.0535	0.0917	0.0909	MGI:1047255	13498	NM_007881	NP_031907	14611	HGNC:30333	18222	NM_001007026,NM_001940	NP_001007027,NP_001931

Tesk2	407;1335;3623;5788	1.0859	0.0864	0.0538	0.0919	0.0699	MGI:2385204	2306;61	XM_006503008|NM_146151|XR_001784124	NP_666263|XP_006503071	518	HGNC:11732	104;20	NM_001320800,NM_007170	NP_009101,XP_016855537,XP_016855538,XP_005270412,XP_006710350,NP_001307729,XP_011538802,XP_011538799,XP_016855536
Ackr3	466;1336;4610;4678	1.0853	0.0932	0.0539	0.0917	0.0699	MGI:1095622	127;78	NM_001271607|NM_007722	NP_031748|NP_001258536	22419	HGNC:23692	57;07	NM_001047841,NM_020311	XP_005246154,NP_064707,XP_016860005,XP_005246155
Cdc7	149;1337;3362;98411	1.0848	1.1619	0.0540	0.0914	0.0699	MGI:1309511	1254;5	NM_001271568|XM_017320634|NM_009863|XM_006534737|NM_001271567|NM_001271566	NP_001258495|NP_001258497|NP_033993|XP_006534800|XP_017176123|NP_001258496	3166	HGNC:17445	831;7	NM_003503,NM_001134419,NM_001134420	NP_001127891,XP_005271298,XP_016857915,XP_016857916,XP_005271301,XP_016857914,NP_001127892,NP_003494
Mapk1	817;1339;42600;63988	1.0837	0.0838	0.0541	0.0913	0.0699	MGI:1346858	2641;13	XM_006522147|NM_011949|NM_001038663	XP_006522210|NP_001033752|NP_036079	37670	HGNC:6871	559;4	NM_002745,NM_138957	NP_002736,NP_620407

Pank2	11773;13443;72783;75334	1.0810140	0.7840	0.5438	0.9144	0.0699	MGI:1921700	7450	XR_001783192|XM_017319300|XM_017319299|XM_006500300|XR_001783191|XM_006500299|NM_153501|XM_017319298|XM_006500298	XP_017174787|XP_006500362|XP_006500361|NP_705721|XP_017174788|XP_006500363|XP_017174789	651266	HGNC:15894	8025	NM_024960,NM_153640,NM_153641,NM_001324191,NM_001324193,NM_153637,NM_153638,NM_001324192,NM_153639	NP_079236,XP_005260892,NP_705902,XP_016883568,XP_016883566,NP_001311121,XP_016883567,XP_005260893,NP_001311122,XP_011527666,XP_011527667,NP_001311120,NP_705904
Nek8	27634;35143;63299	1.0804	1.0344	0.5444	0.9121	0.0699	MGI:1890646	1408599	NM_080849|XM_006532183|XM_006532184|XM_006532185	NP_543125|XP_006532247|XP_006532246|XP_006532248	84442	HGNC:13387	28408 6	NM_178170	XP_016879990,XP_016879988,XP_011522942,XP_016879989,NP_835464,XP_011522940
Dnm1	19934;13466;24103;35887	1.0799	1.0100	0.5450	0.9097	0.0699	MGI:1073844	13429	NM_010065|XR_001780675|XM_006497662|XM_017315328|XM_006497649|XM_006497653|XM_006497658|XM_006497650|XR_374057|NR_125959|XM_006497651|XR_001780678|XM_006497660|XM_006497661|XM_006497652|XR_374055|XM_006497654|XM_006497655|NM_001301737|XR_374058|XM_006497659	XP_006497715|XP_006497725|XP_006497721|XP_017170817|XP_006497722|XP_006497723|XP_006497718|XP_006497716|XP_006497717|XP_006497712|XP_006497713|NP_001288666|XP_006497724|XP_006497714|NP_034195	123905	HGNC:29722	17591	NM_001288738,NM_001005336,NM_001288739,NM_001288737,NM_004408	XP_005251820,NP_001275666,XP_005251826,XP_011516637,XP_006717056,XP_011516638,NP_001275668,XP_006717055,XP_016869860,NP_001275667,NP_004399,XP_016869858,NP_001005336,XP_016869861,XP_016869862,XP_005251825,XP_016869859
Nt5c	10503;13523;62733;;79	1.0766	0.7972	0.5484	0.9119	0.0699	MGI:1354954	5077 3	NM_015807|XM_011249123	NP_056622|XP_011247425	87445	HGNC:17144	30833	NM_001252377,NM_014595	NP_055410,NP_001239306,XP_011523002

	02														
Gpr19	90;13535;27377;44066	10.085490906	0	0	0	0	MGI:892973	147760	XM_006505544|XM_017321393|XM_006505543|XM_006505547|NM_008157|NR_074084|NR_072990|NM_001167696|XM_006505554|NM_001167695|XM_017321391|NM_001167700|XM_017321390|NM_001167694|XM_017321392|NM_001167697|XM_006505545|NM_001167699	XP_006505617|XP_017176879|XP_006505608|NP_001161167|NP_032183|NP_001161166|NP_001161168|XP_017176880|NP_001161171|XP_017176881|NP_001161172|XP_006505610|XP_006505606|XP_017176882|XP_006505607|NP_001161169	447476	HGNC:44733	284 2	NM_006143	NP_006134,XP_016874705,XP_016874702,XP_016874704,XP_011518925,XP_011518927,XP_011518926,XP_016874701,XP_016874703
Sh3bp5l	90;13535;31700;72711	10.085590906	0	0	0	0	MGI:1933124	795616	XM_006534523|NM_024480|NM_001161338|NM_001308168|NM_001308167	NP_077800|NP_001295097|NP_001295096|NP_001154810|XP_006534586	325844	HGNC:29360	804851	NM_030645,NM_001322464,NM_001322462,NM_001322463	NP_085148,NP_001309391,XP_016857895,NP_001309392,XP_016857893,XP_016857894,XP_016857896,NP_001309393
Orai1	83;13357;38747;93477	10.085590906	0	0	0	0	MGI:1925542	109305	XM_006530116|NM_175423|XM_006530117	XP_006530179|XP_006530180|NP_780632	131177	HGNC:25896	848776	NM_032790	NP_116179
Bdnf	82;13667;43767;67888	10.062991	0	0	0	0	MGI:881455	120644	NM_001285422|NM_001285417|NM_001285420|NM_001285416|NM_001048142|NM_001316310|NM_001285418|NM_001285421|NM_001285419|NM_001048141|NM_001048139|NM_007540	NP_001041606|NP_001272346|NP_031566|NP_001272350|NP_001272351|NP_001272348|NP_001041604|NP_001303239|NP_001041607|NP_001272345|NP_001272349|NP_001272347	724545	HGNC:1033	627	NM_001143807,NM_001143811,NM_001143814,NM_170732,NM_170733,NM_001143808,NM_001143810,NM_001143806,NM_170731,NM_001143809,NM_001143816,NM_001143813,NM_001143805,NM_001709,NM_001143812,NM_170734,NM_001143815,NM_170735	NP_001137279,NP_733931,XP_011518582,NP_733929,NP_001137277,NP_001137278,NP_001137285,NP_001137284,NP_001700,NP_001137280,NP_733928,NP_001137288,NP_001137281,NP_001137286,NP_733930,NP_733927,NP_001137283,NP_001137282

Fnbp1	9346;13677;26312;6048	10.0.0.0.0.0	0	8	5	9	1	0	1	MGI:1096069	142	XM_006497693|NM_001177649|XM_006497685|XM_006497690|XM_006497692|XM_017315551|XM_006497691|XM_017315554|XM_006497688|NM_019406|XM_006497686|XM_006497689|NM_001177650|XM_017315555|XM_006497695|XM_006497694|NM_001177648|XM_006497684|NM_001038700|XM_006497687|XR_374060	XP_006497755|NP_001171121|XP_006497750|XP_006497757|NP_001033789|XP_006497751|XP_006497756|XP_017171044|XP_006497752|NP_001171120|XP_006497758|XP_006497749|XP_017171043|XP_006497748|NP_062279|XP_006497754|NP_001171119|XP_006497753|XP_017171040|XP_006497747	1009831	HGNC:17069	23048	NM_015033	XP_011516701,NP_055848,XP_016869980,XP_005251880,XP_005251885,XP_005251890,XP_016869976,XP_005251877,XP_016869981,XP_005251891,XP_005251872,XP_005251887,XP_011516702,XP_011516703,XP_016869977,XP_005251884,XP_016869982,XP_006717079,XP_005251878,XP_005251879,XP_011516704,XP_016869978,XP_005251883,XP_016869983,XP_016869979,XP_005251889,XP_005251881,XP_005251882,XP_005251886,XP_005251888
Slc2a8	19373;13726;26533;49866	1.0.0.0.0.0	1	0	5	9	1	0	1	MGI:1860103	560	NM_019488|XR_374107	NP_062361	69170	HGNC:13812	29988	NM_001271712,NM_014580,NM_001271711	XP_011516905,XP_011516906,NP_055395,XP_006717147,NP_001258641,NP_001258640,XP_016870142,XP_011516904
Tnks1bp1	12973;13766;29844;74044	1.0.0.0.0.0	0	7	5	9	1	0	2	MGI:2446193	228	XM_006499214|XM_006499213|NM_001081260|XM_006499217|XM_006499212|XM_006499211|XM_017317616|XM_006499215	XP_006499275|XP_006499277|XP_006499280|XP_006499274|XP_006499278|XP_006499276|XP_017173105|NP_001074729	14117	HGNC:19081	85456	NM_033396	NP_203754,XP_006718788,XP_011543627
Morf4l1	9033;13800	1.0.0.0.0.0	0	8	5	6	1	3	2	MGI:1096961	217	NM_024431|XM_006511018|NM_001039147	NP_001034236|NP_077751|XP_006511081	86043	HGNC:1693	1093	NM_001265603,NM_006791,NM_206839,NM_001265604,NM_001265605	NP_001252534,XP_016877361,NP_006782,NP_001252532,NP_001252533,NP_996670

	;52800;97511					551				89				
Amer1	204;13866;56266;60744	1.0585	1.0842	0.56911	0.91559	0.9159	MGI:1919595	72345	NM_175179	NP_780388	51852	HGNC:26837	139285	NM_152424	NP_689637
Slc3a2	191;14076;40366;80566	1.0476	1.0922	0.58177	0.93277	0.9271	MGI:969555	1725 4	NM_008577|NM_001161413|XM_017318078|XM_006526733	NP_032603|NP_001154885|XP_006526796|XP_017173567	17951	HGNC:11026	6520	NM_001012661, NM_001012663, NM_001012662, NM_001012664, NM_001013251, NM_002394	NP_001012682, NP_002385,NP_001013269,NP_001012680
Dstyk	1189;14100;59099;83866	1.04611	1.07652	0.58334	0.93222	0.9271	MGI:1925064	21345 2	XM_006529356|XM_017319684|NM_172516|XR_387156	XP_017175173|NP_766104|XP_006529419	19711	HGNC:29043	2578	NM_015375,NM_199462	NP_955749,XP_011507696,XP_011507695,NP_056190,XP_011507694
Lgals3	987;14122;2	1.04511	1.07902	0.58477	0.93170	0.9271	MGI:967778	1685 4	NM_001145953|NM_010705	NP_034835|NP_001139425	37608	HGNC:65633	3958	NM_001177388, NM_002306	NP_001170859, XP_011535061, NP_002297

	752;7186														
Rgs12	643;1418;5490;9370	1.0.5.9.0	0	0	0	0	MGI:1918979	719	XM_006504120|XM_006504123|NM_001163512|NM_173402|XM_006504126|XM_006504125|XM_006504124|XM_006504121|XM_006504122	NP_775578|XP_006504183|XP_006504185|XP_006504187|NP_001156984|XP_006504184|XP_006504188|XP_006504189|XP_006504186	2195	HGNC:9994	602	NM_198230,NM_002926,NM_198229,NM_198587,NM_198227,NM_198430,NM_198432	XP_006713970,XP_016864019,XP_016864022,NP_937872,NP_002917,XP_016864023,XP_011511845,XP_016864018,XP_016864021,NP_937870,XP_006713968,XP_006713969,XP_016864020
Tlk1	1219;1419;29711;7280	1.0.5.9.0	0	0	0	0	MGI:2441683	2280122	XM_006499188|XM_017317580|XM_017317581|XM_006499193|XR_374441|XM_006499191|NM_172664|XM_006499190|XM_006499189	XP_006499256|XP_017173069|XP_006499253|XP_006499251|NP_766252|XP_017173070|XP_006499254|XP_006499252	13065	HGNC:11841	974	NM_012290,NM_001136554,NM_001136555	NP_036422,NP_001130027,XP_011510540,XP_016860911,XP_016860910,NP_001130026
Rassf1	307;1424;32523;73889	1.0.9.5.9.0	0	0	0	0	MGI:1928386	562	XM_006511770|NM_019713|NM_001243748	NP_001230677|NP_062687|XP_006511833	10499	HGNC:9882	116	NM_170714,NM_170716,NM_170717,NM_001206957,NM_170712,NM_170713,NM_007182,NM_170715	XP_011531618,NP_733832,NP_001193886,NP_733831,NP_733830,NP_009113,XP_011531617
Stk17b	872;1425;6433	1.0.8.5.9.0	0	0	0	0	MGI:2138162	982	NM_133810|XM_006496359	NP_598571|XP_006496422	31231	HGNC:11396	962	NM_004226	XP_011510472,XP_011510471,XP_011510473,XP_011510470,NP_004217

	0;9595														
Sqstm1	156;1428;2585;8831	1.0369	1.1284	0.5947	0.9304	0.9271	MGI:1079311	1841	NM_001290769|NM_011018	NP_001277698|NP_035148	3120	HGNC:11280	8878	NM_001142299, NM_001142298, NM_003900	XP_011532985, NP_003891,NP_001135771,NP_001135770,XP_016865499
Slc41a2	660;1430;4792;8387	1.0359	0.8494	0.5960	0.9292	0.9271	MGI:2442940	3383 65	XM_011243498|NM_177388|XM_006513811	XP_011241800|XP_006513874|NP_796362	9870	HGNC:31045	8410 2	NM_001352172, NM_001352169, NM_001352171, NM_032148,NM_001352170	XP_006719693, XP_016875506, NP_001339099, NP_001339100, XP_011537113, XP_011537112, XP_011537115, XP_005269235, XP_016875505, XP_016875503, XP_016875502, XP_011537109, NP_001339098, XP_011537111, XP_011537110, XP_005269233, XP_005269236, NP_001339101, XP_016875504, NP_115524
Cdc42	672;1431;2960;5579	1.0354	0.8461	0.5967	0.9271	0.9271	MGI:1062111	1254 0	NM_009861|NM_001243769	NP_001230698|NP_033991	1372 30	#N/A	#N/A	#N/A	#N/A
Tcirg1	533;1438;4303	1.0319	0.8849	0.6011	0.9306	0.9271	MGI:1350931	2706 0	XM_011248632|NM_001167784|NM_001136091|NM_016921	NP_058617|NP_001161256|XP_011246934|NP_001129563	4392	HGNC:11647	1031 2	NM_006053,NM_006019,NM_001351059	XP_005273766, NP_006044,NP_006010,XP_016872578,XP_016872579,NP_001337988,XP_011543028

	;879													
Bag4	253;1440;5103;8702	1.0309	1.0270	0.060233	0.092933	0.09271	MGI:1914634	6734	NM_026121	NP_080397	3127	HGNC:9400	9530	NM_004874,NM_001204878	NP_001191807, NP_004865
Slc6a17	1278;1441;5017;5213	1.0304	0.074844	0.060229	0.092771	0.09271	MGI:2442535	2297	XM_006501406|NM_172271|NR_121629|XM_006501407|NM_001293689	XP_006501469|XP_006501470|NP_001280618|NP_758475	2775	HGNC:31399	3886	NM_001010898	NP_001010898, XP_006710706
Sema6a	1390;1445;4202;5593	1.0284	0.073777	0.060548	0.092778	0.09278	MGI:1203727	2035	NM_001311097|XM_006525727|NM_018744|XM_006525726	XP_006525789|XP_006525790|NP_061214|NP_001298026	3246	HGNC:10738	5756	NM_020796,NM_001300780,NM_020681	XP_016865164, XP_005272099, XP_016865165, NP_001287709, XP_006714726, NP_065847
Rictor	937;1452;5433;	1.0249	0.078777	0.060999	0.093142	0.09292	MGI:1926007	7857	XM_006520003|XM_006520004|NM_030168	XP_006520066|XP_006520067|NP_084444	3431	HGNC:28611	2532	NM_001285440, NM_152756,NM_001285439	NP_001272369, XP_016864801, XP_016864803, XP_016864802, XP_006714526, NP_689969,NP_001272368,XP_016864804,XP_011512308,XP_016864800,XP_011512307

	65388														
Tfam	58714453;44133;60666	1.0244400	0.8640106	0.6129293	0.0929292	MGI:1078100	2178	XM_017313918|NM_009360	NP_033386|XP_017169407	3113	HGNC:11741	701	NM_012251,NM_003201,NM_001270782	XP_011538422,NP_001257711,NP_003192,XP_011538423
Cnm2	96314556;53753;84889	1.0229227	0.7822525	0.6129292	0.0929292	MGI:2151054	94219	XM_006527490|NM_033569|NM_001102471|XM_006527489	NP_001095941|XP_006527552|NP_291047|XP_006527553	9761	HGNC:103	5485	NM_199077,NM_199076,NM_017649	XP_011538213,NP_060119,NP_951059,XP_006717971,NP_951058,XP_005269990
Hyal2	12001;14653;46753;95999	1.0185	0.7503	0.6183	0.9348	0.9348	MGI:1196334	1587	XM_006511643|XM_006511644|NM_010489|XM_006511645	NP_034619|XP_006511706|XP_006511707|XP_006511708	7776	HGNC:53211	8692	NM_003773,NM_033158	XP_005265581,XP_005265582,NP_003764,NP_149348
Srr	12677;14699;;70607	1.0165	0.7425	0.6210	0.9356	0.9356	MGI:1351636	2736	XM_017314569|NM_001163311|XM_006533457|XM_011249056|NM_013761|XM_017314570|XM_017314571|XM_017314572|XM_011249057	XP_017170061|NP_038789|XP_017170059|XP_017170060|XP_017170058|XP_011247358|XP_006533520|NP_001156783|XP_011247359	2275	HGNC:14398	6382	NM_001304803,NM_021947	NP_001291732,NP_068766,XP_006721629,XP_006721628,XP_011522276

	9 1 9														
Gatad2b	75;147 4;27 23;; 3110	1. 0141	0 8 1 6 1	0 0 6 2 4 2	0 0 9 3 7 4	0 9 3 7 4	MGI:2443225	229542	XM_006501361|XM_006501360|NM_139304|XM_006501359	NP_647465|XP_006501423|XP_006501422|XP_006501424	32484	HGNC:30778	57459	NM_020699	NP_065750,XP_005245421
Vti1b	878;1495;;20583;90003	1. 0040	0 7 8 7 1	0 0 6 3 7 9	0 0 9 5 4 7	0 0 9 4 7 8	MGI:185568	536122	NM_016800|XM_006516088|XM_011244143	XP_011242445|XP_006516151|NP_058080	38178	HGNC:17793	10490	NM_006370	NP_006361
Rab23	1403;150 0;;954 7;;95 511	1. 0016	0 7 2 3 3	0 0 6 4 1 1	0 0 9 5 6 3	0 0 9 4 7 8	MGI:99833	193355	NM_008999|XM_006495802|NM_001159729|XM_006495801	XP_006495864|NP_001153201|NP_033025|XP_006495865	7503	HGNC:14263	51715	NM_016277,NM_001278668,NM_001278667,NM_183227,NM_001278666	NP_057361,NP_001265597,NP_899050,NP_001265595,NP_001265596
Mtss1	1473;150 1;;267 5;;69	1. 0 1 2	0 7 7 9	0 0 6 4 1 6	0 0 9 5 4 0	0 0 9 4 7 8	MGI:2384818	211401	XM_011245543|XM_017316532|XM_006520709|XM_011245546|XM_006520711|XM_006520707|XM_011245541|NM_144800|XM_011245548|XM_006520712|XM_011245542|XM_011245545|XM_006520714|XM_017316531|NM_001146180|XM_011245540|XM_011245544|XM	XP_006520772|XP_017172021|XP_011243843|XP_011243848|XP_011243847|XP_006520775|XP_006520780|XP_006520770|XP_017172020|XP_011243850|NP_659049|XP_011243846|XP_011243844|XP_011243845|XP_011243842|XP_011243849|XP_006520774|XP_	88441	HGNC:20443	97888	NM_001282971,NM_014751,NM_001282974	XP_011515709,XP_006716764,XP_016869590,XP_016869585,XP_016869577,XP_016869584,XP_016869588,XP_006716768,NP_055566,NP_001269903,XP_005251170,XP_011515705,XP_016869587,XP_016869581,XP_016869579,XP_016869586,XP_006716763,XP_

	25								_011245547|XM_006520717	006520777|NP_001139652				011515706,XP_016869575,XP_005251175,XP_016869578,XP_006716767,XP_016869582,XP_016869576,XP_016869589,XP_006716769,XP_016869583,NP_001269900,XP_005251168,XP_006716765,XP_006716766,XP_016869580
Ugt1a10	96;1508;3013;8420	0.97978	0.97704	0.64663	0.95577	0.94778	MGI:3580642	3944430	NM_201641	NP_964003	13281	#N/A	54575	NM_019075	NP_061948
Anapc5	835;1512;5831;7374	0.99609	0.97909	0.64889	0.95833	0.94778	MGI:1929722	5900 8	NM_001289517|XM_006530429|NM_001289520|NM_001289518|XR_387575|NM_001289519|NM_021505|XM_017321048|NM_001042491	NP_001276446|NP_001276449|NP_001276448|NP_001035956|NP_067480|XP_006530492|NP_001276447|XP_017176537	41118	HGNC:15713	51433	NM_016237,NM_001137559,NM_001330489	XP_005253957,XP_016874912,NP_001131031,XP_016874913,NP_001317418,NP_057321
Lamtor3	128;1514;8016;92566	0.99506	1.14861	0.65017	0.95770	0.94778	MGI:1929467	5669 2	NM_019920	NP_064304	10539	HGNC:15606	86449	NM_021970,NM_001243736	NP_001230665,NP_068805
Ocrl	476;115	0.99455	0.98668	0.65078	0.95478	0.94778	MGI:10	32063 4	NM_177215|XM_011251008|XM_017318524	NP_796189|XP_017174013|XP_011249310	233	HGNC:8	49552	NM_001587,NM_001318784,NM_000276	XP_005262479,NP_001305713,XP_011529647,NP_001578,XP_016885043,XP_

	15;31273;36322					9589					108				011529646,NP_000267
Fiz1	10411;15166;67755;89544	0.994117	0.757114	0.651447	0.952778	0.947878	MGI:1344336	2387	NM_001110328|NM_001110330|NM_011813|NM_001110329|XM_006539907	NP_001103800|NP_001103799|NP_035943|NP_001103798|XP_006539970	22663	HGNC:25917	8492	NM_032836	XP_011525728,NP_116225,XP_005259409
Btn2a2	42;15204;40825;85411	0.992281	0.908139	0.653932	0.953278	0.947878	MGI:3606486	2385	NM_175938|NM_001289615|XM_006516664|XM_017315508|NM_001289614|XR_001780781	XP_006516727|NP_001276543|NP_787952|NP_001276544|XP_017170997	5601	HGNC:1137	10385	NM_001197240,NM_001197238,NM_001197239,NM_001197237,NM_006995,NM_181531	XP_016865658,XP_006715016,XP_016865656,NP_001184166,NP_001184168,XP_016865657,XP_011512531,XP_006715018,XP_016865655,NP_001184167,XP_005248854,NP_001184169,XP_011512530,XP_005248855,XP_011512533,NP_008926,NP_853509
Kcnk2	4704;15211;56503;88377	0.991787	0.887846	0.654612	0.955128	0.947878	MGI:109366	1652	NM_001159850|NM_001281847|NM_010607|XM_017318154|XM_006497122|XM_006497121|NM_001281848	NP_001268777|NP_001268776|XP_017173643|XP_006497184|XP_006497185|NP_001153322|NP_034737	7794	HGNC:62777	3776	NM_001017424,NM_014217,NM_001017425	XP_011507825,NP_055032,XP_011507824,XP_016856737,NP_001017424,NP_001017425,XP_011507826,XP_016856738
Dusp5	10516;15212	0.990841	0.754158	0.655498	0.949478	0.947878	MGI:2685	2406722	XM_140740	NP_001078859	3256	HGNC:30	1847	NM_004419	NP_004410

	3;7811;8779						183					71			
C1s1	823;15248;48106;49066	0.0979033	0.0065065	0.0947878	0.0947878	0.0947878	MGI:1355312	5090	XM_011241404|NM_144938|XM_006506365|XM_011241405|NM_001097617	NP_659187|XP_011239707|XP_011239706|NP_001091086|XP_006506428	1314	HGNC:12477	716	NM_201442,NM_001346850,NM_001734	NP_001333779,NP_958850,XP_005253817,NP_001725
Prkca	607;15288;20733;32222	0.9848852	0.0065911	0.0948485	0.0948485	0.0948485	MGI:975595	1875 0	NM_011101	NP_035231	55679	HGNC:9393	5578	NM_002737	XP_016880328,XP_016880329,XP_016880327,XP_016880326,XP_016880330,XP_016880325,NP_002728
Vps4a	584;15353;21633;79200	0.9845523	0.0066400	0.0955255	0.0955255	0.0955144	MGI:1890520	1167333	NM_126165	NP_569053	691322	HGNC:13488	27183	NM_013245	NP_037377
Rps6ka6	1053;15377;	0.9854043	0.0065653	0.0955114	0.0955114	0.0955114	MGI:1914143	6707 1	XM_006528400|XM_006528401|XM_011247706|NM_025949|XM_006528403|XM_011247707|XM_006528402|XM_006528404	XP_006528466|XP_006528467|XP_011246008|XP_006528463|XP_011246009|NP_080225|XP_006528464|XP_006528465	22816	HGNC:10435	27330	NM_014496,NM_001330512	XP_011529222,XP_016884912,XP_016884915,XP_016884914,NP_055311,NP_001317441,XP_016884913,XP_011529221,XP_011529220,XP_011529219

	5352;8227						21								
Trf	2922;15422;55511;71588	0.98200	0.97400	0.06686	0.95530	0.95188	MGI:98821	2204 1	NM_133977	NP_598738	6815 3	HGNC:11740	701 8	NM_001063	XP_016862578, XP_016862579, NP_001054
B4galt1	606;15444;21043;32443	0.98111	0.83688	0.06698	0.95188	0.95188	MGI:95705	1459 5	XM_006537620| XR_001784093| NM_022305	XP_006537683| NP_071641	2037 8	HGNC:924	2683	NM_001497	NP_001488,XP_005251497
Fnta	642;15551;40485;65159	0.97795	0.82525	0.06745	0.95544	0.95256	MGI:1046833	1427 2	NM_008033	NP_032059	1534	HGNC:3782	2339	NM_002027,NM_001018677,NM_001018676	NP_002018
Ppp1r9b	946;15611;56464	0.97345	0.76045	0.06812	0.96119	0.95256	MGI:2387581	2171 24	NM_172261	NP_758465	3278 7	HGNC:9298	8468 7	NM_032595	XP_011523683, NP_115984

	6;8316														
Katna1	115;1562;;5753;;8488	0.0972919	0.0731919	0.0681919	0.0959598	0.0952696	MGI:1344353	2394	XM_006512738|NM_011835	XP_006512801|NP_035965	56014	HGNC:6216	114	NM_007044,NM_001204076	XP_016865698, XP_016865699, XP_016865697, XP_005266861, NP_001191005, XP_016865696, XP_005266862, NP_008975
Igsf3	7625;1563;;3860;;3949	0.0972925	0.0793938	0.0682626	0.0957826	0.0952696	MGI:1926158	7908	XM_006502343|XM_006502342|XM_194109|XM_011240287	NP_997088|XP_006502405|XP_011238589|XP_006502406	11182	HGNC:5950	3321	NM_001542,NM_001007237	XP_011539617, XP_011539618, XP_006710656, XP_005270850, NP_001533,XP_005270851,NP_001007238
Utrn	1470;1564;;5369;;6592	0.0970720335	0.0683358	0.0955826	0.0952696	MGI:1046311	2288	XM_006512717|NM_011682|XM_006512713|XM_006512709|XM_006512715|XM_006512708|XM_006512711|XM_011243167|XM_006512706|XM_011243168|XM_017313925|XM_006512712|XM_006512707|XM_006512710	XP_006512775|XP_006512771|XP_017169414|XP_006512776|NP_035812|XP_006512772|XP_011241469|XP_006512770|XP_011241470|XP_006512773|XP_006512780|XP_006512778|XP_006512769|XP_006512774	21398	HGNC:12635	7402	NM_007124	XP_005267190, XP_011534409, XP_006715623, XP_016866733, NP_009055,XP_011534408,XP_005267187,XP_011534403,XP_016866732,XP_011534404,XP_016866734,XP_005267184,XP_011534411
Mast2	380;1567;;3450	0.0970772	0.0918554	0.0685557	0.0955826	MGI:894676	1776	NM_008641|NM_001042743|XM_006502840|XM_006502835|XM_006502836|XM_006502833|XM_006502839|XM_017320018|XM_006502834	XP_017175507|XP_006502897|XP_006502903|NP_001036208|XP_006502896|XP_006502899|XP_006502898|XP_006502902|NP_032667	74284	HGNC:19035	2319	NM_001324321, NM_015112,NM_001319245,NM_001324320	NP_001306174, XP_016856242, XP_016856241, XP_011539364, XP_005270713, NP_001311249, XP_011539371, XP_016856243, NP_001311250, XP_011539361, XP_011539365, XP_006710540, XP_011539366,

	;3925														XP_011539367, XP_011539370, XP_011539363, XP_016856244, XP_005270712, XP_011539369, NP_055927
Stat5b	1487;1568;;6560;;72225	0.970215	0.0686137	0.953726	0.95226	MGI:1030351	2085	XM_006532723|NM_001113563|NM_011489|XM_017314403	XP_006532786|NP_001107035|XP_017169892|NP_035619	5571	HGNC:11367	677	NM_012448	XP_005257683, XP_016880466, NP_036580
Gnai1	1319;1570;;7561;;95400	0.9693	0.0714	0.068674	0.952626	MGI:957771	1467	NM_010305	NP_034435	74417	HGNC:43844	2770	NM_002069,NM_001256414	NP_002060,NP_001243343
Mxra8	523;1573;;74310;;78500	0.96804	0.0858	0.068966	0.952727	MGI:1922011	7476	XM_011250346|XM_006539235|NM_024263	XP_006539298|XP_011248648|NP_077225	11500	HGNC:75422	5458	NM_001282582, NM_032348,NM_001282584,NM_001282585,NM_001282583	NP_001269511, NP_001269513, XP_016857005, XP_016857006, NP_001269512, NP_001269514, NP_115724
BC031181	1534;1577;;33	0.96624	0.0696924	0.953727	0.95227	MGI:3039614	4078	XM_006526081|XM_006526080|NM_001001181	XP_006526143|XP_006526144|NP_001001181	74274	HGNC:31690	4976	NM_001199346, NM_001035005	NP_001186275, NP_001030177

	76;5122														
Fermt2	4253;1579;2028;4446	0.965333	0.893338	0.693827	0.952727	0.952727	MGI:2385001	21852	XM_006518827|XM_006518826|XM_006518828|NM_146054	XP_006518890|XP_006518891|XP_006518889|NP_666166	4976	HGNC:15767	10979	NM_006832,NM_001134999,NM_001135000	XP_005267342,NP_001128471,NP_006823,XP_006720073,XP_006720072,XP_006720071,NP_001128472
Hmgcr	2825;1585;4060;9269	0.962626	0.971212	0.697953	0.955353	0.955353	MGI:9615959	15357	XM_006517530|XM_127496|XM_006517531	XP_006517594|NP_032281|XP_006517593	30994	HGNC:5006	31556	NM_001130996,NM_000859	XP_011541660,NP_001124468,NP_000850,XP_011541661,XP_011541659
Nmt2	1549;1591;2050;2919	0.960023	0.969023	0.701979	0.958080	0.958080	MGI:1202298	18108	NM_001290370|NM_001290368|NM_001290369|NM_008708	NP_032734|NP_001277299|NP_001277297|NP_001277298	10153	HGNC:7858	93907	NM_001308295,NM_004808	NP_004799,XP_016872436,XP_016872439,XP_016872437,XP_016872442,XP_016872438,XP_006717602,XP_005252699,XP_016872441,NP_001295224,XP_016872440
Traf4	90;1598;2095;	0.956999	0.120355	0.706999	0.961999	0.959998	MGI:1202880	22032	NM_009423|XM_006533156	XP_006533219|NP_033449	31733	HGNC:12034	96118	NM_004295,NM_145751	XP_011523810,XP_011523809,XP_011523808,NP_004286,XP_011523807,XP_011523806

H2-Eb1	24611549;15599;50891;61188	0.954649	0.841976	0.707698	0.959598	0.959598	MGI:9590901	1496 9	NM_010382	NP_034512	10152 4	HGNC:49533	31 27	NM_002125	NP_002116,XP_011512864
Atp5a1	18018;16033;39933;51400	0.954779	1.057105	0.716059	0.960609	0.960609	MGI:8811155	1194 6	NM_007505	NP_031531	2985	HGNC:823	49 8	NM_001001937, NM_001001935, NM_004046,NM_001257334,NM_001257335	NP_001001935, NP_004037,NP_001244264,NP_001244263,XP_016881278,NP_001001937
Pea15a	99161;16147;21066;65322	0.949499	0.744200	0.718813	0.968363	0.968363	MGI:1047999	1861 1	XM_017319302| XM_006496702| NM_001329871| NM_011063|NM_001329869	XP_017174791| NP_035193|NP_001316800|XP_006496765|NP_001316798	7884	HGNC:88222	86 82	NM_003768,NM_001297576,NM_001297578,NM_001297577	NP_001284505, NP_003759,NP_001284507,XP_006711662,NP_001284506
Gria4	12881;16192;5892;60	0.947078	0.970621	0.772159	0.969984	0.969684	MGI:9581111	1480 2	XM_006509845| NM_001113180| XM_006509842| XM_006509844| XR_001778800| XR_001778799| XR_001778798| XM_017313135| XR_379085|XM_011242355|XR_001778797|XR_379084|NM_001113181|NM_019691|XM_006509843|XM_006509841	XP_006509907| NP_001106652| NP_001106651| XP_006509906| XP_017168624| XP_006509904| XP_006509908| XP_006509905| XP_011240657| NP_062665	20227	HGNC:4574	28 93	NM_001077243, NM_001112812, NM_001077244, NM_000829	NP_000820,NP_001070711,XP_011541077,XP_016873099,XP_005271575,XP_016873100,XP_011541079,XP_016873098,XP_011541078,XP_006718886,NP_001070712,NP_001106283

Gadd45a	03550;16299;44400;66799	0.943551	0.83572	0.97284	0.96844	MGI:1077999	131197	NM_007836	NP_031862	1449	HGNC:4095	167	NM_001199741, NM_001199742, NM_001924	NP_001186671, NP_001186670, NP_001915
Atg5	63163;16300;35511;49300	0.941307	0.81092	0.97444	0.96844	MGI:1277186	117193	XM_017313783|NM_001314013|XM_017313782|XM_011243108|NM_053069	NP_001300942|XP_017169271|XP_017169272|NP_444299|XP_011241410	3566	HGNC:589	94 74	NM_001286111, NM_001286108, NM_004849,NM_001286106,NM_001286107	NP_001273037, NP_001273040, NP_001273035, NP_001273036, NP_004840
Bmpr2	9983;16333;23077;83411	0.941769	0.73145	0.97445	0.96844	MGI:1095407	121168	NM_007561|XM_006495633	NP_031587|XP_006495696	929	HGNC:1078	65 9	NM_033346,NM_001204	NP_001195,XP_011509989
Aurka	12;16341;25711;63133	0.941330	0.16232	0.97216	0.96844	MGI:894678	208178	NM_001291185|XM_130737|XM_006499075	NP_035627|XP_006499138|NP_001278114	2670	HGNC:11393	67 90	NM_001323304, NM_003600,NM_001323303,NM_198436,NM_001323305,NM_198437,NM_198433,NM_198434,NM_198435	NP_001310234, NP_001310232, NP_940835,NP_940836,NP_940838,NP_001310233,NP_940837, XP_016883524, NP_003591,NP_940839,XP_016883523
Cd	12	0.	0.	0.	0.	0.	MG	24	XM_140553|XM_017318192|XM	XP_006531807|XP_017173681|	28	HG	55	NM_017525	NP_059995,XP_011543459,XP_

c42bpg	55;16;36;32;08;32;31	9405	7057	7336	9716	9684	I:26528455	05	_017318191|XM_006531744|XM_006531743	XP_006531806|XP_017173680|NP_001028514	384	NC:29829	56		011543462,XP_011543460,XP_011543461,XP_011543457,XP_011543463,XP_016873488,XP_016873485,XP_011543458,XP_016873486,XP_016873487
Vrk3	120;16;42;35;31;58;24	0.9379	0.7099	0.7379	0.9744	0.9684	MGI:2182465	1015	XM_006540538|NM_133945	XP_006540601|NP_598706	9509	HGNC:18996	512;31	NM_016440,NM_001308420,NM_001025778	NP_001020949,XP_006723301,XP_011525325,NP_057524,NP_001295349,XP_005259029,XP_005259028,XP_006723300
Hipk3	1259;16;50;19;97;42;97	0.9345	0.7023	0.7437	0.9792	0.9684	MGI:13148822	1525	NM_001145824|NM_010434	NP_034564|NP_001139296	5592	HGNC:4915	10;14	NM_001278162,NM_001278163,NM_001048200,NM_005734	XP_005252786,NP_001041665,NP_005725,XP_016872566,NP_001265091,NP_001265092,XP_016872565
Cyld	55;16;51;81;52;92;00	0.9341	1.9296	0.7447	0.9772	0.9684	MGI:1921506	74256	XM_006531416|XM_006531414|XM_006531419|XM_006531420|XM_011248524|NM_001276279|NM_001128170|XM_006531417|XM_011248523|NM_001128171|XM_006531415|XM_006531418|NM_173369|XM_011248525|XM_017312989	XP_006531480|XP_006531481|XP_011246827|XP_011246826|XP_006531479|XP_006531477|NP_001121643|NP_775545|XP_006531478|XP_006531482|NP_001121642|XP_011246825|NP_001263208|XP_006531483|XP_017168478	9069	HGNC:2584	154;40	NM_001042355,NM_015247,NM_001042412	XP_016878466,NP_001035877,XP_005255869,XP_016878470,XP_016878469,XP_016878468,NP_001035814,NP_056062,XP_011521213,XP_006721212,XP_011521209,XP_016878467,XP_011521210
Cdk6	126	0.9	0.7	0.7	0.9	0.9	MGI	802	XM_011249319|XM_006534526|NM_030248|XM	NP_084524|XP_011247622|NP_001295112|XP_	127	HGN	802	NM_001278197,NM_025197,NM_176095,NM_00	XP_011523599,NP_788276,XP_016880655,NP_

5rap3	5;1653;4053;5310	3311	0158	4763	7684	:1933126	80	_011249320|NM_001308183	006534589|XP_011247621	18	C:1867	79	1278217,NM_001278216,NM_176096,NM_001278198	001265145,NP_001265146,XP_016880653,NP_001265127,NP_001265126,XP_016880654
N4bp2	13613;1654;2216;3478	0.9693223	0.6974664	0.7974684	0.9684	MGI:2684414	33378	XM_006504005|XM_006504006|XM_017320937|XM_011240752|NM_001024917|XM_006504008|XM_006504007|XM_017320936|XM_006504004|XM_006504003	XP_006504068|NP_001020088|XP_006504067|XP_017176425|XP_006504066|XP_006504070|XP_006504069|XP_017176426|XP_011239054|XP_006504071	323396	HGNC:29851	5572 8	NM_001318359,NM_018177	XP_011512022,NP_060647,XP_016863886,XP_011512019,XP_011512018,XP_011512021,NP_001305288,XP_016863888,XP_011512020,XP_011512023,XP_016863887,XP_006714086
Pak4	9;16583;3083;4234	0.9312	0.1685	0.7497	0.9584	MGI:1917834	70584	XM_017312296|NM_027470|XM_017312297	XP_017167785|NP_081746|XP_017167786	43001	HGNC:16059	1098	NM_001014832,NM_001014835,NM_001014834,NM_001014833,NM_005884,NM_001014831	NP_001014834,NP_001014831,NP_005875,XP_011524622,XP_011524620,XP_011524619,XP_011524618,NP_001014832,NP_001014835,XP_011524621
Rere	40;9;16711;3126;7539	0.9928	0.7585	0.7985	0.9684	MGI:2683486	68703	XM_006539144|NM_001085492|XM_006539143|XM_006539145|XM_006539141|XM_006539142|XM_006539137|XM_006539136|XM_006539138|XM_006539140|XM_006539147|XM_006539139	XP_006539204|XP_006539205|XP_006539201|XP_006539199|XP_006539202|XP_006539210|NP_001078961|XP_006539208|XP_006539203|XP_006539206|XP_006539200|XP_006539207	8101	HGNC:9965	473	NM_001042682,NM_001042681,NM_012102	XP_005263521,XP_016856847,XP_016856848,XP_011539812,XP_011539813,XP_005263523,NP_036234,NP_001036146,NP_001036147
Tspan9	64;1916	0.9254	0.7992	0.7599	0.9384	MGI:19146	10924	NM_175414|XM_006505330|XM_017321311|XM_006505333|XM_017321312|XM	XP_017176800|XP_006505398|XP_006505395|XP_006505396|XP_006505393|	4860	HGNC:2	1086 7	NM_006675,NM_001168320	NP_001161792,XP_011519214,XP_011519215,NP_006666

	72;3482;;42122						245581	_006505335|XM_006505332	XP_017176801|NP_780623		1640				
Dyrk2	604;16773;;24500;;77444	0.920503	0.807607	0.798153	0.796844	MGI:1330301	691811	XM_006514046|XM_011243552|NM_001014390	XP_011241854|NP_001014412|XP_006514109	484437	HGNC:30933	8445	NM_003583,NM_006482	XP_016875521,NP_003574,NP_006473	
Golga7	6491;16778;;21544;;47588	0.922958	0.792583	0.764333	0.798384	MGI:1931029	574337	XM_006509179|NM_020585|NM_001042484	NP_001035949|XP_006509242|NP_065610	93851	HGNC:24876	5112 5	NM_001002296,NM_001174124,NM_016099	NP_001002296,NP_001167595,NP_057183	
Ralet1e	1212;16800;;29211;;33955	0.922011	0.770598	0.798258	0.796844	MGI:2675273	379043	XM_006512780|XM_011243178|XM_006512779|XM_006512777|XM_011243179|XM_006512782|NM_198193	XP_006512842|XP_006512840|XP_011241481|XP_006512843|NP_937836|XP_006512845|XP_011241480	#N/A	#N/A	#N/A	#N/A	#N/A	
Limk2	364;16811	0.992107	0.797606	0.798054	0.796844	MGI:117971	16886	XM_006514548|XM_006514552|XM_006514550|NM_010718|NM_001034030|XM_006514547|NM_173053|XM_011243666	XP_006514611|NP_774958|NP_034848|XP_006514615|XP_011241968|NP_001029202|XP_006514610|XP_006514613	55911	HGNC:66	3985	NM_005569,NM_016733,NM_001031801	NP_005560,NP_057952,NP_001026971	

	;3873;;59544						517				14			
Ugt1a1	1569;16887;;52077;;70324	0.9192	0.6707	0.7710	0.9834	0.9684	MGI:3988988	394436	NM_201645	NP_964007	12803 4	#N/A	5465 8	NM_000463	NP_000454
Arhgap1	828;1688;;2165;;24344	0.9188	0.7536	0.7717	0.9815	0.9684	MGI:2445003	228359	XM_006499251|XM_006499244|XM_011239457|XM_006499246|XM_006499249|XM_006499247|XM_006499250|NR_027371|NR_027373|NM_146124|XM_006499245|XM_006499248|NM_001145902|NR_027372	XP_011237759|NP_666236|XP_006499313|NP_001139374|XP_006499309|XP_006499314|XP_006499311|XP_006499308|XP_006499307|XP_006499312|XP_006499310	20909	HGNC:6733	3932	NM_004308	NP_004299,XP_011518397,XP_016873209
Ubash3b	384;1694;;64111;;86188	0.9163	0.8880	0.7761	0.9843	0.9684	MGI:1920078	72828	XM_006510634|NM_176860|XM_017313612|XM_006510636|XM_006510637|XM_006510632	XP_006510700|NP_789830|XP_006510697|XP_006510695|XP_006510699|XP_017169101	13152	HGNC:29884	8495 9	NM_032873	XP_011541344,XP_005271769,XP_011541343,NP_116262
Rap2c	521;1695;;3	0.9159	0.8310	0.7768	0.9825	0.9684	MGI:1919193	72065	XM_006541546|NM_172413|XM_006541545	NP_766001|XP_006541609|XP_006541608	99848	HGNC:21165	5782 6	NM_001271186,NM_001271187,NM_021183	XP_006724838,NP_001258116,XP_011529678,NP_067006,NP_001258115

	995;5197					15									
Trp53rk	1164;16977;20072;28622	0.915151	0.702525	0.778383	0.981636	0.968384	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Epha1	667;17000;43354;45466	0.913939	0.786866	0.780505	0.981787	0.968384	MGI:1073881	1383 5	XM_011241203|NM_023580	XP_011239505|NP_076069	3835	HGNC:33855	2041	NM_005232	XP_006715943,NP_005223
Zdhhc5	385;17011;49222;57493	0.913515	0.886113	0.781379	0.979784	0.968384	MGI:1923573	2281 36	NM_144887	NP_659136	9147	HGNC:18472	2592 1	NM_015457	XP_016872987,XP_011543201,XP_011543202,NP_056272,XP_011543203
Snrk	971;17042;2100	0.912312	0.726233	0.783397	0.979784	0.968384	MGI:1081044	2062 3	XM_006511998|XM_006512002|XM_006512003|NM_133741|XM_006511999|NM_001164572|XM_006512000	NP_001158044|XP_006512063|XP_006512066|NP_598502|XP_006512062|XP_006512061|XP_006512065	9797	HGNC:30598	5486 1	NM_017719,NM_001330750,NM_001100594	XP_005265302,NP_060189,NP_001317679,XP_011532163,NP_001094064

	0;5405													
Slmap	12081;17055;62688;6567	0.091961	0.069610	0.078409	0.097794	0.096844	MGI:1933549	837	XM_017316227|XM_006519735|XM_006519729|XM_017316229|XM_006519738|XM_006519733|XM_017316228|XM_006519726|XM_006519731|XM_006519734|XM_006519728|NM_001310445|XM_006519732|XM_006519730|NM_001347494|XM_006519725|XM_006519737|NM_032008|XM_006519736|XM_006519727	XP_006519793|XP_006519790|XP_006519792|XP_006519797|XP_006519796|XP_006519798|NP_114397|XP_006519801|XP_017171718|XP_006519789|XP_006519791|XP_006519794|XP_006519788|NP_001297374|XP_006519800|XP_017171716|NP_001334423|XP_017171717|XP_006519795|XP_006519799	314	HGNC:16643	781	NM_007159,NM_001311178,NM_001304421,NM_001311179,NM_001304422,NM_001304423,NM_001304420	XP_016862658,NP_001291351,XP_016862635,XP_016862648,XP_016862645,XP_016862647,XP_005265516,XP_016862655,XP_016862657,XP_016862659,XP_016862652,XP_005265514,XP_016862649,XP_016862640,XP_011532405,XP_005265528,XP_011532408,XP_005265525,NP_001298108,NP_009090,XP_005265518,XP_016862654,XP_005265522,XP_011532406,XP_016862653,XP_016862641,XP_005265527,XP_016862656,XP_016862646,XP_016862644,XP_005265524,XP_016862650,XP_006713389,XP_005265519,NP_001298107,XP_016862637,XP_016862651,XP_005265529,XP_005265515,XP_016862642,XP_005265517,NP_001291350,XP_005265521,XP_016862638,XP_011532407,XP_005265513,XP_016862643,NP_001291349,NP_001291352,XP_016862636,XP_016862639,XP_005265523
Ddx58	11453;17093;35025;59	0.910303	0.702202	0.787070	0.978989	0.968484	MGI:2442858	23007 3	NM_172689	NP_766277	32215	HGNC:19102	23586	NM_014314	NP_055129

Spr1	46165717;17122;22234;;65522	0.9066078944	0.6097925	0.0.9684	MGI:1096355	136	NM_007901	NP_031927	1071	HGNC:31655	19	NM_001320730, NM_001400	NP_001307659, NP_001391		
Slc7a7	11871718;35613;56399	0.9067	0.6957	0.7939	0.9820	0.9684	MGI:1337120	205	XM_006518746| XM_006518754| XM_011245000| XM_006518748| XM_006518752| XM_006518751| XM_006518755| XM_006518753| NM_001253680| NM_001253679| NM_011405	XP_006518809| XP_011243302| XP_006518815| XP_006518814| XP_006518811| XP_006518816| NP_001240609| NP_001240608| XP_006518817| NP_035535|XP_006518818	8871	HGNC:11065	90 56	NM_001126106, NM_003982,NM_001126105	XP_011535600, NP_001119577, XP_006720365, NP_001119578, XP_011535601	
Tspan6	13781;17199;67555;;71887	0.9067	0.6763	0.7945	0.9801	0.9684	MGI:1926264	5649	XM_017318578| NM_019656	NP_062630|XP_017174067	20700	HGNC:11858	71 05	NM_003270,NM_001278741,NM_001278740,NM_001278743,NM_001278742	NP_001265671, NP_003261,XP_011529320,NP_001265670,NP_001265669,NP_001265672		
Trib1	778;17203;90433;;96	0.9057	0.7595	0.7978	0.9684	MGI:2443397	2117	NM_144549	NP_653132	75216	HGNC:16891	10 221	NM_001282985, NM_025195	NP_079471,NP_001269914	

	03														
Prkar2b	11402;17222;23733;;95577	0.970051	0.007066	0.079733	0.096844	MGI:9776760	1908	XM_126885|XM_006515014	XP_006515077|NP_035288	376	HGNC:9392	557	NM_002736	XP_011514700, NP_002727	
Cbl	11152;17282;25892;;75888	0.902707	0.702011	0.980100	0.968400	MGI:882792	1240	XM_006509963|NM_007619|XM_017313115	XP_017168604|XP_006510026|NP_031645	3802	HGNC:1541	867	NM_005188	NP_005179,XP_016874000,XP_011541359	
Nrg1	58017;17299;45344;76166	0.902351	0.008018	0.078383	0.096844	MGI:960883	211323	XM_006509060|XM_011242133|XM_017312639|XM_006509080|XM_017312641|XM_017312638|XM_017312636|XM_006509062|XM_006509067|XM_006509072|NM_178591|XM_006509076|XM_006509078|XM_017312637|XM_006509081|XM_006509061|XM_006509059|XM_017312640|XM_006509065|XM_006509064|XM_006509069|XM_006509068|XM_006509063|XM_006509077|XM_006509066	XP_006509131|XP_006509141|XP_017168126|XP_006509139|XP_006509143|XP_006509130|XP_006509125|XP_006509140|XP_006509129|XP_006509123|XP_006509144|XP_006509122|XP_017168129|XP_006509135|XP_017168127|XP_017168125|NP_848706|XP_006509127|XP_011240435|XP_006509124|XP_006509128|XP_017168128|XP_017168130|XP_006509132|XP_006509126	13845	##N/A	##N/A	#N/A	#N/A	
Optn	14517;17302;	0.961907	0.068025	0.097655	0.096844	MGI:1918188	7164	XM_006497546|XM_006497547|XM_011238987|NM_181848|XM_006497548|XM_011238988	XP_006497611|NP_862896|XP_011237289|XP_006497610|XP_006497609|XP_011237290	1108	HGNC:17142	1013	NM_001008212, NM_001008211, NM_001008213, NM_021980	NP_001008214, NP_001008213, NP_001008212, NP_068815	

	4373;7123					98									
Sico3a1	169;1733;7001;8198	0.9007	1.0438	0.8048	0.9766	0.9684	MGI:1351867	1081161	NM_001038643|NM_023908	NP_076397|NP_001033732	40862	HGNC:10952	2823232	NM_013272,NM_001145044	XP_011519758,NP_001138516,NP_037404,XP_005254948,XP_005254946
Stom	264;1735;45900;93388	0.89930	0.95300	0.80622	0.97556	0.96844	MGI:9540303	1383830	NM_013515	NP_038543	81681	HGNC:33883	20402	NM_004099,NM_001270526,NM_001270527,NM_198194	NP_001257455,NP_937837,NP_004090,NP_001257456
Cyr61	1292;1743;29311;64444	0.89683	0.68032	0.81222	0.98023	0.96844	MGI:8861307	1600707	NM_010516	NP_034646	11944	HGNC:26544	34911	NM_001554	NP_001545
Hk1	551;1744;22	0.89164	0.81132	0.81306	0.97886	0.96844	MGI:9610303	1527575	NM_001146100|XM_006513247|XM_006513242|XM_006513246|XM_006513245|XM_006513244|NM_010438|XM_006513243	XP_006513309|XP_006513307|NP_034568|XP_006513308|XP_006513305|XP_006513306|NP_001139572|XP_006513310	10530	HGNC:49222	30988	NM_000188,NM_033496,NM_033497,NM_001322365,NM_001322364,NM_001322367,NM_001322366,NM_033498,NM_033500	NP_001309295,XP_005269794,NP_000179,NP_001309296,NP_277031,NP_277033,NP_277032,XP_011538034,NP_001309294,NP_001309293,NP_277035

	31;2440														
Wnt5a	821;1746;3067;5624	0.895634	0.743445	0.814578	0.978478	0.968484	MGI:1989588	2241	XM_006518924|XM_006518923|XM_006518925|XM_006518926|NM_001256224|NM_009524	XP_006518987|XP_006518989|NP_001243153|XP_006518988|XP_006518986|NP_033550	2072	HGNC:12784	747	NM_001256105, NM_003392	XP_016862616, XP_011532389, XP_011532387, XP_006713387, XP_011532391, XP_011532390, NP_001243034, XP_011532388, NP_003383,XP_016862617
Tsg101	1460;1748;4065;97699	0.894857	0.661657	0.816070	0.978470	0.968484	MGI:1065811	2208	XM_006540790|NM_021884|XM_006540789|XM_006540788|NM_001348088|NM_001348089|XR_391333	XP_006540853|XP_006540851|XP_006540852|NP_001335017|NP_001335018|NP_068684	4584	HGNC:15971	7251	NM_006292	NP_006283,XP_005253165
Pik3c2a	1332;1749;2157;6908	0.894556	0.675668	0.816854	0.975484	0.968484	MGI:1203729	1870	XM_006507440|XM_006507441|NM_011083	XP_006507504|NP_035213|XP_006507503	2058	HGNC:8971	5286	NM_002645,NM_001321380,NM_001321378	NP_001308309, NP_001308307, NP_002636,XP_016873413,XP_011518488
Actr6	997;1752;8799	0.893338	0.712828	0.819155	0.975584	0.968484	MGI:1914269	6701	XM_006513967|XM_017314062|XM_017314063|XM_006513965|XM_006513966|NM_025914|XM_011243532	XP_006514030|NP_080190|XP_006514028|XP_006514029|XP_017169552|XP_011241834|XP_017169551	6451	HGNC:24025	6443	NM_022496	NP_071941,XP_016875310

	2;9725													
Lgr4	518;1753;5267;;76155	0.8929	0.8206	0.8199	0.9739	0.9684	MGI:1891468	107515	XM_355385	NP_766259	10226	HGNC:13299	5536	NM_001346432, NM_018490	NP_060960,NP_001333361
Psme2	1311;1760;6754;;760404	0.8902	0.6753	0.8255	0.9779	0.9684	MGI:1096365	1918	XR_383146|XR_383145|NM_011190|NM_001029855	NP_001025026|NP_035320	86889	HGNC:9569	5721	NM_002818	XP_006720276, NP_002809
Tenm3	926;1761;4978;;8688	0.8898	0.7219	0.8216	0.9762	0.9684	MGI:1345183	2395	XM_011242216|XM_017312779|XM_006509408|XM_017312782|XM_006509405|XM_017312776|XM_006509406|XM_017312775|XM_006509409|XM_017312781|XM_017312778|NM_011857|XM_017312774|XM_006509407|NM_001145937|XM_017312780|XM_011242218|XM_006509404|XM_011242217|XM_017312772	XP_006509470|XP_006509471|XP_017168264|XP_006509468|XP_006509467|XP_017168261|XP_017168263|XP_011240519|XP_006509469|XP_017168267|NP_035987|XP_006509472|XP_017168270|XP_011240520|NP_001139409|XP_011240518|XP_017168265|XP_017168269|XP_017168268|XP_017168271	22673	HGNC:29944	5571	NM_001080477	XP_016863880, NP_001073946, XP_016863879, XP_016863874, XP_016863883, XP_016863878, XP_016863882, XP_016863885, XP_016863877, XP_016863876, XP_016863881, XP_016863875, XP_016863884
Hsp90aa1	1049;1763;;26	0.8890	0.7035	0.8276	0.9753	0.9684	MGI:9625250	1551	NM_010480	NP_034610	68464	HGNC:5253	3320	NM_001017963, NM_005348	NP_005339,NP_001017963,XP_011535020

	97;5370														
Itga6	16188;17644;15331;79811	0.8886	0.6526	0.8283	0.9736	0.9684	MGI:96605	1640 3	XM_017315707|XM_011239309|NM_001277970|NM_008397|XM_011239308	NP_001264899|XP_011237610|XP_017171196|NP_032423|XP_011237611	2091	HGNC:6142	3655	NM_001079818,NM_000210,NM_001316306	XP_016859496,XP_006712573,XP_016859494,NP_001303235,XP_016859495,XP_006712574,NP_001073286,NP_000201,XP_016859497
Tmem206	13003;17655;37555;54336	0.8883	0.6753	0.8291	0.9719	0.9684	MGI:1914200	6695 0	NM_025864	NP_080140	10097	HGNC:25593	5524 8	NM_001198862,NM_018252	NP_060722,XP_011508020,XP_011508019,XP_016857123,XP_005273234,XP_016857126,XP_016857125,NP_001185791,XP_016857124
Ptprj	10133;17688;25266;41733	0.8871	0.7075	0.8315	0.9722	0.9684	MGI:1045744	1927 1	NM_008982|XM_006498994|NM_001135657|XM_006498992|XM_006498991|XM_006498993	XP_006499056|XP_006499057|XP_006499054|NP_001129129|NP_033008|XP_006499055	2130	HGNC:9673	5795	NM_002843,NM_001098503	XP_016873572,XP_016873574,NP_002834,NP_001091973,XP_016873573
Dbnl	13143;17692;;	0.8867	0.6733	0.8322	0.9706	0.9684	MGI:7000006	1316 9	NM_001146309|NM_013810|NM_001146308	NP_001139780|NP_001139781|NP_038838	8468	HGNC:26996	2898 8	NM_014063,NM_001284315,NM_001284313,NM_001014436,NM_001122956	XP_011513627,NP_001116428,NP_054782,NP_001014436,NP_001271244,NP_001271242

	144;4397														
Def6	1684;1772;5067;9314	0.8856	0.6476	0.8344	0.9706	0.9684	MGI:1346328	2385 3	NM_027185	NP_081461	1103	HGNC:27600	50619	NM_022047	NP_071330
Ibtk	5414;1775;3046;;37665	0.8844	0.8085	0.8368	0.9684	0.9684	MGI:1918677	1088 37	XM_006510766| NM_001081282| XM_006510765	XP_006510829| XP_006510828| NP_001074751	34661	HGNC:178533	2599 8	NM_015525,NM_001300906	NP_056340,NP_001287835,XP_006715516,XP_006715517
Chrna1	1217;1780;;37233;74200	0.8825	0.6805	0.8405	0.9702	0.9692	MGI:878885	1143 5	NM_007389	NP_031415	59	HGNC:19555	1134	NM_001039523, NM_000079	XP_016858746, NP_001034612, XP_016858745, NP_000070
Mif	1243;1786;;8	0.8802	0.6767	0.8452	0.9731	0.9692	MGI:969982	1731 9	NM_010798	NP_034928	556555	HGNC:70977	4282	NM_002415	NP_002406

	324;879													
Tor1a	914;1787;2016;64	0.8799	0.1060	0.8460	0.9715	0.9692	MGI:1353568	3093 1	NM_144884	NP_659133	3726 3	HGNC:30 98	1861	NM_000113	NP_000104
Raf1	637;1788;2789;7521	0.8779	0.7736	0.8469	0.9699	0.9692	MGI:9784 47	1101 57	XM_006505363|NM_029780|XM_006505365|XM_006505364	XP_006505428|NP_084056|XP_006505427|XP_006505426	4814 5	HGNC:98 29	5894	NM_002880	XP_005265415, XP_011532276, XP_005265412, XP_005265414, NP_002871,XP_016862455,XP_005265416,XP_011532277
Ehmt1	1275;1790;2264;4900	0.8787	0.6729	0.8483	0.9692	0.9692	MGI:1924 933	7768 3	XM_017319336|XM_006498423|XM_006498432|XM_006498422|XM_017319335|XM_006498425|XM_006498429|XR_374136|XM_006498427|XM_006498426|XM_006498431|NM_001012518|XM_006498424|NM_172545|NM_001109687|XM_006498430|NM_001109686	XP_006498492|XP_006498495|XP_006498493|XP_006498488|XP_006498489|XP_017174824|XP_006498487|NP_001012536|NP_766133|NP_001103156|XP_017174825|NP_001103157|XP_006498486|XP_006498485|XP_006498494|XP_006498490	1169 8	HGNC:24 650	7981 3	NM_001145527, NM_024757	XP_011517325, XP_016870625, XP_011517324, XP_005266167, XP_016870624, XP_011517328, XP_011517331, XP_011517330, XP_011517326, XP_011517329, XP_006717351, NP_001138999, XP_005266162, NP_079033,XP_016870623,XP_011517335,XP_016870626,XP_016870627,XP_011517323,XP_011517333,XP_011517332,XP_011517327
Mvp	547;1794;	0.8772	0.8029	0.8516	0.9705	0.9705	MGI:1925 66	7838 8	NM_080638|XM_011241952	XP_011240254|NP_542369	3752	HGNC:75 31 1	9961	NM_001293204, NM_001293205, NM_005115,NM_017458	NP_059447,NP_005106,NP_001280134,NP_001280133

	6627;8400						38								
Dab2	1257;1801;8223;9106	0.874625	0.672569	0.856941	0.974137	0.973737	MGI:1091775	131132	NM_001037905|NM_001310446|NM_023118|NM_001008702|XM_017316424|XM_011245324|NM_001102400	NP_001032994|NP_001008702|XP_011243626|NP_001297375|NP_001095870|XP_017171913|NP_075607	1026	HGNC:26622	1601	NM_001244871, NM_001343	NP_001231800, NP_001334
Snx18	1600;1806;2514;7558	0.872727	0.645757	0.860961	0.976161	0.973737	MGI:2137642	170625	NM_130796	NP_570614	14164	HGNC:19245	11257 4	NM_001102575, NM_052870,NM_001145427	XP_016864486, NP_001138899, NP_443102,NP_001096045
Mtdh	625;1813;2256;8125	0.877019	0.877559	0.866505	0.980037	0.973737	MGI:1914404	671154	XM_017316728|XM_017316730|XM_006520149|XM_017316731|XM_017316729|NM_026002|XM_006520152|XM_006520150|XM_006520153|XM_006520148|XM_006520151	XP_006520216|XP_006520211|XP_017172219|XP_006520214|XP_017172220|XP_006520215|XP_017172217|XP_006520212|NP_080278|XP_017172218|XP_006520213	12089	HGNC:29608	9214 0	NM_178812	XP_016869456, XP_011515669, XP_005251156, XP_016869457, XP_011515670, NP_848927,XP_011515672,XP_011515671,XP_016869455
Sgcb	7193;1818;5	0.868383	0.751252	0.870318	0.981838	0.973737	MGI:1346465	240511	NM_011890	NP_036020	195	HGNC:10806	6443	NM_000232	NP_000223

	418;7584						23								
Pik2a	597;1819;8543;9498	0.8679	0.7828	0.8712	0.9804	0.9737	MGI:1934031	8409 5	XR_877696|XM_011247405|XM_011247406|NM_145501	XP_011245707|XP_011245708|NP_663476	10168 1	HGNC:30031	5536 1	NM_018425	NP_060895
Slc44a2	960;1823;4228;7863	0.8664	0.8704	0.8743	0.9814	0.9737	MGI:1915932	6682	XM_011242593|XM_006510575|XM_006510576|NM_001199186|NM_152808	XP_006510639|NP_690021|XP_011240895|XP_006510638|NP_001186115	10711 1	HGNC:17292	5715 3	NM_001145056, NM_020428	XP_005260056, NP_001138528, NP_065161,XP_005260054
Sfi1	18;1826;3914;9249	0.8653	1.5024	0.8767	0.9817	0.9737	MGI:1926137	7888 7	XM_006514900|XM_006514894|XM_017314846|XM_011243798|XM_011243794|XM_006514899|XR_001780076|XR_380988|XM_006514904|XM_017314842|XM_011243792|XM_006514897|XM_017314843|XM_006514908|XM_017314847|XM_017314841|XR_872210|XR_380989|XM_006514903|XM_006514902|XM_011243797|XM_011243795|XM_006514901|XM_006514898|XR_001780077|XR_380990|XM_017314844|XM_006514896|NM_030207|XM_017314845|XR_001780078	XP_017170332|XP_006514971|XP_006514966|NP_084483|XP_017170334|XP_017170333|XP_011242097|XP_006514960|XP_006514965|XP_017170336|XP_006514962|XP_006514967|XP_017170331|XP_006514961|XP_006514964|XP_011242099|XP_006514963|XP_011242094|XP_006514959|XP_017170335|XP_017170330|XP_011242096|XP_011242100|XP_006514957	12707 1	HGNC:2906 4	981 4	NM_001258327, NM_014775,NM_001258325,NM_001007467,NM_001258326	XP_016884647, XP_011528881, XP_016884649, XP_011528883, XP_016884629, XP_016884636, XP_016884645, XP_016884650, XP_016884633, XP_011528889, XP_011528873, XP_016884639, XP_016884630, XP_011528882, XP_016884642, XP_016884637, NP_001245256, XP_016884632, XP_011528885, XP_011528884, XP_016884631, XP_011528872, XP_016884635, XP_016884644, NP_055590,XP_011528879,NP_001245254,XP_016884646,XP_005261925,XP_011528876,XP_016884641,XP_

														016884648,NP_001007468,XP_016884634,XP_011528878,XP_016884640,XP_016884643,XP_006724453,XP_016884628,XP_016884651,XP_016884638,XP_011528877,NP_001245255
Cacul1	118;11829;21833;39600	0.864202	0.1002	0.887911	0.98199	0.97377	MGI:1926082	7883	XM_006527468|NM_001172097|NM_001172096|XM_129335	NP_084473|NP_001165568|XP_006527531|NP_001165567	17821	HGNC:23727	1433844	NM_153810 NP_722517
Setdb1	106;11831;33055;51665	0.863523	0.112308	0.880813	0.97377	MGI:1934229	8450	5	NM_001163642|NM_018877|NM_001163641	NP_061365|NP_001157114|NP_001157113	32157	HGNC:10761	9869	NM_001145415, NM_001243491, NM_012432 NP_036564,XP_016858442,NP_001230420,NP_001138887,XP_016858444,XP_016858443,XP_005245698
Slpr2	938;11836;43011;51166	0.861616	0.070559	0.884646	0.98317	0.97377	MGI:1955669	1473	9	XM_006510019|NM_010333	NP_034463|XP_006510082	3118	HGNC:31669	92944	NM_004230 NP_004221
Chchd3	1225;11838	0.860909	0.66889	0.886282	0.98255	0.97377	MGI:1913133	6607	5	XM_006506467|XM_006506468|NM_025336	XP_006506531|XP_006506530|NP_079612	9851	HGNC:21919	54927	NM_001317178, NM_001317177, NM_017812 NP_001304107, NP_001304106, NP_060282

	;28311;;98033						25				06				
Hsd17b7	11;15067;18396;;56562;;93722	0.8606768	0.8887097	0.9880937	0.9737	MGI:1330808	154910	XM_011238758|XM_006496667|NM_010476|XM_017317108	XP_017172597|XP_011237060|XP_006496730|NP_034606	407278	HGNC:52155	514578	NM_016371,NM_001304513,NM_001304512	NP_001291442,NP_057455,NP_001291441
Pank1	391;18422;;40499;;65988	0.8595611	0.8894117	0.9737	MGI:1922985	757735	XM_006527427|NM_001114339|NM_023792	NP_076281|NP_001107811|XP_006527490	569779	HGNC:85988	533544	NM_148978,NM_148977,NM_138316	XP_016871826,NP_683878,XP_016871823,XP_016871825,XP_016871827,XP_016871824,NP_612189,XP_016871822,NP_683879
Dnm2	855;18433;;33000;;81006	0.8591881	0.8901796	0.9737	MGI:1095477	134430	XM_006509984|XM_006509982|XM_006509975|XM_017313125|XM_006509981|NM_001253893|NM_001253894|XR_001778793|XM_006509973|XM_006509980|NM_001039520|XM_006509983|XM_006509979|NM_007871|XM_006509977|XM_017313127|XM_017313129|XM_017313126|XM_006509976|XM_006509978|XM_017313128|XM_006509974|XM_006509985	XP_017168615|XP_006510044|XP_006510039|XP_006510037|XP_017168617|XP_006510043|XP_006510047|XP_006510042|NP_001240823|XP_017168614|XP_017168618|NP_001034609|XP_006510036|XP_006510040|XP_017168616|NP_001240822|XP_006510045|XP_006510046|XP_006510041|XP_006510048|NP_031897|XP_006510038	908383	HGNC:29744	178545	NM_001190716,NM_004945,NM_001005360,NM_001005362,NM_001005361	NP_001005360,NP_001177645,NP_001005361,NP_004936,NP_001005362
P2rx4	262;1	0.8593	0.8897	0.9737	MGI:1	184438	NM_011026|NM_001310718|NM_001310720|XM_006530196	NP_001297649|XP_006530259|NP_035156|NP_001297647	192323	HGNC:	502545	NM_175567,NM_001261397,NM_175568,NM_001261398,NM_001	XP_011536718,NP_001248326,NP_001248327,NP_002551,NP_001243725

	845;3708;9160	844	37	19	91	37	33885 9					8535	1256796,NM_002560		
Capns1	1502;1848;20255;45399	0.85736	0.64040	0.89456	0.97937	0.97337	MGI:8826636	1236	NM_009795|XM_011250419|XM_011250420|XM_006539488	XP_011248721|XP_011248722|XP_006539551|NP_033925	1327	HGNC:14811	826	NM_001302633, NM_001302632, NM_001749,NM_001003962	XP_005259352, XP_011525661, NP_001289562, XP_005259353, NP_001003962, NP_001740,NP_001289561
Camk2n1	7585;18499;58211;95555	0.85569	0.73668	0.89531	0.97811	0.97337	MGI:1913509	66259	NM_025451	NP_079727	10238	HGNC:24190	55450	NM_018584	NP_061054
Atg13	562;18511;51963;76277	0.85622	0.78766	0.89770	0.97745	0.97337	MGI:1196429	5189 7	XM_006499887|NM_145528|XM_006499889|XM_006499892|XM_006499891|XM_017319122|XM_006499890|XM_006499888	XP_017174611|XP_006499950|XP_006499951|XP_006499952|XP_006499955|NP_663503|XP_006499954|XP_006499953	32292	HGNC:29091	9776	NM_001346322, NM_001346318, NM_001346353, NM_001346354, NM_001346333, NM_001346342, NM_001346314, NM_001346329, NM_001346320, NM_001346359, NM_001346325, NM_001205121, NM_001346352, NM_001205119, NM_001205122, NM_001346332, NM_001346357, NM_001346330, NM_001346326, NM_001205120, NM_001346337, NM_001346344, NM_001346338, NM_001346335, NM_001346315,	NP_001333245, NP_001333264, NP_001346353, XP_011518795, NP_001333255, XP_005253323, NP_001333249, NP_001333257, XP_016874111, NP_001333265, NP_001136145, NP_001333288, NP_001333278, NP_001333263, XP_016874091, XP_016874089, XP_005253320, NP_001333273, NP_001333241, NP_001333244, NP_001333250, XP_016874096, NP_001333240, XP_016874090, NP_001333285, NP_001333269,

														NM_001346324, NM_001346327, NM_001142673, NM_001346311, NM_001346312, NM_001346358, NM_001346350, NM_014741,NM_001346340,NM_001346317,NM_001346346,NM_001346356,NM_001346360,NM_001346349,NM_001346328,NM_001346348,NM_001346313,NM_001346351,NM_001346321,NM_001346319,NM_001346323,NM_001346334,NM_001346316,NM_001346336,NM_001346331,NM_001346355	XP_016874108, XP_016874093, NP_001192051, XP_011518802, NP_001333247, NP_001333260, XP_011518801, NP_001333275, NP_001333266, XP_016874107, NP_001333262, XP_016874100, XP_016874103, XP_016874099, NP_001333243, NP_001333279, NP_001333289, XP_016874105, XP_016874094, NP_001333253, XP_016874110, NP_001333256, NP_001333271, XP_016874101, XP_011518804, XP_016874109, NP_001333259, NP_001192049, XP_016874104, NP_001192048, NP_001333261, NP_001333242, NP_001333252, NP_001333267, XP_016874097, NP_001333251, NP_001333258, XP_016874088, NP_001333248, NP_001333286, XP_016874106, XP_006718458, XP_005253325, XP_011518803, NP_001333277, XP_006718459, NP_001333283, NP_001333281, XP_005253322, XP_005253319, NP_001192050, NP_001333282, XP_011518798, NP_001333254, NP_001333287, XP_006718457, NP_001333280, XP_016874092, NP_001333246, XP_016874098, NP_055556,XP_016874102,XP_011518805,XP_016874095,NP_001333284
Clasp2	6 4 ; 1 8 5 5 ; 6	0 8 5 5 4 8	0 7 7 0 8	0 9 0 1	0 9 5	0 7	MGI:1923707	6 4 9	NM_001286600| XM_017313689| XM_017313687| XM_006512386| XM_017313684| XM_006512389| XM_006512384| XM_017313691| NM_001286601| XM_006512397|	XP_017169177| NP_001273529| XP_017169173| XP_006512454| XP_006512459| XP_006512453| NP_001273528| XP_017169174| XP_006512460| XP_017169176|	2 4 9 4 4	H G N C :	2 3 1 2 1 7 0 7 8	NM_001207044, NM_015097	XP_016861473, XP_006713115, XP_016861469, XP_006713111, XP_016861471, XP_006713105, XP_016861451, XP_016861466, XP_016861457, XP_016861446,

	854;7162						49	NM_001081960|XM_006512387|XM_006512388|XM_017313685|XM_006512394|XM_006512395|NM_029633|XM_006512393|NM_001286603|XM_006512385|NM_001114347|XM_017313688|NM_001286602|NM_001286599|XR_379881|XM_006512392|XM_006512390|XM_006512396|XM_017313690|XM_006512391|XM_017313686	XP_006512456|XP_017169175|XP_017169178|XP_006512451|XP_006512452|NP_083909|XP_017169180|NP_001075429|XP_006512447|XP_006512450|NP_001273532|NP_001107819|XP_006512455|XP_006512449|XP_017169179|XP_006512457|NP_001273531|XP_006512448|NP_001273530|XP_006512458				XP_016861436, NP_001193973, XP_016861437, XP_016861475, XP_016861440, XP_016861458, XP_016861443, XP_016861474, XP_016861460, XP_016861462, XP_016861448, XP_016861463, XP_016861449, XP_006713104, XP_006713116, XP_016861441, XP_006713113, XP_016861439, XP_016861450, XP_016861461, XP_016861464, XP_016861470, XP_016861454, XP_016861445, XP_016861452, XP_011531817, XP_006713103, XP_016861465, XP_016861468, XP_016861472, XP_006713112, XP_016861444, XP_016861447, XP_016861459, XP_016861442, XP_016861438, XP_016861456, XP_016861455, XP_016861467, NP_055912,XP_016861453
Litaf	951;1858;4517;7005	0.8537	0.6999	0.9024	0.9787	0.9737	MGI:1929512	5672	NM_019980|XM_006522427	XP_006522490|NP_064364	3797	HGNC:16841	9516	NM_001136472, NM_004862,NM_001136473	XP_006721046, XP_006721045, XP_006721048, XP_016879385, NP_004853,XP_011521056,NP_001129944,XP_006721047,NP_001129945
Arhgef39	59;18600;46599;76	0.8530	1.2411	0.9041	0.9781	0.9737	MGI:3036286	2309 8	XM_011249998|XM_006537830|XM_131404|XM_011249997	XP_006537893|NP_001013395|XP_011248299|XP_011248300	1922 5	HGNC:25909	8490 4	NM_032818	XP_016870716, NP_116207,XP_016870714,XP_016870715,XP_011516359,XP_016870717

Nfkbid	35721863;27222;31900	0.87406597843737	MGI:3041243	2439 10	XM_011250573|XM_006539953|NM_172142|XM_011250574|XM_006539952|XM_006539951	XP_006540014|XP_006540015|XP_006540016|XP_011248875|XP_011248876|NP_742154	13101	HGNC:15671	84807	NM_139239,NM_001321831	XP_016882882,XP_016882881,XP_011525723,XP_011525722,XP_016882880,XP_016882883,XP_005259397,NP_640332,XP_016882879,NP_001308760,XP_016882884,XP_016882886,XP_011525721,XP_016882885,XP_011525726,XP_016882878
Smpd1	11518663;20200;93255	0.85088 0.67189 0.89787 0.97337	MGI:983255	205 97	NM_011421	NP_035551	457	HGNC:11120	66097	NM_001318087,NM_001007593,NM_000543,NM_001318088	NP_001007594,NP_001305016,NP_000534,XP_011518605,XP_011518606,NP_001305017
Tcaf1	18401;18673;33911;80711	0.85205 0.62034 0.90973 0.97337	MGI:1914665	7757 4	XM_006506753|XM_006506754|XM_006506756|XM_006506755|XM_006506751|XM_006506752|XM_017321830|XM_133096	XP_006506814|XP_006506819|XP_006506816|XP_006506818|XP_006506817|NP_084206|XP_017177319|XP_006506815	88155	HGNC:22201	97407	NM_014719,NM_001206941,NM_001206938	NP_055534,XP_006716254,XP_005250134,XP_016868325,XP_005250132,XP_016868324,NP_001193870,XP_006716255,XP_005250131,NP_001193867,XP_016868323,XP_016868322,XP_005250133
Tbrg4	11883;18711;20611;;26	0.84906 0.86731 0.99737 0.97337	MGI:1100868	213 79	XM_017314423|XR_001779944|NM_001130457|XM_006514607|XM_011243672|XR_001779943|XM_006514608|NM_134011|XR_001779945	XP_017169912|XP_006514671|XP_006514670|NP_598772|NP_001123929|XP_011241974	31259	HGNC:17443	92387	NM_199122,NM_001261834,NM_030900,NM_004749	NP_954573,NP_004740,NP_001248763,NP_112162

Bgn	57 13 50 ; 18 73 ; 68 60 ; 75 03	0. 84 83	0. 65 10	0. 91 49	0. 97 80	0. 97 37	MGI: 88 15 58	12 11 1	XM_006527758| NM_007542	XP_006527821| NP_031568	12 93	HGNC: 1044	63 3	NM_001711	XP_016885213, NP_001702
Rcan3	18 24 ; 18 76 ; 51 30 ; 89 27	0. 84 73	0. 62 24	0. 91 72	0. 97 82	0. 97 37	MGI: 18 58 22 0	53 90 2	XM_017320317| NM_022980	XP_017175806| NP_075356	83 88	HGNC: 3042	11 12 3	NM_001251984, NM_001251978, NM_013441,NM _001251981,NM _001251980,NM _001251977,NM _001251979,NM _001251982,NM _001251983,NM _001251985	NP_001238914, NP_001238907, NP_001238912, NP_001238911, NP_001238908, NP_001238910, NP_038469,NP_ 001238913,NP_ 001238906,NP_ 001238909
Nfe2l2	58 6; 18 82 ; 46 91 ; 91 68	0. 84 51	0. 77 47	0. 92 23	0. 98 13	0. 97 37	MGI: 10 84 20	18 02 4	NM_010902|NR _132727	NP_035032	24 12	HGNC: 7782	47 80	NM_001313901, NM_001145413, NM_001145412, NM_001313900, NM_001313902, NM_001313904, NM_001313903, NM_006164	NP_001138884, NP_001300833, NP_001300829, NP_006155,NP_ 001300832,NP_ 001300831,NP_ 001300830,NP_ 001138885
Uckl1	17 67 ; 18 84 ; 37 54 ; 73	0. 84 44	0. 62 32	0. 92 39	0. 98 06	0. 97 37	MGI: 19 15 80 6	68 15 56	XM_006500708| XM_006500704| XM_006500710| XM_006500706| XM_017319239| XM_006500707| XM_017319240| XM_006500709| XM_011239960| XM_006500705| NM_026765	XP_006500768| XP_006500767| XP_006500770| XP_017174729| XP_006500772| NP_081041|XP_ 006500771|XP_ 017174728|XP_ 006500773|XP_ 006500769|XP_ 011238262	10 14 14	HGNC: 1593 8	54 96 3	NM_001193379, NM_017859	XP_011527175, XP_016883395, XP_011527174, XP_016883392, XP_016883393, XP_016883391, XP_011527170, XP_006723874, XP_016883383, XP_016883390, XP_006723869, XP_016883384, XP_006723871, XP_006723873, XP_016883394, XP_016883387, XP_006723872,

	99													XP_016883389, XP_016883385, XP_011527171, XP_016883386, XP_016883396, XP_016883388, XP_011527172, NP_001180308, NP_060329,XP_006723870,XP_016883397,XP_011527173,XP_005260273
Ldhb	12;1885;;3850;;7887	0.8441	0.6549	0.9247	0.9792	0.9737	MGI:96763	1683	NM_001316322|NM_001302765|NM_008492	NP_001289694|NP_032518|NP_001303251	5564	HGNC:6541	3945	NM_001174097, NM_001315537, NM_002300	NP_001302466, XP_006719137, NP_001167568, NP_002291
Sorbs1	63;1890;;4390;;7150	0.8423	0.7598	0.9285	0.9810	0.9737	MGI:70014	2041	XM_006526793|XM_011247177|XM_011247173|XM_011247192|XM_017318095|XM_006526801|XM_011247197|XM_006526813|XM_011247185|XM_006526792|XM_017318097|XM_006526799|NM_009166|NM_001034964|XM_011247172|NM_001034962|XM_006526805|XM_011247176|XM_011247181|XM_006526798|XM_011247183|XM_017318090|XM_006526804|XM_006526810|XM_011247193|XM_006526790|XM_011247179|XM_006526795|XM_011247184|XM_006526802|NM_178362|XM_017318094|XM_017318093|XM_011247189|XM_011247175|XM_011247186|XM_011247199|XM_011247191|XM_011247195|XM_017318096|XM_017318089|XM_011247178|XM_006526800|XM_011	XP_006526867|XP_011245494|XP_011245486|XP_006526855|XP_006526873|XP_017173582|XP_011245483|XP_011245491|XP_006526861|XP_011245475|XP_006526856|XP_011245478|XP_011245488|XP_006526863|XP_011245501|XP_006526862|XP_011245474|XP_011245500|NP_001030135|XP_011245493|XP_011245481|XP_006526858|XP_006526869|XP_006526870|XP_006526865|XP_017173578|NP_001030134|XP_017173580|XP_017173586|XP_011245479|XP_006526853|XP_011245485|XP_006526852|XP_011245480|XP_017173581|XP_006526864|XP_017173579|XP_006526876|NP_848139|XP_011245487|XP_017173585|NP_033192|XP_011245482|XP_011	832	HGNC:14565	1058	NM_001290294, NM_024991,NM_001034955,NM_001034956,NM_001290297,NM_015385,NM_006434,NM_001290295,NM_001290296,NM_001290298,NM_001034954,NM_001034957	XP_016871029, XP_016871001, XP_016871013, XP_016871005, XP_011537442, XP_016870993, NP_079267,XP_011537452,XP_016870994,XP_006717656,XP_011537469,NP_001277225,NP_006425,XP_016871016,XP_016871012,NP_001277226,XP_016870992,XP_016871014,XP_016871002,NP_056200,XP_016871009,XP_016870997,XP_016871028,XP_016870995,XP_016871004,NP_001030128,XP_016871018,XP_016871023,XP_006717652,XP_016871000,XP_016871024,XP_016871007,XP_011537457,XP_016871025,NP_001277227,NP_001277224,XP_016870999,XP_016871022,XP_016871017,NP_001277223,XP_016871021,NP_001030126,XP_016871026,XP_016870

								7318091|XM_01 1247174|NM_00 1034963|XM_00 6526803|XM_01 1247198|XM_00 6526789|XM_01 1247180|XM_01 7318092|XM_00 6526806|XM_00 6526807|XM_01 1247190	245495|XP_006 526866|XP_011 245499|NP_001 030136|XP_017 173583|XP_011 245477|XP_017 173584|XP_011 245497|XP_011 245492|XP_011 245476|XP_006 526868				996,XP_016870 990,XP_016871 027,XP_016871 008,XP_016871 011,NP_001030 129,XP_016870 998,XP_016870 991,XP_016871 015,XP_016871 006,XP_016871 003,XP_016871 019,NP_001030 127,XP_016870 989,XP_016871 010,XP_016871 020
Furin	12;1891;;20455;;41366	0.8420	0.0821	0.9945	0.9737	0.937	MGI:975133	1850	NM_011046|XM_011250821|XM_011250820|XM_011250823|XM_011250822|XM_011250819|NM_001081454|XM_011250818	XP_011249121|XP_011249125|XP_011249120|NP_001074923|XP_011249122|XP_011249123|XP_011249124|NP_035176	1930	HGNC:8568	5045	NM_001289824, NM_001289823, NM_002569	NP_001276753, NP_001276752, NP_002560
Fastkd3	77;1893;;54882;;62522	0.8420	0.0821	0.9945	0.9737	0.937	MGI:1916827	6957	NM_027123|NM_001330423|XR_382449|XM_006517366|NR_138478|XM_006517364|XM_017315595|NR_138477|XM_006517365|XR_382450|XM_006517367	XP_017171084|XP_006517427|XP_006517429|XP_006517430|XP_006517428|NP_001317352|NP_081399	1145 7	HGNC:28758	7902	NM_024091	XP_006714561, NP_076996
Chd9	14;1894;;38555;;61005	0.8440	0.0821	0.9317	0.9774	0.937	MGI:1924001	1091	XM_017312519|XM_011248272|XM_006530569|NM_001310530|XM_017312521|XM_017312517|XM_006530572|NM_177224|XM_017312520|XM_011248274|XM_017312518|XM_011248273|XM_011248275|XM_006530570|XM_006530571	XP_006530634|XP_006530633|NP_001297459|XP_017168008|XP_017168009|XP_017168010|XP_011246576|XP_011246574|XP_006530632|NP_796198|XP_011246577|XP_006530635|XP_017168006|XP_011246575|XP_017168007	1184 4	HGNC:25701	8025	NM_001352158, NM_015287,NM_001352127,NM_001352157,NM_001308319,NM_025134,NM_001352156	XP_016879215, XP_016879216, XP_005256225, NP_001295248, XP_016879214, XP_005256233, XP_011521649, XP_005256229, XP_006721346, NP_079410,XP_005256226,XP_016879208,XP_016879213,NP_001339087,NP_001339085,XP_006721344,NP_001339086,XP_016879217,XP_016879212,XP_016879209,XP_016879211,XP_016879210,XP_

															016879207,NP_001339056
Plscr3	122989;189505;419964;64488	0.8406	0.6583	0.9326	0.9760	0.9737	MGI:1917560	703.10	NM_023564|XM_006534158|NR_033133|XM_006534157|XM_006534156|NM_001168497	XP_006534219|XP_006534220|XP_006534221|NP_001161969|NP_076053	2321.9	HGNC:16495	57.048	NM_020360,NM_001201576	NP_065093,NP_001188505
Map3k2	346;189;7;3396;4954	0.8399	0.8698	0.9342	0.9755	0.9737	MGI:1346873	264.05	NM_011946	NP_036076	7457.6	HGNC:6854	10.746	NM_006609	NP_006600
Pdk1	272;189;;4099;43599	0.8392	0.9167	0.9357	0.9750	0.9737	MGI:1926119	228.026	XM_017317590|XM_011239446|NM_172665|XM_011239444|XM_011239445|XR_001782095	XP_011237748|NP_766253|XP_011237746|XP_011237747|XP_017173079	1344.37	HGNC:8809	51.63	NM_001278549,NM_002610	XP_011509649,XP_011509645,NP_001265478,XP_011509646,XP_006712657,NP_002601,XP_006712658,XP_011509647
Tgfbr3	320;190;;81366;82411	0.8388	0.8845	0.9368	0.9737	0.9737	MGI:1046377	218.14	NM_011578	NP_035708	2436	HGNC:11774	70.49	NM_001195683,NM_001195684,NM_003243	XP_006710931,NP_001182613,NP_001182612,XP_006710930,NP_003234

Acy3	67;19136900;5237	0.834453	0.74539	0.948481	0.983212	0.98188	MGI:1918920	7167 0	NM_001302481|NM_001302480|NM_001302479|NM_001302482	NP_001289410|NP_001289408|NP_001289411|NP_001289409	12401	HGNC:24104	9170 3	NM_080658	XP_016874039,NP_542389,XP_016874040,XP_016874038
Impa1	32;19146094;819696	0.834090	0.879690	0.949018	0.981818	MGI:1933158	55980	XM_006530077|NM_018864|NM_001310433|XM_006530078	NP_061352|NP_001297362|XP_006530140|XP_006530141	4043	HGNC:60500	3612	NM_001144879,NM_005536,NM_001144878	NP_001138351,NP_005527,NP_001138350	
Hsph1	1859;19200;48792;818282	0.831934	0.613442	0.954249	0.984933	0.98333	MGI:1050053	15505	XM_006504915|NM_001347534|XM_006504916|NM_013559|XM_006504914	XP_006504977|NP_001334463|NP_038587|XP_006504978|XP_006504979	21322	HGNC:16969	1080 8	NM_001286505,NM_006644,NM_001286503,NM_001286504,NM_001349704	NP_001336633,XP_005266293,XP_016875851,XP_016875853,NP_006635,NP_001273434,XP_016875850,XP_016875852,NP_001273433,XP_011533190,XP_011533189,NP_001273432
Pdgfc	344;19246;631919;81422	0.830505	0.866363	0.955773	0.985859	0.98333	MGI:1859631	54635	XM_006501712|XM_017319655|NM_019971	NP_064355|XP_006501775|XP_017175144	9423	HGNC:88001	5603 4	NM_016205	XP_011530426,NP_057289,XP_016863944,XP_016863945

Apoe	46;192513;21134008	0.8309024	0.8095811	0.9844433	0.983	MGI:8805757	116	NM_009696|NM_001305819|NM_001305843|NM_001305844	NP_001292773|NP_001292772|NP_001292748|NP_033826	309511	HGNC:6133	348	NM_001302689,NM_001302688,NM_001302691,NM_000041,NM_001302690	NP_001289617,NP_000032,NP_001289620,NP_001289619,NP_001289618
Fbln5	17133;192940;35755	0.8288879	0.6179616	0.9857833	0.983	MGI:1346091	2387 6	XM_006515866|XM_006515865|XM_006515864|NM_011812	NP_035942|XP_006515928|XP_006515929|XP_006515927	38170	HGNC:36022	1056 16	NM_006329	XP_011534660,XP_016876418,XP_005267324,NP_006320,XP_011534659,XP_011534658
Arhgef1	15113;193000;59166;865 7	0.8285	0.6290	0.9624	0.9844	0.983 3	MGI:1353510	1680 1	XR_391047|NM_001130151|XM_006539565|XM_006539564|NM_001130153|NM_001130152|XM_017322003|NM_001130150|NM_008488	NP_001123622|NP_001123623|XP_006539628|XP_017177492|NP_001123624|XP_006539627|NP_032514|NP_001123625	34545 4	HGNC:681	9138	NM_198977,NM_199002,NM_004706	XP_011525770,XP_005259443,NP_945353,NP_945328,XP_005259447,NP_004697
Ppm1l	13877;193200;62228;70 51	0.8278	0.6377	0.9641	0.9838	0.983 3	MGI:2139740	2420 83	XM_011240119|XM_006501470|NM_178726	NP_848841|XP_006501533|XP_011238421	33158	HGNC:16381	1517 42	NM_001317911,NM_001317912,NM_139245	XP_011510742,NP_640338,NP_001304840,NP_001304841

Dxo	764;19344;42199;92855	0.8271	0.7207	0.96583	0.98333	0.98333	MGI:18904444	1124031	NM_001163770|XM_011246251|XM_017317211|XR_385263|NM_033613	XP_017172700|XP_011244553|NP_291091|NP_001157242	3806 1	HGNC:2992	17 97	NM_005510	XP_016865818, XP_006715068, NP_005501
Adnp	177;19377;75500;95844	0.82611	0.99708	0.96837	0.98337	0.98337	MGI:13387558	1153 8	NM_001310088|NM_009628|NM_001310086	NP_001297017|NP_033758|NP_001297015	7617	HGNC:15766	23 394	NM_001282532, NM_001347511, NM_001282531, NM_015339,NM_181442	NP_852107,NP_001334440,XP_011527050,NP_056154,XP_016883248,NP_001269461,NP_001269460,XP_011527049,XP_016883246,XP_016883247
Slk	1294;19522;53244;76122	0.82113	0.64233	0.98089	0.99429	0.99429	MGI:1032441	2087 4	NM_009289|NM_001164639|XM_006526827	XP_006526890|NP_033315|NP_001158111	2251 5	HGNC:11088	97 48	NM_001304743, NM_014720	NP_055535,NP_001291672,XP_011538703
Rab14	1040;19533;20522;41922	0.82077	0.67055	0.98199	0.99299	0.99299	MGI:1915615	6836 5	NM_026697	NP_080973	4867 9	HGNC:16524	51 552	NM_016322	NP_057406

Asap2	116;1962;5185;7982	0.817739	0.653997	0.989986	0.997979	MGI:2685438	211914	XR_001780443|NM_001098168|XM_006515050|NM_001135192|XM_150333|XM_358146|XM_006515047|XM_006515048	NP_001091637|NP_001128664|NP_001004364|XP_006515113|XP_006515111|XP_006515110	288	HGNC:27211	8853	NM_001135191, NM_003887	XP_006711964, XP_011508706, XP_006711961, NP_003878,XP_011508710,XP_011508707,XP_011508705,XP_011508709,XP_011508711,NP_001128663,XP_006711965,XP_011508708
Styx	1905;1965;2336;8757	0.816743	0.604322	0.992289	0.997989	MGI:1891150	56291	NM_019637	NP_062611	41331	HGNC:11447	6815	NM_001130701, NM_145251	XP_006720305, NP_660294,XP_011535411,NP_001124173,XP_011535410
Atp6ap2	1340;1967;2459;7322	0.816161	0.635739	0.993983	0.997979	MGI:1917745	704955	NM_027439	NP_081715	38097	HGNC:18305	10159	NM_005765	NP_005756
Kif5b	1557;1969;5005;67	0.815454	0.619565	0.995679	0.997979	MGI:1098268	16573	NM_008448	NP_032474	55829	HGNC:63244	37799	NM_004521	XP_016871713, NP_004512

C253;1974;2814;7935	03	0.87600000	0.13972000	1.00000000	1.00000000	1.00000000	MGI:8826263	12	NM_013484	NP_038512	45	HGNC:1248	71	NM_000063,NM_001178063,NM_001282458,NM_001145903,NM_001282459,NM_001282457	NP_001269387,NP_000054,NP_001269388,NP_001171534,NP_001269386,NP_001139375

Part IV Genes enriched in wild type C57BL6 mice treated with both GVAX and anti-PD-1 antibody against the TCRα KO mice without treatment as control

p-value=0 means <1.8677e-05, FDR=0 means <0.000254462430606

GeneSymbol	Ranks of pertur bations	STARS Score	Average Score	p-value	FDR	q-value	Mouse MarkerID	Mouse NCBIEntrezID	Mouse NCBI RefSeq Transcript ID	Mouse NCBI RefSeq Protein ID	HomoloGeneID	HGNCID	Human NCBIEntrezID	Human NCBI RefSeq Transcript ID	Human NCBI RefSeq Protein ID
Ifnar1	5;42;44;55	9.016227	5.532700	0.00000000	0.00000000	0.00000000	MGI:1076588	15975	NM_010508|XR_384931	NP_034638	524	HGNC:5432	3454	NM_000629	XP_011527854,NP_000620,XP_005261021
Ifnar2	20;23;35;57	8.957420	5.000000	0.00000000	0.00000000	0.00000000	MGI:1098243	15976	XM_011246100|XM_006522923|NM_001347258|XM_017316882|NM_010509|NM_001110498	XP_017172371|XP_011244402|NP_001334187|XP_006522986|NP_034639|NP_001103968	49242	HGNC:5433	3455	NM_001289125,NM_001289128,NM_207585,NM_001289126,NM_000874,NM_207584	NP_001276055,NP_001276054,NP_997467,NP_000865,NP_997468,NP_001276057
Stat1	4;10;	8.618926	6.200000	0.00000000	0.00000000	0.00000000	MGI:1	20846	XM_017319464|NM_001205314|XM_017319463|NM_001205313|	XP_006495874|XP_017174952|XP_017174953|NP_001192242|	21428	HGNC:	6772	NM_139266,NM_007315	NP_644671,XP_016860272,XP_006712781,NP_009330

	12;59	42	0	0	0	0	0306 3	XM_006495811|NM_009283	NP_001192243|NP_033309		11362				
Jak1	3;9;22;421	7.3549	5.2600	0	0	0	MGI:966628	NM_146145|XM_011240451|XM_006502812	NP_666257|XP_006502875|XP_011238753	167 8	HGNC:6190	3716	NM_001321857, NM_001321852, NM_001320923, NM_002227,NM_001321853,NM_001321856,NM_001321855,NM_001321854	NP_001308783, NP_001308781, NP_001307852, NP_001308784, NP_001308785, NP_001308786, NP_001308782, NP_002218,XP_016856701
Ifngr1	52;74;111;179	6.9646	4.3440	0	0	0	MGI:1076555	NM_010511	NP_034641	359	HGNC:5439	345 9	NM_000416	NP_000407,XP_016866316,XP_006715534,XP_006715533,XP_011534096,XP_011534095
Safb	10;129;192;208	6.7054	3.9101	0	0	0	MGI:2146974	NM_001163300|XM_006524160|XM_017317445	XP_006524223|NP_001156772|XP_017172934	229	HGNC:10520	629 4	NM_001320572, NM_001201340, NM_001320571, NM_001201338, NM_002967,NM_001201339	NP_001307501, XP_016882605, XP_016882607, NP_001188268, XP_016882604, NP_002958,NP_001307500,NP_001188269,NP_001188267,XP_016882606,XP_016882603
Ppp1r18	143;1887;191;248	6.3792	3.9985	0	0	0	MGI:2140494	NM_001290725|NM_146154|XM_006538464|XM_006538465	NP_001277654|XP_006538528|NP_666266|XP_006538527	855 5	HGNC:9296	551 1	NM_014110,NM_002713,NM_138558	NP_002704,NP_054829,NP_612568,XP_016857083
H2-K1	63;77;79;1151	5.6691	3.6017	0	0	0	MGI:959044	XM_207061|XM_006523678|NM_001347346|XM_017317259|XM_006523680|XR_001782042|XM_017318971|XM_006523673|XM_017317258|XM_006523674|XM_006523677|XM_006523676|XM_017317257|XR_001782043	NP_001334275|XP_017174460|XP_017172746|XP_006523736|XP_017172748|XP_006523741|XP_006523737|XP_006523743|XP_006523739|NP_001001892|XP_017172747|XP_006523740	1283 52	HGNC:49311	3105	NM_002116,NM_001242758	XP_005275388, NP_002107,NP_001229687,XP_016885777
Ifn	8;1	5.2	4.3	0	0	0	MGI	159	NM_008338	NP_032364	40	HGN	34	NM_001329128, NM_005534	XP_011527855, XP_005261026, NP_001316057,

gr2	8;142;489	204	357	0001	0033	0033	:10765	80			41	C:5440	60		XP_011527856, NP_005525
Cdk5	151;158;401;571	4.951104	3.1500002	0.0000065	0.0000065	0.0000065	MGI:1017765	1256	NM_007668|XR_389739|XM_006535626	NP_031694|XP_006535689	362 3	HGNC:1774	10 20	NM_001164410, NM_004935	NP_004926,NP_001157882
Smarce1	6;204;209;601	4.862921	3.6290002	0.0000075	0.0000075	0.0000075	MGI:1927347	573 76	NM_020618|XM_006533827|XM_011249158|XM_006533828	XP_006533890|XP_006533891|XP_011247460|NP_065643	377 27	HGNC:11109	66 05	NM_003079	NP_003070
Pcbp2	241;246;275;652	4.7027023	3.0070003	0.0010008	0.0010008	0.0010008	MGI:1082021	1852 11	XM_011245498|XM_017316500|XM_006520583|XM_006520586|XM_006520582|XM_011245509|XM_011245496|NM_001103166|XM_011245507|XM_011245502|XM_017316498|XM_006520585|XM_017316497|XM_011245497|XM_011245504|XM_011245506|XM_017316501|XM_011245503|XM_017316499|XM_011245508|XM_011245499|NM_001103165|XM_006520584|XM_011245500|XM_011245501|XM_011245495|NM_001174073|NM_011042|XM_011245505	XP_011243805|XP_011243806|XP_011243811|XP_011243801|XP_006520647|XP_017171988|XP_011243803|XP_017171987|XP_011243810|XP_011243808|NP_035172|XP_017171986|XP_011243799|XP_006520646|XP_006520648|XP_011243807|XP_006520645|XP_017171989|NP_001096636|XP_011243800|NP_001167544|NP_001096635|XP_017171990|XP_011243809|XP_006520649|XP_011243804|XP_011243798|XP_011243802|XP_011243797	745 36	HGNC:8648	50 94	NM_001128912, NM_001128914, NM_001128911, NM_031989,NM_001128913,NM_005016,NM_001098620	NP_001092090, NP_114366,NP_001122386,NP_001122383,NP_005007,NP_001122384,NP_001122385
Smarca4	21;33;620	4.6405354	3.5800402	0.0011106	0.0011106	0.0011106	MGI:1881922	205 86	XM_006510122|XM_011242434|XM_011242438|NM_001174079|XM_017313235|XM_017313234|XM_006510120|XM_017313232|XM_011242436|	XP_006510185|XP_017168721|XP_006510180|XP_011240736|XP_006510182|XP_006510183|NP_001167550|NP_001167549|XP_017168723|	135 92 7	HGNC:111	65 97	NM_001128844, NM_003072,NM_001128848,NM_001128849,NM_001128847,NM_001128845,NM_001128846	XP_016882650, XP_006722908, XP_016882652, NP_001122316, XP_016882653, XP_016882649, XP_016882656, XP_016882655, NP_001122317,

	;677							XM_011242437|XM_011242435|XM_017313233|NM_011417|NM_001174078|XM_006510117|XM_006510119	NP_035547|XP_011240738|XP_011240739|XP_011240740|XP_011240737|XP_017168724|XP_017168722		00			NP_001122321,NP_001122318,XP_006722909,XP_016882654,NP_003063,NP_001122319,NP_001122320,XP_016882657,XP_016882651,XP_011526500
Vapa	107;409;659;689	4.624451	2.7401	0.0015	0.0104	0.0106	MGI:1353561	309	XM_017317500|NM_013933|XM_006524385	XP_017172989|NP_038961|XP_006524448	3784	HGNC:12648	92	NM_194434,NM_003574	NP_919415,NP_003565,XP_011524071,XP_016881568
Rps6kb1	53;693;347;706	4.5582848	3.3.2.8	0.0.0.0	0.0.1.0	0.1.1.6	MGI:1270849	725	XM_011249277|XR_001780060|XM_017314792|NM_001114334|XM_006534314|XM_017314793|XM_006534315|XM_017314791|XR_879743|XM_006534317|XM_011249276|NM_028259|XM_011249275	NP_001107806|XP_017170280|XP_011247578|NP_082535|XP_011247577|XP_006534377|XP_006534378|XP_017170282|XP_017170281|XP_006534380|XP_011247579	8170	HGNC:1043	61	NM_003161,NM_001272044,NM_001272043,NM_001272060,NM_001272042	NP_001258989,NP_003152,NP_001258973,XP_011523403,XP_016880420,XP_011523405,XP_016880419,NP_001258971,NP_001258972,XP_016880418,XP_016880421,XP_016880422,XP_011523404
Ankrd17	15;1417;299;717	4.5555	3.4.6.5	0.0.0.4	0.0.1.1	0.1.0.6	MGI:1932101	817	XM_006535287|NM_198010|XM_017321182|XM_006535289|XM_011249595|XM_006535290|XM_006535288|NM_030886|XM_006535291	XP_006535353|NP_112148|XP_017176671|XP_006535350|XP_006535352|XP_011247897|XP_006535354|NP_932127|XP_006535351	8240	HGNC:23575	2605	NM_198889,NM_032217,NM_015574,NM_001286771	NP_056389,XP_016863502,NP_001273700,XP_005265730,XP_005265728,XP_016863505,XP_016863500,NP_115593,XP_016863506,XP_016863503,XP_005265729,XP_016863504,XP_016863501,NP_942592
Msrb1	443;542;646;721	4.5543059	2.5.0.8	0.0.0.4	0.0.1.0	0.1.0.6	MGI:1351642	2736	NM_013759|NM_001346668	NP_038787|NP_001333597	8455	HGNC:14133	5173	NM_016332	NP_057416
Stat2	28;37;68	4.0773	3.1.4.9	0.0.0.1	0.0.3.3	0.3.0.5	MGI:1030	208	XM_006513433|XM_006513435|NM_019963|XM_006513436	XP_006513498|NP_064347|XP_006513496|XP_006513499	3952	HGNC:113	673	NM_198332,NM_005419	XP_016875393,XP_011537000,XP_011536999,XP_011537002,NP_938146,NP_005410,XP_011537001,XP_005269168

	6;1236					39					63				
Msh2	62;1577;4522;9722	4.2.0.1	2.9.7.6	0.0.0.1	0.0.3.2	0.3.0.7	MGI:1018166	1768 5	NM_008628	NP_032654	210	HGNC:7325	44 36	NM_001258281, NM_000251	XP_011531169, XP_005264389, NP_001245210, NP_000242
Arid1a	1317;8444;8555;9744	4.2.0.2	2.3.4.3	0.0.0.1	0.0.3.0	0.3.0.7	MGI:1935147	93760	XM_006539327| XM_006539325| XM_006539326| NM_001080819	XP_006539390| NP_001074288| XP_006539389| XP_006539388	21216	HGNC:11110	82 89	NM_018450,NM_139135,NM_006015	NP_624361,NP_006006
Elavl1	137;200;318;1009	3.9.9.6	2.3.7.2	0.0.0.1	0.0.3.2	0.3.1.9	MGI:1100851	1556 8	XM_006508698| NM_010485	NP_034615|XP_006508761	20367	HGNC:3312	19 94	NM_001419	NP_001410
Tnfrsf12a	154;398;965;1013	3.9.5.5	2.4.2.4	0.0.0.1	0.0.3.1	0.3.1.9	MGI:1351484	2729	NM_001161746| NM_013749	NP_038777|NP_001155218	8451	HGNC:18152	51 33 0	NM_016639	NP_057723
H2-Q6	29;316;	3.8.4.2	2.6.5.4	0.0.0.2	0.0.4.0	0.4.0.2	MGI:95597	110 57	NM_207648	NP_997531	12835 2	HGNC:49	31 05	NM_002116,NM_001242758	XP_005275388, NP_002107,NP_001229687,XP_016885777

	406;1081					35					31				
Axin1	10;323;339;5670	3.8057575	2.4700244	0.0004144	0.0004144	MGI:1096327	105	NM_001159598|XM_006523515|XM_128515|XM_006523516	XP_006523579|NP_033863|XP_006523578|NP_001153070	214	HGNC:9033	832	NM_003502,NM_181050	XP_016879234, XP_016879232, XP_016879236, XP_016879233, XP_011520985, XP_016879235, XP_011520986, XP_011520988, NP_003493,NP_851393,XP_016879237,XP_011520984
H2-T22	301;4325;5455;1146	3.7409	2.4675	0.0002873	0.0004559	MGI:9595956	1503	NM_010397|XM_006523701|XM_006523702|XM_017317264|NM_001347382	NP_001334311|XP_006523764|NP_034527|XP_017172753|XP_006523765	#N/A	#N/A	#N/A	#N/A	#N/A
Srpk1	130;215;358;68577	3.7355	2.5320	0.0002859	0.0004559	MGI:1069908	2081	XM_006523958|NM_016795|XM_011246337|XR_385308	XP_006524021|NP_058075|XP_011244639	1109621	HGNC:11305	6732	NM_003137	NP_003128
Chd8	96;357;366;22911	3.7071	2.4022	0.0003067	0.0004667	MGI:1915022	677712	XM_017316171|XM_006519476|XM_017316172|XM_011245165|XM_017316170|NM_201637	XP_017171660|XP_006519539|XP_017171659|XP_017171661|XP_011243467|NP_963999	724051	HGNC:20153	5768 0	NM_020920,NM_001170629	NP_001164100, NP_065971
Syn	280;	3.6098	2.6000	0.0000	0.0004	MGI:	1040	XM_006525474|XM_006525475|XM_006525472|XM_006525476|	XP_006525534|NP_796314|XP_006525537|XP_006525539|XP_	527474	HGNC	113	NM_007286,NM_001166208,NM_001109974,NM_001166209	NP_001159681, XP_011535854, NP_001159680, XP_005268427,

po	10;1029;1179	16	170	31	67	67	1094946	27	XM_006525468|XM_006525471|NM_001109975|XM_006525470|NM_177340	006525531|XP_006525538|XP_006525533|XP_006525535|NP_001103445		:3067 2	46			NP_009217,NP_001103444,XP_016864497,XP_005268428,XP_006714818,XP_016864496
Tjap1	26;1000;1054;1250	3.5900	2.0.0.6.0.5.3	0.0.0.4.1	0.0.5.9.3	0.5.9.3	MGI:1921344	74094	XM_011246670|XM_011246676|XM_011246664|XM_011246667|XM_011246669|XM_011246674|XM_011246677|XM_011246675|XM_011246666|NM_001252473|XM_011246672|XM_011246663|XM_011246662|XM_011246673|NM_001252475|NM_028751|NM_001252474|XM_011246671|XM_011246678|XM_011246665|XM_011246668	XP_011244979|XP_011244974|NP_001239403|XP_011244975|XP_011244969|XP_011244968|XP_011244977|XP_011244972|XP_011244965|XP_011244971|NP_001239402|XP_011244976|XP_011244980|XP_011244970|XP_011244973|XP_011244967|XP_011244978|NP_001239404|NP_083027|XP_011244964|XP_011244966	1253 4	HGNC:17949	93643	NM_001146016,NM_001146020,NM_001350564,NM_001350566,NM_001146017,NM_080604,NM_001350568,NM_001350567,NM_001350565,NM_001350561,NM_001350562,NM_001350563,NM_001146018,NM_001146019,NM_001350570,NM_001350569	NP_001337491,NP_001337492,NP_001139490,NP_001337493,XP_006715319,XP_016866981,XP_006715332,XP_006715320,XP_006715313,XP_006715315,XP_006715312,NP_001337490,XP_016866978,XP_016866980,NP_001139492,XP_016866979,XP_006715330,NP_001139488,NP_001139491,NP_001139489,XP_006715314,NP_001337497,XP_016866977,XP_006715325,XP_011513297,XP_006715323,XP_006715324,XP_006715329,XP_006715317,NP_001337499,XP_006715326,XP_006715333,XP_006715328,NP_001337494,NP_001337498,XP_006715331,XP_011513298,NP_001337495,XP_016866982,NP_001337496,XP_006715322,NP_542171
Bmpr2	56;2270;4144;3161	3.5488	2.3.0.4.3	0.0.0.4.5	0.0.6.2.8	0.6.1.5	MGI:1095407	12168	NM_007561|XM_006495633	NP_031587|XP_006495696	929	HGNC:10778	659	NM_033346,NM_001204	NP_001195,XP_011509989	
Tao	126	3.5	2.4	0	0	0	MGI	216	XM_006532959|XM_011248929|NM_144825|XM	XP_011247233|XP_006533021|NP_659074|XP_	270	HGN	575	NM_020791,NM_025142	NP_065842,XP_011523362,NP_079418	

k1	;173;1045;1284	4346	9345	0455	6155	6155	:1914490	965	_011248931|XM_006532960|XM_011248930|XM_006532958	011247231|XP_006533022|XP_006533023|XP_011247232	41	C:29259	51							
C3	605;867;1084;13700	3.4307	1.9662	0.0058	0.0771	0.0771	MGI:88227	1266	XM_011246258|NM_009778	XP_011244560|NP_033908	6803 1	HGNC:1318	718	NM_000064	NP_000055					
Cab39	54;84;641;51008	3.3695	2.6755	0.0067	0.0856	0.0856	MGI:1074438	1283	XM_011247907|XM_017312539|XM_006529090|NM_133781|XM_006529091	XP_011246209|XP_017168028|XP_006529154|NP_598542|XP_006529153	6921 2	HGNC:20292	51719	NM_001130850,NM_016289,NM_001130849	NP_001124322,XP_011509652,NP_057373,NP_001124321					
Ets1	336;1099;12233;14666	3.3131	1.9079	0.0075	0.0933	0.0913	MGI:954555	2387 1	NM_011808|NM_001038642|XM_006510269	NP_035938|XP_006510332|NP_001033731	3837	HGNC:3488	213	NM_005238,NM_001330451,NM_001143820,NM_001162422	XP_016872806,NP_001155894,XP_016872805,XP_011540953,NP_005229,XP_011540954,XP_016872804,XP_011540951,XP_016872803,NP_001317380,XP_011540952,NP_001137292					
Jak2	16;90;52528;	3.3101	2.7502	0.0075	0.0913	0.0913	MGI:96629	1645 2	XM_006526715|XM_006526714|XM_011247155|XM_017318068|NM_001048177|XM_006526713|NM_008413	NP_032439|XP_011245457|XP_006526778|XP_006526777|XP_006526776|XP_017173557|NP_001041642	2103 3	HGNC:6192	37 17	NM_001322199,NM_001322194,NM_001322195,NM_004972,NM_001322198,NM_001322196,NM_001322204	NP_004963,NP_001309128,NP_001309124,NP_001309133,NP_001309123,NP_001309127,NP_001309125					

	841														
Gtf2f1	23;481;513;5110	3.2.7.440	2.0.7.27	0.0.0.81	0.0.9.58	0.0.9.58	MGI:1923848	9805	NM_133801|XM_006525194	NP_598562|XP_006525257	1585	HGNC:4652	2962	NM_002096	NP_002087
Rab11b	479;835;1300;1518	3.2.5.235	1.8.9.35	0.0.8.85	0.0.9.80	0.0.8.80	MGI:994255	1932	XM_006523887|NM_008997	NP_033023|XP_006523950	6869	HGNC:9761	9230	NM_004218	NP_004209
Smarcc1	278;319;551;23211	3.1.8.266	2.1.3.33	0.1.0.00	0.1.1.18	0.1.1.13	MGI:1203524	2058	NM_009211	NP_033237	6829	HGNC:11104	6599	NM_003074	NP_003065,XP_011532336
Arid1b	553;1362;1485;15900	3.1.7.20	1.7.2.62	0.1.0.02	0.1.1.17	0.1.1.13	MGI:1926129	2399	NM_001085355|XM_006523221|XM_006523222|XM_006523223	XP_006523286|XP_006523284|XP_006523285|NP_001078824	3234	HGNC:18040	5749	NM_017519,NM_001346813,NM_020732	XP_016866595,XP_016866597,NP_001333742,XP_011534286,NP_065783,NP_059989,XP_016866593,XP_016866592,XP_016866594,XP_016866598,XP_011534290,XP_005267126,XP_016866596
Rock2	273;4	3.1.6	2.0.5	0.0.1	0.1.1	0.1.1	MGI:1	1978	XM_006515020|NM_009072|XM_006515019	XP_006515083|XP_006515082|NP_033098	2101	HGNC:	9475	NM_004850,NM_001321643	XP_005246247,NP_004841,XP_016860867,XP_011508719,XP_

	12;559;9288	42	83	05	13	13	0792 6				1025 52			016860868,NP_001308572
Rabepk	261;282;587;4597	32.1019	2.1493	0.0122	0.1268	0.1250	MGI:2139530	2277 46	XM_006497985|XM_006497987|NM_145522|XM_006497986|XM_006497989|XM_006497988|XM_006497984|XM_017317453	XP_017172942|XP_006498051|XP_006498047|NP_663497|XP_006498052|XP_006498048|XP_006498050|XP_006498049	4872	HGNC:16896	1024 4	NM_001174152,NM_005833,NM_001174153	XP_016869667,XP_005251701,XP_011516422,XP_005251699,XP_005251698,NP_001167624,NP_001167623,XP_016869669,NP_005824,XP_016869666,XP_005251697,XP_016869671,XP_016869668,XP_016869670,XP_016869672
Flot1	495;692;1356;16599	3.0982	1.0876 3	0.0123	0.1250	0.1250	MGI:1100500	1425 51	XM_006523657|NM_008027|XM_006523656	XP_006523719|XP_006523720|NP_032053	3133 7	HGNC:37557	102 11	NM_005803,NM_001318875	NP_001305804,XP_016865646,XP_005248837,XP_006715010,NP_005794,XP_016865647
Bag4	94;450;613;27433	3.0466	2.1410	0.0139	0.1374	0.1374	MGI:1914634	6738 4	NM_026121	NP_080397	3127 0	HGNC:9400	9530	NM_004874,NM_001204878	NP_001191807,NP_004865
Dxo	91;468;636;40233	2.9997	2.1191	0.0154	0.1495	0.1495	MGI:1890444	1124 03	NM_001163770|XM_011246251|XM_017317211|XR_385263|NM_033613	XP_017172700|XP_011244553|NP_291091|NP_001157242	3806 1	HGNC:29922	179 7	NM_005510	XP_016865818,XP_006715068,NP_005501

H2-Q7	23649;66297;72	2.9487	1.9531	0.0173	0.1643	0.1643	MGI:95936	150118	NM_001198560|NM_001198561|XR_385292|NM_010394	NP_034524|NP_001185490|NP_001185489	12835 2	HGNC:49311	31054	NM_002116,NM_001242758	XP_005275388,NP_002107,NP_001229687,XP_016885777
Fkbp1a	17578;16733;18355	2.9234 1	1.8442	0.0184	0.1703	0.1703	MGI:95541	14225	NM_001302079|NM_001302077|NM_008019|NM_001302078|XM_011239292|NM_001302080|XM_017315525|NR_126058	XP_017171014|NP_032045|NP_001289008|NP_001289006|XP_011237594|NP_001289007|NP_001289009	10513 9	HGNC:37111	22804	NM_054014,NM_001199786,NM_000801	NP_463460,NP_001186715,NP_000792
Wbp4	12555;22543;38655	2.8437 9	2.0772 0	0.0200 0	0.1969	0.1969	MGI:109568	22380	NM_018765	NP_061235	38287	HGNC:127399	11193	NM_007187	NP_009118,XP_016875869,XP_005266302
Ppm1b	60472;15299;19244	2.8440 8	1.7408 2	0.0202 1	0.1196 9	0.1196 9	MGI:101841	19043	XM_011246322|XM_006523862|XM_011246323|XM_011246321|NM_001159496|NM_001159497|NM_011151|NM_001159498|XM_006523861|XM_006523860	XP_011244624|XP_006523923|XP_006523924|XP_006523925|XP_011244623|NP_001152968|NP_001152969|NP_001152970|XP_011244625|NP_035281	207	HGNC:9276	54955	NM_002706,NM_177969,NM_177968,NM_001033556,NM_001033557	NP_808907,NP_001028729,NP_002697,XP_016859884,XP_016859885,NP_808908,XP_011531238,XP_016859886
Mif	756;13266	2.8228	1.5448	0.0230	0.2001	0.2001	MGI:9669	17319	NM_010798	NP_034928	55655	HGNC:70	42882	NM_002415	NP_002406

	;18844;19444						82				97				
Ptprs	300;425;742;3051	2.8039	1.9017	0.0240	0.0204	0.248	MGI:97815	1928 0	XM_006523886|NM_001252456|XM_006523878|XM_006523882|XM_006523874|NM_001252455|XM_006523880|XM_006523884|XM_017317350|XM_017317349|XM_006523883|XM_006523881|NM_001252453|XM_006523877|NM_011218|XM_006523879|XM_006523875|XR_385302|XM_006523876	NP_001239385|NP_001239382|XP_006523940|NP_001239384|XP_006523943|XP_006523942|XP_006523941|XP_006523939|XP_017172839|XP_006523944|XP_006523945|XP_006523949|XP_006523947|XP_006523938|XP_006523946|XP_017172838|NP_035348|XP_006523937	2062 6	HGNC:9681	5802	NM_130855,NM_130853,NM_002850,NM_130854	XP_011526460,XP_016882557,XP_016882562,XP_005259667,XP_016882558,XP_011526459,XP_005259666,XP_016882555,NP_002841,XP_016882565,XP_005259664,XP_016882564,XP_005259663,XP_016882561,XP_016882554,XP_005259657,NP_570925,XP_016882556,XP_016882563,XP_016882560,NP_570924,XP_016882559,NP_570923
Fas	89;178;2155;4006	2.7256	2.0902	0.0227	0.0228	0.2280	MGI:95484	1410 2	XM_011247141|NM_007987|NM_001146708	NP_001140180|NP_032013|XP_011245443	27	HGNC:11920	355	NM_152876,NM_152873,NM_152874,NM_152875,NM_001320619,NM_152872,NM_152871,NM_000043,NM_152877	XP_011538066,XP_011538068,NP_000034,NP_001307548,NP_690610,XP_011538069,XP_006717882,XP_011538067,NP_690611
Ippk	160;188;64422;70211	2.6790	1.9443	0.0249	0.0240	0.2406	MGI:1922928	756 78	NR_075085|XM_017315628|XR_001780827|NM_001276399|NM_199056	XP_017171117|NP_001263328|NP_951011	41495	HGNC:14645	6476 8	NM_022755	NP_073592,XP_016870530
Zpr1	311;408;86	2.6129	1.8600	0.0324	0.0261	0.2617	MGI:1330 2	226 87	NM_011752	NP_035882	2900	HGNC:13051	882	NM_003904,NM_001317086	NP_001304015,NP_003895

	3;9412					62									
Tgfbr3	36;2218;12122;7947	2.5531	2.1938	0.0359	0.2843	0.283	MGI:1046377	214	NM_011578	NP_035708	2436	HGNC:11774	704	NM_001195683, NM_001195684, NM_003243	XP_006710931, NP_001182613, NP_001182612, XP_006710930, NP_003234
Nrc5	83;224;17902;23177	2.5301	1.9079	0.0373	0.2906	0.206	MGI:3612191	434341	XM_006531165| XM_006531162| XM_011248428| XM_006531163| XM_006531166| NM_001033207	XP_006531228| XP_006531229| NP_001028379| XP_006531226| XP_006531225| XP_011246730	88935	HGNC:29933	8416 6	NM_032206,NM_001330552	XP_006721360, XP_005256254, NP_001317481, XP_016879258, XP_011521677, XP_006721363, XP_005256258, XP_016879257, XP_011521678, XP_005256250, XP_016879260, XP_005256252, XP_016879256, XP_016879255, XP_011521675, XP_006721361, XP_016879259, NP_115582,XP_005256256,XP_005256253,XP_005256251
Cth	856;9155;9377;60777	2.5092	1.4865	0.0386	0.2953	0.253	MGI:1339968	107869	NM_145953|XM_006500815	XP_006500878| NP_666065	14432	HGNC:25001	1491	NM_001902,NM_001190463,NM_153742	NP_001177392, XP_005270566, NP_714964,XP_016855905,NP_001893
Zbp1	82;256;10071;51811	2.4188	2.1084	0.0453	0.3405	0.305	MGI:1927449	582033	NM_021394|NM_001139519	NP_067369|NP_001132991	10972	HGNC:16176	8103 0	NM_001323966, NM_001160419, NM_001160418, NM_030776,NM_001160417	XP_011527360, XP_016883575, NP_001153889, NP_001153890, NP_001310895, NP_001153891, NP_110403,XP_011527359

Ctps	53;739;1025;2340	2.3.1.4	5.5.4.3	0.0.0.0	3.4.7.9	4.9.3.5	MGI:1858304	517	NM_016748|XM_006503225	XP_006503288|NP_058028	2446	HGNC:25199	1503	NM_001301237, NM_001905	NP_001896,NP_001288166
Mlt1	328;556;1061;68600	2.3.5.4	1.6.1.6	0.0.5.1	0.3.7.5	0.3.7.0	MGI:1927238	6414	XM_006524778|NM_022328	XP_006524841|NP_071723	439	HGNC:71344	4298	NM_005934	XP_011526323, XP_016882308, XP_011526324, NP_005925,XP_011526325
Ppp6r1	258;975;1104;25599	2.3.0.3	1.5.4.3	0.0.5.6	0.4.0.4	0.3.9.4	MGI:2442163	24381	NM_172894|XM_011250556	XP_011248858|NP_766482	8698 2	HGNC:29195	22870	NM_014931	NP_055746
Nptxr	259;293;3064;67766	2.3.0.3	1.6.5.8	0.0.5.6	0.3.9.3	0.3.9.4	MGI:1920590	7340	NM_030689	NP_109614	8620	HGNC:79544	23467	NM_058178,NM_014293	NP_055108
Usp4	911;978	2.2.9.7	1.3.9.2	0.0.5.7	0.3.9.7	0.3.9.4	MGI:989	2258	XM_006511699|XM_006511697|NM_011678|XM_006511696|XM_006511700|NM_001311157	NP_035808|XP_006511763|NP_001298086|XP_006511760|XP_006511762|XP_006511759	2071 6	HGNC:12	7375	NM_003363,NM_199443,NM_001251877	NP_955475,NP_003354,NP_001238806

	;11110;30933					05					627				
Ticam1	387;485;11291;24166	2.27588	1.6718	0.05596	0.04059	0.04059	MGI:2147032	10675 9	NM_174989	NP_778154	8605	HGNC:18348	1E+05	NM_014261,NM_182919	NP_891549
Pim3	281;306;72004;95066	2.26639	1.6239	0.06078	0.04078	0.04078	MGI:1355297	22377 5	NM_145478	NP_663453	56955	HGNC:19310	4E+05	NM_001001852	NP_001001852
Fermt2	309;315;27493;96266	2.24222	1.59330	0.06388	0.04215	0.04215	MGI:2385001	21895 2	XM_006518827|XM_006518826|XM_006518828|NM_146054	XP_006518890|XP_006518891|XP_006518889|NP_666166	4976	HGNC:15767	109 79	NM_006832,NM_001134999,NM_001135000	XP_005267342,NP_001128471,NP_006823,XP_006720073,XP_006720072,XP_006720071,NP_001128472
Ctnnal1	290;325;;26082;	2.21604	1.59244	0.06733	0.04378	0.04378	MGI:1859649	54366	XM_017320319|NM_018761	NP_061231|XP_017175808	2815	HGNC:25122	8727	NM_003798,NM_001286974	NP_001273903,XP_005252348,XP_016870740,NP_003789,XP_016870739

	697														
Yipf3	140;331;2945;5991	2.2006	1.7327	0.0694	0.4452	0.4382	MGI:1062804	280	XM_017317498|NM_145353|XM_006524377	XP_006524440|NP_663328|XP_017172987	917	HGNC:21023	25844	NM_015388	NP_056203,XP_005249047,XP_011512760,XP_005249046
Myo1c	397;399;12048;32666	2.19588	1.6970	0.0744	0.4382	0.4382	MGI:1066112	1791	XM_006532429|NM_008659|NM_001080774|NM_001080775	NP_001074244|NP_001074243|XP_006532492|NP_032685	3204	HGNC:7597	4641	NM_033375,NM_001080779,NM_001080950	NP_203693,NP_001074419,NP_001074248
Pdcd10	43;334;2822;60133	2.19318	1.9707	0.0438	0.4382	0.4382	MGI:1928396	5642	NM_019745	NP_062719	1005	HGNC:8761	11235	NM_007217,NM_145860,NM_145859	XP_005247144,XP_005247145,XP_011510671,NP_009148,XP_006713548,NP_665859,XP_016861134,XP_005247143,NP_665858,XP_016861133,XP_011510670
Raet1e	314;337;2776;88477	2.18561	1.5615	0.0715	0.4389	0.4382	MGI:2675273	3790	XM_006512780|XM_011243178|XM_006512779|XM_006512777|XM_011243179|XM_006512782|NM_198193	XP_006512842|XP_006512840|XP_011241481|XP_006512843|NP_937836|XP_006512845|XP_011241480	#N/A	#N/A	#N/A	#N/A	#N/A
Rhoa	61;34	2.17	1.89	0.07	0.44	0.43	MGI:1	1848	NM_016802|NM_001313962|NM_001313961	NP_001300891|NP_001300890|NP_058082	6898	HGNC:6	3887	NM_001313947,NM_001313941,NM_001313943,NM_001313944,NM_001313946,	NP_001300874,NP_001300872,NP_001300870,NP_001655,NP_001300875,NP_

	2;446;9;8149	32	42	34	45	82	0963442				667	NM_001313945, NM_001664	001300873,NP_001300876
Nf1	161;344;3115;4611	21.1683	16.8761	0.074425	0.04382	0.04382	MGI:9730615	180	XM_006532442|XM_006532441|NM_010897|XM_006532436|XM_006532439|XM_006532438|XM_006532437|XM_006532440	XP_006532500|XP_006532504|XP_006532502|XP_006532499|XP_006532505|XP_006532501|NP_035027|XP_006532503	226	HGNC:7765	476 3	NM_001128147, NM_000267,NM_001042492	XP_005258041, XP_011523159, NP_000258,XP_006721985,NP_001035957,XP_011523154,XP_016880179,XP_006721988,XP_005258040,XP_016880178,XP_006721989,XP_006721987,NP_001121619
Trf	826;1057;12332;74522	21.1662	16.3388	0.074482	0.04382	0.04382	MGI:9882821	2204 1	NM_133977	NP_598738	6815 3	HGNC:11740	701 8	NM_001063	XP_016862578, XP_016862579, NP_001054
Orc1	775;801;1244;93779	21.1552	14.1393	0.074322	0.04432	0.04432	MGI:1328337	1839 2	XM_011240469|NM_011015	NP_035145|XP_011238771	3121 21	HGNC:8487	499 8	NM_004153,NM_001190819,NM_001190818	NP_004144,XP_011539829,XP_016856877,NP_001177747,NP_001177748,XP_016856878
Tbcd	711;869;1251	21.1482	13.9926	0.077 4	0.04439	0.04439	MGI:1916866	1093	XR_388323|XM_006531974|XR_879503|XM_017314220|XR_879504|XM_006531973|NM_029878|XR_001779860|XR_001779861|XR_001779859|XM_006531971|XM_006531975	XP_006532036|NP_084154|XP_017169709|XP_006532038|XP_006532034|XP_006532037	4368	HGNC:11581	690 4	NM_001033052, NM_005993	XP_005256461, XP_016880479, XP_016880478, XP_005256453, XP_006722353, XP_011521896, XP_005256456, XP_011521901, XP_011521895, XP_011521902, XP_011521900, XP_011521891,

	;8265													XP_011521892,NP_005984,XP_016880476,XP_006722354,XP_016880477,XP_006722355,XP_011521899,XP_011521893,XP_011521897
Itgb2	885;10933;12600;55088	2.13.1.1.3.1.4.2.3	0.0.7.8.7	0.4.4.5.9	0.4.4.5.9	MGI:961611	1614	XM_017313814|XM_006513272|NM_008404|XM_006513271	XP_017169303|XP_006513335|XP_006513334|NP_032430	2092	HGNC:6155	3689	NM_001127491,NM_000211,NM_001303238	NP_000202,NP_001290167,XP_016883830,NP_001120963,XP_006724064
Gata6	2121;3644;16895;38455	2.1.2.1.1	1.6.6.5.0	0.8.1.9	0.4.5.7.9	0.4.5.7.9	MGI:107516	1445	NM_010258|XM_017317834	XP_017173323|NP_034388	6844	HGNC:4174	2627	NM_005257	NP_005248
Plk4	656;7488;12912;62122	2.1.0.9.2	1.4.3.5.2	0.0.8.4.1	0.4.6.4.0	0.4.6.4.0	MGI:101783	2083	NM_011495|XM_006500770|NR_045576|NM_173169|XM_011239968|XM_006500768	NP_775261|NP_035625|XP_006500833|XP_011238270|XP_006500831	7962	HGNC:11397	10733	NM_001190801,NM_014264,NM_001190799	XP_016863151,XP_016863152,NP_055079,XP_005262758,NP_001177728,NP_001177730
Cabin1	123;7288;12988;6	2.1.6.0.2.6	1.6.5.8.1	0.0.4.8.5.2	0.4.6.4.2	0.4.6.4.2	MGI:129837	1042	XR_380334|XM_006513021|XR_001779406|XM_006513022|NM_172549|XM_006513020|XR_001779405|XR_001779404|XM_006513019	XP_006513082|XP_006513084|NP_766137|XP_006513083|XP_006513085	4930	HGNC:24187	23523	NM_001201429,NM_012295,NM_001199281	XP_006724243,XP_006724242,XP_005261472,NP_036427,XP_011528331,XP_016884172,NP_001188358,XP_016884173,XP_005261474,XP_016884170,XP_016884171,XP_011528328,XP_005261473,XP_016884169,XP_

	877													006724244,XP_005261476,XP_011528332,NP_001186210
Slc19a2	146;378;543;;8104	2.0896	1.6685	0.0874	0.0470	0.0463	MGI:1928761	116914	NM_001276455|NM_054087	NP_473428|NP_001263384	3825	HGNC:10938	105 60	NM_006996,NM_001319667	NP_008927,NP_001306596
Gabbr1	13;3811;3031;;52668	2.0830	2.1816	0.0886	0.0471	0.0463	MGI:1860139	543 93	NM_019439|XR_001782091|XM_006524632	XP_006524695|NP_062312	1132	HGNC:4070	255 0	NM_021903,NM_021905,NM_001319053,NM_001470,NM_021904	XP_005249039,NP_001305982,NP_068703,NP_001461,XP_016866165,NP_068704,XP_011512757,XP_006715110,XP_011512755
Cdk8	423;996;1329;;52544	2.0734	1.4010	0.0904	0.0479	0.0463	MGI:1196224	264 064	XM_006504836|XM_006504839|XM_006504835|NM_153599|XM_006504840|XM_006504838	XP_006504902|XP_006504899|NP_705827|XP_006504903|XP_006504901|XP_006504898	5565	HGNC:17779	102 4	NM_001346501,NM_001318368,NM_001260	XP_016875807,XP_011533167,XP_016875806,XP_011533166,XP_005266273,NP_001333430,NP_001251,NP_001305297
Mllt4	981;1076;;13473;;87733	2.0568	1.2804	0.0937	0.0486	0.0463	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Php	377	2.0	1.5	0.0	0.0	0.0	MGI	754	XM_203853	NP_083569	85	HGN	290	NM_001287343,NM_001135860,NM_014172,NM	NP_001129333,NP_054891,NP_

t1	;658;1348;4562	558	1589	9381	8123	6933	:192270 4	54			73	C:30033	85	_001287342,NM_001135861	001274271,NP_001274272
Traf4	292;394;3645;39511	2.05506	1.5106	0.0940	0.4764	0.4693	MGI:1202880	2203 2	NM_009423|XM_006533156	XP_006533219|NP_033449	3173	HGNC:12034	9618	NM_004295,NM_145751	XP_011523810,XP_011523809,XP_011523808,NP_004286,XP_011523807,XP_011523806
Cd38	581;1183;13511;43400	2.05311	1.3120	0.0943	0.4728	0.4693	MGI:1074 74	1249 4	NM_007646	NP_031672	1345	HGNC:1667	9552	NM_001775	NP_001766
Nme2	128;569;13533;98344	2.05113	1.7018	0.0947	0.4693	0.4693	MGI:9735 56	1810 3	NM_008705|NM_001077529	NP_001070997|NP_032731	13387 9	HGNC:7850 0	4831	NM_002512,NM_001018137,NM_001018139,NM_001018138,NM_001198682	NP_001018147,NP_002503,NP_001185611,NP_001018148,NP_001018149
Hn1l	172;1262;	2.02966	1.4456	0.0992	0.4858	0.4809	MGI:1196 2	5209	NM_198937	NP_945175	16934	HGNC:141 1	9086 1	NM_144570	NP_653171

	13777;66044					60					37				
Psmb8	5933;10833;13778;32777	2.02887	1.3237	0.0993	0.4809	0.4809	MGI:1346527	16913	NM_010724	NP_034854	56499	HGNC:9545	5696	NM_004159,NM_148919	NP_004150,NP_683720
Yipf4	2653;11933;13887;26444	2.02072	1.3982	0.1010	0.4838	0.4838	MGI:1915114	67864	NM_026417	NP_080693	32658	HGNC:28145	84272	NM_032312	XP_011531427, NP_115688,XP_005264656
Tm2d1	7523;9103;13933;88299	2.01541	1.3711	0.1022	0.4846	0.4840	MGI:2137022	94043	XM_006503494|NM_053157	XP_006503557|NP_444387	12928	HGNC:24142	83941	NM_032027	NP_114416
Ocrl	7953;9664;14043;	2.00577	1.3124	0.1044	0.4897	0.4840	MGI:1095889	32063	NM_177215|XM_011251008|XM_017318524	NP_796189|XP_017174013|XP_011249310	233	HGNC:8108	4952	NM_001587,NM_001318784,NM_000276	XP_005262479, NP_001305713, XP_011529647, NP_001578,XP_016885043,XP_011529646,NP_000267

	3768														
Eil	99;4200;4470;98466	2.0.1.7.0.5.9	1.0.5.3	0.4.8.3	0.4.8.4.0	MGI:1093777	1371 6	NM_007924	NP_031950	476 2	HGNC:23114	8178	NM_006532	NP_006523,XP_016882824,XP_016882825,XP_016882826,XP_011526632	
Fzd8	6883;8388;14106;7665	2.0.0.4	1.3.6.3.5	0.5.5	0.4.8.4.0	MGI:1084600	1437 0	NM_008058	NP_032084	4060 6	HGNC:4046	8325	NM_031866	NP_114072	
Rab5a	240;9899;14283;23133	1.9.8.4.8	1.4.4.7.0	0.1.0.9.0	0.4.9.5.1	0.4.9.5.1	MGI:1059266	2714 57	NM_025887	NP_080163	6814 2	HGNC:9783	5868	NM_004162,NM_001292048	NP_001278977,NP_004153
Map4k4	321;5794;14396;2406	1.9.7.5.4	1.5.4.7.4	0.1.1.1.3	0.5.0.0.4	0.5.0.0.4	MGI:1349394	2692 1	XM_017321021|XM_006496043|XR_001784729|XM_006496045|XM_017321016|XR_001784730|XM_017321002|XM_006496042|XM_017321018|XM_017321001|XM_017321013|XM_006496041|XM_011238530|XM_017320998|XM_017321011|XM_017321004|NM_001252201|NM_008696|NM_001252202|XM_017320994|XM_006496044|XM	NP_001239129|XP_017176483|XP_017176500|NP_001239130|XP_017176505|XP_017176493|XP_017176507|NP_032722|XP_006496107|NP_001239131|XP_006496104|XP_006496106|XP_017176510|XP_017176487|XP_006496108|XP_017176491|XP_006496105|XP_011236832|XP_006496109|XP_017176502|XP_	7442	HGNC:6866	9448	NM_145686,NM_145687,NM_001242559,NM_004834,NM_001242560	XP_016860845,XP_005264116,XP_005264119,XP_006712932,XP_016860851,XP_016860860,XP_016860849,XP_016860852,XP_005264107,XP_006712928,XP_016860848,XP_005264122,XP_005264120,XP_016860841,XP_005264117,XP_016860859,XP_016860850,NP_001229488,XP_016860839,NP_663720,XP_005264126,XP_

								_006496046|NM_001252200|XM_017321010	017176490|XP_017176499					016860857,XP_005264114,XP_016860854,XP_016860861,XP_016860846,XP_016860855,XP_005264123,NP_001229489,XP_016860864,XP_005264125,NP_004825,XP_016860856,XP_005264109,XP_016860840,XP_005264115,XP_016860844,XP_016860842,XP_016860863,XP_016860862,XP_016860858,XP_016860853,XP_016860838,XP_005264121,XP_005264128,XP_016860847,NP_663719,XP_006712931,XP_016860843,XP_005264105
Sped1	431;1168;1451;2426	1.9652	1.321	0.1137	0.0560	0.060	MGI:2150016	1147	NM_001277256|NM_033524	NP_277059|NP_001264185	2491	HGNC:20249	2E+05	NM_152594	XP_011519591,NP_689807,XP_005254259
Lats1	216;442;4839;5451	1.9596	1.5232	0.1149	0.0561	0.061	MGI:1338383	1678	XM_006512567|NM_010690	NP_034820|XP_006512630	5584	HGNC:6514	913	NM_004690,NM_001350340,NM_001350392,NM_001270519,NM_001350339	NP_001257448,NP_001337269,NP_001337268,XP_016866965,XP_006715666,XP_016866964,XP_016866971,NP_004681,XP_016866963,XP_016866966,XP_016866970,NP_001337321,XP_016866967,XP_011534554,XP_016866968,XP_016866969
Spry1	170;460;319	1.9266	1.556	0.1234	0.5382	0.582	MGI:1345139	2406	NM_001305442|NM_001305440|NM_011896|NM_001305441	NP_036026|NP_001292369|NP_001292370|NP_001292371	4266	HGNC:11269	1052	NM_199327,NM_005841,NM_001258038,NM_001258039	NP_001244968,NP_001244967,NP_005832,XP_005262743,XP_016863124,NP_955359

	7;8478														
Anxa2	1346;4669;24698;29688	1.1.1.1.5.9.5.9.5.9	0.0.0.1.2.6.3	0.0.0.5.4.5.4	0.0.0.5.4.5.4	MGI:882466	123106	NM_007585|XM_006510796	NP_031611|XP_006510859	20857	HGNC:537	302	NM_004039,NM_001002857,NM_001136015,NM_001002858	NP_001002858,NP_004030,NP_001129487,NP_001002857,XP_016877581,XP_016877582,XP_016877580,XP_011519779,XP_016877579
Nfkb1	669;8778;15211;31128	1.1.1.1.9.0.7.4	0.0.0.1.3.2.3.5	0.0.0.5.4.2.8.4	0.0.0.5.4.9.0.0	MGI:973112	18033	NM_008689|XM_006501107|XM_006501106	NP_032715|XP_006501169|XP_006501170	2971	HGNC:7794	4790	NM_003998,NM_001319226,NM_001165412	XP_011530308,NP_001158884,NP_001306155,NP_003989,XP_011530310
Tln2	10311;13822;15355;23889	1.1.1.1.8.9.6.2	0.0.0.1.5.9.1.8	0.0.0.5.5.7.8.5	0.0.0.5.5.5.5.5	MGI:1917799	705549	XM_006511438|XM_006511434|XM_011242813|XM_006511441|XM_011242812|NM_001081242|XM_011242811|XM_006511433	XP_011241114|XP_011241113|XP_006511496|XP_006511501|XP_006511504|XP_011241115|XP_006511497|NP_001074711	56692	HGNC:15447	8360	NM_015059	XP_005254769,XP_005254765,XP_005254768,XP_016878157,XP_016878158,XP_005254772,XP_016878156,XP_005254770,XP_005254767,XP_006720780,XP_016878155,XP_016878154,NP_055874,XP_005254771
Arrdc3	470;4800;20078;54	1.1.1.1.8.9.1.5	0.0.0.1.3.3.7.6	0.0.0.5.5.7.3.0	0.0.0.5.5.5.5.5	MGI:2145242	1051171	XR_382418|NM_001042591|XM_006517017	NP_001036056|XP_006517080	69318	HGNC:29263	57561	NM_001329671,NM_001329670,NM_001329672,NM_020801	NP_001316600,NP_001316601,NP_065852,NP_001316599

Nf2	10 102 3; 139 6; 154 6; 940 7	1 . 8 8 7 5	1 . 1 5 5 3	0 . 1 3 4 1	0 . 5 5 6 8	0 . 5 5 5	MGI: 973 07	180 16	XM_006514572|NM_010898|XM_017314334|XM_006514569|XM_006514574|XM_011243669|XM_006514573|NM_001252252|NM_001252253|XM_011243670|NM_001252250|XM_006514570|NM_001252251|XM_006514571|XM_017314335	XP_006514633|XP_011241971|NP_001239180|XP_006514635|XP_006514634|NP_001239182|NP_001239179|NP_035028|XP_011241972|XP_017169823|XP_006514636|XP_017169824|XP_006514637|NP_001239181|XP_006514632	218 0	HGNC: 7773	47 71	NM_181826,NM_016418,NM_181829,NM_181835,NM_181828,NM_181830,NM_181825,NM_181831,NM_181833,NM_181834,NM_181827,NM_181832,NM_000268	NP_861971,NP_861967,NP_861966,XP_016884298,NP_861546,NP_057502,NP_861969,NP_000259,NP_861968,NP_861970,XP_016884299
Uck2	29; 133 3; 155 6; 372 22	1 . 8 7 9 6	1 . 6 3 3 5	0 . 1 3 6 3	0 . 5 6 0 7	0 . 5 5 5	MGI: 193 174 4	809 14	NM_030724|XM_006497040|XM_017312968	NP_109649|XP_017168457|XP_006497103	408 50	HGNC: 12562	73 71	NM_012474	NP_036606,XP_011508272,XP_016857725
Ube2c	149 ;49 0; 282 8; 401 7	1 . 8 7 4 5	1 . 5 5 6 7	0 . 1 3 7 9	0 . 5 6 2 0	0 . 5 5 5	MGI: 191 586 2	681 612	NM_026785	NP_081061	509 6	HGNC: 15937	11 065	NM_001281741,NM_181801,NM_001281742,NM_181800,NM_181803,NM_181802,NM_181799,NM_007019	NP_008950,NP_001268671,NP_861517,NP_861516,NP_861515,NP_001268670
Map3k11	100 6; 141 8; 156 5; 892 5	1 . 8 7 2 6	1 . 1 4 8 1	0 . 1 3 8 5	0 . 5 5 9 3	0 . 5 5 5	MGI: 134 680 80	264 03	XM_006531752|NM_022012|XM_006531753	NP_071295|XP_006531815|XP_006531816	376 18	HGNC: 6850	42 96	NM_002419	NP_002410

Igf2r	33;4922;30255;32400	11.871146	1.3948	0.13889	0.5556	0.5555	MGI:964355	16004	NM_010515	NP_034645	676	HGNC:5467	3482	NM_000876	NP_000867
Nme1	263;1211;1574;89600	1.8656	1.3437	0.14066	0.5573	0.5555	MGI:973555	18102	NM_008704	NP_032730	12851 4	HGNC:7849	4830	NM_198175,NM_000269	NP_000260,NP_937818
Racgap1	235;497;3176;9030	1.8628	1.4577	0.14145	0.5555	0.5555	MGI:1349423	2693 4	NM_012025|XM_011245647|NM_001253808|XM_006521020|XM_011245646|XM_006521019|NM_001253809	XP_011243949|NP_001240737|XP_006521082|XP_011243948|NP_036155|NP_001240738|XP_006521083	807 7	HGNC:9804	2912 7	NM_013277,NM_001320002,NM_001126103,NM_001319999,NM_001320006,NM_001126104,NM_001320000,NM_001320007,NM_001320005,NM_001320001,NM_001320004,NM_001320003	NP_001306930,NP_001306933,XP_016874714,NP_001119576,XP_016874716,XP_011536545,XP_006719422,NP_001306935,NP_001306928,XP_011536540,XP_016874709,NP_001306932,XP_016874710,NP_001306929,NP_001306931,NP_001119575,XP_016874711,XP_016874713,XP_016874715,NP_001306936,NP_001306934,XP_016874712,NP_037409
Neu1	983;1421;1589;91	1.8540	1.1436	0.14411	0.5610	0.5610	MGI:973055	18010	NM_010893	NP_035023	375	HGNC:7758	4758	NM_000434	NP_000425

Cd2ap	44106;11449;16087;53799	1.8395	1.1834	0.1487	0.5737	0.5678	MGI:1330281	148	XM_011246264|XM_011246263|NM_009847|XM_011246265|XR_001782031	XP_011244567|NP_033977|XP_011244565|XP_011244566	763	HGNC:14258	2360	7	NM_012120	NP_036252,XP_005249033,XP_011512751,XP_016866130
Fstl3	57514;14933;16177;52466	1.8327	1.1828	0.1509	0.5772	0.5678	MGI:1890391	8354	NM_031380	NP_113557	4280	HGNC:39733	1027	2	NM_005860	NP_005851
Stag2	84911;18416;19;72100	1.8312	1.1956	0.1514	0.5740	0.5678	MGI:1098583	2084	3	XM_011250983|NM_021465|NM_001290713|XM_011250987|XM_011250984|XM_017318446|NM_001077712|XM_011250986|XM_011250985|XM_011250988|XM_011250989	NP_001277642|XP_011249286|XP_011249289|XP_011249290|XP_017173935|XP_011249291|NP_067440|XP_011249285|NP_001071180|XP_011249287|XP_011249288	3820	6	HGNC:11355	1073	5	NM_001282418,NM_006603,NM_001042749,NM_001042750,NM_001042751	XP_005262416,NP_001269347,XP_016884724,NP_001036215,XP_016884721,XP_005262415,XP_006724791,XP_005262418,XP_016884722,NP_006594,NP_001036216,XP_011529555,XP_005262414,XP_016884723,XP_006724790,XP_005262417,NP_001036214
Dusp4	47410;16200;22211	1.8305	1.2805	0.1515	0.5694	0.5678	MGI:2442191	3195	20	NM_176933	NP_795907	1065	1	HGNC:30700	1846	6	NM_001394,NM_057158	NP_476499,NP_001385,XP_011542730

Slc16a1	51;521;6666;7530	1.1824841	1.2848616	0.1538158	0.1573078	0.1567878	MGI:1060113	2050101	NM_009196	NP_033222	20662	HGNC:10922	65566	NM_003051,NM_001166496	XP_011540328, NP_001159968, XP_011540329, NP_003042
Strn	678;1073;1635;21855	1.8119021	1.2408555	0.1557466	0.1567878	0.1567878	MGI:1333757	2689800	XM_006524357|NM_011500	NP_035630|XP_006524420	23800	HGNC:11424	68001	NM_003162	XP_011531375, NP_003153,XP_005264576
Nr2f2	865;1459;1636;32744	1.8118385	1.1385562	0.1557022	0.1567878	0.1567878	MGI:1352452	1181952	XM_006540578|NM_009697|XM_006540577|NM_183261	XP_006540641|NP_033827|NP_899084|XP_006540640	76288	HGNC:79776	70266	NM_001145156, NM_001145157, NM_001145155, NM_021005	NP_001138627, NP_001138629, NP_066285,NP_001138628
Prps2	180;1323;1639;59800	1.8116363	1.3566366	0.1563563	0.1567878	0.1567878	MGI:9777776	1106391	XM_017318352|NM_026662|NM_001313758|XM_017318351	NP_080938|NP_001300687|XP_017173840|XP_017173841	128301	HGNC:94655	56334	NM_001039091, NM_002765	NP_001034180, NP_002756
Ar	505;	1.1808	1.2088	0.1566	0.1577	0.1577	MGI:	11828	NM_013476	NP_038504	28	HGNC	36367	NM_001011645, NM_001348064, NM_001348061,	NP_001011645, NP_001334993, NP_001334992,

	534;2126;4946	39	07	06	88	86	88064	35				:644	NM_001348063, NM_000044	NP_000035,NP_001334990
Adk	233;1092;1664;39054	1.7979	1.3633	0.1627	0.5814	0.5786	MGI:879300	1153	NM_134079|NM_001243041|XM_006518440|XM_006518441	XP_006518504|XP_006518503|NP_598840|NP_001229970	4891	HGNC:257	132	NM_001202449, NM_001123,NM_006721,NM_001202450	NP_001189378, XP_016871190, XP_016871193, XP_016871188, NP_001114,XP_016871195,XP_016871194,XP_016871187,NP_006712,XP_016871192,NP_001189379,XP_016871191,XP_016871189
Cd248	522;821;1666;31933	1.7964	1.3331	0.1632	0.5786	0.5786	MGI:1917695	7044 5	NM_054042	NP_473383	10699	HGNC:18219	57124	NM_020404	NP_065137
Cdc42ep2	803;1252;1678;57222	1.7877	1.1730	0.1665	0.5853	0.5853	MGI:1929744	1042 52	NM_026772	NP_081048	4933	HGNC:16263	10435	NM_006779	NP_006770,XP_016872583
Xkr8	472;1441;	1.7819	1.1982	0.1688	0.5880	0.5880	MGI:2685858	3815 60	XM_006538989|NM_201368|XM_006538988	NP_958756|XP_006539052|XP_006539051	2306 8	HGNC:255	55113	NM_018053	XP_011539981, XP_011539982, NP_060523

	16866;75666					77				08					
Otud7b	92503;10037;16977;87300	1.7740	1.2013	0.1713	0.5927	0.527	MGI:2654703	229603	XM_006501389|XM_017319546|XM_017319548|XM_006501385|XM_110475|XM_017319547|XM_006501386	XP_006501448|XP_017175037|XP_017175036|XP_017175035|XP_006501452|NP_001020784|NP_001020785|XP_006501449	1062 4	HGNC:16683	569 57	NM_020205	XP_011508089,NP_064590,XP_011508090,XP_016857339,XP_016857340,XP_011508088,XP_011508085,XP_011508086,XP_011508087,XP_011508084
Rap2b	19;56 0;17 36;76 07	1.7876 509	1.8748	0.1700 1	0.6001	MGI:19212622	74012	NM_028712	NP_082988	55701	HGNC:9862	59 12	NM_002886	NP_002877	
Stk38	14;12 82;17 33;82 91	1.7486	1.7041 4	0.1817	0.6179	MGI:2442572	10650 4	XM_011246232|XR_385254|XM_017317192|XM_017317193|XM_011246233|XM_006523385|XM_006523386|XM_017317194|NM_134115	XP_017172681|XP_006523448|XP_006523449|NP_598876|XP_011244535|XP_011244534|XP_017172682|XP_017172683	56033	HGNC:17847	11 329	NM_001305102,NM_007271	XP_006715051,NP_009202,NP_001292031,XP_016865715,XP_006715052	
Tulp3	720;10 08;17 63;9	1.7278	1.2196	0.1897	0.6413	MGI:1329045	22158	XR_868853|NM_011657|XM_006505909	XP_006505972|NP_035787	20711	HGNC:12425	72 89	NM_001160408,NM_003324	NP_001153880,NP_003315	

	215														
Nfkbid	91;163;177;564;646	11.7.1.7.1.9	10.1.9.4.0	00.6.5.0.5	00.6.5.0.5	MGI:3041243	243910	XM_011250573|XM_006539953|NM_172142|XM_011250574|XM_006539952|XM_006539951	XP_006540014|XP_006540015|XP_006540016|XP_011248875|XP_011248876|NP_742154	131101	HGNC:15671	84807	NM_139239,NM_001321831	XP_016882882, XP_016882881, XP_011525723, XP_011525722, XP_016882880, XP_016882883, XP_005259397, NP_640332,XP_016882879,NP_001308760,XP_016882884,XP_016882886,XP_011525721,XP_016882885,XP_011525726,XP_016882878
Nudt7	953;1525;1785;2484	11.7.1.2.9	10.8.2.6.4	00.6.5.3.5	00.6.5.3.5	MGI:1914778	675258	NM_001290180|NM_024446|NM_001290182|NM_024437|NM_001290181|XM_017312945|XM_011248491	XP_017168434|NP_001277110|NP_077757|XP_011246793|NP_001277111|NP_077766|NP_001277109	41564	HGNC:8054	3E+05	NM_001243657, NM_001105663, NM_001243661, NM_001243660	NP_001230589, NP_001230590, NP_001230586, XP_011521335, XP_016878659, XP_011521334, NP_001099133
Pak1ip1	515;600;909;960;9	11.7.1.2.8	10.2.1.9.8	00.6.5.4.2	00.6.5.4.2	MGI:1915333	680833	NM_026550	NP_080826	39574	HGNC:20882	55003	NM_017906	XP_011513023, XP_011513022, XP_005249261, NP_060376
Hs1bp3	31;173;180;4571	11.7.5.0.2.1	00.2.0.2.0	00.6.5.8.1	00.6.5.5.2	MGI:1913244	582400	XM_006515161|NM_021429	XP_006515224|NP_067404	10980	HGNC:24979	64342	NM_022460	XP_016860185, XP_016860186, XP_016860190, NP_071905,XP_016860189,XP_016860188,XP_016860187
Ad	57	11.	00.	00.	00.	MG	10	NM_134052	NP_598813	75	HG	55	NM_018269,NM_001306077	NP_060739,NP_001293006

i1	8;612;3685;87699	69207	20090	20506	67052	IL:21449	4923				081	NC:30576	256		
Cfp	69;16033;18244;42155	1.6868	1.4014	0.2074	0.6698	0.6552	MGI:97545	18636	XM_135820	NP_032849	1969	HGNC:8864	5199	NM_001145252, NM_002621	NP_002612,NP_001138724,XP_016885064
Scn8a	960;13491;18255;25700	1.6861	1.1026	0.2078	0.6661	0.6552	MGI:103169	2027	XM_006520651|XM_006520656|XM_017316514|XM_017316515|XM_017316516|XM_017316519|NM_001077499|XM_006520655|XM_017316512|XM_017316517|XM_017316513|NM_011323|XM_017316518	NP_001070967|XP_006520714|XP_017172007|XP_017172003|XP_017172001|XP_017172002|XP_017172006|XP_017172005|XP_006520718|NP_035453|XP_006520719|XP_017172004|XP_017172008	7927	HGNC:10596	6334	NM_001330260, NM_175894,NM_014191,NM_001177984	NP_055006,XP_016875284,XP_006719619,XP_011536953,XP_011536952,NP_001317189,NP_001171455,XP_016875283,XP_016875285
Ern1	829;11066;18267;60577	1.6855	1.1666	0.2079	0.6617	0.6552	MGI:1930134	7894	NM_023913	NP_076402	55580	HGNC:34499	2081	NM_152461,NM_001433	NP_001424,XP_016879837,XP_016879836
Oasl2	18;155	1.6822	1.2731	0.2097	0.6624	0.6552	MGI:134	2396	XM_006530315|XM_006530316|NM_011854|XM_006530314	XP_006530377|NP_035984|XP_006530379|XP_006530378	#N/A	#N/A	#N/A	#N/A	#N/A

	0;18311;34533					4390								
Crk	35;7336;18333;21077	1.1.0.0.0.0	16809	13724	21024	06594	06552	MGI:88508	1928	XM_006532125|XM_006532124|NM_133656|NM_001277221|NM_001277219	XP_006532188|NP_001264148|NP_001264150|NP_598417|XP_006532187	8185	HGNC:23622	1398	NM_016823,NM_005206	NP_005197,NP_058431
Ptpn14	430;11177;18344;20099	1.1.0.0.0.0	16802	12387	21044	06552	06552	MGI:1024667	1925	XM_006497131|XM_006497133|XM_006497129|XM_006497130|NM_008976|XM_006497134	XP_006497197|XP_006497194|XP_006497193|XP_006497192|XP_006497196|NP_033002	3941	HGNC:96477	5784	NM_005401	NP_005392,XP_016857430
Ccnd3	51;6631;30824;36488	1.1.0.0.0.0	16680	16797	21622	06585	06589	MGI:883155	1245	NM_001081636|XM_011246262|XM_006523552|NM_001081635|XM_006523553|NM_007632	XP_006523616|XP_011244564|NP_001075104|NP_031658|XP_006523615|NP_001075105	2041	HGNC:1585	896	NM_001760,NM_001287434,NM_001287427,NM_001136125,NM_001136017,NM_001136126	XP_011513273,NP_001129597,NP_001129489,NP_001274356,NP_001274363,XP_011513274,NP_001129598,NP_001751
Arhgap1	177;1902;18622	1.1.0.0.0.0	16623	13387	21897	06722	06589	MGI:2445003	2283559	XM_006499251|XM_006499244|XM_011239457|XM_006499246|XM_006499249|XM_006499247|XM_006499250|NR_027371|NR_027373|NM_146124|XM_006499245|XM_006499248|NM_001145902|NR_027372	XP_011237759|NP_666236|XP_006499313|NP_001139374|XP_006499309|XP_006499314|XP_006499311|XP_006499308|XP_006499307|XP_006499312|XP_006499310	2090	HGNC:673	392	NM_004308	NP_004299,XP_011518397,XP_016873209

	;4244													
Gstp2	59;18446;18700;86011	1.6568	1.07044	0.022166	0.067566	0.06589	MGI:958664	1486989	NM_181796	NP_861461	660	HGNC:4638	29502	NM_000852	NP_000843
Smyd3	629;640;2035;38588	1.6565	1.16680	0.022188	0.067177	0.06589	MGI:1916976	69726	XM_017312213|XM_011238864|XM_017312211|NM_027188|XM_006496982|XM_011238865	XP_006497045|XP_017167702|XP_011237166|XP_011237167|XP_017167700|NP_081464	41491	HGNC:15513	64754	NM_001167740,NM_022743	XP_011542561,NP_001161212,XP_011542556,XP_011542559,XP_016857584,XP_011542555,XP_011542560,XP_011542562,XP_011542563,NP_073580,XP_016857583
Numb	1052;1476;1872;33711	1.65516	1.06119	0.022220	0.066809	0.06589	MGI:1074233	18222	XM_006515572|NR_073563|NM_010949|NM_001136075|NM_001272056|XM_011244012|XM_006515573|NR_073564|XM_006515575|NM_001272055|XM_006515577|XM_006515576|XM_006515578|XM_006515574	XP_006515640|XP_011242314|NP_001258984|NP_001258985|XP_006515641|XP_006515635|XP_006515639|NP_035079|NP_001129547|XP_006515637|XP_006515638|XP_006515636	2775	HGNC:80600	86504	NM_001320114,NM_001005743,NM_001005745,NM_003744,NM_001005744	NP_001005744,NP_001005743,NP_001005745,NP_003735,NP_001307043
Tfpt	27;1800;1875;55	1.65336	1.49777	0.022333	0.066668	0.06589	MGI:1916964	69714	NM_001290381|NM_023524	NP_076013|NP_001277310	8349	HGNC:136300	29844	NM_001321792,NM_013342	NP_037474,NP_001308721,XP_005278318

Tem8	50249;8177;18800;46466	1.1.0.0.0.0 1650404	1.3.2.4.6.6 3802476489	MGI:1926283	604455	XM_006524736|NM_021793|XR_001782096|XM_006524738|XM_006524737	XP_006524799|XP_006524800|NP_068565|XP_006524801	109444	HGNC:17205	589886	NM_021259	NP_067082
Panx1	70476;17662;18855;32399	1.1.0.0.0.0 1646472	1.2.2.6.6.6 2669640	MGI:1860055	55991	NM_019482	NP_062355	49416	HGNC:85599	24145	NM_015368	NP_056183,XP_016872953,XP_011541036
Nmt2	10403;18133;18899;56122	1.1.0.2.6.6 6441778	1.0.2.6.5.9 1747895	MGI:1202298	18108	NM_001290370|NM_001290368|NM_001290369|NM_008708	NP_032734|NP_001277299|NP_001277297|NP_001277298	10153	HGNC:78588	93997	NM_001308295,NM_004808	NP_004799,XP_016872436,XP_016872439,XP_016872437,XP_016872442,XP_016872438,XP_006717602,XP_005252699,XP_016872441,NP_001295224,XP_016872440
Rasa2	34565;65353;18900;38111	1.1.0.2.6.6 6449179	1.3.2.6.5.9 4595125	MGI:2149960	11471 3	XM_006510777|NM_053268|XM_017313108|XM_006510775|XM_006510776	XP_017168597|XP_006510840|XP_006510839|NP_444498|XP_006510838	4745	HGNC:9872	59222	NM_006506,NM_001303245,NM_001303246	XP_016862460,NP_001290174,NP_006497,XP_011511361,NP_001290175,XP_016862461,XP_016862459,XP_016862458,XP_016862457
C2	5106	1.1.0.0.0.0 16112		MGI 12		NM_013484	NP_038512	45	HGN	7177	NM_000063,NM_001178063,NM_001282458,NM	NP_001269387,NP_000054,NP_001269388,NP_

	;65153;76932	4283	9883	28908	60889	5889	:88226	63				C:1248	_001145903,NM_001282459,NM_001282457	001171534,NP_001269386,NP_001139375
Vim	276;18119;32300	1.16321	1.1638	0.23388	0.67088	0.6589	MGI:98932	2235 2	NM_011701	NP_035831	2538	HGNC:12692	7431	NM_003380	NP_003371,XP_006717563
Bcap31	374;66163500;78000	1.16305	1.2501	0.23506	0.66966	0.6589	MGI:1350933	2701 61	XM_011247600|NM_001313698|NM_012060|XM_006528048	XP_006528111|NP_036190|NP_001300627|XP_011245902	3809 5	HGNC:16695	1013 4	NM_005745,NM_001139441,NM_001256447,NM_001139457	NP_001132913,NP_005736,NP_001243376,NP_001132929
Fcer1g	1066;18715;94600	1.16283	0.99689	0.23600	0.66810	0.6589	MGI:95496	1412 7	NM_010185	NP_034315	3029	HGNC:36111	2207	NM_004106	NP_004097
Pp2r4	182;663	1.16280	1.39233	0.23633	0.66467	0.6589	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

	;6832;8797														
Tmem59	22;666;2407;4919	1.6244	1.3500	0.2382	0.6656	0.6589	MGI:1929278	563 74	NM_029565	NP_083841	3583	HGNC:12399	952 8	NM_004872,NM_001305052,NM_001305050,NM_001305049,NM_001305051,NM_001305066,NM_001305043	NP_004863,NP_001291979,NP_001291972,XP_006711114,NP_001291980,NP_001291978,NP_001291995,NP_001291981
Tipri	531;667;3514;8860	1.6232	1.1812	0.2388	0.6631	0.6589	MGI:1915087	2265 91	XM_011238792|NM_145513|XM_006496779|XM_006496780	XP_006496843|XP_006496842|NP_663488|XP_011237094	7140	HGNC:30231	3E+05	NM_001031800,NM_152902	NP_001026970,NP_690866
Spire1	294;1779;19284;75544	1.6202	1.1555	0.2402	0.6630	0.6589	MGI:1915416	6816 6	XM_006526204|XM_006526206|NM_176832|XM_006526205|XM_006526203|NM_194355|XM_006526209|XM_006526207	NP_919336|XP_006526269|XP_006526268|XP_006526270|NP_789802|XP_006526272|XP_006526267|XP_006526266	3550 7	HGNC:30622	569 07	NM_001128627,NM_001128626,NM_020148	XP_011524004,XP_011524003,NP_001122099,NP_064533,XP_005258179,NP_001122098,XP_011524005
Cd320	49;1845;19300;	1.6190	1.1953	0.2409	0.6605	0.6589	MGI:1860083	5421 9	NM_001305169|NM_019421	NP_062294|NP_001292098	9573	HGNC:16692	512 93	NM_016579,NM_001165895	NP_057663,NP_001159367

Rgs19	95811479;154;7933;7576	1.6171	1.0102	0.2421	0.6596	0.6589	MGI:1915153	5647 0	NM_026446|NM_001291209|NM_001291208|NM_001291205|NM_001291207|NM_001291210|NM_001291206	NP_001278135|NP_001278134|NP_080722|NP_001278138|NP_001278137|NP_001278136|NP_001278139	2320	HGNC:13735	1028 7	NM_005873,NM_001039467	XP_011526786, XP_011526787, NP_001034556, XP_011526788, XP_005260240, NP_005864,XP_005260239
Mphosph10	6388;674;24733;81566	1.6148	1.1447	0.2433	0.6589	0.6589	MGI:1915223	6797 3	NM_026483	NP_080759	13474 1	HGNC:7213	1019 9	NM_005791	NP_005782
Clcf1	645;679;6680;;7812	1.6088	1.1398	0.2468	0.6643	0.6643	MGI:1930088	5670 8	NM_001310038|NM_001310039|NM_019952	NP_064336|NP_001296967|NP_001296968	8299	HGNC:17412	2352 9	NM_001166212, NM_013246	NP_037378,NP_001159684
Ppp1r11	3338;1732;;19652;;27155	1.5975	1.1358	0.2529	0.6765	0.6765	MGI:1923747	7649 7	NM_029632	NP_083908	32520	HGNC:9285	6992	NM_170781,NM_021959	XP_006715237, NP_068778

Frmd6	26;6944;5779;7941	1.5913	1.2949	0.2564	0.6817	0.6789	MGI:2442579	3197 10	XM_006515977|XM_006515979|NM_028127|XM_006515978	XP_006516041|XP_006516042|NP_082403|XP_006516040	1249	HGNC:19839	1E+05	NM_001267047,NM_001042481,NM_001267046,NM_152330	XP_016876456,XP_011534726,XP_011534725,NP_689543,NP_001253976,XP_006720093,XP_006720092,XP_016876457,NP_001253975,NP_001035946
Agrn	298;6966;2377;88895	1.5889	1.2735	0.2569	0.6789	0.6789	MGI:879611	1163	XM_006538492|XR_390724|XR_881417|XM_017319921|XM_011250178|XM_006538491|XM_006538495|NM_021604|XM_011250176|XM_006538496|XM_011250177|XM_006538494|XM_006538493	XP_011248478|XP_011248480|XP_011248479|XP_006538559|XP_006538555|XP_006538558|NP_067617|XP_017175410|XP_006538557|XP_006538556|XP_006538554	2790 7	HGNC:329	4E+05	NM_198576,NM_001305275	NP_001292204,XP_005244806,XP_011539731,NP_940978
Hmgxb4	530;7133;2679;79533	1.5696	1.1548	0.2622	0.6882	0.6882	MGI:1918073	7082 3	NM_001316754|NM_178017|XM_006531364|XM_006531362|XR_001778467|NM_001316753	NP_821136|XP_006531427|NP_001303683|XP_006531425|NP_001303682	4007	HGNC:50033	1004 2	NM_001003681,NM_014250,NM_005487	XP_006724165,NP_001003681,XP_006724163,XP_006724164
Cpd	46;7255;6168;80033	1.5562	1.6460	0.2656	0.6934	0.6924	MGI:1072665	1287 4	NM_007754	NP_031780	999	HGNC:23001	1362	NM_001304,NM_001199775	NP_001186704,NP_001295
Vmp1	253;7229;	1.5518	1.2874	0.2668	0.6924	0.6924	MGI:1923	7590 9	XM_006534403|XM_006534402|NM_029478	XP_006534465|NP_083754|XP_006534466	2368 6	HGNC:295	81671	NM_030938,NM_001329398,NM_001329395,NM_001329401,NM_001329400,NM_001329399,NM_001329397,NM_001329396,NM	NP_001316326,NP_001316327,NP_001316324,NP_001316331,NP_112200,NP_001316323,NP_001316330,NP_001316328,NP_

	4809;9604					159					59		_001329402,NM_001329394	001316325,NP_001316329
Arhgef39	2893;7443;21501;40188	1.5356	1.2529	0.2715	0.7006	0.6944	MGI:3036286	2309	XM_011249998|XM_006537830|XM_131404|XM_011249997	XP_006537893|NP_001013395|XP_011248299|XP_011248300	19225	HGNC:25909	8490	NM_032818	XP_016870716,NP_116207,XP_016870714,XP_016870715,XP_011516359,XP_016870717
Dnm1	5634;7446;22511;51177	1.5334	1.1259	0.2722	0.6981	0.6944	MGI:1073844	1329	NM_010065|XR_001780675|XM_006497662|XM_017315328|XM_006497649|XM_006497653|XM_006497658|XM_006497650|XR_374057|NR_125959|XM_006497651|XR_001780678|XM_006497660|XM_006497661|XM_006497652|XR_374055|XM_006497654|XM_006497655|NM_001301737|XR_374058|XM_006497659	XP_006497715|XP_006497725|XP_006497721|XP_017170817|XP_006497722|XP_006497723|XP_006497718|XP_006497716|XP_006497717|XP_006497712|XP_006497713|NP_001288666|XP_006497724|XP_006497714|NP_034195	12390	HGNC:2972	1759	NM_001288738,NM_001005336,NM_001288739,NM_001288737,NM_004408	XP_005251820,NP_001275666,XP_005251826,XP_011516637,XP_006717056,XP_011516638,NP_001275668,XP_006717055,XP_016869860,NP_001275667,NP_004399,XP_016869858,NP_001005336,XP_016869861,XP_016869862,XP_005251825,XP_016869859
Prps1	7347;20633;60966	1.5324	1.0798	0.2726	0.6950	0.6944	MGI:977775	1913	NM_021463	NP_067438	68275	HGNC:9462	5631	NM_001204402,NM_002764	NP_001191331,NP_002755
Fgd4	4163;7511;36511	1.5281	1.1787	0.2744	0.6944	0.6944	MGI:2183747	2401	NM_001301817|XM_006522027|XM_006522025|XM_006522024|NM_139232|XM_006522029|XM_006522023|XR_875778|NM_001301818|XM_011245874	XP_011244176|XP_006522087|XP_006522092|NP_631978|XP_006522090|NP_001288747|XP_006522088|NP_001288746|XP_006522086	26727	HGNC:19125	1E+05	NM_001304484,NM_001304480,NM_139241,NM_001330373,NM_001304481,NM_001330374,NM_001304483	XP_016874294,NP_001317302,NP_001291410,XP_011518860,NP_001291413,XP_011518859,XP_016874292,XP_011518857,NP_001291409,XP_011518858,XP_005253361,NP_640334,XP_

	;384 1														005253364,XP_011518856,NP_001291412,XP_005253365,XP_005253366,XP_011518861,XP_016874293,NP_001317303,XP_005253367
Srpk2	754;7622;3686;7859	11.5.1.6.6.5	10.6.7.7.5	02.7.9.4	00.6.9.5.3	MGI:1201408	208.1.7	XM_017320775|XM_017320773|XM_011249758|XM_017320767|NM_009274|XM_006535661|XM_017320771|XM_011249754|XM_017320769|XM_017320768|XM_017320770|XM_011249759|XM_011249752|XM_017320774|XM_017320777|XM_011249755|XM_011249751|XM_006535660|XM_011249757|XM_011249753|XM_017320772|XM_017320776|XM_011249756	XP_017176264|XP_011248058|XP_017176266|XP_017176260|XP_011248057|XP_006535724|NP_033300|XP_006535723|XP_011248055|XP_011248053|XP_017176259|XP_017176261|XP_017176263|XP_017176256|XP_011248060|XP_017176257|XP_011248056|XP_017176262|XP_011248059|XP_011248061|XP_017176258|XP_011248054|XP_017176265	101663	HGNC:11306	67.3.3	NM_001350739,NM_001350741,NM_001350743,NM_001350744,NM_001278273,NM_182692,NM_182691,NM_001350738,NM_001350740,NM_001350746,NM_001350742,NM_001350745	XP_016868051,XP_011514840,NP_001337668,NP_001337675,XP_005250607,XP_005250606,NP_001337671,XP_016868054,NP_001337674,XP_016868050,NP_001337667,NP_872633,NP_872634,NP_001337673,XP_006716161,NP_001265202,XP_016868053,XP_005250608,XP_016868049,XP_011514838,NP_001337670,XP_016868055,NP_001337669,XP_016868052,NP_001337672
Stk11	516;7632;6672;7321	11.5.1.5.5	10.1.2.7.7.6.2	02.6.9.5.3	00.6.9.5.3	MGI:1341870	208.6.9	NR_126043|XM_006513443|XM_006513442|NM_011492|XM_006513439|NM_001301853|NM_001301854|XM_006513441	NP_001288782|XP_006513504|XP_006513506|NP_001288783|XP_006513505|XP_006513502|NP_035622	393	HGNC:11389	67.9.4	NM_000455	XP_005259674,NP_000446,XP_011526511,XP_005259675
Polr3g	634;7688;2409;25711	11.5.1.0.3	10.9.3.5	02.7.9.6.4	00.6.9.5.3	MGI:1914736	674.8.6	XM_283153	NP_001074645	38184	HGNC:30075	10.6.2.2	NM_006467	XP_011541403,XP_016864446,XP_011541406,XP_011541405,XP_005248461,NP_006458,XP_011541404,XP_011541402,XP_011541407
Nme6	32;774	11.5.0.4.1	10.2.1.5.9	02.8.1.5	00.6.9.7.4.3	MGI:186	543.6.9	XM_006512199|XM_006512200|XM_006512197|XM_006512198|NM_018757	XP_006512261|XP_006512262|XP_006512263|XP_006512260|NP_061227	4231	HGNC:20	10.2.0.1	NM_001308434,NM_001308428,NM_001308430,NM_001308433,NM_005793,NM_001308435,NM_001308427,NM	NP_001295356,NP_001295363,NP_005784,XP_016861000,XP_016861001,NP_001295357,XP_016861003,XP_

	;50005;54155					1676					567		_001308431,NM_001308426	016861002,NP_001295359,NP_001295362,XP_016861006,XP_016861007,NP_001295355,NP_001295360,NP_001295364,XP_016861004,XP_016861005
Gng11	35;778;6006;65422	1.5500	1.1949	0.0283	0.0697	0.0695	MGI:1913316	6606	NM_025331	NP_079607	3045	HGNC:44003	2791	NM_004126	NP_004117
Hscb	498;781;4372;92100	1.1496	1.1298	0.0283	0.0695	0.0695	MGI:2141135	1090	XR_001784585|NM_153571|XM_017320582|XM_006534694	XP_006534757|XP_017176071|NP_705799	1345	HGNC:28913	2E+05	NM_001318314,NM_001318316,NM_172002,NM_001318315	XP_016884108,XP_016884109,NP_001305243,NP_741999,NP_001305244,NP_001305245,XP_005261416
Lmnb1	588;796;5099;94955	1.4819	1.0924	0.0289	0.0703	0.0703	MGI:967795	1690	NM_010721	NP_034851	55912	HGNC:66337	4001	NM_001198557,NM_005573	NP_001185486,NP_005564
Socs6	372;805;65344;8	1.4730	1.1724	0.0292	0.0708	0.0707	MGI:1924885	5460	NM_018821|XM_006526513|XM_011247089|XM_011247090	XP_011245391|XP_011245392|NP_061291|XP_006526576	3120	HGNC:16833	9306	NM_004232	XP_016881575,XP_016881576,NP_004223,XP_005266840

Nap1l1	753;320;813;5736;8689	1.1.1.4651	0.0.0.2971	0.0.0.0750	0.0.0.7075	MGI:1855693	5605	XR_001779557|XM_006513893|NM_015781|XR_001779558|XM_006513890|NM_001146707	NP_001140179|XP_006513953|NP_056596|XP_006513956	1292	HGNC:7637	4673	NM_001330232,NM_001307924,NM_139207,NM_001330231,NM_004537	NP_001317161,NP_001317160,XP_011536692,XP_016874828,NP_001294853,NP_004528,XP_016874827,XP_011536695,XP_016874829,XP_006719488,NP_631946
Fnta	5644;8244;4331;6717	1.4.5.1	0.2.9.0	0.7.1.2	0.0.7.5	MGI:104683	1427	NM_008033	NP_032059	1534	HGNC:3782	2339	NM_002027,NM_001018677,NM_001018676	NP_002018
Arl4d	424;827;6231;8806	1.4.5.6	1.1.3.9	0.3.0.1	0.7.1.0	0.0.7.5	MGI:1933155	8098	NM_025404	NP_079680	1255	HGNC:6556	3779	NM_001661	XP_011523084,NP_001652
Gpc4	438;830;2163;4115	1.4.8.8	1.2.9.4	0.3.0.1	0.7.1.3	0.0.7.5	MGI:1049021	1473	NM_008150|XM_011250978	XP_011249280|NP_032176	5558	HGNC:4452	2239	NM_001448	NP_001439
Pga	745;	1.4.4	1.0.3	0.3.7	0.0.7	MGI:	725	XM_132261|NM_001163538	NP_001157010|NP_082549	145	HGNC	2E+	NM_138575,NM_001170544,NM_001170543	NP_612642,NP_001164014,NP_001164015

m5	832;7590;8107	69	47	19	15	75	1919792	42				97	:28763	05		
Tnfsf9	30;8372;27944;43006	1.44222	1.6807	0.30382	0.7122	0.7075	MGI:1101058	2150	NM_009404|XM_006524033	NP_033430|XP_006524096		137221	#N/A	#N/A	#N/A	#N/A
Ppil2	426;8422;67933;82366	1.43759	1.1289	0.30577	0.7128	0.7075	MGI:2447857	6605 3	XM_006522445|XM_006522444|NM_144954|XM_006522447|XM_006522443|NM_001252444|NM_001252445|XM_006522446	NP_001239373|XP_006522510|XP_006522508|XP_006522509|NP_001239374|XP_006522507|NP_659203|XP_006522506		8643	HGNC:9261	2375 9	NM_148175,NM_014337,NM_148176,NM_001317996	XP_011528345,XP_011528351,XP_011528343,XP_011528348,NP_680481,XP_011528352,XP_011528349,NP_680480,XP_016884194,XP_011528344,XP_005261505,XP_016884195,XP_011528346,NP_055152,XP_011528353,NP_001304925
Msh6	715;8511;75233;94922	1.42911	1.0325	0.30900	0.7165	0.7075	MGI:1343961	1768 8	NM_010830	NP_034960		149	HGNC:7329	2956	NM_000179,NM_001281493,NM_001281494,NM_001281492	NP_000170,NP_001268423,XP_011531100,NP_001268422,XP_011531101,NP_001268421
Snap47	676;8578;22766	1.42277	1.0387	0.31189	0.7175	MGI:1915076	6782 6	XM_006534025|XM_006534021|XM_006534022|XM_006534023|XM_006534024|NM_144521	XP_006534084|XP_006534085|XP_006534087|XP_006534086|XP_006534088|NP_653104		14206	HGNC:30669	1E+05	NM_001323931,NM_001323933,NM_001323935,NM_053052,NM_001323934,NM_001323932,NM_001323930	NP_001310863,XP_016855721,NP_444280,NP_001310861,NP_001310864,XP_016855720,NP_001310859,NP_001310862,NP_001310860,XP_006711797

	;4075														
Crlf3	33;8611;24533;98055	1.1419978	1.1678	0.3127	0.7177	0.7075	MGI:1860086	543943	NM_001277106|XR_001780029|NM_018776	NP_001264035|NP_061246	9327	HGNC:17177	5137 9	NM_015986	NP_057070,XP_011523181
Adrbk1	271;8622;47844;57633	1.1419073	1.2030	0.3134	0.7146	0.7075	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Trappc4	415;870;73811;90288	1.1411818	1.1210	0.3116	0.7183	0.7075	MGI:1926211	60409	NM_021789|XM_017313498	XP_017168987|NP_068561	10545 3	HGNC:19943	5139 9	NM_001318490, NM_001318494, NM_001318489, NM_001318488, NM_001318492, NM_016146,NM_001318486	NP_001305417, NP_001305419, NP_001305423, NP_001305418, NP_001305421, NP_057230,NP_001305415
Cbl	245;872;23188;72799	1.1410029	1.2229	0.3171	0.7163	0.7075	MGI:882799	12402	XM_006509963|NM_007619|XM_017313115	XP_017168604|XP_006510026|NP_031645	3802	HGNC:15411	867	NM_005188	NP_005179,XP_016874000,XP_011541359

Ubr2	496;873;2103;5594	1.4091	1.0865	0.3175	0.7135	0.0775	MGI:1861099	2248 2 6	NM_001177374|XR_001782069|XM_358323|XM_006524145	NP_001170845|XP_006524208|NP_666190	261 51	HGNC:21289	2330 4	NM_001184801,NM_015255	XP_016866083,XP_005249023,XP_005249022,XP_016866085,NP_056070,XP_011512740,XP_011512742,XP_011512741,XP_016866086,XP_016866084,NP_001171730,XP_011512743
Cdkn2d	346;874;5697;8694	1.4082	1.1540	0.3178	0.7106	0.0775	MGI:1053887	1258 1	XM_006509968|NM_009878	XP_006510031|NP_034008	3608 1	HGNC:17900	1032	NM_001800,NM_079421	NP_524145,NP_001791
Trib1	740;8753;7103;8219	1.4073	1.0159	0.3182	0.7078	0.0775	MGI:2443397	2117 70	NM_144549	NP_653132	7521 6	HGNC:16891	1022 1	NM_001282985,NM_025195	NP_079471,NP_001269914
Mydgf	267;8793;2588;7280	1.4037	1.2026	0.3197	0.7075	0.0775	MGI:2156020	2810 6	NM_080837	NP_543027	1042 5	HGNC:16948	560 05	NM_019107	NP_061980,XP_016882476
Clic1	812;8896	1.3887	0.9917	0.3262	0.7182	0.0770	MGI:214 4	1145 84	NM_033444	NP_254279	2034 3	HGNC:20	1192	NM_001288,NM_001287594,NM_001287593	NP_001274523,NP_001274522,NP_001279

;7072;81422						8924					62						
Vezt	448;902;28037;28799	1.38355	1.09255	0.32855	0.71970	0.71708	MGI:2143698	2150	NM_172538|NM_001304572|NM_001304575|NM_001304720	NP_001291501|NP_001291649|NP_766126|NP_001291504	9739	HGNC:18258	5591	NM_001352095, NM_001352118, NM_001352111, NM_001352098, NM_001352089, NM_001352099, NM_001352103, NM_001352106, NM_001352117, NM_017599,NM_001352119,NM_001352116,NM_001352088,NM_001352097,NM_001352110,NM_001352115,NM_001352109,NM_001352091,NM_001352105,NM_001352094,NM_001352092,NM_001352104,NM_001352114,NM_001352113,NM_001352101,NM_001352096,NM_001352112,NM_001352100,NM_001352107,NM_001352108,NM_001352102,NM_001352090,NM_001352093	NP_001339025, XP_006719542, NP_001339041, XP_011536849, NP_001339042, NP_001339024, XP_016875093, XP_011536851, NP_001339046, XP_006719541, XP_011536853, NP_001339018, XP_016875081, XP_006719540, XP_006719549, XP_016875091, NP_001339045, XP_016875080, NP_001339033, XP_016875079, NP_001339030, NP_001339027, NP_001339040, NP_001339038, XP_016875084, NP_001339044, NP_001339023, XP_011536845, NP_001339026, NP_001339043, XP_016875085, XP_011536847, NP_001339021, XP_011536854, NP_001339019, XP_006719548, NP_001339017, XP_016875087, XP_011536848, XP_006719545, XP_016875077, XP_006719544, XP_011536852, NP_001339034, XP_006719543, NP_001339031, XP_016875075, XP_006719553, XP_016875083, XP_016875090, XP_011536850, NP_001339020, XP_016875086, XP_016875078, NP_001339048, NP_001339022, XP_016875076, NP_001339036, XP_016875088, XP_016875094, NP_001339032, NP_001339039, XP_011536846, XP_006719547, NP_001339029,

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Magi1	87;903;2920;5341	10.39372171700	MGI:1203522	149	XM_006505588|XM_006505591|XM_006505583|NM_001083320|XM_006505599|XM_006505594|XM_006505587|NR_104594|XM_006505582|XM_011241222|NM_001083321|XM_006505596|NM_001286784|XM_006505600|XM_017321400|XM_006505584|XM_006505595|XM_006505586|NM_010367|XM_006505592|XM_006505590|XM_017321399|XM_006505598|XM_006505581|NM_001286785|XM_006505593|NM_001029850|XM_006505597|XM_006505601|NM_001286788|NM_001286786|XM_006505589|XM_006505580|XR_377424|XM_006505585|XM_011241223	XP_006505644|XP_006505660|XP_006505663|XP_006505662|XP_006505647|XP_006505652|XP_006505651|XP_006505643|XP_011239524|XP_006505645|XP_006505661|XP_017176889|XP_006505646|XP_011239525|XP_006505655|NP_001025021|XP_017176888|XP_006505657|XP_006505658|XP_006505659|NP_001076789|NP_001273713|NP_001273714|XP_006505648|NP_001273717|XP_006505654|XP_006505650|NP_034497|XP_006505653|XP_006505656|XP_006505649|NP_001273715|NP_001076790|XP_006505664	312257	HGNC:946	92 23	NM_004742,NM_001033057,NM_015520	XP_006713473, XP_005265621, XP_006713477, XP_016862993, XP_016862997, XP_016862996, XP_005265631, XP_016862995, XP_011532543, XP_005265627, XP_016862991, XP_006713470, XP_016862989, XP_011532542, XP_016862990, NP_001028229, XP_006713474, XP_005265622, XP_006713471, XP_016862994, XP_016862987, XP_016862986, XP_016862992, XP_016862988, XP_005265625, XP_011532538, XP_005265623, XP_005265628, XP_005265620, XP_006713472, XP_006713475, NP_056335,NP_004733
Ercc6l	113;922;9024;9326	11.3664033	MGI:2654144	2369300	NM_146235	NP_666347	4494 45	HGNC:20794	54821	NM_001009954, NM_017669	NP_060139,NP_001009954
Pld4	523;933;7776	11.30571	0.3410116	0.7306	MGI:1074699	1802	XR_865222|XM_017319346|XR_373244|XM_006495783|XR_001783207|XM_017319345|XM_006495784|XM_006495786|XM_006495790|XR_001783208|XM_006495789|XM_006495787|XM_006	XP_006495849|NP_683739|NP_001074925|XP_006495846|XP_017174834|XP_006495852|XP_006495851|XP_006495850|XP_006495848|XP_006495847|XP_017174835|XP_006495853	88782	HGNC:9062	84812	NM_032726	XP_016860603, XP_016860609, XP_016860606, XP_016860604, XP_005246970, XP_011510314, XP_016860608, XP_016860607, XP_016860605, NP_116115

	;950							495788|XM_006495785|NM_148937|NM_001081456						
Pawr	307;938;719;805	1.1.1.3.1.4.9.7.3.5.3.0	0.0.0.3.7.3.7.3.4.3.2.1	0.0.0.7.3.0.6	MGI:2149961	114774	XM_125814	NP_473397	1940	HGNC:8614	5074	NM_002583	XP_016874868, XP_006719498, XP_016874867, XP_006719499, NP_002574,XP_016874866
Ppap2a	687;939;892;928;3	1.1.0.3.7.3.0.6.3.4.3.6.5.2.1.0.0.8	0.0.0.3.4.3.4.4	0.0.7.3.0.6	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Rrp1b	116;941;287;651;75	1.1.0.3.7.3.0.6.3.4.4.3.2.5.3.5.0.5.0.6.9.4.4	0.0.0.7.3.0.6	MGI:1911972	7462	XR_001782117|XM_006524974|NM_028244|XM_006524973|XM_006524971|XM_006524972|NM_001163734	NP_001157206|XP_006525037|XP_006525035|XP_006525036|NP_082520|XP_006525034	57086	HGNC:23818	2307 6	NM_015056	NP_055871
Mtmr4	393;944;257;260;72	1.1.0.3.4.9.9.4.3.4.8.0.0.4	0.0.0.3.7.3.1.7.5.7	0.0.7.3.0.6	MGI:2180699	17074 9	XM_011248780|XM_006532383|XM_006532384|NM_133215|XM_006532385	XP_006532448|XP_006532447|NP_573478|XP_011247082|XP_006532446	3440	HGNC:7452	9110	NM_004687	XP_005257841, XP_005257843, XP_005257842, XP_006722231, XP_011523762, NP_004678

Tmem50b	41;94;406;753	1.3456	1.0861	0.3470	0.7308	0.7306	MGI:1925225	779 75	NM_030018	NP_084294	21234	HGNC:1280	757	NM_006134	NP_006125,XP_011528048
Gde1	951;955;7114;8412	1.3390	0.9426	0.3503	0.7343	0.7306	MGI:1891827	562 09	NM_019580	NP_062526	41149	HGNC:29644	5157 3	NM_001324066, NM_016641,NM_001324067	NP_057725,NP_001310995,NP_001310996
Pak2	80;957;7183;75344	1.3374	1.4186	0.3512	0.7326	0.7306	MGI:1339984	224 105	NM_177326|XM_006522072	XP_006522135|NP_796300	99711	HGNC:85911	506 2	NM_002577	XP_011511172, NP_002568,XP_016861990
Npr2	684;961;3812;61500	1.3342	0.3925	0.3528	0.7324	0.7306	MGI:1914482	560 32	XM_006511769|XM_006511768|XM_011242897|NM_018879|XR_379769|XM_011242898	XP_006511831|NP_061367|XP_011241200|XP_011241199|XP_006511832	471	HGNC:24969	1064 1	NM_006545	XP_016861045, XP_011531590, XP_016861044, XP_005264865, NP_006536
Sparc	520;963;	1.3326	1.0339	0.3536	0.7306	0.7306	MGI:983	206 92	NM_001290817|NM_009242	NP_001277746|NP_033268	31132	HGNC:112	6678	NM_001309444, NM_001309443, NM_003118	NP_001296373, NP_001296372, NP_003109

	29211;51500					73					19						
Phlb2	48;97;2106;60355	1.3.2.2	1.0.4.8	0.3.5.8	0.7.7.7	0.7.3.7	MGI:2447981	208	XM_006521926|XM_006521920|XM_006521924|XM_006521925|NM_001252442|XM_006521922|NM_153412|XM_006521921|XM_011245859|XM_006521923|XM_006521928|XM_006521929|XM_017316915|XM_006521927	NP_001239371|XP_006521991|XP_006521989|XP_006521984|NP_700461|XP_006521983|XP_006521987|XP_017172404|XP_006521985|XP_006521988|XP_006521990|XP_011244161|XP_006521986|XP_006521992	1710	HGNC:29573	90	1	0	2	NM_145753,NM_001134439,NM_001134438,NM_001134437	NP_001127909,NP_665696,NP_001127911,NP_001127910
Igf1r	98;73;91;45;77;80;75	1.3.1.0.4	0.9.2.2.8	0.3.6.5.3	0.7.4.7.8	0.7.4.3.6	MGI:964333	16	XM_006540642|XM_006540643|XM_006540645|XM_006540644|NM_010513|XM_017321986|XM_006540641	XP_006540704|XP_006540707|XP_006540705|XP_006540708|XP_017177475|XP_006540706|NP_034643	309	HGNC:5465	34	80			NM_000875,NM_001291858,NM_152452	XP_016877627,NP_001278787,XP_016877628,NP_000866,XP_011519818,XP_011519819,XP_016877625,XP_016877626
Itfg3	87;93;24;42;29;49	1.3.3.0.8.8	1.3.8.6.6.2	0.3.7.4.6.0	0.7.4.3.6	#N/A	#N/A	#N/A		#N/A	#N/A	#N/A	#N/A			#N/A	#N/A
Yes1	32;26;99;5;43;08;46	1.3.0.7.3	1.1.5.1	0.3.6.7.1	0.7.4.4.4	0.7.4.3.6	MGI:991447	226	NM_009535|NM_001205132|NM_001205133	NP_033561|NP_001192061|NP_001192062	5590	HGNC:12841	75	25			NM_005433	XP_005258196,NP_005424,XP_016881449

Mapk8ip3	7670;9988;4874;9016	1.30508	0.0972836	0.0374336	0.0744336	MGI:1353598	3057	NM_001163447|NM_001163448|NM_001163449|NM_013931|NM_001163450|NM_001163453|NM_001163451	NP_001156921|NP_001156922|NP_038959|NP_001156923|NP_001156920|NP_001156925|NP_001156919	2279	HGNC:6884	2316	NM_015133,NM_001040439,NM_001318852	NP_001035529,NP_055948,XP_005255247,NP_001305781,XP_011520734,XP_011520731,XP_011520735,XP_011520733,XP_016878570,XP_016878569,XP_011520732,XP_006720932,XP_016878568
Adss	6602;10100;86777;92004	1.29582	0.0995234	0.0375033	0.0747475	MGI:879488	1156	NM_007422|XR_001785476	NP_031448	875	HGNC:2922	159	NM_001126	XP_011542410,NP_001117
Rheb	1883;10144;36166;48444	1.292735	1.223535	0.0375306	0.0747475	MGI:979112	1974 4	NM_053075	NP_444305	12391 6	HGNC:10011	6009	NM_005614	XP_011514759,NP_005605
Stk19	4883;10019;40400;63582	1.28895	1.029776	0.0375188	0.0747475	MGI:1860085	54402	NM_019442	NP_062315	10449	HGNC:11398	88592	NM_032454,NM_004197	NP_004188,NP_115830

Lmbrd1	35;102;1628;8592	1.2874	1.0903	0.3784	0.7500	0.7475	MGI:1915671	6842	NM_026719|XM_017322292|NM_001310483	XP_017177781|NP_001297412|NP_080995	10156	HGNC:23038	55788	NM_018368	NP_060838,XP_011534243
Ubash3b	940;1022;3220;5063	1.2867	1.0918	0.3789	0.7475	0.7475	MGI:1920078	7288	XM_006510634|NM_176860|XM_017313612|XM_006510636|XM_006510637|XM_006510632	XP_006510700|NP_789830|XP_006510697|XP_006510695|XP_006510699|XP_017169101	13152	HGNC:29884	84959	NM_032873	XP_011541344,XP_005271769,XP_011541343,NP_116262
Mapk14	671;1030;7803;9556	1.2807	0.9690	0.3824	0.7510	0.7510	MGI:1346865	2641	NM_001168513|NM_011951|NM_001168514|XM_017317480|NM_001168508	NP_001161986|NP_036081|XP_017172969|NP_001161985|NP_001161980	31777	HGNC:6876	14332	NM_139012,NM_139014,NM_139013,NM_001315	XP_011512612,XP_006715061,NP_001306,XP_016865793,XP_016865789,NP_620581,XP_016865792,XP_016865791,NP_620582,NP_620583,XP_016865790,XP_016865788
Sfi1	905;1041;4019;6034	1.2725	0.9168	0.3772	0.7547	0.7547	MGI:1926137	7887	XM_006514900|XM_006514894|XM_017314846|XM_011243798|XM_011243794|XM_006514899|XR_001780076|XR_380988|XM_006514904|XM_017314842|XM_011243792|XM_006514897|XM_017314843|XM_006514908|XM_017314847|XM_017314841|XR_872210|XR_380989|XM_006514903|XM_006514902|XM_011243797|XM_011243	XP_017170332|XP_006514971|XP_006514966|NP_084483|XP_017170334|XP_017170333|XP_011242097|XP_006514960|XP_006514965|XP_017170336|XP_006514962|XP_006514967|XP_017170331|XP_006514961|XP_006514964|XP_011242099|XP_006514963|XP_011242094|XP_006514959|XP_017170335|XP_017170330|XP_	12707	HGNC:29064	98144	NM_001258327,NM_014775,NM_001258325,NM_001007467,NM_001258326	XP_016884647,XP_011528881,XP_016884649,XP_011528883,XP_016884629,XP_016884636,XP_016884645,XP_016884650,XP_016884633,XP_011528889,XP_011528873,XP_016884639,XP_016884630,XP_011528882,XP_016884642,XP_016884637,NP_001245256,XP_016884632,XP_011528885,XP_011528884,XP_016884631,

								795|XM_006514901|XM_006514898|XR_001780077|XR_380990|XM_017314844|XM_006514896|NM_030207|XM_017314845|XR_001780078	011242096|XP_011242100|XP_006514957						XP_011528872, XP_016884635, XP_016884644, NP_055590,XP_011528879,NP_001245254,XP_016884646,XP_005261925,XP_011528876,XP_016884641,XP_016884648,NP_001007468,XP_016884634,XP_011528878,XP_016884640,XP_016884643,XP_006724453,XP_016884628,XP_016884651,XP_016884638,XP_011528877,NP_001245255
Ppp1r2	84;10428;37388;51006	1.27188	0.92664	0.38777	0.75477	0.75477	MGI:1914099	66849	NM_025800	NP_080076	4546	HGNC:9288	5504	NM_006241,NM_001291504,NM_001316325,NM_001291505	NP_001278434, XP_006713745, NP_006232,NP_001303254,NP_001278433
Gypc	411;10466;71288;74144	1.26889	1.05144	0.38996	0.75449	0.75449	MGI:1098566	71683	NM_001347610|NM_001048207|XM_006526273	XP_006526336|NP_001041672|NP_001334539	12841 5	HGNC:4704	2995	NM_016815,NM_002101,NM_001256584	XP_006712523, NP_058131,NP_002092,NP_001243513
Sped2	1003;10050;23988;;38	1.26603	0.89833	0.39153	0.75533	0.75533	MGI:2150019	11471 6	XM_006514456|NM_033523|XM_006514457|XM_006514458	XP_006514519|XP_006514520|NP_277058|XP_006514521	2491 8	HGNC:17722	2E+05	NM_001128210, NM_181784	XP_005264258, NP_861449,XP_016859065,XP_005264257,NP_001121682,XP_005264259

	82														
Gpr143	27;10600;32488;49722	1.2587	1.1214	0.3960	0.7606	0.7606	MGI:1071193	1824 1	NM_010951|XM_006528746	NP_035081|XP_006528809	230	HGNC:20145	493 5	NM_000273	XP_005274598, NP_000264
Dab2ip	927;10771;32973;38811	1.2508	0.9023	0.4010	0.7668	0.7662	MGI:1916851	691 601	XM_011239173|XM_011239174|NM_001290639|XM_011239172|XM_011239175|XM_017319251|NM_001290640|NM_001290641|XM_006498304|XM_006498311|NM_001114125|XM_006498307|NM_001290637|XM_006498305|NM_001114124|XM_130206	NP_001277570|XP_011237475|XP_006498367|XP_006498370|NP_001107597|NP_001107596|XP_011237477|NP_001277568|XP_006498368|XP_017174740|XP_011237476|XP_011237474|NP_001277569|NP_001001602|XP_006498374|NP_001277566	1305 8	HGNC:17294	2E+05	NM_138709,NM_032552	XP_011516573, XP_011516568, XP_011516572, XP_011516569, XP_005251781, XP_016869789, NP_115941,XP_011516567,XP_005251776,XP_005251778,XP_011516566,XP_016869788,XP_016869787,NP_619723
Ino80	132;10745;54233;61577	1.2487	1.2690	0.4024	0.7662	0.7662	MGI:1915392	681 422	XM_355376	NP_080850	7507 0	HGNC:26956	54617	NM_032196,NM_017553	NP_060023,XP_011519987,XP_011519988
Dgkh	206;10873;46883;49833	1.2395	1.1792	0.4082	0.7739	0.7739	MGI:2444188	380 921	XM_011245102|XM_011245103|NM_001081336|NM_001281794|XM_006519173|XM_011245099|XM_006519172|XM_011245100|XM_006519171|NR_104044|XM_006519169|XM_011245101|NM_001253766	XP_011243404|XP_006519232|XP_006519235|NP_001240695|XP_011243403|XP_006519234|NP_001074805|XP_006519236|NP_001268723|XP_011243405|XP_011243402|XP_011243401	9937 3	HGNC:28544	2E+05	NM_001297429, NM_178009,NM_001204506,NM_001204504,NM_001204505,NM_152910	NP_821077,NP_001191433,NP_001191434,NP_001191435,NP_001284358,NP_690874

Apbb1ip	63;1107;4451;7960	1.2257	0.9504	0.4181	0.7892	0.7867	MGI:1861354	545 19	XM_011239139|XM_006498187|NM_019456|XM_006498186	XP_006498249|NP_062329|XP_006498250|XP_011237441	3243 4	HGNC:17379	545 18	NM_019043	XP_011517816, XP_006717514, NP_061916
Park7	882;1108;2343;4875	1.2250	0.8969	0.4186	0.7867	0.7867	MGI:2135637	573 20	NM_020569	NP_065594	3829 5	HGNC:16369	11 3 15	NM_001123377, NM_007262	NP_001116849, NP_009193,XP_005263481
Ppme1	825;1118;2735;5421	1.2182	0.9039	0.4235	0.7924	0.7877	MGI:1919840	725 90	NM_028292	NP_082568	6099	HGNC:30178	514 00	NM_001271593, NM_016147	NP_057231,XP_016873402,NP_001258522
Igbp1	1098;1119;6878;9342	1.2175	0.8614	0.4240	0.7899	0.7877	MGI:1346500	18 518	XM_196586	NP_032810	44067	HGNC:5461	34 76	NM_001551	NP_001542,XP_016884978,XP_016884979

Corolc	81;112;307;375;7	10.2910.3742.5378.9177.87	MGI:134596	2370	NM_011779	NP_035909	565337	HGNC:22254	2360	3	NM_001105237,NM_014325,NM_001276471	XP_016874611,NP_055140,XP_016874612,XP_016874610,NP_001098707,XP_011536427,NP_001263400
Ankrd13b	85;112;515;491;688	10.2819.1346.8426.8867.87	MGI:2144501	2645	XR_001780009|XM_006533398|XM_011249040|XM_011249043|XM_011249041|XM_006533394|XM_011249038|XM_006533393|XR_388467|XM_006533397|XM_006533389|XR_388468|XM_006533388|XM_011249039|XM_011249042|XM_006533392|XM_006533396|XM_006533399|NM_172945|XM_006533390|XM_006533395	XP_006533452|XP_011247344|XP_011247340|XP_006533459|XP_006533462|XP_006533456|XP_006533458|XP_011247343|NP_766533|XP_006533457|XP_006533453|XP_006533461|XP_011247345|XP_006533460|XP_011247341|XP_006533451|XP_011247342|XP_006533455	27363	HGNC:26363	1E+05	NM_152345	XP_011522622,XP_016879664,XP_005257977,XP_016879663,XP_016879665,XP_011522621,XP_011522623,NP_689558
Pea15a	80;113;942;954;7	10.2910.3142.9398.8777	MGI:1047999	1861	XM_017319302|XM_006496702|NM_001329871|NM_011063|NM_001329869	XP_017174791|NP_035193|NP_001316800|XP_006496765|NP_001316798	7884	HGNC:8822	862	2	NM_003768,NM_001297576,NM_001297578,NM_001297577	NP_001284505,NP_003759,NP_001284507,XP_006711662,NP_001284506
Tfam	507;113;4;361;3;9814	10.2907.4381.7793.0277.87	MGI:1078100	2178	XM_017313918|NM_009360	NP_033386|XP_017169407	31139	HGNC:11741	701	9	NM_012251,NM_003201,NM_001270782	XP_011538422,NP_001257711,NP_003192,XP_011538423

Riok2	148;1135;19833;29388	1.2.2.43	1.2.4.31	0.4.7.87	0.7.8.77	0.7.7.7	MGI:1914295	6704.5	NM_025934	NP_080210	6760	HGNC:18999	5578.1	NM_001159749, NM_018343	NP_001153221, NP_060813,XP_016865117
Ap1b1	5013;1147;31533;53166	1.1.9.88	0.9.7.89	0.4.3.76	0.7.9.49	0.7.9.07	MGI:1096368	11764	NM_001243044|NM_001243043|XM_006514463|XM_006514462|XM_006514461|NM_007454	NP_031480|XP_006514524|NP_001229972|NP_001229973|XP_006514526|XP_006514525	2197 2	HGNC:554	162	NM_001166019, NM_145730,NM_001127	NP_001159491, NP_663782,NP_001118
Xrcc4	10391;1148;28542;66822	1.1.9.82	0.8.5.94	0.4.3.80	0.7.9.24	0.7.9.07	MGI:1333799	1081.38	XM_006517041|NM_028012|XM_006517042|XM_006517043	XP_006517104|XP_006517105|NP_082288|XP_006517106	2555	HGNC:12831	7518	NM_003401,NM_022406,NM_022550,NM_001318013,NM_001318012	NP_072044,XP_016865316,XP_016865317,NP_071801,NP_001304941,XP_016865318,XP_011541928,NP_003392,NP_001304942
Hmgcr	8003;11150;32983;73233	1.1.9.68	0.8.9.81	0.4.3.89	0.7.9.07	0.7.9.07	MGI:961559	1535.7	XM_006517530|XM_127496|XM_006517531	XP_006517594|NP_032281|XP_006517593	3094	HGNC:50006	3156	NM_001130996, NM_000859	XP_011541660, NP_001124468, NP_000850,XP_011541661,XP_011541659
Gn	42	1.	1.	0.	0.	0.	MG	14	NM_010305	NP_034435	74	HG	27	NM_002069,NM_001256414	NP_002060,NP_001243343

ai1	2;115;3333;4881	1942	0091	4408	7908	7908	IC:9577 1	677			417	NC:4384	70		
Eif2ak4	45;1164;8848;90003	1.1877	1.4664	0.4460	0.7969	0.6969	MGI:1353427	2713	XM_006499625|XM_006499626|XM_017318915|NM_013719|NM_001177806|XM_017318909|XM_006499627	XP_006499688|XP_017174398|XP_006499690|NP_038747|XP_006499689|NP_001171277|XP_017174404	4089 1	HGNC:19687	4E+05	NM_001013703	XP_011519901, XP_016877708, XP_005254449, XP_011519902, NP_001013725
Fiz1	660;1188;6699;94844	1.1724	0.1977	0.4584	0.8158	0.8158	MGI:1344336	2387	NM_001110328|NM_001110330|NM_011813|NM_001110329|XM_006539907	NP_001103800|NP_001103799|NP_035943|NP_001103798|XP_006539970	2266 3	HGNC:25917	8492 2	NM_032836	XP_011525728, NP_116225,XP_005259409
Ezr	650;1192;25111;26611	1.1699	0.1910	0.4605	0.8161	0.8161	MGI:989311	2235 0	NM_009510	NP_033536	5574 0	HGNC:12691	7430	NM_001111077, NM_003379	NP_003370,NP_001104547,XP_011534412
Psme2	117;81;1	1.1649	0.8258	0.4647	0.8203	0.8197	MGI:10	1918	XR_383146|XR_383145|NM_011190|NM_001029855	NP_001025026|NP_035320	8688 9	HGNC:9	5721	NM_002818	XP_006720276, NP_002809

	200;7896;9246					9636 5				569				
Cd81	60;12054898;62577	1.1618	1.3919	0.4673	0.8216	0.8197	MGI:1096398	1252 0	NM_133655	NP_598416	2091 5	HGNC:17701	975	NM_004356,NM_001297649	XP_011518794, XP_016874087, NP_001284578, NP_004347
Apmap	868;12094;34200;76099	1.1593	0.8665	0.4694	0.8219	0.8197	MGI:1919131	7181 1	XM_006500200|XM_006500199|NM_027977|XM_017319266|XM_006500198	NP_082253|XP_006500263|XP_017174755|XP_006500261|XP_006500262	4138 0	HGNC:13238	5713 6	NM_020531	XP_005260820, NP_065392
B2m	462;12133;68422;93255	1.1568	0.9735	0.4715	0.8222	0.8197	MGI:8812 7	1201 0	NM_009735	NP_033865	2987	HGNC:914	567	NM_004048	NP_004039,XP_005254606
Cdkl2	369;12177;	1.1544	0.1047	0.4735	0.8225	0.8197	MGI:1858 2	538 6	NM_177270|XM_011249537|XM_017320987|XM_017320990|NM_016912|XM_011249538|XM_017320989|NM_001276315|XM_01	XP_011247839|XP_017176478|XP_011247840|XP_017176476|XP_017176477|NP_796244|NP_001263244|XP_017176479|XP_	5579 3	HGNC:17822	899	NM_001330724, NM_003948	XP_016864299, XP_006714469, XP_005263392, NP_003939,XP_016864300,XP_016864298,NP_001317653

	7524;8423					27	7320988|XM_011249539	011247841|NP_058608					
Uchl1	1953;12205;55222;75799	1.1525	1.1404	0.4750	0.8219	0.8197	MGI:1031449	2222223	NM_011670	NP_035800	37894	HGNC:12513	7345	NM_004181	NP_004172
Xbp1	1055;12211;71276;76177	1.151519	0.8341	0.4756	0.8197	0.8197	MGI:98970	2243343	NM_001271730|NM_013842	NP_038870|NP_001258659	37222	HGNC:12801	7494	NM_001079539, NM_005080	NP_001073007, NP_005071
Ifitm3	9283;12284;25045;45700	1.14766	0.8505	0.4793	0.8228	0.8228	MGI:1913391	6614141	NM_025378	NP_079654	136199	HGNC:54144	10410	NM_021034	NP_066362
42254	12264;12387;3	1.141416	0.8091	0.4848	0.8289	0.8228	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

	985;4856														
Cdc37	828;12390;63266;87099	1.1410	0.1864	0.4853	0.8265	0.8228	MGI:1095311	1539	XM_006509967|NM_016742	XP_006510030|NP_058022	3826	HGNC:17355	1140	NM_007065	NP_008996,XP_011525954
Orc2	2255;12404;21166;48666	1.1404	0.1053	0.4858	0.8241	0.8228	MGI:1328306	1393	XM_011238453|NM_008765|NM_001271526|NM_001025378	NP_001258455|NP_032791|XP_011236755|NP_001020549	4512	HGNC:8488	4999	NM_006190	XP_006712618,XP_011509554,XP_011509555,NP_006181
Fem1a	9559;12422;26911;74755	1.1392	0.1841	0.4869	0.8228	0.8228	MGI:1335089	1454	NM_010192	NP_034322	7713	HGNC:16934	55527	NM_018708	NP_061178
Phactr1	1203;1255;647	1.1315	0.1806	0.4940	0.8316	0.8316	MGI:2659021	2194	XM_006516911|XM_006516907|XM_006516905|XM_017315484|NM_001005740|XM_017315483|XM_017315482|XM_011244395|XM_006516906|NM_001302635|NM_001005748|NM_001302636	XP_017170971|NP_001289565|NP_001005740|XP_006516974|NP_001005748|XP_011242697|NP_001289564|XP_006516969|XP_006516968|XP_006516970|XP_017170972|XP_017170973	3397	HGNC:20990	2E+05	NM_001322312,NM_001322309,NM_001322308,NM_030948,NM_001322310,NM_001322311,NM_001322313,NM_001242648,NM_001322314	XP_016865956,XP_016865953,XP_016865947,NP_001309238,XP_016865948,XP_016865954,XP_016865951,XP_016865950,NP_001309237,NP_001229577,XP_016865955,XP_016865941,NP_001309241,

	6;8130														XP_016865943, XP_016865945, XP_005248991, NP_001309242, NP_001309243, XP_016865958, NP_001309240, NP_001309239, XP_016865952, XP_016865946, XP_016865949, XP_016865944, NP_112210
Gata3	211;1263;7648;9724	1.1268	1.1115	0.4983	0.8357	0.8357	MGI:95663	14462	NM_008091|XM_006497355|XM_006497354	XP_006497418|XP_006497417|NP_032117	1550	HGNC:4172	2625	NM_002051,NM_001002295	NP_002042,XP_005252500,NP_001002295,XP_005252499
Dip2a	254;1270;7012;9070	1.1227	1.0721	0.5022	0.8388	0.8384	MGI:2385920	64451	NM_001081419|XM_006513940|XM_006513939|XR_001779571|XM_006513941	XP_006514003|NP_001074888|XP_006514002|XP_006514004	41012	HGNC:17217	23181	NM_206891,NM_206889,NM_206890,NM_001146114,NM_015151,NM_001146115,NM_001146116	XP_011527794, NP_001139587, XP_016883783, XP_016883781, XP_016883784, XP_016883786, XP_016883785, XP_016883791, XP_016883780, XP_016883792, NP_001139588, XP_016883794, XP_016883789, XP_011527804, XP_016883793, XP_016883782, NP_996774,XP_016883790,NP_996772,XP_016883788,NP_055966,XP_011527803,NP_996773, XP_016883787
Arhgap17	537;1273;4438;5972	1.1209	0.9281	0.5038	0.8384	0.8384	MGI:1917747	70497	NM_001122642|XM_006508201|NM_001122641|XR_869745|NM_001122640|NM_001316713|NM_001122643|NM_144529|XM_017312292	NP_001116113|XP_006508264|NP_001116112|XP_017167781|NP_001303642|NP_001116114|NP_001116115|NP_653112	9984	HGNC:18239	55114	NM_001006634, NM_018054	XP_016878879, XP_011544175, NP_060524,XP_011544179,NP_001006635,XP_011544176,XP_011544177,XP_011544180,XP_011544178
Cc	193	1.1	1.1	0.5	0.8	0.8	MGI	203	NM_013653	NP_038681	22	HGN	63	NM_001278736, NM_002985	NP_002976,NP_001265665

I5	;12806;27244;56266	169	2478	0784	1839	4:98262	04				44	C:10632	52		
Dist	9566;12881;45396;69644	1.1163	0.1830	0.5083	0.8394	0.8394	MGI:1926170	78920	XM_006516392|NM_030225|XM_017315247	NP_084501|XP_006516455|XP_017170736	1456	HGNC:29111	1743	NM_001933,NM_001244883	NP_001231812,NP_001924
Mul1	6991;12889;55329;92911	1.1176	0.1876	0.5129	0.8439	0.8439	MGI:1915600	68350	XM_006539134|NM_026689	NP_080965|XP_006539197	1157	HGNC:257622	7959	NM_024544	XP_011540439,NP_078820
Rap1b	4753;12933;21126;25006	1.1094	0.1944	0.5153	0.8445	0.8445	MGI:894315	2154	NM_024457	NP_077777	6871	HGNC:98577	5908	NM_001251921,NM_001251918,NM_015646,NM_001010942,NM_001251922,NM_001251917	NP_001238847,NP_001010942,NP_001238846,NP_056461,NP_001238851,NP_001238850
Trip6	2273;13	1.1043	0.1085	0.5203	0.8497	0.8497	MGI:13	22051	XM_006504563|NM_011639	XP_006504626|NP_035769	3775	HGNC:1	7205	NM_003302	NP_003293

	02;3162;3360					4345 8					2311			
Rnf34	1171;1312;7239;9496	1.0.7.9.3.5	0.5.2.6.1	0.8.5.6.0	0.8.5.2.2	MGI:2153340	807 51	NM_030564|XM_006530512	NP_085041|XP_006530575	1183 9	HGNC:17297	801 96	NM_025126,NM_194271,NM_001256858	NP_079402,NP_919247,NP_001243787
Mdm2	1172;1314;5584;8877	1.0.7.9.7.5	0.5.2.7.3	0.8.5.4.7	0.8.5.2.2	MGI:969 52	1724 6	NM_001288586|NM_010786|XM_017313822	NP_034916|NP_001275515|XP_017169311	1793	HGNC:6973	419 3	NM_006879,NM_001278462,NM_001145339,NM_006878,NM_032739,NM_001145340,NM_001145336,NM_006881,NM_001145337,NM_002392,NM_006880,NM_006882	XP_006719462,NP_001265391,XP_005268929,XP_006719463,NP_001138811,NP_002383,NP_001138812,NP_001138809
Stk40	2281;1316;2227;6761	1.0.9.6.4	1.0.8.0.6	0.5.2.8.5	0.8.5.3.4	0.8.5.2.2	MGI:1921428	741 178	XM_006503441|NM_001145827|XM_017320414|NM_028800|XM_006503442	NP_083076|XP_006503505|XP_006503504|NP_001139299|XP_017175903	1254 2	HGNC:21373	839 31	NM_001282547,NM_032017,NM_001282546	NP_114406,NP_001269476,NP_001269475
H2-D1	244;131	1.0.9.5.3	1.0.6.6.4	0.5.2.9.7	0.8.5.2.2	MGI:9584	1496 4	NM_010380	NP_034510	1283 52	HGNC:49	310 5	NM_002116,NM_001242758	XP_005275388,NP_002107,NP_001229687,XP_016885777

	8;8714;97933					96				31					
Pdpk1	59.0;1322;30627;79006	10.0897319	0.0853126	0.0852126	0.0852126	MGI:1338068	168077	XM_017317320|XM_017317323|NM_001286662|NM_011062|XM_017317327|XM_017317325|NM_001080773|XM_017317321|XM_017317324|XM_017317322|XM_017317326	XP_017172815|XP_017172809|NP_001074242|NP_035192|XP_017172816|NP_001273591|XP_017172813|XP_017172810|XP_017172811|XP_017172812|XP_017172814	376433	HGNC:8816	51170	NM_031268,NM_002613,NM_001261816	XP_016878765,XP_016878761,NP_112558,XP_016878766,XP_011520823,NP_001248745,XP_016878764,XP_016878760,XP_011520825,XP_016878763,NP_002604,XP_016878762
Stk38l	473.0;1341;82696;88996	10.0832627	0.0954227	0.0866845	0.0866845	MGI:1922250	23253	XM_017321560|XM_006507029|XR_001785124|XM_006507032|XM_006507034|XM_006507027|XM_006507031|NM_172734|NM_001346666|XM_006507033	XP_006507097|XP_006507090|XP_006507092|XP_017177049|XP_006507096|XP_006507095|NP_766322|XP_006507094|NP_001333595	562993	HGNC:17848	2301 2	NM_015000	XP_006719122,XP_016874525,XP_011518915,XP_005253399,XP_006719121,NP_055815
Arl13b	822;1342;58571;96111	10.0832164	0.0854335	0.0864545	0.0864545	MGI:1915396	681146	XM_006522503|NM_026577|XM_006522504|XM_006522505	XP_006522568|XP_006522566|XP_006522567|NP_080853	188200	HGNC:25419	2E+05	NM_182896,NM_001174151,NM_001321328,NM_001174150,NM_144996	NP_001167621,XP_011510835,XP_006713595,XP_016861342,XP_011510834,XP_011510836,NP_878899,NP_659433,XP_011510837,NP_001167622,NP_001308257
Slc20a2	220;1359;5	10.0772961	0.0557321	0.0877141	0.0877141	MGI:1978511	20516	XM_006509043|NM_011394|XM_006509044	XP_006509107|XP_006509106|NP_035524	685311	HGNC:10947	6575	NM_001257181,NM_006749,NM_001257180	XP_016869241,XP_016869238,NP_001244109,XP_016869239,XP_005273670,XP_006716454,XP_005273672,NP_006740,NP_001244110,XP_016869240,XP_

	739;8564														016869237,XP_006716453
Il6ra	317;1361;6654;7110	1.0718	1.0028	0.5544	0.8757	0.8741	MGI:1053044	1614	NM_010559|NM_001310676	NP_001297605|NP_034689	474	HGNC:6019	3570	NM_181359,NM_000565,NM_001206866	XP_005245196,NP_001193795,XP_006711362,XP_016856690,XP_006711361,NP_852004,XP_005245197,XP_016856689,NP_000556,XP_016856688
Pml	958;1365;3867;5486	1.0697	1.0806	0.5568	0.8764	0.8741	MGI:1046622	1854	XM_006510862|XM_006510864|NM_178087|NM_008884|NM_001311088|XM_006510860|XM_017313212|XM_006510861	NP_032910|XP_006510924|NP_001298017|XP_006510923|XP_006510925|XP_017168701|XP_006510927|NP_835188	1324 5	HGNC:9113	5371	NM_002675,NM_033239,NM_033244,NM_033240,NM_033247,NM_033249,NM_033246,NM_033250,NM_033238	NP_150241,NP_150242,NP_002666,NP_150249,NP_150247,NP_150250,NP_150243,NP_150253,NP_150252
Pmp22	1299;1366;3909;8026	1.0691	1.0765	0.5574	0.8741	0.8741	MGI:976311	1858	NM_008885|NM_001302261|NM_001302260|NM_001302258|NM_001302259|NM_001302255|NM_001302257	NP_001289184|NP_001289188|NP_001289186|NP_001289190|NP_001289189|NP_001289187|NP_032911	7482	HGNC:9118	5376	NM_153322,NM_001281456,NM_153321,NM_001281455,NM_000304,NM_001330143	XP_016880264,NP_001317072,NP_001268385,NP_001268384,NP_696996,NP_000295,XP_016880265,NP_696997
Surf2	909;1379;913	1.0622	1.0810 9	0.5654	0.8835	0.8822	MGI:9844 4	2093 1	XM_006497827|NM_013678	XP_006497890|NP_038706	8430	HGNC:11475	6835	NM_001278928,NM_017503	NP_001265857,NP_059973

	4;9140													
Sntb1	10911;13813;35888;81022	10.0784156622	0.0.5.8.8.2	0.0.8.2.2	MGI:1017781	20649	XM_006520671|NM_016667	XP_006520734|NP_057876	9618	HGNC:11168	6641	NM_021021	NP_066301,XP_011515541	
Stx4a	73513;13855;52000;57544	10.0.8.5.8.8.2.4.4.3.0.6.9.0.8.2.9.9.1.3.0	0.0.5.8.8.2.4	0.0.8.8.2.4	MGI:893577	20909	XM_006507540|NM_009294|XM_006507541|XM_006507539|XM_006507542|XM_006507543	XP_006507603|NP_033320|XP_006507602|XP_006507606|XP_006507605|XP_006507604	10543	HGNC:11439	6810	NM_004604,NM_001272095,NM_001272096	XP_011544227,NP_001259025,XP_005255578,NP_001259024,NP_004595	
Cp	10655;13888;37473;48199	10.0.7.5.8.5.7.5.8.2.4.0.7.5.6.8.8.2.4.8.4.7.6	0.0.5.8.8.2.4	0.0.8.8.2.4	MGI:884776	1287 0	XM_017319446|NM_001276248|XM_011249655|NM_001276250|NM_007752|XM_006535381	XP_017174935|XP_011247957|NP_001263179|NP_031778|NP_001263177|XP_006535444	75	HGNC:22955	13562	NM_000096	XP_016861223,NP_000087,XP_006713562,XP_016861224,XP_006713563,XP_006713564,XP_011510737	
Tmem206	67513;13923;40445	10.0.8.5.5.4.5.7.3.1.8.8.2.9.8.2.8	0.0.5.8.8.2.8	0.0.8.8.2.8	MGI:1914200	66950	NM_025864	NP_080140	1097	HGNC:25593	55248	NM_001198862,NM_018252	NP_060722,XP_011508020,XP_011508019,XP_016857123,XP_005273234,XP_016857126,XP_016857125,NP_001185791,XP_016857124	

	;5380														
Ccdc124	13541;13981;69855;91355	1.0523	0.7526	0.5767	0.8853	0.8828	MGI:1916403	2348	XM_006509655|XM_134222	NP_081240|XP_006509718	4170	HGNC:25171	1E+05	NM_001136203, NM_138442	NP_612451,NP_001129675
Exoc2	11701;13999;70699;77899	1.0518	0.7701	0.5772	0.8831	0.8828	MGI:1913732	6648 2	XM_017315564|NM_025588|XM_011244327|XM_006516726|XM_011244328|XM_017315565|XM_011244326	XP_011242628|XP_017171053|NP_079864|XP_011242630|XP_011242629|XP_017171054|XP_006516789	10122	HGNC:24968	5577 0	NM_018303	XP_016866515, NP_060773,XP_016866509,XP_016866508,XP_016866513,XP_016866511,XP_016866510,XP_016866514,XP_016866512,XP_016866507
Rab31	6080;14025;45800;53500	1.0507	0.8707	0.5791	0.8828	0.8828	MGI:1914603	1065 72	NM_133685	NP_598446	5001	HGNC:9771	11031	NM_006868	NP_006859,XP_016881017,XP_016881018
Anp32e	27214;14099;37377;	1.0466	1.0204	0.5833	0.8862	0.8848	MGI:1913721	6647 1	NM_023210|NM_001253758|NM_001253757|XM_011240193	NP_075699|NP_001240687|XP_011238495|NP_001240686	41519	#N/A	#N/A	#N/A	#N/A

	90866													
H2-M3	48;14111;31122;95400	1.04565	0.09085	0.0584656	0.0885850	0.0884848	MGI:9591915	149	NM_013819	NP_038847	13255	HGNC:49644	31335	NM_002127	NP_002118,XP_016866305,XP_016866307,XP_016866306
Azi2	592;14144;33777;65088	1.04403	0.08723	0.0586548	0.0884848	0.0884848	MGI:1351332	2721 5	XM_006512147|NM_013727|NM_001286508|NM_001048146|NM_001286507|XM_011242976|XM_006512149|XR_001778916|XM_006512148	XP_006512210|XP_006512211|XP_011241278|NP_001041611|XP_006512212|NP_038755|NP_001273436|NP_001273437	8443	HGNC:24002	643 43	NM_001134433,NM_001271650,NM_022461,NM_001134432	XP_005265449,NP_001127904,XP_011532312,XP_011532311,NP_071906,NP_001258579,NP_001127905,XP_011532313
Bag6	13;14244;26322;42441	1.03589	0.07504	0.0592848	0.0891282	0.0888181	MGI:1919439	2247 27	XM_006524111|XM_006524115|NM_057171|XM_017317434|XM_006524110|XM_006524116|XM_006524113|XM_006524114|XM_006524117|XM_006524118|XM_006524109|XM_006524119|NM_001252468|XM_017317432|XM_006524112|NM_001252469|XM_017317433|XM_017317431|XM_017317436|XM_017317435	XP_006524178|XP_006524177|XP_006524182|XP_006524175|XP_017172924|XP_017172920|XP_006524174|XP_017172925|NP_001239398|XP_006524176|NP_001239397|XP_006524179|NP_476512|XP_006524173|XP_017172922|XP_006524181|XP_017172921|XP_017172923|XP_006524172|XP_006524180	3409	HGNC:13919	79 17	NM_001199697,NM_001098534,NM_001199698,NM_080702,NM_080703,NM_004639	XP_016866778,XP_016866784,XP_016866765,XP_016866785,XP_016866779,XP_016866777,NP_542433,XP_016866787,XP_016866786,NP_004630,XP_016866764,XP_016866781,XP_016866768,XP_016866770,NP_001186627,NP_001186626,XP_016866771,XP_016866773,XP_016866774,XP_016866775,XP_016866766,XP_016866780,XP_016866767,XP_016866783,NP_542434,XP_016866782,XP_016866776,XP_016866769,XP_016866772,NP_001092004,XP_011513194
Apl	47;103	1.0391	0.09589	0.0588	0.0888	MGI:	118	NM_001102456|NM_001102455|XM_006509951|	XP_006510015|NP_001095925|NP_033821|NP_	203	HGNC	33 34	NM_001328685,NM_001328682,NM_001142276,NM_001243299,	NP_001315615,NP_001135750,NP_001230228,NP_001135748,

p2	1425;2228;5566	84	07	34	91	81	880447	04	NM_009691|XM_006509952	001095926|XP_006510014	96	:598	NM_001142278, NM_001328684, NM_001642,NM_001142277,NM_001328686	NP_001315613, NP_001135749, NP_001315614, NP_001315611, NP_001633
Anapc4	26;1427;6502;7727	1.0374	1.0509	0.0594	0.0881	0.0881	MGI:1098673	520	NM_024213	NP_077175	4087	HGNC:19990	2945	NM_013367,NM_001286756	XP_005248216, NP_037499,NP_001273685,XP_011512140,XP_011512141,XP_016863627
Akap8	138;1431;3475;6454	1.0354	1.0153	0.0597	0.0888	0.0887	MGI:1928488	5639	XM_006524663|XM_006524665|XR_001782093|NM_019774|XM_006524664|NR_131219|XM_006524666|NR_131218	XP_006524726|XP_006524727|XP_006524728|NP_062748|XP_006524729	4278	HGNC:378	1027	NM_005858	NP_005849,XP_011525926,XP_016881630
Epha2	546;1435;5737;9125	1.0334	0.0883	0.0599	0.0889	0.0889	MGI:952788	1386	XM_006538528|NM_010139	XP_006538591|NP_034269	20929	HGNC:3386	1969	NM_001329090, NM_004431	XP_016856026, XP_016856025, NP_001316019, XP_016856023, NP_004422,XP_016856024
Aldh18a1	627;1438	1.0319	0.0851	0.0860	0.0889	0.0890	MGI:1888	5645	NM_153554|NM_019698	NP_062672|NP_705782	2142	HGNC:97	5832	NM_001323418, NM_001323412, NM_001323415, NM_001323413, NM_001323419, NM_001323414, NM_001323417, NM_001017423,	NP_001310345, NP_001310347, NP_001310344, NP_001017423, NP_001310348, NP_002851,NP_001310346,NP_001310342,NP_

	;8933;8937					908					22		NM_002860,NM_001323416	001310341,NP_001310343
Impa2	113;1447;26211;79766	1.0276146	0.0607549	0.0894926	0.0892663	MGI:2149728	1146	NM_053261	NP_444491	2279	HGNC:6051	361	NM_014214	NP_055029,XP_011523961,XP_011523963
Nptn	645;14522;48799;63488	1.0248481	0.0610664	0.0896426	0.0892663	MGI:1080077	203	XM_006510884|NM_009145|XM_006510883|XM_006510882|NM_001293673|XM_006510886|XM_006510885|XM_017313224	XP_017168713|XP_006510949|XP_006510945|XP_006510948|NP_033171|XP_006510947|NP_001280602|XP_006510946	10561	#N/A	#N/A	#N/A	#N/A
Smarcd2	262;14554;20018;21899	1.0239	0.0611953	0.0895326	0.0892663	MGI:1933621	8796	NM_001130187|XM_006534552|NM_031878	NP_114084|NP_001123659|XP_006534615	20671	HGNC:11107	663	NM_001330439,NM_001098426,NM_003077,NM_001330440	NP_001317368,NP_001317369,XP_005257661,XP_016880456,NP_001091896
Ankrd54	785;14576;	1.0212439	0.0611380	0.0895026	0.0892663	MGI:2444422	2236	XM_006520800|XM_017316567|NM_144849|XM_011245584|XM_017316566	XP_006520863|XP_017172056|NP_659098|XP_011243886|XP_017172055	16352	HGNC:25185	1E+05	NM_001349853,NM_138797	NP_001336782,XP_011528186,XP_011528184,XP_011528185,XP_016884080,XP_006724199,XP_011528179,XP_011528181,XP_011528180,XP_011528182,

	600;6802						09								XP_006724200, NP_620152,XP_016884082,XP_016884079
Inpp5k	7004;14611;7384;8005	1.0205	0.0831	0.0616	0.0895	0.0892	MGI:1948999	1062	XM_006532507|NM_008916|XR_388367	NP_032942|XP_006532570	7505	HGNC:33882	5176	NM_016532,NM_001135642,NM_130766	XP_016880246, XP_005256743, NP_001129114, XP_016880245, XP_011522238, XP_016880248, XP_016880247, XP_016880244, XP_011522236, NP_570122,XP_005256740,NP_057616,XP_005256742
Atrnl1	4354;14644;29044;62655	1.0901190	0.0611580	0.0895	0.0892	26	MGI:2147749	2255	XM_006527051|XM_006527049|XM_006527052|XM_006527053|NM_181415|XR_001782587|XM_011247244	XP_006527112|XP_006527116|XP_011245546|NP_852080|XP_006527114|XP_006527115	4589	HGNC:29063	2603	NM_207303,NM_001276282	XP_011537891, XP_016871527, NP_001263211, XP_011537893, XP_016871526, XP_011537890, XP_011537889, XP_016871529, NP_997186,XP_011537892,XP_016871525,XP_016871524,XP_016871528
Ddr1	1744;14688;23677;60044	1.0170	0.0960	0.0620	0.0895	0.0892	MGI:992116	1305	XM_011246259|NM_001198833|NM_001198831|NM_007584|XR_001782030|XM_006523538|XM_006523536|XM_006523535|XM_006523533|XM_006523537|XM_006523534|NM_172962	XP_006523598|XP_011244561|NP_001185762|XP_006523597|XP_006523601|NP_031610|NP_001185760|XP_006523596|NP_766550|XP_006523599|XP_006523600	6821	HGNC:2730	780	NM_001202522, NM_001297652, NM_001297654, NM_013993,NM_001954,NM_001202523,NM_001202521,NM_001297653,NM_013994	XP_006715248, XP_011513184, NP_001284582, XP_016866758, NP_001284583, XP_011513189, XP_011513190, NP_054699,NP_001945,XP_011513187,NP_054700,NP_001189451,NP_001284581,NP_001189450,NP_001189452,XP_016866757,XP_011513186,XP_011513188,XP_011513185
Tnfsf12	11311;14691;45	1.0165	0.0757	0.0621	0.0893	0.0892	MGI:1196259	2144	NM_011614	NP_035744	7979	HGNC:11927	8742	NM_003809	NP_003800

	32;53705														
Pscr1	568;14711;58556;94011	1.0156	0.0865424	0.0892626	0.0892626	MGI:893575	220238	NM_011636|XM_006511052	NP_035766|XP_006511115	4148	HGNC:9092	5359	NM_021105	XP_016862117, XP_011511209, XP_011511206, XP_005247595, XP_011511207, NP_066928,XP_011511208,XP_016862118
Dhx58	10860;14955;40422;48922	1.0040	0.075624	0.063741	0.091129	0.090677	MGI:1931560	80861	NM_030150	NP_084426	69371	HGNC:29517	79132	NM_024119	XP_016880548, XP_016880549, NP_077024
Top2b	12450;14980;65455;81833	1.0026	0.073677	0.063951	0.091117	0.090677	MGI:987791	219744	NM_009409	NP_033435	13471	HGNC:11990	7155	NM_001068,NM_001330700	XP_011532359, NP_001317629, XP_005265484, NP_001059
Fastkd3	13890;15000;50	1.0016	0.072440	0.064091	0.091017	0.090677	MGI:1916827	695777	NM_027123|NM_001330423|XR_382449|XM_006517366|NR_138478|XM_006517364|XM_017315595|NR_138477|XM_006517365|XR_382450|XM_006517367	XP_017171084|XP_006517427|XP_006517429|XP_006517430|XP_006517428|NP_001317352|NP_081399	1145	HGNC:28758	7902	NM_024091	XP_006714561, NP_076996

	79;6823													
Ubap1	67;15027;75311;90811	1.1.1.2.0.0.7.8.7.9	0.0.6.4.2.2	0.0.9.0.9.1	0.0.9.0.6.7	MGI:2149543	671 23	XM_006538197|NM_023305|XM_006538198|NM_001290454|XM_006538196	XP_006538261|XP_006538260|NP_075794|NP_001277383|XP_006538259	954	HGNC:12461	51 271	NM_001171204, NM_001171203, NM_001171201, NM_001171202, NM_016525	NP_001164675, NP_001164672, XP_011516202, XP_016870291, XP_006716842, XP_016870290, NP_001164674, XP_011516200, XP_011516201, NP_001164673, NP_057609
Chd1	733;15055;24344;93888	0.0.9.9.3.3	0.0.8.1.3.5	0.0.6.4.4.1	0.0.9.0.8.9	0.0.9.0.6.7	MGI:883933	1 2 6 4 8	NM_007690	NP_031716	6817 4	HGNC:19155	1 1 0 5	NM_001270	XP_005271924, NP_001261,XP_016864481,XP_016864480,XP_005271923,XP_011541414
H2-Ke6	477;15077;38767;58377	0.0.9.9.8.3	0.0.8.8.5.4	0.0.6.4.5.4	0.0.9.0.7.8	0.0.9.0.6.7	MGI:959111	1 4 9 7 9	NM_013543	NP_038571	5658 8	HGNC:35544	7 9 2 3	NM_014234	NP_055049
Acp6	1243;15100;26711;	0.0.9.9.6.9	0.0.7.3.5.1	0.0.6.4.7.4	0.0.9.0.7.6	0.0.9.0.6.7	MGI:1931010	6 6 6 5 9	NM_019800|XR_375565|XR_375566	NP_062774	4112 8	HGNC:29609	5 1 2 0 5	NM_001323625, NM_016361	NP_001310554, NP_057445,XP_016856911,XP_011507903

	7560														
Guk1	20;15123;37433;42377	0.9960	10.0560	0.0648	0.0906	0.0677	MGI:958711	149233	XM_006532245|NM_008193|NM_001159410|XM_006532246	XP_006532309|NP_032219|NP_001152882|XP_006532308	665	HGNC:4693	29887	NM_000858,NM_001159390,NM_001242839,NM_001159391,NM_001242840	NP_001152863,NP_001229768,NP_001152862,XP_005273161,XP_005273163,XP_016856584,NP_001229769,XP_016856582,XP_005273162,XP_016856585,XP_011542476,NP_000849,XP_005273160,XP_016856581,XP_016856580,XP_016856583
Vegfa	139;15204;33045;39155	0.992200	10.1654213	0.0911139	0.0911139		MGI:103178	223239	NM_001025257|NM_001025250|NM_001317041|NM_001110267|NM_001287058|NM_001287057|NM_009505|NM_001110266|NM_001287056|NM_001110268	NP_001103737|NP_001273986|NP_001273985|NP_001020421|NP_001303970|NP_001103738|NP_001103736|NP_033531|NP_001273987|NP_001020428	2534	HGNC:12680	74222	NM_001025370,NM_001025366,NM_001025367,NM_001171626,NM_001033756,NM_001317010,NM_001204384,NM_001171628,NM_003376,NM_001025369,NM_001171630,NM_001204385,NM_001287044,NM_001171629,NM_001171624,NM_001171623,NM_001025368,NM_001171622,NM_001171627,NM_001171625	NP_001165097,NP_001020538,NP_001165096,NP_001273973,NP_001165098,NP_001191314,NP_001020540,NP_001165099,NP_003367,NP_001028928,NP_001191313,NP_001165094,NP_001020539,NP_001165095,NP_001303939,NP_001165100,NP_001020541,NP_001020537,NP_001165093,NP_001165101
Cmklr1	140;15311;60711;73922	0.981	0.0.9716	0.0.9187	0.0.9162		MGI:1096033	147477	XM_006530165|XM_006530164|NM_008153|XM_006530166	XP_006530229|NP_032179|XP_006530228|XP_006530227	12967	HGNC:21211	12401	NM_001142344,NM_001142345,NM_001142343,NM_004072	NP_004063,NP_001135817,NP_001135815,NP_001135816,XP_016874309
Kiz	427;15333;48577;	0.9862	0.0.9028	0.0.9628	0.0.9175	0.0.9162	MGI:2684960	228730	XM_006499300|XM_130476|XM_006499298|XM_011239478|XM_006499299	XP_011237780|NP_001028470|XP_006499361|XP_006499362|XP_006499363	10219	HGNC:15865	55857	NM_001163022,NM_001163023,NM_001276389,NM_001352434,NM_018474,NM_001352435,NM_001352436	NP_001263318,XP_016883441,XP_016883440,XP_011527598,NP_060944,NP_001156495,XP_016883443,XP_011527599,XP_011527601,NP_001339364,NP_001339363,XP_011527600,NP_001156494,NP_

	80177													001339365,XP_016883442
Rgcc	95;15377;46522;;94499	0.98433	1.20588	0.66544	0.91811	0.91622	MGI:1913464	6214	NM_025427	NP_079703	8544	HGNC:20369	28984	NM_014059	NP_054778
Dusp14	14461;15388;37055;;81266	0.98388	0.71812	0.66161	0.91622	0.91622	MGI:1927168	5640 5	XM_006533796|XM_006533799|XM_006533797|XM_006533798|NM_019819	XP_006533860|XP_006533859|XP_006533861|NP_062793|XP_006533862	5100	HGNC:17007	11072	NM_007026	XP_005257034,NP_008957,XP_011522536
Fbxl2	92443;15433;56533;;93633	0.98166	0.76881	0.66955	0.91779	0.91779	MGI:1919429	7179	XM_006512295|XR_379879|XM_011243027|XR_379878|XM_011243028|NM_178624|XR_379880|XM_006512294	NP_848739|XP_006512358|XP_011241330|XP_011241329|XP_006512357	13581 4	HGNC:13598	25827	NM_001349316,NM_001349324,NM_012157,NM_001349319,NM_001171713,NM_001349320,NM_001349326,NM_001349325,NM_001349321,NM_001349322,NM_001349323	NP_001165184,XP_005265073,NP_001336250,XP_016861582,NP_001336245,NP_001336252,XP_005265072,NP_001336255,XP_005265074,NP_001336248,NP_001336253,XP_011531861,NP_001336251,NP_001336254,XP_005265071,XP_016861581,XP_016861583,NP_001336249,NP_036289
Calm1	98251;15511;49277;;62	0.97793	0.97573	0.67492	0.92248	0.91888	MGI:8825511	1313	NM_009790|NM_001313934	NP_001300863|NP_033920	11617	#N/A	#N/A	#N/A	#N/A

Mpp5	6612753;15573;83643;87288	0.9752	0.721	0.6787	0.9247	0.9188	MGI:1927339	5617	NM_019579|XM_006516098|XM_006516097|XM_017315139	XP_006516160|XP_017170628|XP_006516161|NP_062525	9512	HGNC:18669	6439	NM_001256550, NM_022474	XP_005268060, NP_071919,XP_011535388,NP_001243479,XP_011535389
Hipk3	7803;15633;50023;69233	0.97255	0.7900	0.68277	0.92772	0.9188	MGI:1314882	1525 9	NM_001145824|NM_010434	NP_034564|NP_001139296	55923	HGNC:49155	10114	NM_001278162, NM_001278163, NM_001048200, NM_005734	XP_005252786, NP_001041665, NP_005725,XP_016872566,NP_001265091,NP_001265092,XP_016872565
Igsf3	6683;15673;32722;81766	0.97077	0.8148	0.68554	0.92811	0.9188	MGI:1926158	7908	XM_006502343|XM_006502342|XM_194109|XM_011240287	NP_997088|XP_006502405|XP_011238589|XP_006502406	1182	HGNC:59500	3321	NM_001542,NM_001007237	XP_011539617, XP_011539618, XP_006710656, XP_005270850, NP_001533,XP_005270851,NP_001007238
Efna2	15663;15699;83029	0.96988	0.6962	0.68677	0.92700	0.9188	MGI:1027077	1363 7	NM_007909	NP_031935	1075	HGNC:32222	1943	NM_001405	NP_001396,XP_016881938,XP_016881939

Tnip2	79463;15722;26333;37822	0.0.0.0.0.0	9.8.6.9.9.1	6.7.8.8.2.8	8.8.8.6.6.8	9.9.6.6.3.8	MGI:2386643	231130	NM_139064	NP_620703	11515	HGNC:19118	79155	NM_024309,NM_001161527,NM_001292016	NP_077285,NP_001278945,NP_001154999
Slc16a3	50863;15733;40275;58455	0.0.0.0.0.0	9.8.6.9.9.1	6.6.8.2.4.8	8.1.9.0.7.8	0.6.3.3.3.9	MGI:1933438	80879	NM_001038653|NM_030696|XM_011249321|NM_001038654|XM_011249322	XP_011247624|NP_001033743|NP_001033742|NP_109621|XP_011247623	37900	HGNC:10924	91235	NM_001042422,NM_001206951,NM_001206950,NM_001206952,NM_001042423,NM_004207	XP_011521909,NP_001193880,NP_001193879,NP_004198,NP_001193881,NP_001035888,NP_001035887
Trps1	14326;15773;43577;45299	0.0.0.0.0.0	9.7.6.9.9.1	6.0.9.2.5.8	6.3.2.0.6.8	4.4.0.6.1.6	MGI:1927616	83925	XM_011245777|NM_001310481|NM_032000|NM_001310485|XM_011245780|XM_006521560|XM_006521563|XM_011245776|XM_011245778	XP_011244078|XP_006521623|XP_011244082|NP_001297414|XP_011244079|XP_006521626|XP_011244080|NP_001297410|NP_114389	85560	HGNC:12340	72277	NM_001282903,NM_014112,NM_001282902,NM_001330599	XP_011515568,XP_011515569,XP_005251106,NP_054831,XP_011515566,XP_016869290,XP_006716688,NP_001269831,NP_001317528,NP_001269832,XP_011515570
Slc4a1ap	78653;15781;50865;90229	0.0.0.0.0.0	9.7.6.9.9.1	6.8.9.2.3.8	5.5.7.7.6.8	4.4.4.1.0.8	MGI:1196608	20534	NM_009206|XM_006503811|NM_001347328|XM_006503809|XM_017320752|XM_006503808|XM_006503810	XP_006503873|XP_006503872|XP_017176241|NP_033232|NP_001334257|XP_006503871|XP_006503874	75433	HGNC:13813	22950	NM_018158	NP_060628

Ahr	76;15579;49544;92588	0.96534	1.24334	0.69334	0.92117	0.91888	MGI:1050443	116122	NM_001314027|NM_013464	NP_038492|NP_001300956	1224	HGNC:3488	196	NM_001621	NP_001612
Ehd3	6144;15811;34466;45988	0.96441	0.82618	0.69488	0.92088	0.91888	MGI:1928900	57440	NM_020578	NP_065603	818387	HGNC:32444	30845	NM_014600	NP_055415,XP_011531108
Gba	186;15833;43811;56200	0.96355	1.05562	0.69162	0.91988	0.91888	MGI:956565	144166	NM_008094|NM_001077411|XM_006500998|XM_006500997|NR_122037	XP_006501060|NP_001070879|NP_032120|XP_006501061	68040	HGNC:4177	269	NM_001005749, NM_001005742, NM_001171811, NM_001005750, NM_001171812, NM_001005741, NM_000157	NP_001165283, NP_001005742, NP_001165282, NP_000148,NP_001005741
Tmem173	117;15855;89200;97122	0.96266	1.15122	0.69175	0.91888	0.91888	MGI:1919762	725122	NM_001289591|XM_128954|NM_001289592|XM_017317994	NP_001276521|NP_082537|NP_001276520|XP_017173483	188688	HGNC:27962	3E+05	NM_198282,NM_001301738	NP_938023,XP_011535941,XP_005268502,NP_001288667,XP_011535942
Stxb	926;	0.955	0.775	0.700	0.992	0.992	MGI:	209	NM_009295|NM_001113569	NP_033321|NP_001107041	2382	HGNC	6812	NM_003165,NM_001032221	NP_001027392, NP_003156

p1	159;331;3244;9454	91	66	31	34	15	1073;63	10				:1144			
Jmy	164;1594;4051;56188	0.958690	1.07038	0.92155	0.9215	MGI:1913096	5748	NM_021310	NP_067285	1055	HGNC:28916	1E+05	NM_152405	XP_011541457, XP_005248487, NP_689618	
Slc29a2	525;1600;2461;57866	0.954860	0.84907	0.70882	0.92426	MGI:1345278	1340	XM_006531664|XM_017318055|NM_007854|XM_017318057|XM_017318056	XP_017173544|XP_017173545|XP_006531727|NP_031880|XP_017173546	37493	HGNC:11004	317	NM_001300868, NM_001532,NM_001300869	NP_001287797, XP_016873126, XP_016873123, XP_011543276, XP_016873119, XP_016873125, NP_001523,XP_016873122,XP_016873124,XP_016873127,NP_001287798,XP_016873120,XP_016873121	
Orai1	528;16013;53996;73166	0.955584	0.84089	0.92266	0.92266	MGI:1925542	1093	XM_006530116|NM_175423|XM_006530117	XP_006530179|XP_006530180|NP_780632	13117	HGNC:25896	8487	NM_032790	NP_116179	
Map2k1	154;516	0.954343	0.68971	0.71102	0.92266	MGI:134	26395	NM_008927|XM_006511196	NP_032953|XP_006511259	2063	HGNC:68	5604	NM_002755	NP_002746,XP_016877901,XP_016877900,XP_011520085,XP_016877902	

	04;6306;6467				6866					40				
Fzd2	764;16144;27394;38022	0.94991	0.7821	0.71809	0.92899	0.92699	MGI:1888513	5726	NM_020510	NP_065256	2037	HGNC:4040	2535	NM_001466	NP_001457
G3bp1	931;16166;20311;49944	0.94907	0.75073	0.71993	0.92789	0.92699	MGI:1351465	2704	XM_006533444|NM_013716	XP_006533507|NP_038744	38096	HGNC:30292	1016	NM_198395,NM_005754	NP_005745,NP_938405,XP_016864412,XP_006714812,XP_016864411,XP_006714813
Hdac4	1450;16183;31411;69955	0.94832	0.69301	0.72008	0.92771	0.92699	MGI:3036234	2087327	XM_006529311|XM_136806|XM_017319486|XM_017319479|XM_017319501|XM_017319477|XM_017319478|XM_017319487|XM_006529314|XM_006529315|XM_017319482|XM_006529313|XM_017319488|XM_006529312|XM_017319480|XM_017319498|XM_017319476	XP_017174987|XM_017174965|NP_997108|XP_006529376|XP_017174990|XP_017174975|XP_017174967|XP_006529377|XP_017174971|XP_006529378|XP_017174969|XP_017174968|XP_017174977|XP_017174976|XP_017174966|XP_006529374|XP_006529375	55946	HGNC:14063	975	NM_006037	XP_011510524,XP_006712940,XP_011510520,XP_011510519,XP_011510526,XP_011510532,NP_006028,XP_016860884,XP_011510522,XP_011510521,XP_011510528,XP_016860883,XP_011510523,XP_011510525,XP_006712943,XP_006712941,XP_011510527,XP_011510529,XP_006712942
Rdx	794;16211	0.94693	0.77432	0.72269	0.92699	0.92699	MGI:9788	1968	NM_001104617|NM_001104616|NM_009041	NP_001098086|NP_001098087|NP_033067	37707	HGNC:999	596	NM_002906,NM_001260495,NM_001260493,NM_001260492,NM_001260494,NM_001260496	NP_001247425,NP_002897,NP_001247421,NP_001247423,NP_001247424,NP_001247422

	;412;4;794					87				44				
Map3k2	126;1624;367;710	0.946	0.072	0.725	0.927	0.971	MGI:1346873	26405	NM_011946	NP_036076	7457	HGNC:6854	1074	NM_006609	NP_006600
Dusp1	866;1631;2729;5416	0.9426	0.7585	0.7300	0.9307	0.9297	MGI:1051120	19252	NM_013642	NP_038670	3254	HGNC:30644	1843	NM_004417	NP_004408
Frs2	1506;1633;5976;7158	0.94170	0.6860	0.7315	0.9299	0.9297	MGI:1100860	32782	NM_177798	NP_808466	4846	HGNC:16971	10818	NM_001278356, NM_001278351, NM_001278353, NM_001278355, NM_001278357, NM_001278354, NM_001042555, NM_006654	NP_001036020, NP_001265280, NP_001265283, NP_001265285, NP_001265286, XP_016874207, XP_016874206, NP_006645,XP_016874208,NP_001265284,NP_001265282
Fam132a	1112;1648	0.9354	0.7187	0.7420	0.9404	0.9297	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

	;6875;9336														
Kat2b	918;16500;56491;61244	0.974345	0.743394	0.93297	MGI:1343094	1519	XM_006523820|XR_385299|NM_001190846|NM_020005|XR_001782056	XP_006523883|NP_001177775|NP_064389	20834	HGNC:8638	850	NM_003884	XP_016862913,XP_016862912,XP_005265585,NP_003875
Mtmr3	12593;16511;66899;80211	0.973411	0.743975	0.93297	MGI:1921552	7430 2	XM_006514846|XM_017314807|XM_006514845|NM_028860|XM_006514847|XM_006514848	XP_017170296|XP_006514908|XP_006514909|XP_006514911|XP_006514910|NP_083136	23662	HGNC:74511	897	NM_153050,NM_001013676,NM_153051,NM_021090	XP_005261862,XP_016884523,XP_005261860,NP_694690,XP_016884520,XP_005261865,XP_016884518,XP_016884521,XP_005261861,XP_016884522,NP_694691,XP_005261863,NP_066576,XP_016884517,XP_016884519
Mum1	10366;16522;20499;49588	0.973776	0.744757	0.93297	MGI:1915364	6811 4	XM_006514026|NM_023431|XM_006514025	XP_006514088|NP_075920|XP_006514089	11349	HGNC:29641	8493 9	NM_032853	XP_011526684,XP_011526685,NP_116242,XP_016882890,XP_011526687,XP_011526682,XP_011526686
Cep152	758;16533;	0.973330	0.774539	0.93297	MGI:2139 0	9910 0	XM_006500473|XM_017319354|XM_011239871|XR_001783212|XR_001783214|NM_001081091|XR_001783213|XM_006500474|XM_011239870	XP_011238172|XP_017174843|XP_006500536|NP_001074560|XP_011238173|XP_006500537	37159	HGNC:2922	2299 5	NM_014985,NM_001194998	NP_001181927,NP_055800,XP_011519681,XP_011519677,XP_011519683,XP_016877503,XP_006720500,XP_016877504,XP_011519676,XP_

	3639;5314						83				98				011519675,XP_011519680,XP_016877505
Dusp16	7555;16565;64377;70800	0.9320	0.7750	0.7476	0.9340	0.9297	MGI:1917936	7068	NM_130447|NM_001048054	NP_569714|NP_001041519	1560	HGNC:17909	8082	NM_030640	XP_005253545, XP_011519159, XP_016875477, XP_006719218, NP_085143,XP_011519158
Ak3	16467;16557;37177;41844	0.9316	0.6725	0.7483	0.9322	0.9297	MGI:1860835	5624	NM_021299|XM_006527285	XP_006527285|NP_067274	2174	HGNC:17376	508	NM_001199853, NM_001199856, NM_001199855, NM_001199852, NM_016282,NM_001199854	NP_001186784, NP_001186781, NP_057366,NP_001186785,NP_001186782
Snai1	6693;16600;23887;53611	0.9304	0.7884	0.7504	0.9322	0.9297	MGI:983330	2061	NM_011427	NP_035557	4363	HGNC:11128	6615	NM_005985	NP_005976
Papss1	10355;16611;6	0.9299	0.7258	0.7512	0.9305	0.9297	MGI:1330587	2397	NM_011863|NM_001289479|NM_001289477|NM_001289478	NP_035993|NP_001276406|NP_001276407|NP_001276408	8174	HGNC:8603	9061	NM_005443	XP_011530703, XP_011530702, NP_005434

	9 3 6 ; 9 1 9 3														
Herc6	1 4 3 7 ; 1 6 6 3 ; 5 3 8 7 ; 9 0 0 5	0 . 9 2 9 1	0 . 6 8 4 5	0 . 7 5 2 7	0 . 9 2 9 7	0 . 9 2 9 7	MGI:1914388	671 38	NM_025992	NP_080268	7 0 7 6 8	HGNC:26072	55 08	NM_001013005, NM_001013000, NM_017912,NM_001013002,NM_001165136	NP_060382,NP_001158608,XP_011530355,XP_016863822,XP_005263140
Cyth3	9 4 2 ; 1 6 7 2 ; 5 3 5 9 ; 6 4 4 9	0 . 9 2 5 4	0 . 7 3 7 2	0 . 7 5 9 5	0 . 9 3 5 4	0 . 9 3 4 7	MGI:1335107	191 59	NM_011182|XM_017320729|NM_001163548	NP_001157020|XP_017176218|NP_035312	3 1 6	HGNC:9504	92 65	NM_004227	NP_004218
Fyn	6 2 8 ; 1 6 7 4 ; 7 2 8 5 ; 8 4 9 9	0 . 9 2 4 5	0 . 8 0 2 3	0 . 7 6 1 1	0 . 9 3 4 7	0 . 9 3 4 7	MGI:9560 2	143 60	NM_001122893|XM_006512539|NM_001122892|XM_011243117|NM_008054|XM_006512540	XP_006512602|NP_001116364|NP_032080|NP_001116365|XP_006512603|XP_011241419	4 8 0 6 8	HGNC:4037	25 34	NM_002037,NM_153047,NM_153048,NM_001242779	NP_694593,XP_016866142,XP_016866139,XP_005266949,NP_002028,XP_016866144,NP_694592,XP_016866143,XP_005266947,XP_016866140,XP_016866141
Sash1	1 0 0 2 ; 1 6 8 0 ; 5 7	0 . 9 2 2 1	0 . 7 2 6 5	0 . 7 6 5 3	0 . 9 3 7 3	0 . 9 3 5 5	MGI:1917347	707 7	NM_175155|XM_006512839|XM_006512840|XM_011243205|XM_006512841|XM_006512837|XM_017314079	XP_017169568|XP_006512904|XP_006512900|XP_006512902|XP_011241507|XP_006512903|NP_780364	6 9 1 8 2	HGNC:19182	23 32 8	NM_001346507, NM_001346506, NM_001346508, NM_001346505, NM_001346509, NM_015278	NP_056093,XP_016866092,NP_001333435,NP_001333438,XP_016866088,NP_001333434,XP_016866089,XP_016866087,XP_016866094,XP_005266932,XP_011533942,XP_016866096,XP_

	05;6468													016866091,XP_016866093,NP_001333436,XP_016866095,XP_016866090,NP_001333437
Bivrb	1415;1681;6568;8898	0.92177	0.68244	0.76760	0.93555	0.93555	MGI:2385271	23016	NM_001290525|NM_144923	NP_659172|NP_001277454	573	HGNC:10633	645	NM_000713	NP_000704
Cdc42ep3	1189;1684;2369;2864	0.92044	0.70244	0.76811	0.93555	0.93555	MGI:2384718	26040	NM_026514|XM_006524295	XP_006524358|NP_080790	4708	HGNC:16943	1060	NM_001270436,NM_001270438,NM_001270437,NM_006449	NP_001257366,NP_001257365,NP_006440,XP_011530784,NP_001257367
Smurf2	1018;1694;31244;67711	0.91633	0.72144	0.77533	0.94166	0.93822	MGI:1913563	66313	XM_126673|XM_006533936|XM_017314705|XR_001780039	XP_006533999|XP_017170194|NP_079757	41490	HGNC:16809	6475	NM_022739	XP_005257642,XP_011523430,NP_073576
Myl12a	1481;1696;;5	0.91555	0.67466	0.77666	0.94066	0.93822	MGI:1914518	67268	XM_006524822|NM_026064	XP_006524885|NP_080340	68515	HGNC:29827	1E+05	NM_033546,NM_001144944,NM_001144946,NM_001144945	NP_001138417,NP_291024,NP_001138416

	290;6530														
Smarcd3	250;1698;7409;7597	0.914713	0.977182	0.793982	0.938382	0.938382	MGI:1914243	6693	XM_006535797|XR_389749|XM_006535798|XM_017321074|NM_025891|XM_006535799|XM_006535796	NP_080167|XP_006535861|XP_006535860|XP_006535862|XP_006535859|XP_017176563	2314	HGNC:11108	6604	NM_003078,NM_001003802,NM_001003801	NP_001003802,NP_001003801,NP_003069,XP_016868045,XP_011514823
Ppm1l	97;1699;4821;51722	0.914363	0.772630	0.779082	0.938382	0.938382	MGI:2139740	24083	XM_011240119|XM_006501470|NM_178726	NP_848841|XP_006501533|XP_011238421	3315	HGNC:16381	2E+05	NM_001317911,NM_001317912,NM_139245	XP_011510742,NP_640338,NP_001304840,NP_001304841
Ptk2	351;1708;6507;83199	0.910707	0.902453	0.785333	0.943303	0.943303	MGI:954481	140883	XR_383981|XM_006520421|XM_006520418|XM_006520434|XM_011245452|XM_011245453|XM_006520426|XM_006520420|XM_006520423|XM_006520416|XM_006520425|XM_006520432|XM_006520428|XM_006520427|XM_017316429|XM_006520435|XM_006520431|XM_006520415|XM_006520424|XM_006520429|NM_007982|XM_006520430|XM_006520433|XM_006520422|XR_001781493|NM_001130409|XM_017316428	NP_032008|XP_006520491|XP_006520484|XP_006520490|XP_011243755|XP_017171918|XP_006520485|XP_006520478|XP_006520496|XP_006520495|NP_001123881|XP_006520487|XP_006520498|XP_006520479|XP_017171917|XP_006520497|XP_006520486|XP_006520488|XP_006520494|XP_006520481|XP_006520483|XP_011243754|XP_006520489|XP_006520493|XP_006520492	7314	HGNC:9611	5747	NM_001352733,NM_001352697,NM_001352716,NM_001352746,NM_001352738,NM_001352752,NM_001352706,NM_001352740,NM_001352747,NM_001352723,NM_001352735,NM_001352732,NM_001352709,NM_001352701,NM_153831,NM_001352703,NM_001352712,NM_001352737,NM_001352741,NM_001352717,NM_001199649,NM_001352707,NM_001316342,NM_001352743,NM_001352720,NM_001352695,NM_001352699,NM_001352718,NM_001352711,NM_001352694,NM_001352745,NM	XP_016869172,NP_001339624,XP_016869145,XP_016869164,XP_016869155,XP_006716671,NP_001339671,XP_016869165,NP_001339679,XP_016869173,XP_016869169,XP_016869148,XP_016869176,NP_001339680,XP_005251070,NP_001339650,NP_001339658,NP_001339672,XP_016869159,XP_016869153,XP_016869162,NP_001339668,NP_001339627,XP_016869150,XP_016869178,NP_001339642,NP_001339667,NP_001339654,NP_001339665,XP_016869163,XP_016869144,

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1352731,NM_00	NP_001339662,
1352719,NM_00	NP_001339645,
1352721,NM_00	NP_001339635,
1352729,NM_00	XP_016869166,
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	001339670,XP_

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Foxm1	112;1710;4830;6758	0.090999	0.070466	0.078669	0.094255	0.094033	MGI:1347487	1423 5	NM_008021	NP_032047	7318	HGNC:38188	2305	NM_001243089, NM_001243088, NM_202003,NM_021953,NM_202002	NP_001230018, XP_005253733, XP_011519232, XP_011519233, NP_001230017, XP_011519234, NP_973732,NP_973731,NP_068772,XP_011519237,XP_011519235,XP_011519236
Sik3	1268;1714;3095;7308	0.090883	0.068833	0.078999	0.094355	0.094033	MGI:2446296	7061	XM_006510590| XM_194455	XP_006510653| NP_081774	57023	HGNC:29165	2337	NM_001281748, NM_025164,NM_001281749	NP_001268677, XP_011541025, XP_011541023, XP_011541024, XP_011541027, XP_005271541, XP_005271538, XP_005271542, NP_001268678, XP_016872913, NP_079440,XP_016872916,XP_016872914,XP_011541026,XP_016872915,XP_011541028,XP_005271539
Evc2	1080;1715;3704;5611	0.090789	0.070899	0.079069	0.094199	0.094033	MGI:1915775	6852 5	NM_145920|XM_006504082	XP_006504145| NP_666032	17117	HGNC:19747	1E+05	NM_147127,NM_001166136	XP_016863228, XP_016863227, XP_016863226, XP_016863224, XP_016863225, NP_667338,NP_001159608
Aif1l	1331;1717;2250	0.090711	0.068220	0.079222	0.094113	0.094033	MGI:1919598	1089 7	NM_145144	NP_660126	12863	HGNC:28904	835433	NM_001185096, NM_001002260, NM_001185095, NM_031426	NP_001172024, XP_016870666, NP_113614,NP_001172025

	;474242														
Fscn1	10516;17199;24500;55582	0.907163	0.718	0.793936	0.940303	0.94033	MGI:1352745	1408	NM_007984	NP_032010	481644	HGNC:11148	6624	NM_003088	NP_003079
Trap	857;17272;38722;78644	0.903101	0.74044	0.794096	0.940483	0.94033	MGI:2153272	1068 3	XM_006504790|XM_006504786|XM_006504789|XR_377189|XM_006504787|XM_006504794|XM_006504782|XM_017320576|XM_017320577|XM_006504788|XM_006504785|XM_011240999|XM_006504795|XM_017320578|XM_006504793|NM_001081362|XM_006504783|XM_006504792|XM_006504784|XM_017320575|XR_377190|XM_006504781	XP_006504855|XP_006504851|XP_017176064|XP_006504847|XP_006504844|XP_006504848|XP_006504846|XP_006504850|NP_001074831|XP_006504845|XP_017176066|XP_006504849|XP_011239301|XP_006504852|XP_006504856|XP_006504853|XP_006504858|XP_017176065|XP_017176067|XP_006504857	39246	HGNC:12347	8295	NM_001244580,NM_003496	NP_001231509,NP_003487
Tchp	898;17282;26633;72111	0.902730	0.733031	0.803103	0.943103	0.94033	MGI:1925082	7783 2	XM_006530508|NM_029992|XM_006530509|XM_006530511|XM_006530510	XP_006530571|XP_006530574|XP_006530572|NP_084268|XP_006530573	12686	HGNC:28135	8426 0	NM_032300,NM_001143852	XP_011537139,NP_001137324,NP_115676,XP_016875513,XP_016875514,XP_011537138
Ddx50	10343;17342	0.907003	0.71012	0.804757	0.940303	0.94033	MGI:2182303	9421 3	XM_006514346|XM_011243608|XM_006514345|NM_053183	XP_006514409|XP_011241910|NP_444413|XP_006514408	56986	HGNC:17906	7900 9	NM_024045	XP_016872119,XP_016872117,XP_016872115,XP_016872118,XP_011538446,XP_005270205,NP_076950,XP_016872116

	702;6814														
Mknk1	3843;1741;3703;5114	0.897876	0.878609	0.894903	0.940343	MGI:894316	1736	XM_006502825|NM_021461|NM_001285488|XM_017320015|XM_006502823|XM_006502822|NM_001285487	XP_006502886|NP_067436|NP_001272416|XP_017175504|NP_001272417|XP_006502888|XP_006502885	37838	HGNC:7110	8569	NM_198973,NM_003684,NM_001135553	XP_016858142,NP_001129025,NP_003675,XP_006711070,XP_016858143,XP_016858151,XP_006711078,XP_016858145,XP_016858146,XP_016858155,XP_016858153,XP_016858144,XP_006711064,XP_016858157,NP_945324,XP_016858150,XP_016858148,XP_006711076,XP_006711063,XP_006711069,XP_016858156,XP_016858154,XP_016858141,XP_006711066,XP_016858149,XP_016858147,XP_006711072,XP_016858152,XP_006711065,XP_006711077
Cpne3	1440;1742;2939;5660	0.897223	0.668307	0.810707	0.947076	0.940343	MGI:1917818	7058	NM_027769|XM_017320384	NP_082045|XP_017175873	20839	HGNC:23166	8895	NM_003909	XP_005251150,NP_003900,XP_016869434
Cap1	6903;1744;2971;4732	0.897644	0.772222	0.812229	0.946903	0.940343	MGI:882662	1231	NM_007598|NM_001301067|XM_006502697|XM_006502695	XP_006502758|NP_001287996|NP_031624|XP_006502760	74572	HGNC:2004	1048 7	NM_001350477,NM_001350485,NM_001330502,NM_001350481,NM_001350480,NM_001105530,NM_001350475,NM_001350478,NM_001350484,NM_006367,NM_001350476,NM_001350479,NM_001350483,NM_001350482	XP_011538813,XP_016855558,NP_001337410,NP_001337407,NP_001337408,NP_001337412,NP_006358,XP_016855560,NP_001337406,XP_011538815,XP_011538814,NP_001099000,NP_001317431,XP_005270425,XP_016855562,NP_001337413,NP_001337404,XP_011538817,NP_

															001337409,XP_016855561,NP_001337405,XP_011538812,NP_001337414,XP_016855556,XP_016855557,NP_001337411,XP_016855559,XP_011538811,XP_011538816
Lapt m4a	114;1745;5377;5413	0.0.0.0.0.0	0.8.6.8.9.9	0.9.5.1.4.4	0.6.2.3.5.0	0.0.0.0.0.3	MGI:1080117	1775	NM_008640	NP_032666	7427	HGNC:6924	9741	NM_014713	NP_055528
Abr	35;1746;3508;5441	0.0.0.0.0.0	0.8.8.8.9.9	0.9.8.1.4.5	0.5.7.3.3.6	0.0.0.0.0.3	MGI:1077711	1094	XM_006531982|XM_006531984|NM_001346670|NM_001291186|NM_198895|NM_198018|NM_198894	NP_942598|NP_942597|XP_006532045|NP_932135|NP_001278115|NP_001333599|XP_006532047	11081	HGNC:81	29	NM_021962,NM_001092,NM_001322842,NM_001322840,NM_001256847,NM_001282149,NM_001159746,NM_001322841	XP_016880032,XP_016880031,XP_016880028,XP_011522114,XP_011522115,XP_011522117,NP_001083,NP_001243776,XP_011522112,NP_001269078,XP_016880030,NP_068781,NP_001309769,XP_011522116,NP_001309771,NP_001153218,XP_011522113,XP_016880029,NP_001309770
Rps6ka6	1725;1747;3987;9701	0.0.0.0.0.0	0.8.6.8.9.9	0.9.5.1.4.4	0.5.2.0.4.1	0.5.2.0.4.3	MGI:1914321	6701	XM_006528400|XM_006528401|XM_011247706|NM_025949|XM_006528403|XM_011247707|XM_006528402|XM_006528404	XP_006528466|XP_006528467|XP_011246008|XP_006528463|XP_011246009|NP_080225|XP_006528464|XP_006528465	22816	HGNC:10435	2730	NM_014496,NM_001330512	XP_011529222,XP_016884912,XP_016884915,XP_016884914,NP_055311,NP_001317441,XP_016884913,XP_011529221,XP_011529220,XP_011529219
Snap91	1723;117	0.0.0.0.0.0	0.8.6.8.9.9	0.9.5.1.4.4	0.4.0.5.0.3	0.4.3.3.0.3	MGI:109	2061 6	XM_006510902|NM_001277986|XM_006510904|XM_017313237|NM_001277985|XM_006510900|XM_006510894|	XP_006510960|XP_006510963|NP_001264915|XP_006510957|NP_038697|NP_001264912|XP_017168725|XP_	84291	HGNC:14	9892	NM_001256718,NM_001256717,NM_014841,NM_001242793,NM_001242794,NM_001242792	XP_016867071,XP_016867045,XP_011534577,XP_016867070,XP_016867043,XP_016867064,XP_016867044,

	48;448;838						13 2	XM_006510899|XM_006510895|XM_017313236|XM_006510901|XM_006510903|NM_013669|XM_006510897|XM_006510898|NM_001277982|XM_006510896|NM_001277983|NR_102729	017168726|XP_006510959|XP_006510962|XP_006510966|NP_001264911|NP_001264914|XP_006510958|XP_006510964|XP_006510965|XP_006510961|XP_006510967	98 6			XP_016867072, XP_016867067, XP_016867060, XP_016867049, XP_016867052, XP_016867069, XP_016867057, XP_011534579, XP_016867063, XP_016867054, XP_016867055, XP_016867061, XP_016867059, XP_011534573, XP_005248827, NP_001229723, XP_016867050, XP_016867051, XP_011534567, NP_001243647, XP_006715678, XP_016867068, XP_016867062, XP_016867058, XP_016867079, XP_016867074, XP_011534568, NP_001243646, NP_055656,XP_016867075,XP_016867073,XP_016867078,NP_001229721,NP_001229722,XP_016867076,XP_016867077,XP_011534571,XP_016867066,XP_016867053,XP_011534575,XP_016867047,XP_011534578,XP_016867046,XP_016867056,XP_016867048,XP_016867065
Gnas	49;388;934;177;517;229;895;656	0.0.0.0.0.0	MGI:957777	146833	XR_374413|XM_006498780|NM_010309|XM_006498777|NM_001077510|XR_374414|XM_006498778|NM_201617|NM_022000|NM_001310083|NR_003258|NM_001077507|XM_006498776|XM_006498779|NM_019690|NM_001310085|XM_017315658|NM_201616|NM_201618|XM_006498774	XP_017171147|XP_006498837|NP_001297014|NP_963910|NP_068840|NP_001070978|NP_062664|NP_963911|NP_034439|XP_006498841|NP_001070975|XP_006498839|XP_006498840|NP_963912|XP_006498842|XP_006498843|NP_001297012	55 55 34	HGNC:4392	27 78	NM_000516,NM_001309861,NM_001309842,NM_001309883,NM_016592,NM_001309840,NM_001077490,NM_001077489,NM_001077488,NM_080425,NM_080426	XP_016883308, XP_016883310, NP_001070956, XP_016883307, XP_016883306, NP_000507,XP_016883304,XP_016883309,NP_001296812,NP_536351,NP_057676,NP_536350, NP_001070957, XP_016883301, XP_016883303, NP_001296769, XP_016883302, XP_016883305, NP_001070958, NP_001296771, XP_016883311, NP_001296790
Eda2r	36;868;175;757	0.0.0.0.0.0	MGI:2442	245527	NM_175540|NM_001161433|XM_006528025|XM_006528026|NM_001161432	NP_001154904|NP_001154905|XP_006528088|XP_006528089|NP_780749	110 33	HGNC:17	60 04 01	NM_001199689, NM_001324206, NM_001199688, NM_001324204, NM_001199687, NM_001242310, NM_001324201, NM_001324202,	XP_011529307, XP_016885195, NP_001311135, XP_016885197, NP_001311130, XP_016885196, NP_001311133, NP_001186616,

	;6866;9200						860					56	NM_001324199, NM_001324205, NM_021783	XP_011529306, NP_001311128, XP_016885194, NP_001311134, NP_001311131, NP_001229239, XP_011529304, XP_011529302, NP_068555,XP_016885192,XP_011529309,XP_016885193,XP_011529308,XP_011529303,XP_011529305
Slc31a1	123017600;33066;71944	0.089023	0.068330	0.082447	0.094438	0.094077	MGI:1333843	20529	NM_175090|XM_006537774	XP_006537774|NP_780299	1399	HGNC:11016	1317	NM_001859	NP_001850
Rgs20	120617;35901;81433	0.088983	0.068530	0.082556	0.094223	0.094077	MGI:1929866	58175	XM_006495553|NM_001177795|NM_021374|XM_011238400|NM_001290372|XM_011238401|XM_006495554	XP_011236702|NP_001277301|XP_006495617|NP_067349|NP_001171266|XP_006495616|XP_011236703	2745	HGNC:14600	8601	NM_001286674, NM_001286673, NM_001286675, NM_003702,NM_170587	NP_001273602, NP_001273604, NP_733466,XP_011515924,NP_001273603,NP_003693
Ubd	169117;17622;34409	0.088942	0.064926	0.082647	0.094077	0.094077	MGI:1344410	24108	NM_023137	NP_075626	4665	HGNC:18795	10537	NM_006398	NP_006389
Lam	160	0.08	0.06	0.08	0.09	0.09	MGI	167	NM_010685|XR_001782739|NM	NP_001277414|NP_001017959|NP_034815	78	HGN	39	NM_001122606, NM_013995,NM_002294	NP_002285,NP_054701,NP_001116078

p2	5;177;1999;52299	848	514	3579	4483	:9674 8	84	_001017959|NM_001290485		09	C:6501	20			
Nr3c1	128 5;176;347 8;9767	0.8 8 4 0	0.6 7 4 6	0.8 3 7 3	0.9 4 8 3	0.9 4 8 3	MGI:9582 4	148 15	XM_017317837|XM_006525666|XM_006525660|XM_017317835|XM_006525663|XM_006525665|XM_006525662|XM_017317838|XM_006525664|XM_006525659|XM_006525658|NM_008173|XM_006525661|XM_017317836	XP_006525725|XP_006525723|XP_017173325|XP_006525721|XP_017173327|XP_017173326|XP_017173324|XP_006525726|XP_006525728|XP_006525727|NP_032199|XP_006525729|XP_006525722|XP_006525724	309 60	HGNC:7978	29 08	NM_001024094,NM_001020825,NM_000176,NM_001204263,NM_001204259,NM_001204264,NM_001018074,NM_001018077,NM_001204261,NM_001204258,NM_001204265,NM_001018076,NM_001204260,NM_001018075,NM_001204262	NP_001191188,NP_001018086,NP_001018085,XP_016864887,XP_016864886,XP_005268479,XP_005268480,NP_001191191,NP_001018661,NP_001191194,XP_005268477,XP_011535939,NP_001191189,XP_005268476,NP_001191190,NP_001191187,NP_001018087,NP_001191193,NP_001191192,NP_001019265,NP_001018084,NP_000167
Ppp2r5e	172 1;178 3;427 9;573 5	0.8 8 1 4	0.6 4 3 8	0.8 4 2 8	0.9 5 1 9	0.9 5 1 9	MGI:1349 473	269 32	XM_006515927|XM_006515926|NM_012024|XM_006515925	XP_006515989|XP_006515990|NP_036154|XP_006515988	559 62	HGNC:9313	55 29	NM_001282180,NM_001282179,NM_001282182,NM_006246,NM_001282181	NP_001269110,NP_001269108,NP_006237,NP_001269109,NP_001269111
Smarcad1	162 8;178 8;856 7;89	0.8 7 9 5	0.6 4 7 5	0.8 4 6 7	0.9 5 3 9	0.9 5 3 9	MGI:9545 53	139 90	NM_001253392|XM_006505512|XM_006505513|XM_011241205|XM_132597|XR_001785096|XM_006505510|XM_006505509	NP_031984|XP_006505575|XP_006505573|XP_006505576|NP_001240321|XP_006505572|XP_011239507	530 1	HGNC:18398	56 91 6	NM_020159,NM_001254949,NM_001128429,NM_001128430	NP_064544,NP_001121901,NP_001241878,XP_016863953,NP_001121902,XP_016863952,XP_016863954

Dgkq	77105;17793;42088;74188	0.0.8769648	0.0.8507	0.0.9560	0.0.957	MGI:1029188	105124	XM_006534726|XR_001784588|XM_017320603|XM_011249397|NM_199011|XM_011249392|XR_001784590|XR_001784592|XR_001784589|XR_001784591	XP_011247699|NP_950176|XP_017176092|XP_011247694|XP_006534789	20352	HGNC:28556	160	9	NM_001347	XP_011511714, XP_011511717, XP_016863303, XP_011511716, NP_001338,XP_011511713,XP_016863304
Clstb	10053;17796;58433;91600	0.0.8765	0.0.8703	0.0.8531	0.0.9562	0.0.957	MGI:1921575	74325	XM_006517418|NM_001347512|NM_028870	XP_006517481|NP_083146|NP_001334441	37532	HGNC:20911	12	12	NM_007097,NM_001834	XP_016864516, NP_001825,NP_009028,XP_016864515
Ndfip1	11763;17993;38163;82177	0.0.8753	0.0.6813	0.0.8556	0.0.9565	0.0.957	MGI:1929601	65113	XM_006526149|NM_022996	NP_075372|XP_006526212	12730	HGNC:17592	80762		NM_030571	NP_085048
Trpt1	77793;18033;26673;;32	0.0.8738	0.0.7409	0.0.8588	0.0.9576	0.0.957	MGI:1333115	107328	XM_006526579|NR_027351|XM_006526577|XM_006526578|NM_153597	XP_006526640|XP_006526641|NP_705825|XP_006526642	12878	HGNC:20316	83707		NM_001160389, NM_001160392, NM_001330298, NM_001160393, NM_031472,NM_001033678,NM_001160390	XP_016873890, NP_001153864, NP_001028850, XP_005274402, NP_001153865, XP_006718770, XP_005274403, XP_016873889, NP_001153861, NP_001317227, NP_113660,XP_006718769,XP_005274404,NP_001153862

	49														
Setx	643;1807;5213;6631	0.87721	0.78621	0.95857	0.95857	0.95857	MGI:244348 0	269254	XM_006498082|XM_011239105|XM_006498080|XM_011239106|XR_001782867|XM_006498079|NM_198033	XP_006498142|XP_011237407|NP_932150|XP_006498145|XP_006498143|XP_011237408	4100 3	HGNC:4445	2306 4	NM_001351528,NM_015046,NM_001351527	XP_011516708,NP_001338456,XP_016869986,XP_016869985,XP_016869984,NP_055861,NP_001338457,XP_005272228,XP_011516706,XP_005272230,XP_011516709,XP_011516710,XP_011516707,XP_005272229
Sgpp1	15243;1808;3121;9132	0.87209	0.64909	0.86293	0.95573	0.95573	MGI:213576 0	815353 5	NM_030750	NP_109675	1016 96	HGNC:17720	8153 7	NM_030791	NP_110418,XP_016877167
Plcb4	17003;1809;4495;4745	0.87163 96	0.86336	0.95577	0.95577	0.95577	MGI:107464 4	1879 8	XM_006498942|XM_006498939|XM_017316414|XM_006498951|NM_013829|XM_006498936|XM_006498937|XM_006498948|XM_006498947|XM_017316368|XM_011239357|XM_006498943|XM_006498950|XM_006498941|XM_006498945|XM_006498944|XM_006498940|XM_011239359|XM_006498946|XM_006498938|XM_011239358	XP_006499010|XP_006499002|XP_006499000|NP_038857|XP_006499004|XP_006499006|XP_017171857|XP_017171903|XP_006498999|XP_011237661|XP_006499003|XP_006499005|XP_006499011|XP_006499001|XP_006499007|XP_006499014|XP_006499013|XP_006499008|XP_011237659|XP_011237660|XP_006499009	8471	HGNC:9059	5332	NM_000933,NM_001172646,NM_182797	NP_877949,XP_016883370,XP_006723631,NP_001166117,XP_016883373,XP_016883374,NP_000924,XP_016883371,XP_005260785,XP_016883369,XP_016883372,XP_005260781,XP_016883375,XP_011527556,XP_006723632
Nrg1	99018;2065;4	0.86715	0.87010	0.87222	0.96274	0.96274	MGI:960833	211323	XM_006509060|XM_011242133|XM_017312639|XM_006509080|XM_017312641|XM_017312638|XM_017312636|XM_006509062|XM_006509067|XM_006509072|NM_178591|XM_006509076|XM_006509078|XM_017312637|XM_006509081|XM	XP_006509131|XP_006509141|XP_017168126|XP_006509139|XP_006509143|XP_006509130|XP_006509125|XP_006509140|XP_006509129|XP_006509123|XP_006509144|XP_006509122|XP_017168129|XP_006509135|XP_017168127|	13845 1	#N/A	#N/A	#N/A	#N/A

	752							_006509061|XM_006509059|XM_017312640|XM_006509065|XM_006509064|XM_006509069|XM_006509068|XM_006509063|XM_006509077|XM_006509066	XP_017168125|NP_848706|XP_006509127|XP_011240435|XP_006509124|XP_006509128|XP_017168128|XP_017168130|XP_006509132|XP_006509126						
Slc9a6	28671;18211;53511;84622	0.8671	0.9207	0.8730	0.9612	0.9604	MGI:2443511	2367941	XM_006527980|XM_006527979|NM_172780	NP_766368|XP_006528043|XP_006528042	55971	HGNC:11079	1047	NM_001177651,NM_001330652,NM_001042537,NM_006359	XP_016884714,NP_001036002,NP_001171122,XP_006724789,XP_016884712,NP_001317581,XP_011529545,XP_016884713,NP_006350
Pld2	72264;18233;66563;93033	0.8664946	0.8744944	0.9604044	0.9604044	0.9604044	MGI:892877	1880611	NM_001302475|XR_001779918|XM_011248797|XM_011248795|NM_008876|XR_001779917|XM_011248794|XM_017314339|XM_011248796|NM_001302476	NP_001289405|XP_011247099|XP_011247096|XP_017169828|NP_001289404|NP_032902|XP_011247098|XP_011247097	55672	HGNC:9068	5338	NM_002663,NM_001243108	NP_002654,NP_001230037,XP_016880253,XP_005256753
Hmox1	11204;18288;29154;;74388	0.8646463	0.6823855	0.9623233	0.9623233	0.9623233	MGI:961663	1536811	NM_010442	NP_034572	31075	HGNC:5013	3162	NM_002133	NP_002124
Acvr1	15288;18377;	0.8614313	0.6443	0.8858	0.9679	0.9642	MGI:879111	1147711	XM_006497622|NM_007394|XM_017315006|XM_017315005|NM_001110205|NM_001110204	NP_031420|XP_017170494|XP_006497685|NP_001103675|NP_001103674|XP_017170495	7	HGNC:1771	90	NM_001105,NM_001347664,NM_001347665,NM_001111067,NM_001347663,NM_001347667,NM_001347666	XP_005246997,NP_001104537,NP_001334593,XP_011510410,NP_001334595,NP_001096,NP_001334592,NP_001334596,XP_011510408,XP_006712888,XP_

	3808;6647													011510409,XP_005246996,NP_001334594
Vps26a	56;18383;20555;84211	0.8609	1.2562	0.8865	0.9663	0.9642	MGI:1353654	3093	NM_133672|NM_001113355|XM_006513734	NP_598433|XP_006513797|NP_001106826	6842	HGNC:12711	9559	NM_001318946, NM_001318945, NM_001318944, NM_001035260, NM_004896	NP_001305875, NP_004887,NP_001305873,NP_001030337,NP_001305874
Acsl5	12;27;18399;26244;48122	0.8606	0.6636	0.8874	0.9648	0.9642	MGI:1919129	4325 6	XR_001782597|XR_001782598|NM_027976|XM_006527178	XP_006527241|NP_082252	69208	HGNC:16526	5170 3	NM_016234,NM_203380,NM_203379	XP_016871813, NP_057318,NP_976313,NP_976314
Dpp3	1519;18433;34211;37155	0.8591	0.6438	0.8905	0.9658	0.9642	MGI:1922471	7521	XM_006531854|NM_133803	NP_598564|XP_006531917	4021 0	HGNC:3008	1007 2	NM_001256670, NM_005700,NM_130443	NP_005691,NP_569710,NP_001243599
Siae	831;18447;61	0.8587	0.7230	0.8912	0.9642	0.9642	MGI:1048 03	2261 9	NM_011734	NP_035864	8001	HGNC:18187	5441 4	NM_170601,NM_018978,NM_001199922	NP_001186851, XP_016873419, NP_733746

	65;67488														
Limk1	10822;18522;50599;78766	0.085582	0.068267	0.089677	0.096888	0.096888	MGI:1045722	16885	XM_006504396|NM_010717|NM_001305875|NR_131247	NP_001292804|XP_006504459|NP_034847	1738	HGNC:6613	3984	NM_001204426,NM_002314,NM_016735	NP_002305,NP_001191355
Trak2	81660;62466;84099	0.085300	0.072304	0.090406	0.097338	0.097338	MGI:1918077	70827	XM_017312290|XM_006496281|XM_006496282|NM_172406|XM_011238600|XM_006496280	NP_765994|XP_006496344|XP_011236902|XP_006496343|XP_006496345|XP_017167779	22861	HGNC:13206	6608	NM_015049	XP_011509992,XP_016860261,NP_055864
Cacnb3	18122;18688;39833;82344	0.085011	0.062411	0.091178	0.097785	0.097785	MGI:1033077	1297	XM_017316417|NM_001044741|XM_006520360|XM_017316418|XM_006520361|XM_006520362|XM_017316419|XM_017316415|XM_017316416|NM_001286226|XM_006520367|NM_007581|XM_006520364|XM_006520370|XM_006520365|XM_006520363	XP_017171906|XP_006520430|XP_006520425|XP_006520433|XP_006520428|NP_001273155|XP_017171904|NP_031607|XP_017171908|XP_017171907|NP_001038206|XP_017171905|XP_006520424|XP_006520426|XP_006520427|XP_006520423	20187	HGNC:14033	784	NM_001206917,NM_001206915,NM_000725,NM_001206916	XP_016875448,NP_001193844,XP_011537030,XP_011537029,XP_016875447,NP_000716,NP_001193846,XP_016875446,NP_001193845
Ptpn23	16093;18773;40	0.084699	0.063222	0.091885	0.098400	0.098333	MGI:2144837	104831	NM_001081043|XM_011242931	NP_001074512|XP_011241233	13706	HGNC:14406	25930	NM_001304482,NM_015466	NP_001291411,NP_056281,XP_005265088

	47;8856														
Pik3r3	1676;1879;42944;87011	0.842823	0.623201	0.920133	0.983383	0.983383	MGI:1092777	1871 0	XM_006502859|NM_181585|XM_006502861|XM_017320039|XM_006502860|XM_017320040|XM_017320041	XP_006502922|XP_006502923|XP_017175528|NP_853616|XP_017175530|XP_006502924|XP_017175529	2690	HGNC:8981	8503	NM_001328654, NM_001328653, NM_001303428, NM_001328652, NM_001328649, NM_001328651, NM_001114172, NM_001303429, NM_001328648, NM_003629,NM_001328650	NP_001315581, NP_001315577, NP_001315583, NP_003620,NP_001315579,NP_001290358,NP_001315578,NP_001290357,XP_016858103,NP_001107644,NP_001315580,NP_001315582
Prdx3	649;1886;43025;59855	0.843737	0.756259	0.925971	0.987139	0.983939	MGI:1880344	1757	NM_007452	NP_031478	4944	HGNC:93544	1093 5	NM_001302272, NM_006793,NM_014098	NP_006784,NP_001289201
Emp2	8141;18887;32193;63644	0.843486	0.718667	0.926675	0.985855	0.983939	MGI:1098726	1373 1	NM_007929	NP_031955	1089	HGNC:33344	2013	NM_001424	XP_006720927, NP_001415
Ppp1r21	1671;1888;2166	0.843070	0.623700	0.922755	0.983939	0.983939	MGI:1921075	7382 5	NM_028658|XM_017317677	NP_082934|XP_017173166	4481 1	HGNC:30595	1E+05	NM_001135629, NM_152994,NM_001193475,NM_001135630	NP_001180404, NP_001129101, XP_016858791, NP_694539,XP_016858790

	0;25595														
Ncam1	62626;18894;28888;33177	0.8401909	0.7461069	0.9326943	0.9848643	0.9843	MGI:972811	179167	XM_006510066|XM_006510075|XM_006510064|XM_006510061|NM_001081445|XM_006510069|XM_006510060|XM_017313195|XM_006510063|XM_017313197|XM_006510062|XM_006510055|XM_006510057|XM_017313201|XM_017313199|XM_006510070|NM_010875|NM_001311065|XM_017313200|XM_017313193|XM_006510058|XM_006510059|XM_017313198|XM_006510065|XM_017313194|XM_011242415|XM_006510071|XM_011242416|XM_006510073|NM_001113204|XM_006510056|XM_006510068|XM_017313192|XM_017313196|XM_011242414|XM_006510067|XM_006510074|XM_011242413	XP_006510136|XP_006510121|XP_017168690|XP_017168681|XP_006510133|XP_006510134|XP_017168682|XP_011240717|XP_006510137|XP_006510126|XP_006510123|XP_011240718|XP_017168688|XP_017168685|XP_017168684|XP_017168687|XP_017168683|XP_006510118|XP_011240716|XP_006510128|XP_006510130|NP_001106675|XP_006510129|XP_006510119|XP_011240715|XP_017168689|XP_006510124|XP_006510131|NP_001297994|XP_006510127|XP_006510132|XP_006510122|XP_006510125|NP_001074914|NP_035005|XP_017168686|XP_006510120|XP_006510138	407547	HGNC:7656	464	NM_000615,NM_001242607,NM_181351,NM_001076682,NM_001242608	NP_851996,NP_001229536,NP_001070150,NP_000606,NP_001229537
Pfkfb3	97;18396;65233;68244	0.8402023	0.1209433	0.9386343	0.9848643	0.9843	MGI:2181202	170768	NM_001177757|XM_006497369|XM_006497368|NM_001177753|XM_006497367|NM_001177752|XM_017315954|NM_001177755|NM_001177754|NM_001177756|NM_001177758|NM_133232	NP_001171226|NP_001171225|XP_006497431|NP_001171229|XP_017171443|NP_001171228|XP_006497430|NP_001171223|NP_001171224|NP_001171227|NP_573495|XP_006497432	887087	HGNC:8874	5209	NM_001323017,NM_001323016,NM_001145443,NM_004566,NM_001314063,NM_001282630	XP_016871814,NP_001300992,NP_001138915,XP_016871817,XP_016871818,NP_001269559,XP_005252521,NP_001309945,NP_001309946,XP_011517795,XP_016871816,XP_016871815,NP_004557
Epb4.1l2	94;18982;20955;	0.8394195	0.6941609	0.9368573	0.9848643	0.9843	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

	75962														
Prkg2	11143;19033;45733;60244	0.83786	0.66961	0.94016	0.98763	0.98433	MGI:1081773	1092	NM_008926|XM_006534821|XM_006534820	XP_006534884|XP_006534883|NP_032952	4556	HGNC:9416	5593	NM_001282485, NM_001282482, NM_001282483, NM_001282481, NM_001282480, NM_006259	NP_001269411, NP_001269410, XP_016863902, XP_016863906, NP_006250,NP_001269412,XP_016863904,NP_001269414,XP_016863905,NP_001269409,XP_005263183,XP_016863907,XP_016863903
Tmed1	65443;19043;30477;67744	0.83744	0.75188	0.94098	0.98861	0.98433	MGI:1062001	1703	NR_136911|NM_001324510|NM_010744|NR_136912	NP_034874|NP_001311439	21360	HGNC:17291	1101 8	NM_006858	XP_006722694, NP_006849
Mmp16	67073;19055;55643;74199	0.83715	0.74718	0.94184	0.98473	0.98433	MGI:1276107	1738	XM_017320017|NM_019724|NR_135158	XP_017175506|NP_062698	55939	HGNC:7162	4325	NM_022564,NM_032297,NM_005941	NP_005932
Mtss1l	11753;19083;66481;6	0.83617	0.66143	0.94430	0.98503	0.98433	MGI:3039591	2465 4	XM_006531014|XM_006531013|NM_198625|NM_001310591|XM_006531016|XM_006531015|XM_006531018|XM_006531017|XM_006531011|XM_006531012	XP_006531081|XP_006531074|XP_006531076|NP_001297520|XP_006531078|XP_006531079|NP_941027|XP_006531080|XP_006531077|XP_006531075	70926	HGNC:25094	9215 4	NM_138383	NP_612392,XP_016879368,XP_016879373,XP_016879372,XP_011521752,XP_011521760,XP_011521755,XP_016879370,XP_016879369,XP_005256293,XP_011521756,XP_016879371

	74														
Cnnm4	21503;19133;47393;47433	0.08343	0.06325	0.09483	0.09867	0.09843	MGI:2151060	942 20	NM_033570	NP_291048	75662	HGNC:1105	26504	NM_020184	XP_005263972, NP_064569,XP_011509257,XP_011509258,XP_016859288,XP_005263971
Pdk1	13523;19163;27377;81144	0.08333	0.06433	0.09508	0.09871	0.09843	MGI:1926119	228026	XM_017317590|XM_011239446|NM_172665|XM_011239444|XM_011239445|XR_001782095	XP_011237748|NP_766253|XP_011237746|XP_011237747|XP_017173079	13443 7	HGNC:8809	51634	NM_001278549, NM_002610	XP_011509649, XP_011509645, NP_001265478, XP_011509646, XP_006712657, NP_002601,XP_006712658,XP_011509647
Golga7	14963;19173;64155;68911	0.08329	0.06322	0.09517	0.09856	0.09843	MGI:1931029	57437	XM_006509179|NM_020585|NM_001042484	NP_001035949|XP_006509242|NP_065610	9385	HGNC:24876	51125	NM_001002296, NM_001174124, NM_016099	NP_001002296, NP_001167595, NP_057183
261030 1B20Rik	21303;19203;34596;	0.08319	0.09621	0.09541 1	0.09858	0.09843	MGI:1914407	671 57	NM_026005|XM_006538200	NP_080281|XP_006538263	18641	HGNC:27232	2E+05	NM_177965	NP_808880,XP_005250856

Rhod	525 257; 19211; 60833; 73688	0. 83162	0. 92442	0. 95550	0. 98443	0. 98433	MGI: 108446	118 554	XM_006531644| NM_001329989| NM_007485	XP_006531707| NP_031511|NP_ 001316918	224 09	HGNC: 6700	299 84	NM_001300886, NM_014578	NP_001287815, NP_055393
Aida	72; 19275; 36475; 58600	0. 82955	1. 18701	0. 96011	0. 98722	0. 98722	MGI: 191973 7	108 909	NM_181732	NP_859421	112 68	HGNC: 25761	648 53	NM_022831	NP_073742
Cnpd1	214; 19400; 45463; 72033	0. 82518	0. 95778	0. 97108	0. 99619	0. 99119	MGI: 191642 1	691 711	NM_026977|XM _006496542|XM _006496541|XM _006496540	XP_006496604| XP_006496603| XP_006496605| NP_081253	923 8	HGNC: 25220	270 13	NM_001321389, NM_001321390, NM_001321391, NM_015680	NP_001308320, NP_001308318, NP_001308319, NP_056495
Sema4b	791; 19411; 27522; 71445	0. 82488	0. 87139	0. 97186	0. 99469	0. 99119	MGI: 107559	203 52	XM_011250830| NM_013659	XP_011249132| NP_038687	842 6	HGNC: 10730	105 09	NM_001324033, NM_001324030, NM_020210,NM _198925,NM_00 1324032,NM_00 1324031,NM_00 1324029,NM_00 1324034	NP_001310963, NP_945119,NP_ 064595,NP_001 310958,NP_001 310962,NP_001 310959,NP_001 310961,NP_001 310960

Phka1	375;1948;;2447;;30899	0.8224	0.8456	0.9778	0.9984	0.9919	MGI:975776	1679	NM_173021|XM_006527894|NM_008832|XM_017318427|XM_006527895	NP_032858|NP_766609|XP_006527957|XP_006527958|XP_017173916	1981	HGNC:8925	525	NM_001172436, NM_002637,NM_001122670	NP_001165907, NP_002628,NP_001116142,XP_006724724
Fcho2	1758;1950;;2279;;63100	0.8217	0.6123	0.9796	0.9979	0.9919	MGI:3505790	2183	XM_011244652|XR_001780779|XR_001780778|NM_172591|XR_873743	XP_011242954|NP_766179	9030	HGNC:25180	1E+05	NM_138782,NM_001146032	XP_016864509, XP_016864506, XP_016864510, XP_016864507, XP_016864511, XP_016864508, NP_620137,NP_001139504,XP_016864512,XP_016864505
Hmox2	6822;1951;;6315;;71188	0.8214	0.7366	0.9804	0.9964	0.9919	MGI:1093773	1539	NM_001136066|XM_006521803|XM_006521804|NM_010443	NP_034573|XP_006521867|NP_001129538|XP_006521866	1611	HGNC:5014	3163	NM_001286267, NM_001286269, NM_001127204, NM_001286270, NM_002134,NM_001127206,NM_001286271,NM_001286268,NM_001127205	NP_001273200, XP_016878686, NP_001273199, NP_001273196, XP_016878685, NP_001120677, NP_001273198, NP_002125,NP_001120678,NP_001273197,NP_001120676,XP_011520775
Lgals9	1153;1952;;3563;;73899	0.8211	0.6567	0.9813	0.9949	0.9919	MGI:1094966	1685	NM_001159301|NM_010708	NP_001152773|NP_034838	13462	HGNC:24842	3E+05	NM_001042685	NP_001036150

Ehd4	13;1954;2997;3028	0.820491	0.639130	0.983044	0.994419	0.991949	MGI:1919619	9878	XM_017319352|NM_133838	NP_598599|XP_017174841	26430	HGNC:32455	3084	NM_139265	NP_644670,XP_016877589
Pip4k2a	11;1956;2177;6703	0.818972	0.657247	0.984738	0.993819	0.991949	MGI:1298206	1871	NM_008845|XM_006497396|XM_006497397|XM_006497394|XM_006497395	XP_006497458|NP_032871|XP_006497457|XP_006497459|XP_006497460	37995	HGNC:8997	5305	NM_005028,NM_001330062	XP_016871819,NP_005019,XP_016871820,XP_011517798,XP_006717513,NP_001316991,XP_016871821
Jmjd6	83;1958;7270;7363	0.819118	0.702868	0.986432	0.993219	0.991949	MGI:1858910	1078177	XR_001779857|XR_879502|XR_879501|XR_388322|XR_388319|XM_006531960|NM_033398|XR_388320|XR_001779858	XP_006532023|NP_203971	9046	HGNC:19355	23210	NM_001081461,NM_015167	NP_055982,NP_001074930
Fastkd2	14;1960;3818;4781	0.818484	0.631410	0.988181	0.992616	0.991949	MGI:1922869	7561	NM_172422|XM_006496313	XP_006496376|NP_766010	8957	HGNC:29160	2286	NM_001136194,NM_014929,NM_001136193	NP_001129666,NP_001129665,NP_055744

Parn	146;196;2;303;3606;9069	0.8178	0.6268	0.9896	0.9919	0.9919	MGI:1921358	74108	XM_011246024|XM_017317144|XM_006522652|NM_028761|XM_011246023|XM_017317145	XP_006522715|XP_017172634|XP_011244325|NP_083037|XP_017172633|XP_011244326	3109	HGNC:8609	5073	NM_001242992, NM_002582,NM_001134477	XP_011520812, NP_001127949, NP_002573,XP_011520813,XP_011520816,NP_001229921,XP_016878747,XP_011520815,XP_016878749,XP_016878748
Dr2	731;1970;3873;6560	0.8151	0.8721	0.9966	0.9966	0.9966	MGI:1345277	18214	XM_006496696|XM_022563|XM_006496697|XM_006496698	XP_006496759|XP_006496761|XP_006496760|NP_072075	68505	HGNC:27731	4921	NM_001014796, NM_006182	XP_011507888, XP_006711407, XP_011507889, NP_006173,XP_011507890,NP_001014796

5 Part V Genes enriched in TCRα KO mice treated with GVAX against the KO mice without treatment control

p-value=0 means <3.7385e-05, FDR=0 means <0.000426186148012

GeneSymbol	Ranksofpertur bations	STARScore	Average Score	p-value	FDR	q-value	Mouse MarkerID	Mouse NCBI EntrezID	Mouse NCBI RefSeq Transcript ID	Mouse NCBI RefSeq Protein ID	Homologene ID	HGNC ID	Human NCBI EntrezID	Human NCBI RefSeq Transcript ID	Human NCBI RefSeq Protein ID
Ifnar2	7;12;99	7.843	5.210	0	0	0	MGI:109	15976	XM_011246100|XM_006522923|NM_001347258|XM_017316882|NM_010509|NM_001110498	XP_017172371|XP_011244402|NP_001334187|XP_006522986|NP_034639|NP_001103968	49242	HGNC:54	3455	NM_001289125, NM_001289128, NM_207585,NM_001289126,NM_000874,NM_207584	NP_001276055, NP_001276054, NP_997467,NP_000865,NP_997468,NP_001276057

	;108						8243					33		
Ifnar1	11;24;114;142	7.3685	4.8472	0.0000	0.0000	0.0000	MGI:107658	15975	NM_010508|XR_384931	NP_034638	524	HGNC:5432	3454	NM_000629	XP_011527854, NP_000620,XP_005261021
Stat1	22;52;103;233	6.5082	4.4229	0.0000	0.0000	0.0000	MGI:103063	20846	XM_017319464| NM_001205314| XM_017319463| NM_001205313| XM_006495811| NM_009283	XP_006495874| XP_017174952| XP_017174953| NP_001192242| NP_001192243| NP_033309	21428	HGNC:11362	6772	NM_139266,NM_007315	NP_644671,XP_016860272,XP_006712781,NP_009330
Jak1	10;30;57;1545	6.1160	3.9977	0.0000	0.0000	0.0000	MGI:96628	16451	NM_146145|XM_011240451|XM_006502812	NP_666257|XP_006502875|XP_011238753	1678	HGNC:6190	3716	NM_001321857, NM_001321852, NM_001320923, NM_002227,NM_001321853,NM_001321856,NM_001321855,NM_001321854	NP_001308783, NP_001308781, NP_001307852, NP_001308784, NP_001308785, NP_001308786, NP_001308782, NP_002218,XP_016856701
H2-K1	126;288;365;426	5.4600	3.1992	0.0000	0.0028	0.0028	MGI:95904	14972	XM_207061|XM_006523678|NM_001347346|XM_017317259|XM_006523680|XR_001782042|XM_017318971|XM_006523673|XM_017317258|XM_006523674|XM_006523677|XM_006523676|XM_017317257|XR_001782043	NP_001334275| XP_017174460| XP_017172746| XP_006523736| XP_017172748| XP_006523741| XP_006523737| XP_006523743| XP_006523739| NP_001001892| XP_017172747| XP_006523740	128352	HGNC:4931	3105	NM_002116,NM_001242758	XP_005275388, NP_002107,NP_001229687,XP_016885777
Safb	15;393;516;526	5.0937	3.1589	0.0001	0.0058	0.0058	MGI:2146974	224903	NM_001163300| XM_006524160| XM_017317445	XP_006524223| NP_001156772| XP_017172934	2229	HGNC:10520	6294	NM_001320572, NM_001201340, NM_001320571, NM_001201338, NM_002967,NM_001201339	NP_001307501, XP_016882605, XP_016882607, NP_001188268, XP_016882604, NP_002958,NP_001307500,NP_001188269,NP_001188267,XP_016882606,XP_016882603
Rps	55;	4.9	3.3	0.0	0.0	0.0	MGI	725	XM_011249277| XR_001780060| XM_017314792|	NP_001107806| XP_017170280| XP_011247578|	817	HGN	61	NM_003161,NM_001272044,NM_001272043,NM	NP_001258989, NP_003152,NP_001258973,XP_

6kb1	66;528;568	60285	5002911	0091	:1270849	08	NM_001114334|XM_006534314|XM_017314793|XM_006534315|XM_017314791|XR_879743|XM_006534317|XM_011249276|NM_028259|XM_011249275	NP_082535|XP_011247577|XP_006534377|XP_006534378|XP_017170282|XP_017170281|XP_006534380|XP_011247579	03	C:10436	98	_001272060,NM_001272042	011523403,XP_016880420,XP_011523405,XP_016880419,NP_001258971,NP_001258972,XP_016880418,XP_016880421,XP_016880422,XP_011523404
Stat2	13;;16;;835;;795252	43.8038461	3.2040038	0.0014403	0.0114403	MGI:1030399	20847	XM_006513433|XM_006513435|NM_019963|XM_006513436	XP_006513498|NP_064347|XP_006513496|XP_006513499	395 2	HGNC:11363	67 3	NM_198332,NM_005419	XP_016875393,XP_011537000,XP_011536999,XP_011537002,NP_938146,NP_005410,XP_011537001,XP_005269168
Smarca4	43;;69;;238;;1986	43.2106280	3.1008085	0.0038086	0.0338086	MGI:8881922	20586	XM_006510122|XM_011242434|XM_011242438|NM_001174079|XM_017313235|XM_017313234|XM_006510120|XM_017313232|XM_011242436|XM_011242437|XM_011242435|XM_017313233|NM_011417|NM_001174078|XM_006510117|XM_006510119	XP_006510185|XP_017168721|XP_006510180|XP_011240736|XP_006510182|XP_006510183|NP_001167550|NP_001167549|XP_017168723|NP_035547|XP_011240738|XP_011240739|XP_011240740|XP_011240737|XP_017168724|XP_017168722	13592 7	HGNC:11100	65 97	NM_001128844,NM_003072,NM_001128848,NM_001128849,NM_001128847,NM_001128845,NM_001128846	XP_016882650,XP_006722908,XP_016882652,NP_001122316,XP_016882653,XP_016882649,XP_016882656,XP_016882655,NP_001122317,NP_001122321,NP_001122318,XP_006722909,XP_016882654,NP_003063,NP_001122319,NP_001122320,XP_016882657,XP_016882651,XP_011526500
Smarce1	166;;255;;824;;923	42.1610687	2.0001205	0.0050 4	0.0050 4	MGI:1927347	57376	NM_020618|XM_006533827|XM_011249158|XM_006533828	XP_006533890|XP_006533891|XP_011247460|NP_065643	37727	HGNC:11109	66 05	NM_003079	NP_003070
Vezt	29;;37;;302;;1910	43.0077556	3.0000514	0.0005333	0.0053 3	MGI:2143698	21508	NM_172538|NM_001304572|NM_001304575|NM_001304720	NP_001291501|NP_001291649|NP_766126|NP_001291504	97 39	HGNC:18258	55 91	NM_001352095,NM_001352118,NM_001352111,NM_001352098,NM_001352089,NM_001352099,NM_001352103,NM_001352106,NM_001352117,NM_017599,NM_001352119,NM_001352116,NM_001352088,NM_001352097,NM_001352110,NM_001352115,NM_001352109,NM	NP_001339025,XP_006719542,NP_001339041,XP_011536849,NP_001339042,NP_001339024,XP_016875093,XP_011536851,NP_001339046,XP_006719541,XP_011536853,NP_001339018,XP_016875081,XP_006719540,XP_006719549,XP_016875091,NP_001339045,

												_001352091,NM_001352105,NM_001352094,NM_001352092,NM_001352104,NM_001352114,NM_001352113,NM_001352101,NM_001352096,NM_001352112,NM_001352100,NM_001352107,NM_001352108,NM_001352102,NM_001352090,NM_001352093	XP_016875080, NP_001339033, XP_016875079, NP_001339030, NP_001339027, NP_001339040, NP_001339038, XP_016875084, NP_001339044, NP_001339023, XP_011536845, NP_001339026, NP_001339043, XP_016875085, XP_011536847, NP_001339021, XP_011536854, NP_001339019, XP_006719548, NP_001339017, XP_016875087, XP_011536848, XP_006719545, XP_016875077, XP_006719544, XP_011536852, NP_001339034, XP_006719543, NP_001339031, XP_016875075, XP_006719553, XP_016875083, XP_016875090, XP_011536850, NP_001339020, XP_016875086, XP_016875078, NP_001339048, NP_001339022, XP_016875076, NP_001339036, XP_016875088, XP_016875094, NP_001339032, NP_001339039, XP_011536846, XP_006719547, NP_001339029, NP_001339035, NP_001339047, XP_006719546, NP_001339028, XP_016875089, XP_016875082, XP_011536855, NP_060069,XP_016875092,NP_001339037
Sik2	43;437;;916;;9833	4.2.3.-	0.0.1.-	0.0.5.-	0.0.74	MGI:2445031	2353444	NM_178710|XR_379116|XM_017313332|XM_006510266|XM_006510267	XP_006510329|NP_848825|XP_006510330|XP_017168821	22875	HGNC:21680	235	NM_015191	XP_016872906, NP_056006,XP_016872907

Rock2	293;702;728;1011	3.9.5.8.6	2.3.3.4	0.0.1.0.1.9	0.0.6.0.4	0.0.6.0.4	MGI:1079266	198 78	XM_006515020|NM_009072|XM_006515019	XP_006515083|XP_006515082|NP_033098	210 10	HGNC:10252	94 75	NM_004850,NM_001321643	XP_005246247,NP_004841,XP_016860867,XP_011508719,XP_016860868,NP_001308572
Dusp12	389;732;1029;1067	3.8.6.5.0	2.1.6.5.0	0.0.2.0.3	0.0.7.0.3	0.0.7.0.3	MGI:1890614	80 91 5	XR_373626|NM_023173|XM_006497042	NP_075662|XP_006497105	523 8	HGNC:30667	11 26 6	NM_007240	NP_009171,XP_005244919
Kirrel	315;636;936;1110	3.7.9.6.3	2.2.6.2	0.0.2.7	0.0.7.6.8	0.0.7.6.8	MGI:1891396	17 06 43	XM_017319471|XM_011240029|NM_001170985|XM_006501076|NM_130867|XM_011240028	NP_570937|XP_011238330|XP_006501139|XP_017174960|NP_001164456|XP_011238331	100 89	HGNC:15734	55 24 3	NM_018240,NM_001286349	NP_060710,XP_005245362,NP_001273278
Cdk5	271;325;379;1486	3.6.6.2.2	2.5.4.0.8	0.0.0.3.5	0.0.9.5.1	0.0.9.5.1	MGI:1017655	1256 8	NM_007668|XR_389739|XM_006535626	NP_031694|XP_006535689	362 3	HGNC:17744	10 20	NM_001164410,NM_004935	NP_004926,NP_001157882
Dxo	246;363;400	3.5.6.4.4	2.4.0.7	0.0.4.4	0.1.1.1.2	0.1.1.1.2	MGI:1890404	114 03	NM_001163770|XM_011246251|XM_017317211|XR_385263|NM_033613	XP_017172700|XP_011244553|NP_291091|NP_001157242	380 61	HGNC:29922	17 97	NM_005510	XP_016865818,XP_006715068,NP_005501

	9;7604					44									
Yipf3	4949;7070;1532;;3459	3.5266	2.3780	0.0048	0.1444	0.1144	MGI:1062800	2806 4	XM_017317498|NM_145353|XM_006524377	XP_006524440|NP_663328|XP_017172987	9177	HGNC:21023	2584 4	NM_015388	NP_056203,XP_005249047,XP_011512760,XP_005249046
Nrc5	3780;9044;9311;1397	3.3968	2.0040	0.0062	0.1417	0.1417	MGI:3612191	4343 41	XM_006531165|XM_006531162|XM_011248428|XM_006531163|XM_006531166|NM_001033207	XP_006531228|XP_006531229|NP_001028379|XP_006531226|XP_006531225|XP_011246730	8893 5	HGNC:29933	8416 6	NM_032206,NM_001330552	XP_006721360,XP_005256254,NP_001317481,XP_016879258,XP_011521677,XP_006721363,XP_005256258,XP_016879257,XP_011521678,XP_005256250,XP_016879260,XP_005256252,XP_016879256,XP_016879255,XP_011521675,XP_006721361,XP_016879259,NP_115582,XP_005256256,XP_005256253,XP_005256251
Taok1	4036;4966;6055;;14422	3.3417 7	2.0071	0.0153	0.1523	MGI:1914490	2169 65	XM_006532959|XM_011248929|NM_144825|XM_011248931|XM_006532960|XM_011248930|XM_006532958	XP_011247233|XP_006533021|NP_659074|XP_011247231|XP_006533022|XP_006533023|XP_011247232	2704 1	HGNC:29259	5755 1	NM_020791,NM_025142	NP_065842,XP_011523362,NP_079418
Synj2	6411;1006;1104;14	3.3200 62	1.9007 4	0.0152 73	0.1523	MGI:1201671	2097 75	XM_006523206|XR_385129|XM_006523205|NM_001290698|XR_385128|NM_001113351|NM_001113353|XM_006523202|XM_006523212|NM_011523|XM_006523204|XM_017317372|XM_006523208|XM_017317373|XM_006523203|NM_001113352	XP_006523266|NP_001106822|NP_001106823|XP_017172862|NP_001106824|XP_006523269|XP_006523275|XP_006523265|NP_001277627|XP_006523267|NP_035653|XP_017172861|XP_006523271|XP_006523268	1177 03	HGNC:11504	8871	NM_003898,NM_001178088	XP_011534529,XP_005267255,XP_011534526,XP_005267256,XP_011534528,XP_011534532,NP_003889,NP_001171559,XP_005267257,XP_016866895,XP_006715655,XP_011534527,XP_011534530

Pcbp2	55 12 3; 597 ; 114 2; 1483	3 . 2 9 3 1	2 . 1 4 6 6	0 . 0 0 7 9	0 . 1 0 6 7	0 . 1 5 3 2	MGI:1082021	185 21	XM_011245498|XM_017316500|XM_006520583|XM_006520586|XM_006520582|XM_011245509|XM_011245496|NM_001103166|XM_011245507|XM_011245502|XM_017316498|XM_006520585|XM_017316497|XM_011245497|XM_011245504|XM_011245506|XM_017316501|XM_011245503|XM_017316499|XM_011245508|XM_011245499|NM_001103165|XM_006520584|XM_011245500|XM_011245501|XM_011245495|NM_001174073|NM_011042|XM_011245505	XP_011243805|XP_011243806|XP_011243811|XP_011243801|XP_006520647|XP_017171988|XP_011243803|XP_017171987|XP_011243810|XP_011243808|NP_035172|XP_017171986|XP_011243799|XP_006520646|XP_006520648|XP_011243807|XP_006520645|XP_017171989|NP_001096636|XP_011243800|NP_001167544|NP_001096635|XP_017171990|XP_011243809|XP_006520649|XP_011243804|XP_011243798|XP_011243802|XP_011243797	745 36	HGNC:8648	509 4	NM_001128912,NM_001128914,NM_001128911,NM_031989,NM_001128913,NM_005016,NM_001098620	NP_001092090,NP_114366,NP_001122386,NP_001122383,NP_005007,NP_001122384,NP_001122385
H2-Q6	72 ; 251 ; 509 ; 4193	3 . 2 8 4 0	2 . 4 2 0 7	0 . 0 0 8 1	0 . 1 5 3 2	0 . 1 5 3 2	MGI:955935 7	110 557	NM_207648	NP_997531	1283 52	HGNC:49311	310 5	NM_002116,NM_001242758	XP_005275388,NP_002107,NP_001229687,XP_016885777
Trip6	68 1; 921 ; 1458 ; 1603	3 . 1 5 7 9	1 . 7 8 4 2	0 . 0 1 0 7	0 . 1 9 5 5	0 . 1 9 5 5	MGI:1343458 ; 1605 11	220 51	XM_006504563|NM_011639	XP_006504626|NP_035769	377 57	HGNC:12311	720 5	NM_003302	NP_003293
Vegfa	35 ; 113 ; 3072 ;	3 . 1 1 4 5	2 . 4 8 3 7	0 . 0 1 1 8	0 . 0 2 0 7	0 . 2 0 7 5	MGI:1031782 ; 1031 784	223 39	NM_001025257|NM_001025250|NM_001317041|NM_001110267|NM_001287058|NM_001287057|NM_009505|NM_001110266|NM_001287056|NM_001110268	NP_001103737|NP_001273986|NP_001273985|NP_001020421|NP_001303970|NP_001103738|NP_001103736|NP_033531|NP_001273987|NP_001020428	253 34	HGNC:12680	742 2	NM_001025370,NM_001025366,NM_001025367,NM_001171626,NM_001033756,NM_001317010,NM_001204384,NM_001171628,NM_003376,NM_001025369,NM_001171630,NM_001204385,NM	NP_001165097,NP_001020538,NP_001165096,NP_001273973,NP_001165098,NP_001191314,NP_001020540,NP_001165099,NP_003367,NP_001028928,NP_001191313,NP_001165094,NP_

	3604													_001287044,NM_001171629,NM_001171624,NM_001171623,NM_001025368,NM_001171622,NM_001171627,NM_001171625	001020539,NP_001165095,NP_001303939,NP_001165100,NP_001020541,NP_001020537,NP_001165093,NP_001165101
Vapa	135;3128;6011;21933	3.2.0.1.2.1.0.7.1.8	2.0.1.8.1.7.0.2.9.4	0.0.2.1.1.9.0.7.8.5	0.0.1.2.7.9.1.0.6.1	MGI:1353561	3096	XM_017317500|NM_013933|XM_006524385	XP_017172989|NP_038961|XP_006524448	37824	HGNC:12648	9218	NM_194434,NM_003574	NP_919415,NP_003565,XP_011524071,XP_016881568
Chd8	2973;3028;6488;17011	3.0.5.4.8.2.3.1.6.9.0.1.1.3.5.0.2.1.9.8.0.2.1.7.9.2	2.3.1.6.9.1.1.3.5.5.0.2.1.7.9.2	0.0.1.2.1.9.8.0.2.1.7.9.2	0.0.2.1.1.3.5.0.2.1.7.9.2	MGI:1915022	6772	XM_017316171|XM_006519476|XM_017316172|XM_011245165|XM_017316170|NM_201637	XP_017171660|XP_006519539|XP_017171659|XP_017171661|XP_011243467|NP_963999	72405	HGNC:20153	5768	NM_020920,NM_001170629	NP_001164100,NP_065971
Tm2d1	81;124;5559;71544	3.0.3.4.8.2.6.4.7.2.0.1.4.4.1.0.2.1.7.9.2	2.0.1.4.4.1.2.1.7.9.2	0.0.2.2.1.1.0.2.1.7.9.2	0.0.2.1.7.9.2	MGI:2137022	9403	XM_006503494|NM_053157	XP_006503557|NP_444387	12928	HGNC:24142	8394	NM_032027	NP_114416
Tgfbr3	82;125;13599;92711	3.0.2.7.9.1.8.7.7.2.1.7.9.2	2.0.1.4.3.1.0.4.6.3.7.2.1.7.9.2	0.0.2.1.7.9.2	0.0.2.1.7.9.2	MGI:1046377	2181	NM_011578	NP_035708	24436	HGNC:11774	7049	NM_001195683,NM_001195684,NM_003243	XP_006710931,NP_001182613,NP_001182612,XP_006710930,NP_003234
C3	574	2.9	1.7	0.0	0.2	MGI	122	XM_011246258|NM_009778	XP_011244560|NP_033908	680	HGN	718	NM_000064	NP_000055

	;6999;16388;17600	956	774	153	255	255	:88227	66			31	C:1318		
Srpk1	145;375;659;62577	2.9545	2.1003	0.0168	0.2391	0.2344	MGI:1069088	20815	XM_006523958|NM_016795|XM_011246337|XR_385308	XP_006524021|NP_058075|XP_011244639	11096	HGNC:11305	6732	NM_003137	NP_003128
Ifngr2	136;137;877;24222	2.9494	2.2729	0.0170	0.2344	0.2344	MGI:1076544	15980	NM_008338	NP_032364	4041	HGNC:5440	3460	NM_001329128, NM_005534	XP_011527855, XP_005261026, NP_001316057, XP_011527856, NP_005525
Igf2r	924;12091;12111;18388	2.9202	1.7057	0.0181	0.2424	0.2424	MGI:964435	16004	NM_010515	NP_034645	676	HGNC:5467	3482	NM_000876	NP_000867
Msrb1	349;6556;7855	2.8782	2.0359	0.0199	0.2591	0.2477	MGI:1351642	27361	NM_013759|NM_001346668	NP_038787|NP_001333597	8455	HGNC:14133	5173 4	NM_016332	NP_057416

	;1883														
Ubash3b	9963;10075;11778;18844	2.8773	1.7202	0.0200	0.0253677	0.024	MGI:1920078	728	XM_006510634|NM_176860|XM_017313612|XM_006510636|XM_006510637|XM_006510632	XP_006510700|NP_789830|XP_006510697|XP_006510695|XP_006510699|XP_017169101	13152	HGNC:29884	84959	NM_032873	XP_011541344, XP_005271769, XP_011541343, NP_116262
Ino80c	4425;6661;7044;87222	2.8706	1.7741	0.0200	0.0249877	0.024	MGI:2443014	2252280	NM_172625	NP_766213	45426	HGNC:26994	12547	NM_194281,NM_001308064,NM_001098817	XP_005258254, XP_005258253, XP_011524114, NP_001294993, XP_016881038, NP_919257,NP_001092287
Marcks	675;11125;17022;19026	2.8608	1.6250	0.0200	0.0247747	0.024	MGI:969907	1711 8	NM_008538	NP_032564	0	#N/A	#N/A	#N/A	#N/A
Ankrd17	26;2754;7243;19833	2.8350	2.6022	0.0202	0.0255733	0.025	MGI:1932101	8170 2	XM_006535287|NM_198010|XM_017321182|XM_006535289|XM_011249595|XM_006535290|XM_006535288|NM_030886|XM_006535291	XP_006535353|NP_112148|XP_017176671|XP_006535350|XP_006535352|XP_011247897|XP_006535354|NP_932127|XP_006535351	82403	HGNC:23575	26057	NM_198889,NM_032217,NM_015574,NM_001286771	NP_056389,XP_016863502,NP_001273700,XP_005265730,XP_005265728,XP_016863505,XP_016863500,NP_115593,XP_016863506,XP_016863503,XP_005265729,XP_016863504,XP_016863501,NP_942592
Hn1l	118;	2.8207	2.0022	0.0225	0.025	MGI:	520		NM_198937	NP_945175	169	HGNC	9088	NM_144570	NP_653171

	159;203;1;8501	200	27	83	33	119620	09			34	:14137	61		
Cab39	102;160;1145;2551	2.816674	2.157429	0.0229	0.0254933	MGI:1074388	128	XM_011247907|XM_017312539|XM_006529090|NM_133781|XM_006529091	XP_011246209|XP_017168028|XP_006529154|NP_598542|XP_006529153	69212	HGNC:20292	517179	NM_001130850,NM_016289,NM_001130849	NP_001124322,XP_011509652,NP_057373,NP_001124321
Hmgcr	696;1338;1929;1972	2.798067	1.536739	0.0239	0.0259133	MGI:961559	153	XM_006517530|XM_127496|XM_006517531	XP_006517594|NP_032281|XP_006517593	30994	HGNC:5006	3156	NM_001130996,NM_000859	XP_011541660,NP_001124468,NP_000850,XP_011541661,XP_011541659
Ptprs	198;362;919;1973	2.797141	2.144639	0.0253933	0.0253933	MGI:97815	192	XM_006523886|NM_001252456|XM_006523878|XM_006523882|XM_006523874|NM_001252455|XM_006523880|XM_006523884|XM_017317350|XM_017317349|XM_006523883|XM_006523881|NM_001252453|XM_006523877|NM_011218|XM_006523879|XM_006523875|XR_385302|XM_006523876	NP_001239385|NP_001239382|XP_006523940|NP_001239384|XP_006523943|XP_006523942|XP_006523941|XP_006523939|XP_017172839|XP_006523944|XP_006523945|XP_006523949|XP_006523947|XP_006523938|XP_006523946|XP_017172838|NP_035348|XP_006523937	20626	HGNC:96881	5802	NM_130855,NM_130853,NM_002850,NM_130854	XP_011526460,XP_016882557,XP_016882562,XP_005259667,XP_016882558,XP_011526459,XP_005259666,XP_016882555,NP_002841,XP_016882565,XP_005259664,XP_016882564,XP_005259663,XP_016882561,XP_016882554,XP_005259657,NP_570925,XP_016882556,XP_016882563,XP_016882560,NP_570924,XP_016882559,NP_570923
Ccnd3	74;34	2.775	2.1502	0.0255	0.025	MGI:8	1245	NM_001081636|XM_011246262|XM_006523552|NM_001081635|	XP_006523616|XP_011244564|NP_001075104|NP_031658|XP_	20419	HGNC:	896	NM_001760,NM_001287434,NM_001287427,NM_001136125,NM	XP_011513273,NP_001129597,NP_001129489,NP_001274356,NP_001274363,

	7;761;7748	18	53	49	77	77	8315	XM_006523553|NM_007632	006523615|NP_001075105		1585		_001136017,NM_001136126	XP_011513274,NP_001129598,NP_001751
Nptxr	79;177;43722;58844	2.7304	2.1178	0.0264	0.2679	0.2679	MGI:1920590	7340	NM_030689	NP_109614	8620	HGNC:79544	2346 7	NM_058178,NM_014293	NP_055108
Rrp1b	170;199;68860;90900	2.6306	1.9076	0.0309	0.3067	0.3067	MGI:1919712	7462	XR_001782117|XM_006524974|NM_028244|XM_006524973|XM_006524971|XM_006524972|NM_001163734	NP_001157206|XP_006525037|XP_006525035|XP_006525036|NP_082520|XP_006525034	5708 6	HGNC:238188	2307 6	NM_015056	NP_055871
Rap1b	730;750;88525;26188	2.5581 1	1.5798	0.0336	0.3262	0.3184	MGI:8943155	2154 49	NM_024457	NP_077777	6871 9	HGNC:98557	59 08	NM_001251921,NM_001251918,NM_015646,NM_001010942,NM_001251922,NM_001251917	NP_001238847,NP_001010942,NP_001238846,NP_056461,NP_001238851,NP_001238850
Lmnb1	130;213;12766;72	2.5728	1.9974	0.0342	0.3246	0.3184	MGI:967795	1690 6	NM_010721	NP_034851	5591 2	HGNC:66377	400 1	NM_001198557,NM_005573	NP_001185486,NP_005564

Spta n1	35 45 59; 818; 892; 7623	2.5607184	1.6084320	0.0313188	0.0314	MGI:983866	2074 0	XM_006497812| XM_006497813| NM_001177668| XM_006497815| NM_001309460| XM_006497809| XM_006497814| NM_001177667| XM_006497810| XM_006497816	XP_006497873| XP_006497875| NP_001171139| NP_001296389| XP_006497872| NP_001171138| XP_006497879| XP_006497878| XP_006497877| XP_006497876	2353	HGNC:11273	67 09	NM_001130438, NM_001195532, NM_003127	XP_006717314, NP_001182461, XP_006717315, XP_006717317, XP_016870550, XP_006717316, XP_006717308, XP_006717311, XP_016870548, XP_006717313, XP_016870549, XP_006717312, XP_006717310, XP_006717309, NP_003118,NP_001123910
Lats1	51; 2163; 7555; 7244	2.5616062	2.1026349	0.0318484	0.0318483	MGI:1338883	1679 8	XM_006512567| NM_010690	NP_034820|XP_006512630	5584 3	HGNC:6514	91 13	NM_004690,NM_001350340,NM_001350392,NM_001270519,NM_001350339	NP_001257448, NP_001337269, NP_001337268, XP_016866965, XP_006715666, XP_016866964, XP_016866971, NP_004681,XP_016866963,XP_016866966,XP_016866970,NP_001337321,XP_016866967,XP_011534554,XP_016866968,XP_016866969
Nme3	188; 7733; 927; 3263	2.5222737	1.7037232	0.0332693		MGI:1930182	7905 9	NM_019730	NP_062704	2056 2	HGNC:7851	48 32	NM_002513	XP_011520806, NP_002504,XP_005255389,XP_011520805
Nf2	107; 684; 930; 6869	2.5813279	1.8032753	0.0329933	0.0329937	MGI:973077	1801 6	XM_006514572| NM_010898|XM_017314334|XM_006514569|XM_006514574|XM_011243669|XM_006514573|NM_001252252|NM_001252253|XM_011243670|NM_001252250|XM_006514570|NM_001252251|XM_006514571|XM_017314335	XP_006514633| XP_011241971| NP_001239180| XP_006514635| XP_006514634| NP_001239182| NP_001239179| NP_035028|XP_011241972|XP_017169823|XP_006514636|XP_017169824|XP_006514637|NP_001239181|XP_006514632	2180	HGNC:7773	47 71	NM_181826,NM_016418,NM_181829,NM_181835,NM_181828,NM_181830,NM_181825,NM_181831,NM_181833,NM_181834,NM_181827,NM_181832,NM_000268	NP_861971,NP_861967,NP_861966,XP_016884298,NP_861546, NP_057502,NP_861969,NP_000259,NP_861968, NP_861970,XP_016884299
Ticam1	776; 876; 94	2.4999	1.8074	0.0338	0.0338	MGI:2147 0	1067 59	NM_174989	NP_778154	8605	HGNC:183	14 80 22	NM_014261,NM_182919	NP_891549

	4;5487					32				48					
C2	419;803;963;2229	2.4749	1.5921	0.0406	0.3432	0.3432	MGI:882263	12	NM_013484	NP_038512	45	HGNC:12483	71	NM_000063,NM_001178063,NM_001282458,NM_001145903,NM_001282459,NM_001282457	NP_001269387,NP_000054,NP_001269388,NP_001171534,NP_001269386,NP_001139375
Tnfrsf12a	58;2452;2244;2684	2.4542	2.0454	0.0042	0.3491	0.3438	MGI:1351484	27	NM_001161746|NM_013749	NP_038777|NP_001155218	841	HGNC:18152	51	NM_016639	NP_057723
Cat	134;247;2153;3610	2.4473	1.8652	0.0426	0.3468	0.3438	MGI:882711	12	NM_009804	NP_033934	551	HGNC:15164	84	NM_001752	NP_001743
Cabin1	984;2844;9899;2242	2.4414	2.0616	0.0433	0.3438	0.3438	MGI:1298375	10	XR_380334|XM_006513021|XR_001779406|XM_006513022|NM_172549|XM_006513020|XR_001779405|XR_001779404|XM_006513019	XP_006513082|XP_006513084|NP_766137|XP_006513083|XP_006513085	4930	HGNC:24187	23	NM_001201429,NM_012295,NM_001199281	XP_006724243,XP_006724242,XP_005261472,NP_036427,XP_011528331,XP_016884172,NP_001188358,XP_016884173,XP_005261474,XP_016884170,XP_016884171,XP_011528328,XP_005261473,XP_016884169,XP_006724244,XP_005261476,XP_011528332,NP_001186210
Ra	41	2.	1.	0.	0.	0.	MG	74	NM_028712	NP_082988	55	HG	59	NM_002886	NP_002877

p2b	7;4728;10033;82391	42387192	0.4494	34944	IPR:19212622	012			701	NCBI:98622	12			
Tmem101	187;680;10244;84631	2.39778	1.7170	0.04681	0.03615	MGI:1923797	76547	XM_017314829|NM_029649	NP_083925|XP_017170318	12649	HGNC:28653	8433	NM_001304814, NM_001304813, NM_032376	XP_011523649, NP_115752,XP_011523648,XP_011523651,XP_011523655,NP_001291742,XP_005257794,NP_001291743,XP_011523653
H2-Q7	175;266;11204;53011	2.38467	1.9477	0.04881	0.03656	MGI:95936	15018	NM_001198560|NM_001198561|XR_385292|NM_010394	NP_034524|NP_001185490|NP_001185489	12835 2	HGNC:49311	3105	NM_002116,NM_001242758	XP_005275388, NP_002107,NP_001229687,XP_016885777
Cxcl10	58;1020;10410;77100	2.37721	1.4561	0.04884	0.03648	MGI:1352450	15945	NM_021274	NP_067249	12033	HGNC:10637	3627	NM_001565	NP_001556
Msh2	151;2744;	2.35936	1.8338	0.00506	0.03718	MGI:101018	17685	NM_008628	NP_032654	210	HGNC:73	4436	NM_001258281, NM_000251	XP_011531169, XP_005264389, NP_001245210, NP_000242

	152 0;2 22 25					16					25				
Nme2	161;400;1057;9822	21.3581	18.6892	00.0507	00.3669	00.3669	MGI:973556	181103	NM_008705|NM_001077529	NP_001070997|NP_032731	133879	HGNC:7850	483 1	NM_002512,NM_001018137,NM_001018139,NM_001018138,NM_001198682	NP_001018147,NP_002503,NP_001185611,NP_001018148,NP_001018149
Synpo	280;282;1176;41355	21.3353	18.8477	00.0531	00.3782	00.3782	MGI:1094446	104027	XM_006525474|XM_006525475|XM_006525472|XM_006525476|XM_006525468|XM_006525471|NM_001109975|XM_006525470|NM_177340	XP_006525534|NP_796314|XP_006525537|XP_006525539|XP_006525531|XP_006525538|XP_006525533|XP_006525535|NP_001103445	527 4	HGNC:30672	11 34 6	NM_007286,NM_001166208,NM_001109974,NM_001166209	NP_001159681,XP_011535854,NP_001159680,XP_005268427,NP_009217,NP_001103444,XP_016864497,XP_005268428,XP_006714818,XP_016864496
Maged1	537;1035;1115;65600	21.2914	14.3458	00.0578	00.4052	00.4052	MGI:1930187	94275	NM_019791	NP_062765	5077	HGNC:68133	95 00	NM_006986,NM_001005332,NM_001005333	NP_001005333,NP_008917,XP_011529137,NP_001005332,XP_016885469,XP_016885468,XP_016885467
Rabepk	345;642;1133;5	21.2714	16.0188	00.0599	00.4139	00.4139	MGI:2139530	227746	XM_006497985|XM_006497987|NM_145522|XM_006497986|XM_006497989|XM_006497988|XM_006497984|XM_017317453	XP_017172942|XP_006498051|XP_006498047|NP_663497|XP_006498052|XP_006498048|XP_006498050|XP_006498049	4872	HGNC:16896	10 24 4	NM_001174152,NM_005833,NM_001174153	XP_016869667,XP_005251701,XP_011516422,XP_005251699,XP_005251698,NP_001167624,NP_001167623,XP_016869669,NP_005824,XP_016869666,XP_005251697,XP_016869671,XP_016869668,XP_

	869													016869670,XP_016869672
Tchp	460;1019;1181;6533	2.2.1.1	1.4.3.3	0.0.6.6	0.4.5.3	0.5.1.7	MGI:1925082	778	XM_006530508|NM_029992|XM_006530509|XM_006530511|XM_006530510	XP_006530571|XP_006530574|XP_006530572|NP_084268|XP_006530573	1268	HGNC:28135	842	NM_032300,NM_001143852	XP_011537139,NP_001137324,NP_115676,XP_016875513,XP_016875514,XP_011537138
Traf7	169;8111;1192;8177	2.2.2.2	1.6.0.7	0.0.8.0	0.4.6.0	0.5.1.2	MGI:3042141	2246199	NM_153792|NM_001172113|NM_001172114	NP_001165585|NP_722487|NP_001165584	1298	HGNC:20456	8423	1	NM_032271,NM_206835	XP_005255684,NP_115647,XP_011521002
Nf1	218;329;4753;6572	2.2.0.5	1.6.4.4	0.0.6.8	0.4.5.3	0.5.1.2	MGI:973061	1801	XM_006532442|XM_006532441|NM_010897|XM_006532436|XM_006532439|XM_006532438|XM_006532437|XM_006532440	XP_006532500|XP_006532504|XP_006532502|XP_006532499|XP_006532505|XP_006532501|NP_035027|XP_006532503	226	HGNC:7765	4763	NM_001128147,NM_000267,NM_001042492	XP_005258041,XP_011523159,NP_000258,XP_006721985,NP_001035957,XP_011523154,XP_016880179,XP_006721988,XP_005258040,XP_016880178,XP_006721989,XP_006721987,NP_001121619
Mknk1	128;979;1202;3440	2.1.9.7	1.6.0.8	0.0.6.6	0.4.5.9	0.5.1.2	MGI:894316	1736	XM_006502825|NM_021461|NM_001285488|XM_017320015|XM_006502823|XM_006502822|NM_001285487	XP_006502886|NP_067436|NP_001272416|XP_017175504|NP_001272417|XP_006502888|XP_006502885	3783	HGNC:7110	8569	NM_198973,NM_003684,NM_001135553	XP_016858142,NP_001129025,NP_003675,XP_006711070,XP_016858143,XP_016858151,XP_006711078,XP_016858145,XP_016858146,XP_016858155,XP_016858153,XP_016858144,XP_006711064,XP_016858157,NP_945324,XP_016858150,XP_016858148,XP_006711076,XP_006711063,XP_006711069,XP_016

														858156,XP_016858154,XP_016858141,XP_006711066,XP_016858149,XP_016858147,XP_006711072,XP_016858152,XP_006711065,XP_006711077
Akap8	13;341;3399;;4778	2.17232	1.0724	0.0465	0.0461	MGI:1928488	563 9	XM_006524663|XM_006524665|XR_001782093|NM_019774|XM_006524664|NR_131219|XM_006524666|NR_131218	XP_006524726|XP_006524727|XP_006524728|NP_062748|XP_006524729	428	HGNC:3788	1027 0	NM_005858	NP_005849,XP_011525926,XP_016881630
Rgmb	458;562;1243;4990	2.15626	1.0754	0.0478	0.0478	MGI:1916049	679 9	XM_006524863|XM_006524864|NM_178615|XM_006524865	NP_848730|XP_006524928|XP_006524927|XP_006524926	6535 5	HGNC:26896	285704	NM_173670,NM_001012761	XP_011541649, NP_001012779, XP_011541648, XP_011541647, XP_016864879, XP_005272023, XP_016864880
Spry1	190;368;2601;5639	2.11204	1.0828	0.0517	0.0512	MGI:1345139	240 63	NM_001305442|NM_001305440|NM_011896|NM_001305441	NP_036026|NP_001292369|NP_001292370|NP_001292371	4266	HGNC:11269	1025 2	NM_199327,NM_005841,NM_001258038,NM_001258039	NP_001244968, NP_001244967, NP_005832,XP_005262743,XP_016863124,NP_955359
Sparc	32;373;5607;;77	2.10071	1.0961	0.0846	0.0521	MGI:983773	206 92	NM_001290817|NM_009242	NP_001277746|NP_033268	3113 2	HGNC:11219	667 8	NM_001309444, NM_001309443, NM_003118	NP_001296373, NP_001296372, NP_003109

Rela	23210;3744;43311;50999	2.0985	1.5983	0.0851	0.5171	0.5152	MGI:1032900	1969	XM_006531694|NM_009045|XM_006531695	XP_006531758|NP_033071|XP_006531757	32064	HGNC:9955	5970	NM_001145138,NM_021975,NM_001243985,NM_001243984	XP_011543508,NP_001138610,NP_068810,NP_001230914,XP_011543509,NP_001230913
Ino80	3119;3776;28644;47033	2.0940	1.5127	0.0859	0.5152	0.5152	MGI:1915392	6814	XM_355376	NP_080850	75070	HGNC:26956	54617	NM_032196,NM_017553	NP_060023,XP_011519987,XP_011519988
Ehd4	6388;1158;13205;51588	2.0818	1.3160	0.0882	0.5223	0.5199	MGI:1919619	9878	XM_017319352|NM_133838	NP_598599|XP_017174841	26430	HGNC:32455	30844	NM_139265	NP_644670,XP_016877589
Gpr56	3421;12755;13244;59933	2.0780	1.3673	0.0889	0.5199	0.5199	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Cu	183	2.0	1.6	0.0	0.5	0.5	MGI	757	XM_017313680|NM_001161618|NM_027807	NP_082083|XP_017169169|NP_001155090	25	HGN	80	NM_003478	XP_016873854,XP_011541315,NP_003469,XP_

l5	;391;58466;94244	614	078	920	312	312	:19229677	17				97	C:2556	65		016873852,XP_016873853,XP_005271739
Orc1	586;861;1364;23006	2.0413	1.3885	0.0958	0.5458	0.5458	MGI:1328337	1839 2	XM_011240469|NM_011015	NP_035145|XP_011238771		3121 21	HGNC:8487	499 8	NM_004153,NM_001190819,NM_001190818	NP_004144,XP_011539829,XP_016856877,NP_001177747,NP_001177748,XP_016856878
Cdkn1a	92;405;2603;79422	2.0321	1.7364	0.0975	0.5491	0.5491	MGI:1045556	1257 5	NM_007669|NM_001111099	NP_001104569|NP_031695		333	HGNC:1784	102 6	NM_001291549,NM_001220777,NM_000389,NM_001220778,NM_078467	NP_001278478,NP_001207707,NP_001207706,NP_000380,NP_510867
Ppm1b	306;840;13933;58222	2.0154	1.4675	0.1008	0.5608	0.5505	MGI:1018411	1904 3	XM_011246322|XM_006523862|XM_011246323|XM_011246321|NM_001159496|NM_001159497|NM_011151|NM_001159498|XM_006523861|XM_006523860	XP_011244624|XP_006523923|XP_006523924|XP_006523925|XP_011244623|NP_001152968|NP_001152969|NP_001152970|XP_011244625|NP_035281		2027	HGNC:9276	549 5	NM_002706,NM_177969,NM_177968,NM_001033556,NM_001033557	NP_808907,NP_001028729,NP_002697,XP_016859884,XP_016859885,NP_808908,XP_011531238,XP_016859886
Ddx23	162;416;423	2.0099	1.6071	0.1021	0.5611	0.5505	MGI:1921601	7435 1	XM_006521493|NM_001080981	XP_006521556|NP_001074450		3542	HGNC:17347	941 6	NM_004818	NP_004809

	7;6107														
Sped1	28;1362;14055;42400	2.0048	1.3501	0.1031	0.5596	0.5505	MGI:2150016	1147155	NM_001277256|NM_033524	NP_277059|NP_001264185	2491	HGNC:20249	16174	NM_152594	XP_011519591,NP_689807,XP_005254259
Ifngr1	358;7411;14077;22088	2.0031	1.4761	0.1034	0.5550	0.5505	MGI:1076555	15979	NM_010511	NP_034641	359	HGNC:54399	34559	NM_000416	NP_000407,XP_016866316,XP_006715534,XP_006715533,XP_011534096,XP_011534095
Tmem59	226;4222;28611;45333	1.9980	1.5332	0.1045	0.5543	0.5505	MGI:1929278	56374	NM_029565	NP_083841	3583	HGNC:12399	95288	NM_004872,NM_001305052,NM_001305050,NM_001305049,NM_001305051,NM_001305066,NM_001305043	NP_004863,NP_001291979,NP_001291972,XP_006711114,NP_001291980,NP_001291978,NP_001291995,NP_001291981
Gabbr1	17;4233;22011;63544	1.9960	2.0801	0.1050	0.5505	0.5505	MGI:1860139	54393	NM_019439|XR_001782091|XM_006524632	XP_006524695|NP_062312	1132	HGNC:40700	25050	NM_021903,NM_021905,NM_001319053,NM_001470,NM_021904	XP_005249039,NP_001305982,NP_068703,NP_001461,XP_016866165,NP_068704,XP_011512757,XP_006715110,XP_011512755

Rbbp7	150;9033;14332;93377	1.9814	1.5334	0.1082	0.5606	0.5581	MGI:1194910	24568	NM_009031	NP_033057	5570	HGNC:9890	5931	NM_002893,NM_001198719	NP_001185648, NP_002884
Camk2g	4985;9511;14360;2860	1.9780	1.3609	0.1089	0.5581	0.5581	MGI:882599	12325	NM_001039139|XM_006518490|XM_006518493|XM_006518491|XM_017315826|XM_006518497|XM_006518494|XM_006518498|XM_006518488|XM_017315827|XM_017315828|XM_006518496|XM_006518489|NM_001039138|XM_006518495|XM_006518492|NM_178597|XR_874287|XM_006518500	XP_006518558|NP_001034227|XP_006518560|XP_006518556|NP_001034228|XP_006518553|XP_017171316|NP_848712|XP_017171315|XP_006518551|XP_006518555|XP_006518563|XP_006518554|XP_017171317|XP_006518557|XP_006518561|XP_006518559|XP_006518552	1559	HGNC:1463	8181	NM_172173,NM_172170,NM_001222,NM_001204492,NM_172169,NM_172172,NM_172171,NM_001320898	XP_016872207, XP_016872223, XP_016872206, XP_005270257, XP_005270260, XP_016872209, XP_016872208, XP_006718061, XP_005270256, XP_016872217, XP_005270255, NP_001213,XP_016872219,XP_006718059,XP_016872224,XP_016872228,XP_016872226,XP_016872211,XP_016872218,NP_751909,NP_751910,XP_006718056,XP_016872205,NP_751911, XP_016872212, XP_016872221, XP_006718060, XP_016872210, XP_016872216, XP_011538527, XP_016872214, XP_016872225, XP_016872215, NP_001191421, XP_016872220, NP_751913,XP_016872227,XP_016872222,XP_005270254,XP_005270252,XP_016872213,XP_005270258,XP_005270262,NP_001307827
Polr3g	3484;4339;43911;53	1.9652	1.4314	0.1121	0.5678	0.5650	MGI:1914736	67486	XM_283153	NP_001074645	3818	HGNC:30075	1062	NM_006467	XP_011541403, XP_016864446, XP_011541406, XP_011541405, XP_005248461, NP_006458,XP_011541404,XP_011541402,XP_011541407

Ubap1	20080;44415;62881;94011	11.9736155	00.11.16.30	00.56.62	0.56.50	MGI:2149543	673	XM_006538197|NM_023305|XM_006538198|NM_001290454|XM_006538196	XP_006538261|XP_006538260|NP_075794|NP_001277383|XP_006538259	9554	HGNC:12461	51271	NM_001171204, NM_001171203, NM_001171201, NM_001171202, NM_016525	NP_001164675, NP_001164672, XP_011516202, XP_016870291, XP_006716842, XP_016870290, NP_001164674, XP_011516200, XP_011516201, NP_001164673, NP_057609
Tmem206	85959;11644;14622;39577	11.9255902	00.11.14.56.59	00.56.50	0.56.50	MGI:1914200	6695	NM_025864	NP_080140	10097	HGNC:25593	5524	NM_001198862, NM_018252	NP_060722,XP_011508020,XP_011508019,XP_016857123,XP_005273234,XP_016857126,XP_016857125,NP_001185791,XP_016857124
Slc1a5	28713000;14753;91233	11.9451167	00.13.15.17.24	00.56.50	0.56.50	MGI:1053054	2051	XR_391053|XM_006539695|XR_391052|NM_009201	NP_033227|XP_006539758	2115	HGNC:10943	6510	NM_005628,NM_001145145,NM_001145144	NP_001138617, NP_005619,XP_005259224,NP_001138616
Aamp	79613009;14786;87711	11.9426	00.21.17.06	00.57.65.50	0.56.50	MGI:1078090	2272	XM_006495958|XM_006495957|NM_146110|NM_001190444	NP_001177373|XP_006496020|NP_666222|XP_006496021	846	HGNC:18	14	NM_001087,NM_001302545	NP_001078,NP_001289474
Ecs	512	11.9	00.1	00.5	0.5	MGI	685	XM_358515|XM_006526210	XP_006526273|NP_001028313	868	HGN	641	NM_001293739, NM_001077693	NP_001280668, NP_001071161

cr	;718;1479;4995	417	194	177	650	650	:19157955	45			11	C:35454	700		
Stag2	697;942;1501;2415	119236	1.3059	0.1222	0.5804	0.5804	MGI:1098583	2084	XM_011250983|NM_021465|NM_001290713|XM_011250987|XM_011250984|XM_017318446|NM_001077712|XM_011250986|XM_011250985|XM_011250988|XM_011250989	NP_001277642|XP_011249286|XP_011249289|XP_011249290|XP_017173935|XP_011249291|NP_067440|XP_011249285|NP_001071180|XP_011249287|XP_011249288	382	HGNC:11355	107	NM_001282418,NM_006603,NM_001042749,NM_001042750,NM_001042751	XP_005262416,NP_001269347,XP_016884724,NP_001036215,XP_016884721,XP_005262415,XP_006724791,XP_005262418,XP_016884722,NP_006594,NP_001036216,XP_011529555,XP_005262414,XP_016884723,XP_006724790,XP_005262417,NP_001036214
Dgkh	207;470;4935;5868	119088	1.5064	0.1263	0.5937	0.5915	MGI:2444188	3809211	XM_011245102|XM_011245103|NM_001081336|NM_001281794|XM_006519173|XM_011245099|XM_006519172|XM_011245100|XM_006519171|NR_104044|XM_006519169|XM_011245101|NM_001253766	XP_011243404|XP_006519232|XP_006519235|NP_001240695|XP_011243403|XP_006519234|NP_001074805|XP_006519236|NP_001268723|XP_011243405|XP_011243402|XP_011243401	9937	HGNC:2854	1608	NM_001297429,NM_178009,NM_001204506,NM_001204504,NM_001204505,NM_152910	NP_821077,NP_001191433,NP_001191434,NP_001191435,NP_001284358,NP_690874
Impa2	111;1227;1524;2828	119054	1.1846	0.1274	0.5929	0.5915	MGI:2149728	1146 63	NM_053261	NP_444491	22799	HGNC:60551	3613	NM_014214	NP_055029,XP_011523961,XP_011523963
Rras	883;1112	119018	1.2308	0.1284	0.5915	0.5915	MGI:9811	2011 30	XM_006540721|NM_009101	XP_006540784|NP_033127	4565	HGNC:104	6237	NM_006270	NP_006261

	;15285855					79					47				
Axin1	33;4833;15905;20599	1.8863	1.5502	0.1326	0.0604	0.0648	MGI:1096327	105	NM_001159598|XM_006523515|XM_128515|XM_006523516	XP_006523579|NP_033863|XP_006523578|NP_001153070	214	HGNC:9033	812	NM_003502,NM_181050	XP_016879234, XP_016879232, XP_016879236, XP_016879233, XP_011520985, XP_016879235, XP_011520986, XP_011520988, NP_003493,NP_851393,XP_016879237,XP_011520984
Arl4d	35;12662;15644;51006	1.8734	1.2972	0.1363	0.0615	0.0652	MGI:1933155	809	NM_025404	NP_079680	1255	HGNC:6556	379	NM_001661	XP_011523084, NP_001652
Rhoq	304;15111;15744;65688	1.8656	1.2707	0.1387	0.0619	0.0674	MGI:1931553	1042	XR_001782024|NM_145491	NP_663466	2274	HGNC:17736	2343	NM_012249	NP_036381,XP_011531030,XP_016859205,XP_011531028,XP_005264286
Strn	612;1415;1557	1.8625	1.1983	0.1396	0.0618	0.0674	MGI:1333757	26890	XM_006524357|NM_011500	NP_035630|XP_006524420	2380	HGNC:11424	6801	NM_003162	XP_011531375, NP_003153,XP_005264576

	8;8202														
Nme6	3550;5000;3265;50003	1.1857938	1.3738	0.1408	0.6174	0.6174	MGI:1861676	549	XM_006512199|XM_006512200|XM_006512197|XM_006512198|NM_018757	XP_006512261|XP_006512262|XP_006512263|XP_006512260|NP_061227	4231	HGNC:20567	102 01	NM_001308434,NM_001308428,NM_001308430,NM_001308433,NM_005793,NM_001308435,NM_001308427,NM_001308431,NM_001308426	NP_001295356,NP_001295363,NP_005784,XP_016861000,XP_016861001,NP_001295357,XP_016861003,XP_016861002,NP_001295359,NP_001295362,XP_016861006,XP_016861007,NP_001295355,NP_001295360,NP_001295364,XP_016861004,XP_016861005
Cd38	4887;5088;34800;93199	1.8448478	1.3078	0.1452	0.6306	0.6192	MGI:1074744	1249	NM_007646	NP_031672	1345	HGNC:1667	952	NM_001775	NP_001766
Tanc1	10811;11611;16021;71855	1.8444411	1.1811	0.1458	0.6255	0.6192	MGI:1914110	6686 0	XM_017319202|XM_017319201|XM_017319205|XM_006500034|XM_006500036|XM_006500040|XM_017319203|XM_006500035|NM_001290659|XM_017319200|XM_017319204|XM_006500037|XM_130249|XM_006500039	XP_006500103|XP_006500098|XP_017174691|NP_001277588|XP_006500102|XP_017174694|XP_006500099|XP_006500097|XP_017174692|XP_017174689|XP_017174693|NP_938036|XP_006500100|XP_017174690	18946	HGNC:29364	854 61	NM_001350062,NM_033394,NM_001350064,NM_001350065,NM_001145909,NM_001350063	NP_001336991,XP_016860633,NP_001336993,XP_016860641,NP_203752,XP_016860647,XP_006712873,XP_016860631,XP_016860645,NP_001336994,XP_016860637,XP_011510364,XP_006712877,XP_016860644,NP_001336992,XP_011510350,XP_011510357,XP_016860646,XP_011510361,XP_011510353,NP_001139381,XP_016860643,XP_006712875,XP_016860630,XP_016860640,XP_016860634,XP_016860642,XP_016860632,XP_005246975,XP_011510360,XP_011510355,XP_016860639,XP_016860636,XP_016860638,XP_016860635

Pard3	10;38;124;144;161;587	1.1.164.8.2	0.0.14.8.2	0.0.63.1.5	0.0.61.9.2	MGI:2135608	9374	NM_033620|NM_001309391|XM_006531528|NM_001013580|XM_006531526|XM_006531533|XM_006531530|XM_006531527|XM_006531521|XM_006531532|XM_006531529|NM_001309392|XM_006531524|XM_006531523|NM_001122850|XM_006531531|NM_001013581|XM_006531520	XP_006531590|XP_006531593|XP_006531584|XP_006531589|XP_006531594|NP_001296321|XP_006531592|XP_006531596|NP_001116322|XP_006531586|NP_296369|XP_006531587|XP_006531591|XP_006531595|NP_001013598|NP_001296320|NP_001013599|XP_006531583	1048 9	HGNC:16051	5628	NM_001184785, NM_001184791, NM_001184789, NM_001184790, NM_001184794, NM_001184793, NM_001184786, NM_001184788, NM_019619,NM_001184792,NM_001184787	XP_011517883, XP_005252593, XP_011517875, XP_011517885, NP_001171721, XP_011517880, NP_001171715, XP_005252592, XP_011517873, NP_001171720, XP_005252587, XP_011517878, XP_005252589, XP_016871919, NP_001171719, XP_011517871, XP_011517886, XP_005252588, NP_062565,XP_005252591,NP_001171714,NP_001171723,NP_001171718,XP_011517872,XP_011517874,NP_001171716,XP_011517881,XP_011517879,XP_005252585,NP_001171717,XP_011517877,NP_001171722
Cry2	1391;1572;1621;7587	1.1.0817	0.0.1499	0.0.6330	0.0.6192	MGI:1270859	1295 3	NM_009963|XM_017315281	XP_017170770|NP_034093	5646 6	HGNC:23855	1408	NM_001127457, NM_021117	NP_066940,NP_001120929
Mapk11	468;519;;2171;;93600	1.1.3063	0.0.1508	0.0.6307	0.0.6192	MGI:1338024	1909 4	NM_011161	NP_035291	5568 4	HGNC:68733	5600	NM_002751	NP_002742,XP_011529008
Hnrnpa0	372;520	1.1.3488.2.57	0.0.1513	0.0.6270	0.0.6192	MGI:192	7713 4	NM_029872	NP_084148	1368 09	HGNC:50	1094 9	NM_006805	NP_006796

	;7001;9481					4384				30						
Prpf4b	28;5211;17382;8234	1.8824941	1.8831418	0.1521362	0.1619	0.6192	MGI:1095844	19113 4	XM_017315427|XM_017315436|XM_017315437|XM_017315434|XM_017315430|XM_017315432|XM_006516583|XM_017315433|XM_017315429|XM_017315435|NM_013830|XM_017315441|XM_006516582|XM_017315440|XM_006516584|XM_017315426|XM_017315428|XM_017315425|XM_017315439|XM_017315431|XM_017315438	XP_017170924|XP_017170925|XP_017170923|XP_017170914|XP_017170926|XP_017170915|XP_017170920|XP_006516645|XP_017170922|XP_017170927|XP_017170930|XP_006516646|XP_017170919|XP_006516647|XP_017170918|XP_017170921|XP_017170917|XP_017170916|XP_017170929|XP_017170928|NP_038858	13408 5	HGNC:17346	88 9	NM_176800,NM_003913	XP_016866920,XP_016866901,XP_016866904,XP_016866902,XP_016866910,XP_016866913,XP_016866914,XP_016866903,XP_016866906,XP_016866905,XP_016866907,XP_016866916,XP_016866912,XP_016866915,XP_011513272,XP_016866924,XP_016866918,XP_016866921,XP_016866899,XP_016866908,XP_016866911,XP_016866917,XP_016866909,NP_003904,XP_016866900,XP_016866922,XP_016866923,XP_016866919
Epb4.1l2	59;15811;16300;9194	1.8230	1.1627	0.1521	0.6192	0.6192	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Gtf2f1	115;524;2694;;9633	1.8194	1.5831	0.1535	0.6194	0.6194	MGI:1923848	98053	NM_133801|XM_006525194	NP_598562|XP_006525257	1585	HGNC:4652	29 6 2	NM_002096	NP_002087	

Fkbp1a	264;529;3902;4982	1.8116	1.4088	0.1562	0.6248	0.6248	MGI:95541	14225	NM_001302079|NM_001302077|NM_008019|NM_001302078|XM_011239292|NM_001302080|XM_017315525|NR_126058	XP_017171014|NP_032045|NP_001289008|NP_001289006|XP_011237594|NP_001289007|NP_001289009	105139	HGNC:3711	2280	NM_054014,NM_001199786,NM_000801	NP_463460,NP_001186715,NP_000792
Parn	1525;1562;1663;3121	1.7986	1.0664	0.1608	0.6375	0.6272	MGI:1921358	74108	XM_011246024|XM_017317144|XM_006522652|NM_028761|XM_011246023|XM_017317145	XP_006522715|XP_017172634|XP_011244325|NP_083037|XP_017172633|XP_011244326	31098	HGNC:8609	5073	NM_001242992,NM_002582,NM_001134477	XP_011520812,NP_001127949,NP_002573,XP_011520813,XP_011520816,NP_001229921,XP_016878747,XP_011520815,XP_016878749,XP_016878748
Dab2	155;544;3588;7549	1.7887	1.5057	0.1643	0.6459	0.6272	MGI:109175	13132	NM_001037905|NM_001310446|NM_023118|NM_001008702|XM_017316424|XM_011245324|NM_001102400	NP_001032994|NP_001008702|XP_011243626|NP_001297375|NP_001095870|XP_017171913|NP_075607	1026	HGNC:2662	1601	NM_001244871,NM_001343	NP_001231800,NP_001334
Adk	581;599;1678;7919	1.7877	1.4017	0.1646	0.6415	0.6272	MGI:87930	11534	NM_134079|NM_001243041|XM_006518440|XM_006518441	XP_006518504|XP_006518503|NP_598840|NP_001229970	4891	HGNC:257	132	NM_001202449,NM_001123,NM_006721,NM_001202450	NP_001189378,XP_016871190,XP_016871193,XP_016871188,NP_001114,XP_016871195,XP_016871194,XP_016871187,NP_006712,XP_016871192,NP_001189379,XP_016871191,XP_016871189
Tfpt	140;5	1.78	1.52	0.16	0.63	0.62	MGI:1	69714	NM_001290381|NM_023524	NP_076013|NP_001277310	8349	HGNC:	29844	NM_001321792,NM_013342	NP_037474,NP_001308721,XP_005278318

	45;7905;8848	720	60	48	70	72	9169964				13630			
Ppp2cb	249;5466;20583;4673	1.7857	1.4076	0.1653	0.6335	0.6272	MGI:1321161	1905 3	NM_017374|XM_006509033	XP_006509096|NP_059070	3789	HGNC:9300	5516	NM_004156,NM_001009552	NP_001009552
Tnfsf9	20;5491;32944;41300	1.7812	1.9376	0.1670	0.6344	0.6272	MGI:1101058	2195 0	NM_009404|XM_006524033	NP_033430|XP_006524096	13721	#N/A	#N/A	#N/A	#N/A
Cnnm4	941;13133;16897;63977	1.7798	1.1424	0.1674	0.6308	0.6272	MGI:2151060	9420 0	NM_033570	NP_291048	7562	HGNC:105	2650 4	NM_020184	XP_005263972,NP_064569,XP_011509257,XP_011509258,XP_016859288,XP_005263971
Ppp1r10	61;1305;16933	1.7769	1.4982	0.1683	0.6292	0.6272	MGI:1289273	5204 0	XM_006524619|XM_006524616|XM_006524618|XM_006524617|NM_001163818	XP_006524679|XP_006524681|XP_006524680|NP_001157290|XP_006524682	2033	HGNC:9284	5514	NM_002714	NP_002705,XP_011513024,XP_006715193,XP_016866484

	;8947														
Prksh	542;553;5722;95433	1.7753536	1.2516922	0.1622	0.6272	0.6272	MGI:1078777	19089	XM_006510095|XM_006510096|NM_008925|NM_001293650|NM_001293651	NP_001280579|XP_006510158|XP_006510159|NP_001280580|NP_032951	20056	HGNC:9411	55899	NM_001289102,NM_002743,NM_001001329,NM_001289104,NM_001289103	XP_016882466,XP_011526434,NP_001276031,NP_002734,XP_011526432,NP_001001329,NP_001276032,NP_001276033,XP_011526433
Gria4	220;12291705;56122	1.7683815	1.3631717	0.1631	0.6314	0.6314	MGI:958111	14802	XM_006509845|NM_001113180|XM_006509842|XM_006509844|XR_001778800|XR_001778799|XR_001778798|XM_017313135|XR_379085|XM_011242355|XR_001778797|XR_379084|NM_001113181|NM_019691|XM_006509843|XM_006509841	XP_006509907|NP_001106652|NP_001106651|XP_006509906|XP_017168624|XP_006509904|XP_006509908|XP_006509905|XP_011240657|NP_062665	20227	HGNC:4574	2893	NM_001077243,NM_001112812,NM_001077244,NM_000829	NP_000820,NP_001070711,XP_011541077,XP_016873099,XP_005271575,XP_016873100,XP_011541079,XP_016873098,XP_011541078,XP_006718886,NP_001070712,NP_001106283
Ddr1	514;12033;17200;24333	1.7523779	1.2273599	0.1647	0.6377	0.6377	MGI:992116	13005	XM_011246259|NM_001198833|NM_001198831|NM_007584|XR_001782030|XM_006523538|XM_006523536|XM_006523535|XM_006523533|XM_006523537|XM_006523534|NM_172962	XP_006523598|XP_011244561|NP_001185762|XP_006523597|XP_006523601|NP_031610|NP_001185760|XP_006523596|NP_766550|XP_006523599|XP_006523600	68212	HGNC:2730	7800	NM_001202522,NM_001297652,NM_001297654,NM_013993,NM_001954,NM_001202523,NM_001202521,NM_001297653,NM_013994	XP_006715248,XP_011513184,NP_001284582,XP_016866758,NP_001284583,XP_011513189,XP_011513190,NP_054699,NP_001945,XP_011513187,NP_054700,NP_001189451,NP_001284581,NP_001189450,NP_001189452,XP_016866757,XP_011513186,XP_011513188,XP_011513185
Tbrg4	667;16122;17223;34	1.7563	1.1752621	0.1676438	0.6377	0.6377	MGI:1100868	21379	XM_017314423|XR_001779944|NM_001130457|XM_006514607|XM_011243672|XR_001779943|XM_006514608|NM_134011|XR_001779945	XP_017169912|XP_006514671|XP_006514670|NP_598772|NP_001123929|XP_011241974	31259	HGNC:17443	9238	NM_199122,NM_001261834,NM_030900,NM_004749	NP_954573,NP_004740,NP_001248763,NP_112162

Neu1	81 55; 1651; 17277; 86044	1.1.1.18	0.0.63776	0.0.63777	MGI:97305	180 10	NM_010893	NP_035023	375	HGNC:7758	475 8	NM_000434	NP_000425	
Oai1	371; 1139; 17460; 77600	1.1.2.7396	0.0.18225	0.0.65011	MGI:1925542	1093 05	XM_006530116|NM_175423|XM_006530117	XP_006530179|XP_006530180|NP_780632	1311 7	HGNC:25896	848 76	NM_032790	NP_116179	
Mnat1	40; 578; 7928; 79555	1.1.7.73922	0.0.18.28	0.0.64.611	MGI:1062207	174 20	NM_008612|XM_011244008|XM_006515526	XP_006515589|NP_032638|XP_011242310	1821	HGNC:7181	433 1	NM_001177963, NM_002431	XP_005267744, XP_016876822, XP_005267745, XP_016876821, XP_016876823, NP_002422,NP_001171434	
Anxa3	756; 1474; 17566; 60400	1.1.12.7326	0.0.18.5295	0.0.64.4955	MGI:1201378	1174 5	NM_013470	NP_038498	68445	HGNC:541	306	NM_005139	NP_005130	
Em	388	1.1.2.17	0.0.1.16	0.0.6.6	MGI	137	NM_001146346|NM_010129	NP_001139818|NP_034259	10	HGN	20	NM_001313905, NM_001425	NP_001300834, XP_011524907, NP_001416	

p3	;589;3247;3318	2398	8981	5835	5655	:109872 9	32				90	C:3335	14		
Stx2	346;1040;1776;4243	1.7190	1.2973	0.1911	0.6603	0.6565	MGI:1080059	1352	XR_001784605|XR_001784606|XM_006504276|NM_001286034|XR_377049|NM_007941|NM_001286033	XP_006504339|NP_001272962|NP_031967|NP_001272963	37559	HGNC:3403	2054	NM_194356,NM_001351052,NM_001351050,NM_001351049,NM_001980,NM_001351051	XP_016874470, XP_016874475, NP_001337981, XP_016874467, NP_001337979, XP_016874477, XP_016874474, NP_919337,XP_016874472,XP_005253614,XP_016874478,XP_016874468,XP_016874471,XP_016874473,NP_001337980,NP_001971,XP_016874469,XP_016874476,NP_001337978
Mreg	223;593;5785;5866	1.7184	1.3961	0.1915	0.6565	0.6565	MGI:2151839	3812 69	XM_011238551|XM_355212|XM_006496111	XP_011236853|XP_006496174|NP_001005423	9954	HGNC:25478	5568 6	NM_018000	NP_060470,XP_016859964,XP_011509770
Ppp1r9b	395;596;4291;6044	1.7143	1.2816	0.1933	0.6579	0.6579	MGI:2387581	2171 24	NM_172261	NP_758465	32787	HGNC:9298	8468 7	NM_032595	XP_011523683, NP_115984
Lsm2	343;760;	1.7108	1.3775	0.1948	0.6581	0.6581	MGI:906	2756	NM_001204274|NM_001204273|NM_030597|NM_001110101	NP_001191202|NP_085100|NP_001103571|NP_001191203	48535	HGNC:139	5781 9	NM_021177	NP_067000

	1788;2797						76					40			
Ube2b	607;1470;1800;4650	1.7028	1.1369	0.1983	0.6650	0.6588	MGI:102944	22210	XM_011248967|XM_006533161|XM_006533160|NM_009458	XP_006533223|XP_006533224|XP_011247269|NP_033484	101298	HGNC:12473	7320	NM_003337	NP_003328
Cd164	301;1408;1816;1999	1.6921	1.2311	0.2031	0.6758	0.6588	MGI:1859568	53599	NM_016898	NP_058594	38129	HGNC:1632	8763	NM_001346500, NM_001142404, NM_001142402, NM_001142401, NM_006016,NM_001142403	NP_001135873, NP_001333429, NP_001135875, NP_001135876, NP_001135874, NP_006007
Nap1l1	153;613;2227;4310	1.6914	1.4597	0.2034	0.6722	0.6588	MGI:1855693	53605	XR_001779557|XM_006513893|NM_015781|XR_001779558|XM_006513890|NM_001146707	NP_001140179|XP_006513953|NP_056596|XP_006513956	129218	HGNC:7637	4673	NM_001330232, NM_001307924, NM_139207,NM_001330231,NM_004537	NP_001317161, NP_001317160, XP_011536692, XP_016874828, NP_001294853, NP_004528,XP_016874827,XP_011536695,XP_016874829,XP_006719488,NP_631946
Peak1	736;774;1820;	1.6894	1.2733	0.2042	0.6699	0.6588	MGI:2442366	24895	XM_006511167|XM_006511168|NM_172924	XP_006511231|XP_006511230|NP_766512	18259	HGNC:29431	7934	NM_024776	XP_011520344, XP_005254727, XP_011520342, XP_005254732, XP_011520343, XP_005254730, XP_011520337, XP_011520338, NP_079052,XP_011520340,XP_005254728,XP_005254731,XP_011520341,XP_

	32887														011520339,XP_011520336,XP_011520335
Itgb8	82;9200;18233;;44552	1.16875	1.21554	0.20536	0.06686	0.06588	MGI:1338035	3209110	NM_177290	NP_796264	18567	HGNC:61663	3696	NM_002214	XP_011513696, XP_016867667, XP_016867670, XP_016867672, XP_011513695, XP_016867669, XP_011513698, NP_002205,XP_016867668,XP_016867671
Mtmr4	11133;13377;18272;;82722	1.16848	1.09044	0.20644	0.06677	0.06588	MGI:2180699	17074949	XM_011248780|XM_006532383|XM_006532384|NM_133215|XM_006532385	XP_006532448|XP_006532447|NP_573478|XP_011247082|XP_006532446	3440	HGNC:74552	9110	NM_004687	XP_005257841, XP_005257843, XP_005257842, XP_006722231, XP_011523762, NP_004678
Itpkb	5225;6199;19411;;43288	1.16835	1.34644	0.20699	0.06643	0.06588	MGI:1092355	32040404	XM_205854|XM_006496902|XM_006496903	XP_006496966|XP_006496965|NP_001074644	1672	HGNC:61779	3707	NM_002221	XP_005273177, XP_016856700, NP_002212
Myo6	98410;11077;18377;;28855	1.16782	1.14067	0.20959	0.06779	0.06588	MGI:1047855	17921020	XM_011242669|XM_011242667|XM_017313191|XM_011242671|XM_006510836|XM_006510838|NM_001039546|XM_011242670|XM_011242668|XM_006510835	XP_006510901|XP_006510898|XP_011240972|XP_017168680|XP_011240969|XP_011240973|XP_006510899|NP_001034635|XP_011240971|XP_011240970	56417	HGNC:76055	4646	NM_001300899, NM_004999	XP_005248778, XP_005248777, XP_005248781, NP_004990,XP_005248779,XP_005248776,XP_016866388,NP_001287828,XP_005248783

Il12rb1	7843;9693;18399;64944	1.67203569	1.62030058	0.26610058	0.66580058	0.65880058	MGI:1045779	161	XM_006509560|XM_006509559|XM_011242266|XM_006509562|XM_006509558|XM_006509561|XM_006509557|NM_008353	XP_006509620|XP_006509621|XP_011240568|XP_006509625|XP_006509622|XP_006509623|XP_006509624|NP_032379	404	HGNC:5971	3594	NM_001290023,NM_153701,NM_001290024,NM_005535	NP_005526,XP_006722804,XP_011526269,XP_011526279,XP_011526275,XP_011526271,XP_011526278,NP_001276953,XP_011526273,XP_011526270,NP_714912,XP_011526268,XP_011526272,NP_001276952,XP_016882251,XP_011526276,XP_011526277,XP_011526274
Cpped1	18026;18033;18466;64355	1.67248	0.98121	0.26610	0.66580	0.65880	MGI:2443300	22397	XM_006522013|XM_006522015|NM_146067|XM_006522016|XM_006522014	XP_006522078|XP_006522077|NP_666179|XP_006522076|XP_006522079	10142	HGNC:25632	5531 3	NM_018340,NM_001099455	NP_060810,NP_001092925
Il6st	12388;17288;18509;83099	1.66985	1.01563	0.21336	0.66620	0.65880	MGI:965560	1619 5	NM_010560	NP_034690	16452	HGNC:6021	3572	NM_002184,NM_175767,NM_001190981	XP_016864930,NP_001177910,XP_016864931,NP_786943,NP_002175
Gsk3b	55012;12473;18644;25744	1.66075	1.17458	0.21778	0.67556	0.65880	MGI:1861437	5637	XM_006522426|XM_006522425|NM_019827|NM_001347232	NP_001334161|XP_006522489|NP_062801|XP_006522488	55629	HGNC:4617	2932	NM_002093,NM_001146156	NP_001139628,XP_006713673,XP_006713674,NP_002084

Tnip2	12722;18444;18699;57633	10.1657546	0.0994695	0.0676258	0.0658858	MGI:2386643	231130	NM_139064	NP_620703	11515	HGNC:19118	79155	NM_024309,NM_001161527,NM_001292016	NP_077285,NP_001278945,NP_001154999
Ubac1	57040;64065;50211;67855	1.1.6.1.6.5	0.2.6.8.5.2	0.2.7.3.2.0	0.6.5.8.8	MGI:1920995	98766	XM_006498465|XM_011239219|XM_006498464|NM_133835	XP_006498527|XP_011237521|NP_598596|XP_006498528	9409	HGNC:30221	1042 2	NM_016172	NP_057256
Notch2	17066;18666;18750;79900	1.0.6.9.2.6.5.3.6.7	0.2.2.7.1.4	0.6.7.2.9	0.6.5.8.8	MGI:973664	1812 9	NM_010928	NP_035058	7865	HGNC:7882	4853	NM_001200001,NM_024408	NP_077719,XP_005270958,XP_011539821,XP_016856861,XP_011539822,XP_016856862,NP_001186930
Ppme1	57570;70909;18766;68977	1.1.6.3.1.2.5.3.0.7	0.2.2.1.6	0.6.6.9.1	0.6.5.8.8	MGI:1919840	72590	NM_028292	NP_082568	6099	HGNC:30178	5140 0	NM_001271593,NM_016147	NP_057231,XP_016873402,NP_001258522
Tenn	387	1.1.6	0.2.2	0.0.6	0.6.6	MGI	239	XM_011242216|XM_017312779|XM_006509408|	XP_006509470|XP_006509471|XP_017168264|	226	HGN	55 7	NM_001080477	XP_016863880,NP_001073946,XP_016863879,

m3	;643;3159;8432	5247	5419	2657	5858	:1345183	65	XM_017312782|XM_006509405|XM_017312776|XM_006509406|XM_017312775|XM_006509409|XM_017312781|XM_017312778|NM_011857|XM_017312774|XM_006509407|NM_001145937|XM_017312780|XM_011242218|XM_006509404|XM_011242217|XM_017312772	XP_006509468|XP_006509467|XP_017168261|XP_017168263|XP_011240519|XP_006509469|XP_017168267|NP_035987|XP_006509472|XP_017168270|XP_011240520|NP_001139409|XP_011240518|XP_017168265|XP_017168269|XP_017168268|XP_017168271	73	C:2994	14		XP_016863874, XP_016863883, XP_016863878, XP_016863882, XP_016863885, XP_016863877, XP_016863876, XP_016863881, XP_016863875, XP_016863884
Tln2	12985;15655;18775;57188	11.6523289	10.2262218	06.6518	00.6588	MGI:191779	705499	XM_006511438|XM_006511434|XM_011242813|XM_006511441|XM_011242812|NM_001081242|XM_011242811|XM_006511433	XP_011241114|XP_011241113|XP_006511496|XP_006511501|XP_006511504|XP_011241115|XP_006511497|NP_001074711	566922	HGNC:15447	836047	NM_015059	XP_005254769, XP_005254765, XP_005254768, XP_016878157, XP_016878158, XP_005254772, XP_016878156, XP_005254770, XP_005254767, XP_006720780, XP_016878155, XP_016878154, NP_055874,XP_005254771
Ppp1r8	3996;6448;3249;92222	11.6515483	10.2258258	06.6588	00.6588	MGI:2140494	10336	NM_001290725|NM_146154|XM_006538464|XM_006538465	NP_001277654|XP_006538528|NP_666266|XP_006538527	8555	HGNC:9296	55117	NM_014110,NM_002713,NM_138558	NP_002704,NP_054829,NP_612568,XP_016857083
Sdccag3	9116;1456;19300;43377	11.6190	10.6700	02.7393	70.7043	MGI:1915362	68112	XM_006498262|XM_006498263|NM_001085408|NM_026563|NM_001085407|XM_006498261|XR_374114|XR_374113	NP_080839|XP_006498324|NP_001078877|XP_006498325|XP_006498326|NP_001078876	7457	HGNC:10667	1087	NM_006643,NM_001039708,NM_001039707	XP_016869707, XP_005266107, XP_016869708, NP_001034796, NP_006634,XP_005266108,NP_001034797,XP_011516459
Pdp	86;6	11.6144	10.5240	07.7000		MGI:	186	XM_017317320|XM_017317323|NM_001286662|NM_011062|XM	XP_017172815|XP_017172809|NP_001074242|NP_035192|XP_	376	HGNC	5170	NM_031268,NM_002613,NM_001261816	XP_016878765, XP_016878761, NP_112558,XP_016878766,XP_

k1	73;3919;;8156	60	26	09	42	20	13806	8	_017317327|XM_017317325|NM_001080773|XM_017317321|XM_017317324|XM_017317322|XM_017317326	017172816|NP_001273591|XP_017172813|XP_017172810|XP_017172811|XP_017172812|XP_017172814	43	:8816			011520823,NP_001248745,XP_016878764,XP_016878760,XP_011520825,XP_016878763,NP_002604,XP_016878762
Ppp1r14b	1170;1428;;194926	11.6072	1.0442	0.24580	0.7140	0.7020	MGI:1076822	18938	NM_008889	NP_032915	7483	HGNC:90557	26472	NM_138689	NP_619634
Sirt1	120;682;;72617;;72977	1.6053	1.4672	0.24720	0.7128	0.7020	MGI:2135607	93759	NM_019812|NM_001159589	NP_062786|NP_001153061	56556	HGNC:14929	2341 1	NM_012238,NM_001142498,NM_001314049	NP_001135970,NP_036370,NP_001300978
Lamtor1	148;685;;40577;;59044	1.6017	1.4218	0.24860	0.7130	0.7020	MGI:1913758	66508	NM_025605	NP_079881	9909	HGNC:26068	55004	NM_017907	NP_060377
Rab31	663;;1438;;1	1.6017	1.0983	0.24880	0.7090	0.7020	MGI:1914646	10657	NM_133685	NP_598446	5001	HGNC:97711	11031	NM_006868	NP_006859,XP_016881017,XP_016881018

	958;2236						03								
H22-T22	492;6866;20999;22506	1.6006	1.1838	0.2492	0.7059	0.7020	MGI:959596	1503	NM_010397|XM_006523701|XM_006523702|XM_017317264|NM_001347382	NP_001334311|XP_006523764|NP_034527|XP_017172753|XP_006523765	#N/A	#N/A	#N/A	#N/A	#N/A
Rabac1	2723;14233;19600;82066	1.6005	1.2114	0.2494	0.7020	0.7020	MGI:1201692	1447	NM_010261	NP_034391	38182	HGNC:97944	1056	NM_006423	NP_006414
Ralb	802;14333;19699;38822	1.5950	1.0760	0.2522	0.7056	0.7042	MGI:1927244	6413	NM_022327|XM_006529782	XP_006529845|NP_071722	20632	HGNC:9840	589	NM_002881	XP_005263786,XP_011509875,XP_011509876,XP_005263784,NP_002872,XP_016860110,XP_005263781,XP_016860111,XP_005263785
Ly75	3577;6922;53755;6	1.5936	1.2406	0.2533	0.7042	0.7042	MGI:1066662	1707	NM_013825	NP_038853	31085	HGNC:67229	4065	NM_002349	NP_002340

	3														
	7														
	9														
Adrbk1	49;6986;7428;8392	1.1.1.5866757	0.0.0.2558569	0.0.0.7069	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Stk40	573;7056;3100;5122	1.1.1.5786454	0.0.0.2579084	0.0.0.7084	MGI:1921428	741778	XM_006503441|NM_001145827|XM_017320414|NM_028800|XM_006503442	NP_083076|XP_006503505|XP_006503504|NP_001139299|XP_017175903	1254 2	HGNC:21373	8393 1	NM_001282547,NM_032017,NM_001282546	NP_114406,NP_001269476,NP_001269475
Mapk8ip3	2026;7133;3360;9122	1.1.1.5696418	0.0.0.2610308	0.0.0.7108	MGI:1353598	30957	NM_001163447|NM_001163448|NM_001163449|NM_013931|NM_001163450|NM_001163453|NM_001163451	NP_001156921|NP_001156922|NP_038959|NP_001156923|NP_001156920|NP_001156925|NP_001156919	2279 0	HGNC:6884	2316 2	NM_015133,NM_001040439,NM_001318852	NP_001035529,NP_055948,XP_005255247,NP_001305781,XP_011520734,XP_011520731,XP_011520735,XP_011520733,XP_016878570,XP_016878569,XP_011520732,XP_006720932,XP_016878568
Rsad2	3966;7222;6071;7738	1.1.1.5596	0.0.0.2033	0.0.0.7147	MGI:1929628	58185	NM_021384	NP_067359	1096 9	HGNC:30908	9154 3	NM_080657	XP_011508717,NP_542388,XP_011508716
Nra	11;55	1.1.1.4556	0.0.0.2671	0.0.0.711	MGI:	671	NM_026012	NP_080288	120	#N/A	#N/A	#N/A	#N/A

dd	725;2436;3619	620	90	42	30	30	1914419	69				91			
Ptms	655;7344;5057;6655	1.54640	1.1060	0.26722	0.7167	0.7157	MGI:1916452	692	XM_355811	NP_081264	0	#N/A	#N/A	#N/A	#N/A
Pdcd10	206;7388;3889;8072	1.54200	1.1324	0.26844	0.7157	0.7157	MGI:1928396	564	NM_019745	NP_062719	10505	HGNC:8761	11235	NM_007217,NM_145860,NM_145859	XP_005247144, XP_005247145, XP_011510671, NP_009148,XP_006713548,NP_665859,XP_016861134,XP_005247143,NP_665858,XP_016861133,XP_011510670
Arhgap1	450;759;3210;8820	1.51978	1.1597	0.27750	0.72791	0.7269	MGI:2445003	228	XM_006499251|XM_006499244|XM_011239457|XM_006499246|XM_006499249|XM_006499247|XM_006499250|NR_027371|NR_027373|NM_146124|XM_006499245|XM_006499248|NM_001145902|NR_027372	XP_011237759|NP_666236|XP_006499313|NP_001139374|XP_006499309|XP_006499314|XP_006499311|XP_006499308|XP_006499307|XP_006499312|XP_006499310	20909	HGNC:673	392	NM_004308	NP_004299,XP_011518397,XP_016873209
Katna1	200;765;221	1.51344	1.1315	0.27700	0.73011	0.7269	MGI:1344353	239	XM_006512738|NM_011835	XP_006512801|NP_035965	56014	HGNC:62116	1104	NM_007044,NM_001204076	XP_016865698, XP_016865699, XP_016865697, XP_005266861, NP_001191005, XP_016865696, XP_005266862, NP_008975

	7;7839														
Tmem231	501;7616;5208;7452	1.5124	1.1364	0.2774	0.7269	0.7269	MGI:2685024	2347	XM_006530926|XM_011248363|XM_134593|XM_011248362	NP_001028493|XP_011246665|XP_006530989|XP_011246664	78035	HGNC:37234	79583	NM_001077416, NM_001077418	NP_001070886, NP_001070884
Elp2	164;779;3708;7751	1.4990	1.3492	0.2815	0.7335	0.7335	MGI:1889642	5852	NM_021448|XM_006526130|XM_006526129	XP_006526193|XP_006526192|NP_067423	6019	HGNC:18248	55250	NM_018255,NM_001242875,NM_001242879,NM_001242876,NM_001324469,NM_001324467,NM_001324466,NM_001324465,NM_001324468,NM_001242878,NM_001242877	NP_001229804, NP_001311397, NP_001311394, NP_001229805, NP_001229807, NP_001311395, NP_001229808, NP_001311396, NP_060725,NP_001229806
Arid1b	737;7900;2163;;32566	1.4879	1.0569	0.2853	0.7392	0.7375	MGI:1926129	2399	NM_001085355|XM_006523221|XM_006523222|XM_006523223	XP_006523286|XP_006523284|XP_006523285|NP_001078824	32344	HGNC:18040	57492	NM_017519,NM_001346813,NM_020732	XP_016866595, XP_016866597, NP_001333742, XP_011534286, NP_065783,NP_059989,XP_016866593,XP_016866592,XP_016866594,XP_016866598,XP_011534290,XP_005267126,XP_016866596
Acpp	556;7933;4950;;77443	1.4848	1.1038	0.2863	0.7375	0.7375	MGI:1928480	5631	NM_207668|NM_019807	NP_062781|NP_997551	55552	HGNC:125	55	NM_001134194, NM_001292037, NM_001099	NP_001127666, NP_001278966, NP_001090,XP_011511248,XP_011511249

Sik1	211;799;;2535;;58044	1.4789	1.2875	0.2883	0.7385	0.7385	MGI:1047544	1691	NM_010831	NP_034961	7847	#N/A	#N/A	#N/A	#N/A
Furin	201;8155;4449;;83977	1.4632	1.2896	0.2938	0.7483	0.7404	MGI:975113	1855 0	NM_011046|XM_011250821|XM_011250820|XM_011250823|XM_011250822|XM_011250819|NM_001081454|XM_011250818	XP_011249121|XP_011249125|XP_011249120|NP_001074923|XP_011249122|XP_011249123|XP_011249124|NP_035176	1930	HGNC:8568	5045	NM_001289824,NM_001289823,NM_002569	NP_001276753,NP_001276752,NP_002560
Zch2	158;819;;43014;;48566	1.4593	1.3370	0.2951	0.7476	0.7404	MGI:2679294	24552 2	NM_001289696|XM_011247587|XM_141965|NM_001289697	NP_001276626|XP_011245889|NP_001276625|NP_001003916	1026 6	HGNC:24931	5590 6	NM_001243804,NM_001178032,NM_018684,NM_001178033	NP_001230733,NP_001171503,NP_001171504,NP_061154
Ccny	323;825;;8040;;8882	1.4536	1.1900	0.2973	0.7490	0.7404	MGI:1915224	6797 4	NM_026484|XM_017317976|XM_017317975|XM_017317974	XP_017173464|XP_017173465|NP_080760|XP_017173463	1221 9	HGNC:23354	2197 71	NM_001282854,NM_001282852,NM_181698,NM_001282853,NM_145012	XP_011517671,XP_011517663,NP_001269783,XP_016871330,XP_016871329,XP_011517667,XP_011517664,NP_001269781,XP_011517666,NP_859049,NP_659449,XP_011517660,XP_011517670,XP_011517659,XP_016871328,XP_006717455,XP_011517665,XP_011517662,NP_001269782,XP_011517668,XP_011517669
Np	507	1.14	1.11	0.12	0.77	0.7	MGI	114	NM_001287102|XM_006500915|NM_001287103|	XP_006500978|NP_001274032|NP_001025007|	141	HGN	255	NM_001184690,NM_198278,NM_001184692,NM	NP_001171621,XP_011530127,XP_011530122,

nt	;826;3538;7054	526	043	976	456	404	:21488111	249	NM_001287101|NM_001029836|NM_033525	NP_001274031|NP_001274030|NP_277060	38	C:27405	743	_001184691,NM_001184693,NM_001033047	NP_001171619, XP_016863473, XP_011530124, XP_005262947, NP_001171620, NP_001171622, XP_005262945, XP_011530126, XP_011530125, NP_001028219
Ubr2	90;827;2891;3004	1.45168	1.45080	0.29806	0.74206	0.74044	MGI:1861099	22482	NM_001177374|XR_001782069|XM_358323|XM_006524145	NP_001170845|XP_006524208|NP_666190	2615	HGNC:21289	2330	NM_001184801, NM_015255	XP_016866083, XP_005249023, XP_005249022, XP_016866085, NP_056070,XP_011512740,XP_011512742,XP_011512741,XP_016866086,XP_016866084,NP_001171730,XP_011512743
Iqgap1	783;829;5013;8106	1.44977	1.02804	0.29807	0.74044	0.74044	MGI:1352757	29875	XR_001785567|XM_006540950|NM_016721|XR_391347	NP_057930|XP_006541013	7451	HGNC:6110	8826	NM_003870	NP_003861
Rrp8	833;841;2859;8112	1.43844	1.01025	0.30325	0.74773	0.74773	MGI:1914251	10187	XR_378204|NM_025897|NM_133951	NP_080173|NP_598712	5621	HGNC:29030	2337	NM_015324	NP_056139,XP_011518257,XP_016872912
Ifitm2	19;848;3174	1.43194	1.77405	0.30574	0.74948	0.74843	MGI:1933382	8087	NM_030694	NP_109619	7457	HGNC:54133	1058	NM_006435	NP_006426

	;5067													
Clp1	7033;8533;7355;8116	1.4273	1.0344	0.30774	0.74963	0.74833	MGI:2138968	9898 5	NM_133840	NP_598601	4975	HGNC:16999	1078	NM_001142597, NM_006831	NP_006822,NP_001136069
Efna5	6344;8556;61399;88005	1.4245	1.0506	0.30885	0.74833	0.74833	MGI:1074440	13640	NM_207654|XM_006523598|NM_010109	XP_006523661|NP_997537|NP_034239	1482	HGNC:3225	1946	NM_001962	XP_006714628, XP_016864694, XP_011541552, NP_001953,XP_011541553
Ankle2	2996;8665;78005;86522	1.41635	1.18850	0.31208	0.75228	0.75244	MGI:2261856	7178 2	NM_001253814|NM_027922	NP_001240743|NP_082198	35424	HGNC:29101	2314 1	NM_015114	XP_005266217, XP_005266216, XP_011533089, XP_006719798, XP_016874565, NP_055929,XP_011533090
H2-Eb1	7557;8722;19977;53544	1.41000	1.01366	0.31448	0.75555	0.75244	MGI:959011	1496 9	NM_010382	NP_034512	10152 4	HGNC:4953	3127	NM_002125	NP_002116,XP_011512864
Ne	39	1.	1.	0.	0.	0.	MG	17	NM_008682|XM_006513334	XP_006513397|NP_032708	74	HG	12	NM_152905,NM_001135176,NM	XP_011536205, XP_011536208,

dd1	4;873;;3833;;70005	40912952	12315244	75275244	75275244	IG:97293	997				39	NC:77223	141	_001135177,NM_001135175	NP_001128649, XP_005268701, NP_690869,XP_016874290,NP_001128647,XP_011536206,NP_001128648,XP_006719300,XP_016874291,XP_011536207
Cit	80;879;;2869;;62122	1.40037	1.00154	0.37539	0.37539	MGI:105313	1704	XM_006530137|XM_017320640|XM_006530142|XM_006530131|XM_006530141|XM_006530148|XM_006530151|XM_017320646|XM_017320645|NM_007708|XM_017320647|XM_017320641|XM_006530143|XM_006530153|XM_006530149|XM_006530152|XM_006530135|XM_006530147|XM_017320644|XM_006530146|XM_017320642|XM_006530133|XM_006530136|XM_006530145|XM_006530130|XM_006530139|XM_006530138|XM_011248163|XM_006530140|XM_017320643|XM_006530134|XM_006530150|XM_006530132	XP_006530196|XP_006530206|XP_006530212|XP_017176134|XP_006530201|XP_006530204|XP_006530198|XP_006530193|XP_017176132|XP_006530197|XP_006530194|NP_031734|XP_006530205|XP_017176135|XP_006530214|XP_006530202|XP_011246465|XP_006530208|XP_017176129|XP_017176133|XP_017176131|XP_006530203|XP_017176130|XP_006530209|XP_006530200|XP_006530211|XP_017176136|XP_006530210|XP_006530215|XP_006530199|XP_006530213|XP_006530195|XP_006530216	2140	HGNC:1985	1111	NM_001206999, NM_007174	XP_016874226, XP_011536092, XP_011536091, XP_006719269, XP_016874228, XP_011536090, XP_011536094, XP_011536086, XP_011536085, XP_011536089, XP_011536087, XP_016874227, NP_009105,NP_001193928,XP_016874224,XP_016874225,XP_011536093
Best1	478;8866;;2337;;82133	1.39755	1.08700	0.32056	0.32056	MGI:1346332	2411 5	XM_129203	NP_036043	378955	HGNC:12703	7439	NM_001300786, NM_001300787, NM_001139443, NM_004183	XP_005274276, XP_016873717, NP_001132915, XP_005274273, XP_011543535, XP_016873719, XP_011543532, NP_001287716, XP_005274278, NP_004174,NP_001287715,XP_005274272,XP_011543531,XP_016873718,XP_005274267
Zbp1	344;899;;21	1.38611	1.14400	0.37263	0.37639	MGI:1927474	5820 3	NM_021394|NM_001139519	NP_067369|NP_001132991	10972	HGNC:16176	8103	NM_001323966, NM_001160419, NM_001160418, NM_030776,NM_001160417	XP_011527360, XP_016883575, NP_001153889, NP_001153890, NP_001310895, NP_001153891, NP_110403,XP_011527359

	74;5861						49								
Bcl10	624;9099;37198;87984	1.3774	1.0298	0.0329917	0.0769768	0.0768687	MGI:1337994	120422	NM_009740	NP_033870	2912	HGNC:9889	8915	NM_001320715, NM_003921	XP_011540700, XP_011540699, NP_003912,XP_011540701,NP_001307644
Cdk8	445;912;3792;44077	1.3749	1.0895	0.0330447	0.0768687	0.0768687	MGI:1196224	2640644	XM_006504836|XM_006504839|XM_006504835|NM_153599|XM_006504840|XM_006504838	XP_006504902|XP_006504899|NP_705827|XP_006504903|XP_006504901|XP_006504898	5565	HGNC:17779	10244	NM_001346501, NM_001318368, NM_001260	XP_016875807, XP_011533167, XP_016875806, XP_011533166, XP_005266273, NP_001333430, NP_001251,NP_001305297
Wbp4	1823;929;4036;84399	1.3605	1.2585	0.0337373	0.0778079	0.0779979	MGI:1095688	223880	NM_018765	NP_061235	38287	HGNC:12739	11193	NM_007187	NP_009118,XP_016875869,XP_005266302
Mta2	2423;934;67673;84077	1.3563	1.1986	0.0339212	0.0778129	0.0779979	MGI:1346340	2394242	XM_017318190|NM_011842|XM_017318189	XP_017173679|NP_035972|XP_017173678	3480	HGNC:74111	9219	NM_001330292, NM_004739	NP_001317221, NP_004730,XP_016874050

Ptk2	248;937;8616;9035	1.3538	1.1924	0.3403	0.7799	0.7799	MGI:95481	14083	XR_383981|XM_006520421|XM_006520418|XM_006520434|XM_011245452|XM_011245453|XM_006520426|XM_006520420|XM_006520423|XM_006520416|XM_006520425|XM_006520432|XM_006520428|XM_006520427|XM_017316429|XM_006520435|XM_006520431|XM_006520415|XM_006520424|XM_006520429|NM_007982|XM_006520430|XM_006520433|XM_006520422|XR_001781493|NM_001130409|XM_017316428	NP_032008|XP_006520491|XP_006520484|XP_006520490|XP_011243755|XP_017171918|XP_006520485|XP_006520478|XP_006520496|XP_006520495|NP_001123881|XP_006520487|XP_006520498|XP_006520479|XP_017171917|XP_006520497|XP_006520486|XP_006520488|XP_006520494|XP_006520481|XP_006520483|XP_011243754|XP_006520489|XP_006520493|XP_006520492	7314	HGNC:9611	5747	NM_001352733, NM_001352697, NM_001352716, NM_001352746, NM_001352738, NM_001352752, NM_001352706, NM_001352740, NM_001352747, NM_001352723, NM_001352735, NM_001352732, NM_001352709, NM_001352701, NM_153831,NM_001352703,NM_001352712,NM_001352737,NM_001352741,NM_001352717,NM_001199649,NM_001352707,NM_001316342,NM_001352743,NM_001352720,NM_001352695,NM_001352699,NM_001352718,NM_001352711,NM_001352694,NM_001352745,NM_001352704,NM_001352700,NM_001352751,NM_001352724,NM_001352736,NM_001352708,NM_001352748,NM_001352730,NM_001352734,NM_001352750,NM_001352714,NM_001352713,NM_001352727,NM_001352726,NM_001352710,NM_001352696,NM_001352728,NM_001352698,NM_001352744,NM_001352742,NM_001352705,NM_005607,NM_001352722,NM_001352749,NM_001352731,NM_001352719,NM_001352721,NM_001352729,NM_001352725,NM_001352739,NM_001352715,NM_001352702	XP_016869172, NP_001339624, XP_016869145, XP_016869164, XP_016869155, XP_006716671, NP_001339671, XP_016869165, NP_001339679, XP_016869173, XP_016869169, XP_016869148, XP_016869176, NP_001339680, XP_005251070, NP_001339650, NP_001339658, NP_001339672, XP_016869159, XP_016869153, XP_016869162, NP_001339668, NP_001339627, XP_016869150, XP_016869178, NP_001339642, NP_001339667, NP_001339654, NP_001339665, XP_016869163, XP_016869144, NP_001339656, NP_001339655, NP_001339651, NP_001339628, NP_001339633, XP_016869154, NP_001339681, NP_001339636, NP_001339631, NP_001339634, XP_016869167, NP_001339629, NP_001339666, XP_016869147, XP_016869177, XP_016869158, NP_001339669, XP_005251069, NP_001339647, NP_001339677, XP_016869175, XP_005251060, NP_001339659, NP_001339644, NP_001339662, NP_001339645, NP_001339635, XP_016869166, NP_001339661, NP_001303271, XP_016869156, NP_001339632, NP_001339639, NP_001339673, XP_016869142, NP_001339623, NP_001339678, NP_001339643, XP_016869141, NP_001339674, NP_001339649, NP_001339625, NP_001339653, NP_001339657,

														XP_011515496, NP_005598,XP_ 016869146,NP_ 001339630,NP_ 001186578,NP_ 001339638,NP_ 001339626,XP_ 016869151,NP_ 001339641,NP_ 001339660,XP_ 016869171,XP_ 016869161,NP_ 001339675,NP_ 001339646,XP_ 016869143,XP_ 016869179,NP_ 001339637,NP_ 001339663,XP_ 016869152,XP_ 016869168,XP_ 016869174,XP_ 006716673,NP_ 001339648,XP_ 006716672,NP_ 001339676,NP_ 001339664,XP_ 016869140,XP_ 016869149,XP_ 016869170,NP_ 001339652,NP_ 001339670,XP_ 016869160,NP_ 001339640,NP_ 722560,XP_016 869157
Msh6	54;947;3421;37333	1.3456	1.5063	0.3445	0.7854	0.7803	MGI:1343961	1768	NM_010830	NP_034960	149	HGNC:7329	2956	NM_000179,NM_001281493,NM_001281494,NM_001281492	NP_000170,NP_001268423,XP_011531100,NP_001268422,XP_011531101,NP_001268421
Slc29a2	256;955;3530;55665	1.3390	1.1787	0.3477	0.7889	0.7803	MGI:1345278	1340	XM_006531664|XM_017318055|NM_007854|XM_017318057|XM_017318056	XP_017173544|XP_017173545|XP_006531727|NP_031880|XP_017173546	37493	HGNC:11004	317	NM_001300868,NM_001532,NM_001300869	NP_001287797,XP_016873126,XP_016873123,XP_011543276,XP_016873119,XP_016873125,NP_001523,XP_016873122,XP_016873124,XP_016873127,NP_001287798,XP_016873120,XP_016873121
Cdk1	84;9611;	1.33427	1.4067	0.3501	0.7904	0.7803	MGI:883	1254	NM_007659	NP_031685	68203	HGNC:17	983	NM_001170406,NM_001130829,NM_001320918,NM_001786,NM_001170407,NM_033379	NP_001163877,NP_001307847,NP_001777,NP_001163878,NP_203698,XP_005270360

	9069;9493					51					22				
Stk19	8883;9622;21966;33099	1.33341	0.95012	0.35061	0.78744	0.78033	MGI:1860085	5402	NM_019442	NP_062315	10449	HGNC:11398	8859	NM_032454,NM_004197	NP_004188,NP_115830
Polr3d	2633;9666;39666;93311	1.33301	1.16889	0.35223	0.78744	0.78033	MGI:1914315	6705	NM_001164082|NM_025945|XM_006519438	NP_001157554|XP_006519501|NP_080221	1303	HGNC:10800	661	NM_001722	NP_001713
Vmp1	505;9677;43115;83111	1.32933	1.04334	0.35237	0.78445	0.78033	MGI:1923159	7509	XM_006534403|XM_006534402|NM_029478	XP_006534465|NP_083754|XP_006534466	23686	HGNC:29559	8161711	NM_030938,NM_001329398,NM_001329395,NM_001329401,NM_001329400,NM_001329399,NM_001329397,NM_001329396,NM_001329402,NM_001329394	NP_001316326,NP_001316327,NP_001316324,NP_001316331,NP_112200,NP_001316323,NP_001316330,NP_001316328,NP_001316325,NP_001316329
Plk3	847;9722;49622;63	1.32543	0.95348	0.35485	0.78033	0.78033	MGI:1096044	1279	5	NM_001313916|NM_013807	NP_001300845|NP_038835	20865	HGNC:21544	12631	NM_004073	NP_004064

Magi1	91720;97;2296;2831	10.3247911	0.0.3551	0.0.7823	0.0.7803	MGI:1203522	149	XM_006505588|XM_006505591|XM_006505583|NM_001083320|XM_006505599|XM_006505594|XM_006505587|NR_104594|XM_006505582|XM_011241222|NM_001083321|XM_006505596|NM_001286784|XM_006505600|XM_017321400|XM_006505584|XM_006505595|XM_006505586|NM_010367|XM_006505592|XM_006505590|XM_017321399|XM_006505598|XM_006505581|NM_001286785|XM_006505593|NM_001029850|XM_006505597|XM_006505601|NM_001286788|NM_001286786|XM_006505589|XM_006505580|XR_377424|XM_006505585|XM_011241223	XP_006505644|XP_006505660|XP_006505663|XP_006505662|XP_006505647|XP_006505652|XP_006505651|XP_006505643|XP_011239524|XP_006505645|XP_006505661|XP_017176889|XP_006505646|XP_011239525|XP_006505655|NP_001025021|XP_017176888|XP_006505657|XP_006505658|XP_006505659|NP_001076789|NP_001273713|NP_001273714|XP_006505648|NP_001273717|XP_006505654|XP_006505650|NP_034497|XP_006505653|XP_006505656|XP_006505649|NP_001273715|NP_001076790|XP_006505664	312572	HGNC:946	92 23	NM_004742,NM_001033057,NM_015520	XP_006713473,XP_005265621,XP_006713477,XP_016862993,XP_016862997,XP_016862996,XP_005265631,XP_016862995,XP_011532543,XP_005265627,XP_016862991,XP_006713470,XP_016862989,XP_011532542,XP_016862990,NP_001028229,XP_006713474,XP_005265622,XP_006713471,XP_016862994,XP_016862987,XP_016862986,XP_016862992,XP_016862988,XP_005265625,XP_011532538,XP_005265623,XP_005265628,XP_005265620,XP_006713472,XP_006713475,NP_056335,NP_004733
H2-Q4	600;9755;3031;3699	1.3230094	1.0.3559	0.0.7803	0.0.7803	MGI:955933	15015	NM_001143689	NP_001137161	128352	HGNC:49331	31 05	NM_002116,NM_001242758	XP_005275388,NP_002107,NP_001229687,XP_016885777
Bag4	44;1009;3099;4652	1.2965256	1.0.3708091	0.0.7909	0.0.7953	MGI:1914634	6734	NM_026121	NP_080397	312700	HGNC:940	95 30	NM_004874,NM_001204878	NP_001191807,NP_004865
Cnp	100	1.2	0.0.9	0.0.3	0.0.8	0.0.7	MGI	691	NM_026977|XM_006496542|XM	XP_006496604|XP_006496603|	92	HGN	27 0	NM_001321389,NM_001321390,	NP_001308320,NP_001308318,

pd1	2;10100;50005;63666	9583	1333	7132	0625	995	:191642	71	_006496541|XM_006496540	XP_006496605|NP_081253	38	C:25220	13	NM_001321391, NM_015680	NP_001308319, NP_056495
Atrnl1	954;10122;25433;33111	1.2917421	0.9372041	0.8049	0.7995	MGI:2147749	226255	XM_006527051|XM_006527049|XM_006527052|XM_006527053|NM_181415|XR_001782587|XM_011247244	XP_006527112|XP_006527116|XP_011245546|NP_852080|XP_006527114|XP_006527115	458089	HGNC:29063	2603	33	NM_207303,NM_001276282	XP_011537891, XP_016871527, NP_001263211, XP_011537893, XP_016871526, XP_011537890, XP_011537889, XP_016871529, NP_997186,XP_011537892,XP_016871525,XP_016871524,XP_016871528
Stil	109;10147;56847;90766	1.2933927	1.3370211	0.3802	0.0395	MGI:1074777	204600	XM_017320088|NM_001304555|NM_001304559|XM_006502907|XM_006502905|XM_006502906|NM_001304551|NM_009185|NM_001304553	NP_033211|XP_017175577|XP_006502970|NP_001291482|XP_006502968|NP_001291488|XP_006502969|NP_001291484|NP_001291480	228283	HGNC:10879	6491	64	NM_001282937, NM_001048166, NM_003035,NM_001282939,NM_001282938,NM_001282936	XP_016857616, XP_016857615, XP_016857613, XP_011540293, XP_011540300, XP_011540296, XP_006710897, XP_011540294, NP_001269867, XP_011540303, NP_001041631, NP_001269866, XP_011540298, XP_016857614, NP_001269865, XP_016857612, NP_003026,NP_001269868
Vps26a	65;10155;58511;72488	1.2492000	1.4403795	0.3799	0.0795	MGI:1353654	309130	NM_133672|NM_001113355|XM_006513734	NP_598433|XP_006513797|NP_001106826	68420	HGNC:12711	9559	59	NM_001318946, NM_001318945, NM_001318944, NM_001035260, NM_004896	NP_001305875, NP_004887,NP_001305873,NP_001030337,NP_001305874
Ap1b1	240;110	1.2844	1.1643	0.3781	0.0851	0.8011	MGI:1076411	164	NM_001243044|NM_001243043|XM_006514463|XM_006514462|XM_006514461|NM_007454	NP_031480|XP_006514524|NP_001229972|NP_001229973|XP_006514526|XP_006514525	21972	HGNC:5	162	NM_001166019, NM_145730,NM_001127	NP_001159491, NP_663782,NP_001118

	25;36868;50299					9638					54				
Cdc37	67;10275;35422;49755	1.2829	0.9686	0.3790	0.8038	0.8011	MGI:1095311	12539	XM_006509967|NM_016742	XP_006510030|NP_058022	38268	HGNC:17355	1140	NM_007065	NP_008996,XP_011525954
Clk1	56;10288;39699;42266	1.2822	1.4669	0.3795	0.8011	0.8011	MGI:1074033	12747	NR_027853|NR_027854|NM_001042634	NP_001036099	10153	HGNC:2068	1195	NM_001162407, NM_001024646, NM_004071	NP_001155879, NP_004062
Fam132a	63;10466;71133;94022	1.2689	1.4351	0.3877	0.8147	0.8120	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
H2-DMb1	407;10477;66	1.2681	1.0529	0.3882	0.8120	0.8120	MGI:9592922	14999	NM_010387	NP_034517	68231	HGNC:49355	3109	NM_002118	NP_002109

	52;74244														
Dck	106;10556;34255;51266	1.26116	1.32144	0.392222	0.8167	0.8157	MGI:1027266	1317 8	NM_007832	NP_031858	616	HGNC:2704	1633	NM_000788	NP_000779
Tpr	497;10559;86922;94633	1.25944	1.01144	0.39355	0.8157	0.8157	MGI:1922066 6	1089 89	NM_133780|XM_006529065	NP_598541|XP_006529128	37753	HGNC:12017	7175	NM_003292	NP_003283
Ehmt1	1017;10644;86811;91400	1.25583	0.8913	0.39159	0.8169	0.8169	MGI:1924933	7683	XM_017319336|XM_006498423|XM_006498432|XM_006498422|XM_017319335|XM_006498425|XM_006498429|XR_374136|XM_006498427|XM_006498426|XM_006498431|NM_001012518|XM_006498424|NM_172545|NM_001109687|XM_006498430|NM_001109686	XP_006498492|XP_006498495|XP_006498493|XP_006498488|XP_006498489|XP_017174824|XP_006498487|NP_001012536|NP_766133|NP_001103156|XP_017174825|NP_001103157|XP_006498486|XP_006498485|XP_006498494|XP_006498490	11698	HGNC:24650	7981 3	NM_001145527,NM_024757	XP_011517325,XP_016870625,XP_011517324,XP_005266167,XP_016870624,XP_011517328,XP_011517331,XP_011517330,XP_011517326,XP_011517329,XP_006717351,NP_001138999,XP_005266162,NP_079033,XP_016870623,XP_011517335,XP_016870626,XP_016870627,XP_011517323,XP_011517333,XP_011517332,XP_011517327
Tcirg1	579;10737;	1.24949	0.94789	0.4001	0.8218	0.8182	MGI:1350 9	2706 0	XM_011248632|NM_001167784|NM_001136091|NM_016921	NP_058617|NP_001161256|XP_011246934|NP_001129563	4392	HGNC:11647	1031 2	NM_006053,NM_006019,NM_001351059	XP_005273766,NP_006044,NP_006010,XP_016872578,XP_016872579,NP_001337988,XP_011543028

	685;9724					31									
Strada	377;1077;4684;7412	1.2466	1.0567	0.0401.0.8218.2	0.0.8.1	MGI:1919399	721.49	XM_011249270|NM_028126|XM_006534294|NM_001252448|XM_006534297|NM_001252449|XM_006534296|XM_006534293|XM_006534295	NP_001239378|XP_006534360|XP_006534357|XP_006534356|NP_082402|NP_001239377|XP_006534358|XP_006534359|XP_011247572	1244	HGNC:30172	923.35	NM_001165969,NM_001003787,NM_001003788,NM_001165970,NM_153335,NM_001003786	XP_005257857,NP_001003787,XP_016880803,NP_001003788,XP_011523768,XP_005257856,XP_011523769,XP_005257860,NP_699166,NP_001159442,XP_005257855,XP_005257858,XP_005257854,NP_001159441,XP_016880801,NP_001003786,XP_016880802
Plcg2	749;10800;47272;87266	1.2444	0.9326	0.4031	0.0.8207.8182	MGI:9761616	2347.79	NM_172285	NP_758489	5567	HGNC:9066	536.36	NM_002661	NP_002652
Ctdnep1	39;10844;58177;59411	1.2416	1.5240	0.4050	0.0.8208.182	MGI:1914431	671.881	NM_026017	NP_080293	9100	HGNC:190085	233.99	NM_015343,NM_001143775	NP_056158,NP_001137247
Ank2	197;10855;47062;	1.2409	1.1802	0.0.4058.1558.2	0.0.8.1.8.2	MGI:880255	10.96.76	XM_011239987|XM_011239989|XM_006500899|XM_017319431|XM_006500900|XR_001783641|XM_017319436|XM_017319434|XM_006500888|XM_017319428|NM_001034168|XM_006500881|XM_017319429|XM_006500906|	XP_006500953|XP_011238290|XP_011238294|XP_011238292|XP_006500963|XP_011238293|XP_017174917|XP_017174925|XP_006500965|XP_017174927|XP_017174916|XP_011238288|XP_006500950|XP_006500948|	0	#N/A	#N/A	#N/A	#N/A

	5468							XM_017319437|XM_006500894|XM_006500904|XM_011239986|XM_017319433|XM_017319432|XM_006500902|XM_017319426|XM_006500901|XM_006500893|XM_006500886|XM_011239990|XM_006500884|XM_017319427|XM_017319438|XM_011239993|XM_006500898|XM_017319435|XM_006500903|XM_017319430|NM_001327939|XM_011239992|XM_011239996|XM_017319425|XM_006500889|XM_011239995|XM_011239994|XM_006500885|XM_006500895|XM_011239991|XM_006500891|XM_006500880|XM_011239988|NM_001327938|NM_178655|XM_006500887|XM_006500890	XP_017174922|XP_006500954|XP_011238296|XP_006500958|XP_017174920|XP_006500967|XP_006500952|XP_011238295|XP_006500943|XP_006500944|XP_006500966|XP_006500957|XP_011238298|XP_006500956|XP_006500947|XP_017174914|XP_017174919|NP_001029340|XP_006500964|XP_006500961|XP_017174924|NP_848770|XP_011238297|XP_011238289|XP_006500949|XP_017174923|XP_006500969|XP_017174926|XP_017174918|XP_006500951|XP_006500962|XP_017174915|XP_011238291|XP_017174921|NP_001314868|NP_001314867				
Abcb6	406;1101;3898;4920	1.2.2.98	1.0.3.42	0.4.1.31	0.8.2.99	0.8.2.35	MGI:1921354	741	NM_023732|XM_006496552	XP_006496615|NP_076221	1137	HGNC:47	1058	NM_001349828,NM_005689	NP_005680,NP_001336757
Mapk14	456;1103;2181;9502	1.2.2.84	1.0.1.17	0.4.1.40	0.8.2.81	0.8.2.35	MGI:1346865	2641	NM_001168513|NM_011951|NM_001168514|XM_017317480|NM_001168508	NP_001161986|NP_036081|XP_017172969|NP_001161985|NP_001161980	3177	HGNC:6876	1432	NM_139012,NM_139014,NM_139013,NM_001315	XP_011512612,XP_006715061,NP_001306,XP_016865793,XP_016865789,NP_620581,XP_016865792,XP_016865791,NP_620582,NP_620583,XP_016865790,XP_016865788

Tf1	33;110;6308;6791	1.2.2.1	1.0.7.4	0.4.1.5	0.8.2.6	0.8.3.5	MGI:105044	22;130	XR_374069|NM_009442|XR_374068|XM_006497852|XR_374070|XM_006497851	XP_006497915|XP_006497914|NP_033468	13;22;23	#N/A	#N/A	#N/A	#N/A
Sptbn1	22;110;2047;6717	1.2.2.1	1.1.5.0	0.4.1.6	0.8.2.6	0.8.3.5	MGI:983888	20;74;2	XM_006514601|XR_001779935|NM_009260|XM_006514599|NM_175836|XM_006514600	NP_033286|XP_006514664|XP_006514663|XP_006514662|NP_787030	23;54	HGNC:11275	67;11	NM_003128,NM_178313	NP_003119,XP_006712150,XP_016860269,XP_016860268,NP_842565,XP_005264575,XP_005264574,XP_016860270
Ptchd1	39;2;1114;5293;6478	1.2.2.0	1.0.3.6	0.4.1.9	0.8.2.7	0.8.3.5	MGI:2685233	21;161;2	XM_011247812|XM_006528793|XM_142262	XP_011246114|XP_006528856|NP_001087219	18;302	HGNC:263922	13;941;1	NM_173495	NP_775766,XP_011543751
Bmpr2	48;9;116;4049;4620	1.2.1.9	0.9.4.4	0.4.2.0	0.8.2.6	0.8.3.5	MGI:1095407	12;168	NM_007561|XM_006495633	NP_031587|XP_006495696	92;9	HGNC:10778	65;9	NM_033346,NM_001204	NP_001195,XP_011509989
Ari	205	1.2.1	1.1.4	0.4.8	0.8.8	MGI	937	XM_006539327|XM_006539325|	XP_006539390|NP_001074288|	212	HGN	82	NM_018450,NM_139135,NM_006015	NP_624361,NP_006006

d1a	;11;48;701	189	634	208	235	:193514	60	XM_006539326|NM_001080819	XP_006539389|XP_006539388	16	C:11110	89			
Cd99l2	45;112;358;75144	1.2161	1.4806	0.4229	0.8241	0.841	MGI:2177151	171486	XM_011247542|NM_138309|XM_006527887|XM_011247540|NM_001199349|XM_011247541|XM_006527886|XM_017318407	XP_017173896|XP_011245844|XP_011245843|XP_011245842|XP_006527950|XP_006527949|NP_612182|NP_001186278	13574 3	HGNC:18237	83692	NM_134446,NM_001184808,NM_001242614,NM_134445,NM_031462	NP_113650,XP_016885379,NP_604395,NP_604394,NP_001171737,XP_016885380,NP_001229543,XP_011529504
Bcap31	32;113;557;67;705	1.2061	1.0639	0.4303	0.8349	0.843	MGI:1350933	27061	XM_011247600|NM_001313698|NM_012060|XM_006528048	XP_006528111|NP_036190|NP_001300627|XP_011245902	38095	HGNC:16695	10134	NM_005745,NM_001139441,NM_001256447,NM_001139457	NP_001132913,NP_005736,NP_001243376,NP_001132929
Adi1	79;114;433;796	1.2003	0.9403	0.8351	0.843	MGI:2144929	104923	NM_134052	NP_598813	75081	HGNC:30576	55256	NM_018269,NM_001306077	NP_060739,NP_001293006	
Slc20a1	10;88;11	1.2008	0.8543	0.8352	0.843	MGI:108	20515	XM_017316753|NM_001159593|XM_011239399|NM_015747	XP_017172242|NP_001153065|XP_011237701|NP_056562	38049	HGNC:10	6574	NM_005415	NP_005406,XP_016860258,XP_016860260,XP_016860257,XP_016860259	

	44;30555;57811					392					946				
Igf2	451;1148;2257;62669	1.19826	0.4362	0.8357	0.8243	MGI:96434	1602	NM_010514|NM_001122736|NM_001122737|XM_006508487|NM_001315489|NM_001315488	NP_001302418|NP_001116208|XP_006508550|NP_001302417|NP_001116209|NP_034644	510	HGNC:5466	3481	NM_001007139,NM_001291862,NM_000612,NM_001127598,NM_001291861	NP_001278791,NP_000603,NP_001121070,NP_001007140,NP_001278790
Mfsd2a	971;1150;2176;55444	1.19684	0.43772	0.83441	0.8243	MGI:1923824	765574	XM_006503477|XM_131683	NP_083938|XP_006503540	19229	HGNC:25897	8487	NM_001136493,NM_001287808,NM_001287809,NM_001349822,NM_032793,NM_001349821,NM_001349823	NP_001129965,XP_011540614,XP_005271342,NP_001336752,NP_001274738,NP_116182,NP_001336750,NP_001274737,NP_001336751
Bag6	868;1153;29199;57277	1.19449	0.44383	0.83383	0.8243	MGI:1919439	224727	XM_006524111|XM_006524115|NM_057171|XM_017317434|XM_006524110|XM_006524116|XM_006524113|XM_006524114|XM_006524117|XM_006524118|XM_006524109|XM_006524119|NM_001252468|XM_017317432|XM_006524112|NM_001252469|XM_017317433|XM_017317431|XM_017317436|XM_017317435	XP_006524178|XP_006524177|XP_006524182|XP_006524175|XP_017172924|XP_017172920|XP_006524174|XP_017172925|NP_001239398|XP_006524176|NP_001239397|XP_006524179|NP_476512|XP_006524173|XP_017172922|XP_006524181|XP_017172921|XP_017172923|XP_006524172|XP_006524180	3409	HGNC:13919	7917	NM_001199697,NM_001098534,NM_001199698,NM_080702,NM_080703,NM_004639	XP_016866778,XP_016866784,XP_016866765,XP_016866785,XP_016866779,XP_016866777,NP_542433,XP_016866787,XP_016866786,NP_004630,XP_016866764,XP_016866781,XP_016866768,XP_016866770,NP_001186627,NP_001186626,XP_016866771,XP_016866773,XP_016866774,XP_016866775,XP_016866766,XP_016866780,XP_016866767,XP_016866783,NP_542434,XP_016866782,XP_016866776,XP_016866

															769,XP_016866772,NP_001092004,XP_011513194
Rad	925;1155;4807;7883	1.1.1.9360	0.8.7.4.0	0.4.3.9.6	0.8.3.1.7	0.8.2.4.3	MGI:1930943	5643 7	XM_006531206|NM_019662	NP_062636|XP_006531269	3071	HGNC:10446	6236	NM_004165,NM_001128850	NP_004156,NP_001122322
Ercc3	9991;1159;3960;4527	1.1.9.1.0	0.8.6.1.4	0.4.4.1.4	0.8.3.1.8	0.8.2.4.3	MGI:954144	1387 2	NM_133658|XR_385973|XM_006525636	NP_598419|XP_006525699	96	HGNC:3435	2071	NM_000122,NM_001303416,NM_001303418	NP_001290347,NP_000113,XP_011509096,XP_011509097,NP_001290345,XP_016859072
Dist	587;1163;8194;84100	1.1.8.4.4	0.9.4.6.0	0.4.4.3.4	0.8.3.2.1	0.8.2.4.3	MGI:1926170	7892 0	XM_006516392|NM_030225|XM_017315247	NP_084501|XP_006516455|XP_017170736	1456	HGNC:29111	1743	NM_001933,NM_001244883	NP_001231812,NP_001924
Cap1	2211;1166;2778;52	1.1.8.6.4	1.3.1.9	0.4.4.4.9	0.8.3.1.4	0.8.2.4.3	MGI:882622	1231	NM_007598|NM_001301067|XM_006502697|XM_006502695	XP_006502758|NP_001287996|NP_031624|XP_006502760	7457 2	HGNC:2004 0	1048 7	NM_001350477,NM_001350485,NM_001330502,NM_001350481,NM_001350480,NM_001105530,NM_001350475,NM_001350478,NM_001350484,NM_006367,NM_001350476,NM_001350479,NM_001350483,NM_001350482	XP_011538813,XP_016855558,NP_001337410,NP_001337407,NP_001337408,NP_001337412,NP_006358,XP_016855560,NP_001337406,XP_011538815,XP_011538814,NP_001099000,NP_001317431,XP_005270425,XP_016855562,NP_001337413,NP_001337404,XP_

	38													011538817,NP_001337409,XP_016855561,NP_001337405,XP_011538812,NP_001337414,XP_016855556,XP_016855557,NP_001337411,XP_016855559,XP_011538811,XP_011538816
Akt1p	46;167;708;717	1.1858	0.9872	0.0445	0.0829	0.0843	MGI:3693832	139	NM_001302268|XM_011248304|XM_006530669|XM_006530673|NM_001302267|XM_017312571|XM_017312573|XM_011248305|XM_017312572|XM_011248306|NM_001302266|NM_001302337|XM_011248302|XM_011248307|NM_010241|XM_017312574|XM_011248303	XP_006530732|XP_017168062|XP_011246608|NP_001289266|XP_017168060|NP_001289197|XP_011246607|XP_017168063|NP_001289195|NP_001289196|XP_006530736|NP_034371|XP_011246604|XP_017168061|XP_011246606|XP_011246605|XP_011246609	721	HGNC:16710	6400	NM_001012398,NM_022476,NM_001308325	NP_001295254,XP_005256154,XP_016879053,XP_016879055,XP_005256152,NP_001012398,XP_016879054,NP_071921,XP_005256153,XP_005256155
Plk2	1031;1168;3556;7090	1.1854	0.0446	0.0826	0.0843	MGI:1097900	20620		NM_152804	NP_690017	21317	HGNC:19699	10769	NM_001252226,NM_006622	NP_001239155,NP_006613
Tsg101	360;1169;9354;9372	1.1845	1.0345	0.0446	0.0824	0.0843	MGI:1065811	2208	XM_006540790|NM_021884|XM_006540789|XM_006540788|NM_001348088|NM_001348089|XR_391333	XP_006540853|XP_006540851|XP_006540852|NP_001335017|NP_001335018|NP_068684	4584	HGNC:15971	7251	NM_006292	NP_006283,XP_005253165
Ehd1	561;1177	1.1794	0.9495	0.0450	0.0828	0.0828	MGI:1341	1360	NM_010119	NP_034249	81678	HGNC:32	10938	NM_001282444,NM_001282445,NM_006795	XP_011543041,NP_001269374,NP_001269373,NP_006786

;25368;6938						878				42					
Ppp2r5c	64;118;3965;4701	10.194572143	0.0.0.0.0.0.48356352	MGI:1349475	269 31	XM_006515919|XM_017315083|XM_017315084|XM_006515922|NM_001135001|XM_017315081|XM_006515921|NM_001081457|NM_012023|XM_017315086|XM_006515923|XM_006515918|XM_006515924|XM_017315085|NM_001081458|XM_006515920|XM_017315082|XM_006515917	XP_017170571|NP_001074927|XP_017170573|XP_006515987|XP_006515982|XP_006515981|NP_001128473|XP_017170570|XP_017170574|XP_017170575|XP_006515983|XP_017170572|XP_006515985|XP_006515986|XP_006515980|XP_006515984|NP_001074926|NP_036153	128665	#N/A	#N/A	#N/A	#N/A
Itm2b	217;1191;5703;7415	1.1.1.0.0.0.17057	1.2.4.8.3.3.7.7.5.2	MGI:1309517	1643 2	NM_008410	NP_032436	7388	HGNC:6174	945	NM_021999	NP_068839			
Plscr3	231;1201;2226;3438	1.1.1.0.0.0.16422	1.1.4.8.4.1.9.3.7.7	MGI:1917560	703 10	NM_023564|XM_006534158|NR_033133|XM_006534157|XM_006534156|NM_001168497	XP_006534219|XP_006534220|XP_006534221|NP_001161969|NP_076053	2321 9	HGNC:16495	57048	NM_020360,NM_001201576	NP_065093,NP_001188505		
Map4k3	67;8;123;350	1.1.4.9.2	0.0.4.8.0.2	0.0.8.6.0.9.6.3.1	MGI:2154405	225 028	XM_006524199|XM_006524196|XM_006524197|XM_006524194|XM_006524198|XM_006524192|XM_006524195|NM_001290345	XP_006524258|NP_001277274|XP_006524262|XP_006524257|XP_006524260|XP_006524259|XP_006524261|XP_006524255	2683	HGNC:6865	8491	NM_001270425,NM_003618	NP_003609,NP_001257354		

	02;8466														
Tmem8	8553;12237;32988;83044	1.1422	0.1860203	0.4882697	0.8631	MGI:1926283	60455	XM_006524736|NM_021793|XR_001782096|XM_006524738|XM_006524737	XP_006524799|XP_006524800|NP_068565|XP_006524801	1094	HGNC:17205	5898 6	NM_021259	NP_067082
Ulk1	6321;12404;27831;63599	1.1404	0.1909	0.4884 2	0.8631	MGI:1270126	2241	NM_001347394|XM_011249420|NM_009469|XM_011249419|XM_006534851|XM_006534852	XP_006534914|XP_011247722|NP_001334323|XP_011247721|XP_006534915|NP_033495	2640	HGNC:12558	8408	NM_003565	NP_003556,XP_011537101,XP_011537100
Dclk1	4821;12411;56522;90200	1.1395	0.1948	0.8631	MGI:1330861	1311 75	NM_001195538|XM_006500982|NM_001195540|XM_006500979|NM_001195539|NM_001111053|XM_011240007|XM_006500981|XM_017319448|XM_017319447|NM_019978|XM_006500983|NM_001111051|XM_006500978|NM_001111052	XP_006501041|NP_001182469|NP_001182468|XP_006501046|NP_001104522|NP_064362|NP_001182467|XP_006501042|XP_006501044|XP_011238309|XP_017174936|XP_017174937|NP_001104523|NP_001104521|XP_006501045	13053 0	HGNC:27000	9201	NM_001330072,NM_001195415,NM_001195416,NM_004734,NM_001195430,NM_001330071	XP_006719956,NP_001317000,NP_001317001,XP_016876337,NP_001182344,NP_001182359,NP_004725,XP_016876336,NP_001182345,XP_005266649
Ripk2	911;12455;24268;;	1.1374	1.2914	0.4869	0.8673 1	MGI:1891456	1926 56	NM_001329751|XM_006537679|XM_006537678|XR_390315|NM_138952|XM_006537677|NR_138102	NP_001316680|XP_006537742|NP_620402|XP_006537741|XP_006537740	37856	HGNC:10020	8767	NM_003821	XP_005251149,NP_003812,XP_011515659

Nbp2	806 10.1384496;12503;57933;70788	10.1848631	0.0.0.0.0.0	MGI:2684414	337	XM_006504005|XM_006504006|XM_017320937|XM_011240752|NM_001024917|XM_006504008|XM_006504007|XM_017320936|XM_006504004|XM_006504003	XP_006504068|NP_001020088|XP_006504067|XP_017176425|XP_006504066|XP_006504070|XP_006504069|XP_017176426|XP_011239054|XP_006504071	323396	HGNC:29851	557278	NM_001318359,NM_018177	XP_011512022,NP_060647,XP_016863886,XP_011512019,XP_011512018,XP_011512021,NP_001305288,XP_016863888,XP_011512020,XP_011512023,XP_016863887,XP_006714086
Esyt2	35012531;60493;87344	1.1.0.4.8.6.3.1 3.1.4.1.3.2.7.0	0.0.0.0.0.0	MGI:1261845	526345	XM_011244139|XM_006516072|XM_017315129|XM_006516075|XM_017315130|XR_001780465|XM_017315131|NM_028731|XR_001780464|XR_001780466|XM_017315128|XR_001780467	XP_006516135|XP_017170618|XP_017170617|XP_006516138|XP_017170619|NP_083007|XP_011242441|XP_017170620	326999	HGNC:22211	574888	NM_020728	NP_065779
Cdkn2d	11325;12555;40747;89888	1.1.3.1.1.5 1.8.1.4.3	0.0.0.0.0.0	MGI:1053887	125811	XM_006509968|NM_009878	XP_006510031|NP_034008	360881	HGNC:17900	10321	NM_001800,NM_079421	NP_524145,NP_001791
Rgs19	99125;39623;93	1.1.3.0.3 0.8.3.2.2	0.0.0.0.0.0	MGI:1915153	564701	NM_026446|NM_001291209|NM_001291208|NM_001291205|NM_001291207|NM_001291210|NM_001291206	NP_001278135|NP_001278134|NP_080722|NP_001278138|NP_001278137|NP_001278136|NP_001278139	233200	HGNC:137735	10287	NM_005873,NM_001039467	XP_011526786,XP_011526787,NP_001034556,XP_011526788,XP_005260240,NP_005864,XP_005260239

Ino80b	7074;1258;5220;6045	1.1297	0.1876540	0.4863	0.8631	MGI:1917270	7020	NM_023547	NP_076036	3256	HGNC:13324	8344	NM_031288	NP_112578	
28104M09Rik	5711;1264;9409;9641	1.1628	0.1919748	0.4865	0.8654	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
Sirpa	5274;2832;5998	1.1203	0.1953012	0.4876	0.8654	MGI:1085563	1912	XM_006498986|NM_001291019|XM_017316569|NM_001291022|XM_017316564|NM_001177647|NM_001291020|NM_001291021|XM_017316561|XM_017316568|NM_007547	NP_001277951|NP_001277949|XP_006499049|NP_031573|XP_017172057|NP_001171118|XP_017172058|NP_001277950|XP_017172053|NP_001277948|XP_017172050	7246	HGNC:9662	1408;85	NM_001040022,NM_001330728,NM_001040023,NM_080792	XP_005260727,NP_542970,XP_011527475,XP_005260726,NP_001035112,NP_001035111,XP_006723608,NP_001317657	
Stxbp5	10027;6722;9147	1.1621	1.1256043	0.8715	0.8654	MGI:1926058	7808	XR_380096|NM_001081344|XM_006512928|XM_006512927|XM_011243236|XR_001779636|XM_006512926|XR_380094|XR_380092|XM_011243237|XM_011243238	XP_006512990|XP_006512989|XP_011241538|XP_011241540|XP_006512991|XP_011241539|NP_001074813	16402	HGNC:19665	1349;57	NM_001127715,NM_139244	XP_016865757,XP_006715402,XP_016865756,NP_001121187,NP_640337,XP_011533755	

Erp29	117;1278;5651;9116	1.1180	0.1802	0.5049	0.8688	0.8654	MGI:1914647	6737	NM_026129	NP_080405	4963	HGNC:13799	1096	NM_006817,NM_001034025	XP_016874209,NP_006808,NP_001029197
Snrk	809;1280;5227;6041	1.1169	0.1856	0.5061	0.8676	0.8654	MGI:1081044	2063	XM_006511998|XM_006512002|XM_006512003|NM_133741|XM_006511999|NM_001164572|XM_006512000	NP_001158044|XP_006512063|XP_006512066|NP_598502|XP_006512062|XP_006512061|XP_006512065	9797	HGNC:30598	5486	NM_017719,NM_001330750,NM_001100594	XP_005265302,NP_060189,NP_001317679,XP_011532163,NP_001094064
Fiad1	635;1281;6926;6940	1.1163	0.1896	0.5067	0.8654	0.8654	MGI:2443030	3194	NM_177041	NP_796015	11598	HGNC:24671	8038	NM_025207,NM_001184891,NM_201398,NM_001184892	NP_079483,NP_001171821,NP_001171820,NP_958800
Hsp90aa1	727;1292;24633;62400	1.1100	0.1870	0.5128	0.8725	0.8702	MGI:9625050	1519	NM_010480	NP_034610	68464	HGNC:5253	3320	NM_001017963,NM_005348	NP_005339,NP_001017963,XP_011535020

Slc41a2	745;1293;4647;7350	10.1094	0.0865	0.513	0.8702	0.8702	MGI:2442940	338365	XM_011243498|NM_177388|XM_006513811	XP_011241800|XP_006513874|NP_796362	9870	HGNC:31045	84102	NM_001352172,NM_001352169,NM_001352171,NM_032148,NM_001352170	XP_006719693,XP_016875506,NP_001339099,NP_001339100,XP_011537113,XP_011537112,XP_011537115,XP_005269235,XP_016875505,XP_016875503,XP_016875502,XP_011537109,NP_001339098,XP_011537111,XP_011537110,XP_005269233,XP_005269236,NP_001339101,XP_016875504,NP_115524
Sesn3	457;1297;3640;8766	10.1071	0.9501	0.5157	0.8709	0.8709	MGI:1922997	757747	NM_030261	NP_084537	14386	HGNC:23060	14368	NM_001271594,NM_144665	XP_011540916,NP_001258523,NP_653266
Npr2	1062;1316;4091;6877	10.0964	0.0805	0.5265	0.8786	0.8789	MGI:1914482	56032	XM_006511769|XM_006511768|XM_011242897|NM_018879|XR_379769|XM_011242898	XP_006511831|NP_061367|XP_011241200|XP_011241199|XP_006511832	4771	HGNC:24969	10641	NM_006545	XP_016861045,XP_011531590,XP_016861044,XP_005264865,NP_006536
Cerk	717;1318;4064;6235	10.0953	0.0865	0.5276	0.8846	0.8789	MGI:2386052	223753	XM_006520831|NM_145475|XM_011245588	XP_011243890|XP_006520894|NP_663450	11247	HGNC:19256	64781	NM_022766,NM_182661	XP_016884398,NP_073603

Rubbl2	267;13119;;36333;;77544	1.0947	1.0482	0.5282	0.8823	0.8789	MGI:1342299	2017 4	XM_006540722|XM_006540723|NM_011304	NP_035434|XP_006540785|XP_006540786	4856	HGNC:10475	1085 6	NM_001321191, NM_006666,NM_001321190	NP_001308119, NP_006657,NP_001308120,XP_011524632
Suclg2	1098;13211;;83433;;84933	1.0939 36	0.7995	0.5295	0.8812	0.8789	MGI:1306824	2017 17	NM_011507|XM_017321481|NM_001326558	NP_001313487|NP_035637|XP_017176970	2854	HGNC:11450	8801	NM_001177599, NM_003848	NP_003839,XP_016862909,XP_016862904,XP_016862905,XP_016862907,XP_016862908,NP_001171070,XP_016862906
Scara5	224;13222;;45855;;84422	1.0931 1	1.0825	0.5300	0.8789	0.8789	MGI:1918395	7114 5	NM_028903|NM_001168318	NP_083179|NP_001161790	1256	HGNC:28701	2861 33	NM_173833	NP_776194
Rab5a	486;13266;;50188;;51699	1.0909	0.9312	0.5323	0.8795	0.8795	MGI:1059266	2714 57	NM_025887	NP_080163	6814 2	HGNC:97833	5868	NM_004162,NM_001292048	NP_001278977, NP_004153

Dep tor	12 18; 13 35; 32 16; 33 39	10 85 89	07 82 11	00 53 76	00 88 50	00 80 03	MGI: 21 46 32 22	97 99 8	NM_145470|NM_001037937	NP_663445|NP_001033026	32 55 1	HGNC: 22 95 3	64 79 8	NM_001283012, NM_022783	NP_001269941, NP_073620,XP_016869224
Ly96	11 02; 13 40; 56 01; 61 90	10 83 32	07 93 38	00 54 04	00 88 64	00 80 03	MGI: 13 41 90 9	17 08 7	NM_016923|NM_001159711	NP_001153183|NP_058619	91 09	HGNC: 17 15 56	23 64 3	NM_015364,NM_001195797	NP_056179,NP_001182726,XP_011515810,XP_016868789,XP_016868788
Cd320	14 9; 13 42; 53 04; 96 46	10 82 21	10 16 05	00 54 17	00 85 3	00 80 03	MGI: 18 60 08 3	54 21 9	NM_001305169|NM_019421	NP_062294|NP_001292098	95 73	HGNC: 16 69 2	51 29 3	NM_016579,NM_001165895	NP_057663,NP_001159367
Rab12	11 41; 13 43; 21 20; 47 17	10 81 15	07 88 3	00 54 23	00 88 32	00 80 03	MGI: 89 42 84	19 32 8	XM_006523888|XM_006523889|XR_876464|NM_024448	XP_006523951|XP_006523952|NP_077768	10 38 79	HGNC: 31 33 2	20 14 75	NM_001025300	XP_006722363, NP_001020471

F3	976;1347;;6524;;8382	10.0793	0.0889	0.0544	0.0883	0.0803	MGI:888381	140666	NM_010171	NP_034301	15111	HGNC:35441	21552	NM_001178096, NM_001993	NP_001984,NP_001171567
Dusp16	1242;1349;;25091;;28155	10.0778358	0.0545826	0.0880	3		MGI:1917936	7068	6	NM_130447|NM_001048054	NP_569714|NP_001041519	15604	HGNC:17909	8082	4	NM_030640	XP_005253545, XP_011519159, XP_016875477, XP_006719218, NP_085143,XP_011519158
Sfn	157;1350;;2475;;95088	10.0777	0.1475	0.0546	4	0.0880	3	MGI:1891831	55948	NM_018754	NP_061224	4475	HGNC:10773	2810	0	NM_006142	NP_006133
Mrc2	701;1356;;54933;;59499	10.0745	0.0855	0.0550	0	0.0883	1	MGI:1078188	1534	NM_008626|XM_006532406	NP_032652|XP_006532469	4408	HGNC:16875	9902	NM_006039	XP_011523845, NP_006030	
Ps	80	10.	0.	0.	0.	0.	MG	16	NM_010724	NP_034854	56	HG	56	NM_004159,NM_148919	NP_004150,NP_683720		

mb8	8;136;7;135;;3477	0683246	8355666	5890606	8856	I:13465277	913			499	NC:9545	96			
Cnnm2	45;137;3;2118;;60122	1.0.0.0.0.0	0936548	5603	8934	8856	MGI:2151054	9419	XM_006527490|NM_033569|NM_001102471|XM_006527489	NP_001095941|XP_006527552|NP_291047|XP_006527553	9761	HGNC:103	5480 5	NM_199077,NM_199076,NM_017649	XP_011538213,NP_060119,NP_951059,XP_006717971,NP_951058,XP_005269990
Ptov1	108;137;;4005;;64111	1.0.0.0.0.0	0786386	5622	8933	8856	MGI:1933946	8411 3	XR_391372|XR_001778019|NM_133949|XM_006541323	XP_006541386|NP_598710	9687	HGNC:9632	5363 5	NM_001305105,NM_017432,NM_001305108	XP_016882369,XP_011525337,XP_006723307,NP_059128,XP_011525336,XP_011525335,XP_005259055,NP_001292034,XP_016882368,NP_001292037
Ptpn14	100;137;;2131;;3195	1.0.0.0.0.0	0796289	5628	8811	8856	MGI:1024667	1925 0	XM_006497131|XM_006497133|XM_006497129|XM_006497130|NM_008976|XM_006497134	XP_006497197|XP_006497194|XP_006497193|XP_006497192|XP_006497196|NP_033002	3941	HGNC:9647	5784	NM_005401	NP_005392,XP_016857430
Hda	130	1.0.0.7	0.0.5	0.0.8	0.0.8	MGI	562	XM_006521203|NM_019572|XM_006521210|NM	NP_001191210|NP_001191206|NP_001191209|	91	HGN	515	NM_015401,NM_016596,NM_00	NP_056216,XP_011536782,XP_016874945,XP_

c7	6;1379;5928;78199	622	618	64089	8596	:1891835	33	_001204281|NM_001204278|XR_875307|NM_001204279|XR_875306|XM_006521207|XM_006521209|NM_001204276|XM_011245699|NM_001204275|XM_006521205|NM_001204280|NM_001204277|XM_006521208	NP_062518|NP_001191204|XP_011244001|NP_001191205|XP_006521270|NP_001191207|NP_001191208|XP_006521272|XP_006521268|XP_006521271|XP_006521266|XP_006521273	24	C:1407	64	1308090,NM_001098416	011536783,XP_011536785,XP_016874944,NP_001295019,XP_011536784,XP_011536780,NP_001091886,XP_011536781
Mum1	649;13800;34500;61611	1.0617	0.086152	0.056466	0.088577	0.08856	MGI:1915364	6814	XM_006514026|NM_023431|XM_006514025	XP_006514088|NP_075920|XP_006514089	11349	HGNC:29641	8493	NM_032853	XP_011526684,XP_011526685,NP_116242,XP_016882890,XP_011526687,XP_011526682,XP_011526686
Lppr2	617;13813;28887;71667	1.0613	0.087365	0.056516	0.088556	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Tjap1	322;13870;35113;41644	1.0580	0.095929	0.056866	0.088800	MGI:1921344	7409 4	XM_011246670|XM_011246676|XM_011246664|XM_011246667|XM_011246669|XM_011246674|XM_011246677|XM_011246675|XM_011246666|NM_001252473|XM_011246672|XM_011246663|XM_011246662|XM_011246673|NM_001252475|NM_028751|NM_001252474|XM_011246671|XM_011246678|XM_011246665|XM_011246668	XP_011244979|XP_011244974|NP_001239403|XP_011244975|XP_011244969|XP_011244968|XP_011244977|XP_011244972|XP_011244965|XP_011244971|NP_001239402|XP_011244976|XP_011244980|XP_011244970|XP_011244973|XP_011244967|XP_011244978|NP_001239404|NP_083027|XP_011244964|XP_011244966	12534	HGNC:17949	9364 3	NM_001146016,NM_001146020,NM_001350564,NM_001350566,NM_001146017,NM_080604,NM_001350568,NM_001350567,NM_001350565,NM_001350561,NM_001350562,NM_001350563,NM_001146018,NM_001146019,NM_001350570,NM_001350569	NP_001337491,NP_001337492,NP_001139490,NP_001337493,XP_006715319,XP_016866981,XP_006715332,XP_006715320,XP_006715313,XP_006715315,XP_006715312,NP_001337490,XP_016866978,XP_016866980,NP_001139492,XP_016866979,XP_006715330,NP_001139488,NP_001139491,NP_001139489,XP_006715314,NP_001337497,XP_016866977,

														XP_006715325, XP_011513297, XP_006715323, XP_006715324, XP_006715329, XP_006715317, NP_001337499, XP_006715326, XP_006715333, XP_006715328, NP_001337494, NP_001337498, XP_006715331, XP_011513298, NP_001337495, XP_016866982, NP_001337496, XP_006715322, NP_542171
Ppm1d	4309;13999;22699;49166	1.0518	0.0934 43	0.0576 0	0.0896 5	0.0893 7	MGI:1858214	5389 2	NM_016910	NP_058606	3118 5	HGNC:9277	8493	NM_003620	NP_003611
Pip4k2a	1329;14022;37744;62344	1.0502	0.0753 7	0.0578 78	0.0896 1	0.0893 7	MGI:1298206	1871 8	NM_008845|XM_006497396|XM_006497397|XM_006497394|XM_006497395	XP_006497458|NP_032871|XP_006497457|XP_006497459|XP_006497460	3795 5	HGNC:8997	5305	NM_005028,NM_001330062	XP_016871819, NP_005019,XP_016871820,XP_011517798,XP_006717513,NP_001316991,XP_016871821
Pgp	8711;14033;;73944;;95922	1.0497	0.0811 2	0.0578 44	0.0894 0	0.0893 7	MGI:1914328	6707 8	NM_025954	NP_080230	5513	HGNC:8909	2838 71	NM_001042371	NP_001035830

Cth	13;14;27;28	1.0481	0.7537	0.5802	0.8938	0.8937	MGI:1339968	1078	NM_145953|XM_006500815	XP_006500878|NP_666065	1432	HGNC:25001	1491	NM_001902,NM_001190463,NM_153742	NP_001177392,XP_005270566,NP_714964,XP_016855905,NP_001893
Eya1	8;14;29;50;36	1.0461	0.8066	0.5827	0.8947	0.8937	MGI:1093444	1048	NM_010164|XM_006495452|XM_017315422|XM_017315414|NM_001252192|XM_011238344|NM_001310459|XM_017315348|XM_017315381|XM_011238346|XM_006495451|XM_006495446|XM_011238347|XR_001780756	XP_006495515|XP_011236648|XP_017170837|XP_017170903|XP_017170870|XP_006495509|XP_017170911|NP_034294|NP_001239121|XP_006495514|XP_011236649|XP_011236646|NP_001297388	7494	HGNC:3519	213 8	NM_000503,NM_001288574,NM_172058,NM_172059,NM_001288575,NM_172060	XP_016868695,XP_016868692,NP_742057,XP_016868694,XP_016868702,XP_016868696,NP_742055,XP_016868700,XP_011515785,XP_016868698,NP_742056,XP_016868699,XP_016868691,NP_001275504,XP_016868701,NP_001275503,XP_016868690,XP_016868697,NP_000494,XP_011515786,XP_016868693
Jak2	68;14;12;43;56;66;96	1.0451	1.0307	0.5840	0.8937	0.8937	MGI:9662 9	1645 2	XM_006526715|XM_006526714|XM_011247155|XM_017318068|NM_001048177|XM_006526713|NM_008413	NP_032439|XP_011245457|XP_006526778|XP_006526777|XP_006526776|XP_017173557|NP_001041642	2103 3	HGNC:6192	3717	NM_001322199,NM_001322194,NM_001322195,NM_004972,NM_001322198,NM_001322196,NM_001322204	NP_004963,NP_001309128,NP_001309124,NP_001309133,NP_001309123,NP_001309127,NP_001309125
Elavl1	45;14;24;;37;79;;66;61	1.0389	0.9178	0.5917	0.9023	0.8944	MGI:1100851	1556 8	XM_006508698|NM_010485	NP_034615|XP_006508761	2036 7	HGNC:33122	1994	NM_001419	NP_001410

Mphosph8	628;1425;6455;6525	1.0385923	0.0590203	0.0898944	MGI:1922589	75339	XR_383218|XM_006519640|XR_383217|NM_023773	NP_076262|XP_006519703	1138	HGNC:29810	547337	NM_017520	NP_059990,XP_011533426
Cd2ap	7628;1427;5187;6098	1.0825937	0.0589944	0.0899444	MGI:1330281	1488	XM_011246264|XM_011246263|NM_009847|XM_011246265|XR_001782031	XP_011244567|NP_033977|XP_011244565|XP_011244566	7663	HGNC:14258	23607	NM_012120	NP_036252,XP_005249033,XP_011512751,XP_016866130
Riok3	1282;1437;3809;39866	1.0749058	0.0599058	0.0905858	MGI:1914128	66878	XR_001782391|XR_001782389|NM_024182|XM_017317969|XR_001782390	NP_077144|XP_017173458	2843	HGNC:11451	8780	NM_145906,NM_001348193,NM_003831	XP_011524545,XP_011524544,NP_001335122,NP_003822
Rgs20	1230;1444;2034;2140	1.0289	0.0752344	0.0604495	0.090775	MGI:1929866	58175	XM_006495553|NM_001177795|NM_021374|XM_011238400|NM_001290372|XM_011238401|XM_006495554	XP_011236702|NP_001277301|XP_006495617|NP_067349|NP_001171266|XP_006495616|XP_011236703	2745	HGNC:14600	86001	NM_001286674,NM_001286673,NM_001286675,NM_003702,NM_170587	NP_001273602,NP_001273604,NP_733466,XP_011515924,NP_001273603,NP_003693

Vav2	13;14;146;32;15;;75900	1.0279	0.7388	0.0056	0.0884	0.0075	MGI:1027178	225	NM_009500|XM_017317167|XM_006497858|XM_006497854|NR_133905|XM_006497856	XP_006497919|XP_006497921|XP_006497917|XP_017172656|NP_033526	2530	HGNC:12658	740	NM_003371,NM_001134398	XP_016870601,XP_016870597,XP_005272270,NP_003362,XP_016870598,XP_016870599,NP_001127870,XP_016870602,XP_016870600
Ar	932;1451;31899;55555	1.0254	0.7888	0.0608	0.0910	0.0075	MGI:8806 4	1183 5	NM_013476	NP_038504	28	HGNC:6444	367	NM_001011645,NM_001348064,NM_001348061,NM_001348063,NM_000044	NP_001011645,NP_001334993,NP_001334992,NP_000035,NP_001334990
Gata6	144;1454;20785;28511	1.0239	1.0138	0.0610	0.0910	0.0075	MGI:1075 16	1446 5	NM_010258|XM_017317834	XP_017173323|NP_034388	6844 9	HGNC:4174	2627	NM_005257	NP_005248
Tie1	114;1460;43177;58811	1.0210	0.0751	0.0614	0.0912	0.0075	MGI:1046 36	218 5	XM_017320106|XM_011249978|XM_017320108|NM_001285529|NM_001285531|XM_017320110|XM_011249985|XM_011249981|XM_017320107|XM_011249980|XM_017320105|XM_006537766|XM_006537759|XM_017320112|XM_006537760|NM_001285530|XM_011249982|XM_006537758|NM_001285532|XM_011249986|	NP_001272460|XP_011248280|XP_011248282|XP_011248281|XP_017175594|NP_001272459|XP_017175600|XP_006537824|XP_017175601|XP_006537829|XP_017175598|XP_011248284|NP_001272458|XP_006537821|XP_011248288|XP_006537823|XP_017175597|XP_011248283|NP_001272461|NP_035729|XP_	2058	HGNC:11837	708	NM_005077,NM_001303104,NM_001303103	NP_001290033,NP_005068,XP_005252211,XP_005252219,XP_016870554,XP_006717322,XP_011517253,XP_005252208,XP_006717324,XP_005252213,XP_006717326,XP_016870555,XP_005252220,XP_006717325,XP_005252210,XP_006717323,NP_001290032,XP_005252209,XP_016870553,XP_006717321

									XM_017320111|XM_011249979|XM_017320104|XM_006537761|NM_011599|XM_017320109	006537822|XP_017175595|XP_011248287|XP_017175593|XP_017175596|XP_017175599				
Stk10	104;1461;7565;8424	1.0205	0.7693	0.6150	0.9106	0.9075	MGI:1094399	2088	XM_017314404|NM_009288	XP_017169893|NP_033314	38122	HGNC:11388	6793	NM_005990	XP_016865277,NP_005981
Nme1	2341;1463;4282;9541	1.0195	1.0369	0.6163	0.9095	0.9075	MGI:973555	1810 2	NM_008704	NP_032730	12851 4	HGNC:7849	4830	NM_198175,NM_000269	NP_000260,NP_937818
Paps1	695;1464;3232;6077	1.0190	0.8322	0.6169	0.9075	0.9075	MGI:1330587	2371	NM_011863|NM_001289479|NM_001289477|NM_001289478	NP_035993|NP_001276406|NP_001276407|NP_001276408	81740	HGNC:8603	9061	NM_005443	XP_011530703,XP_011530702,NP_005434
Sri	733;1473;64655;	1.0146	0.8212	0.6229	0.9133	0.9127	MGI:984199	1095 2	NM_001080974|XM_006503527|XM_017320600|NM_025618	NP_001074443|XP_017176089|XP_006503590|NP_079894	37736	HGNC:11292	6717	NM_001256891,NM_001256892,NM_003130,NM_198901	NP_001243821,XP_011514830,NP_001243820,NP_003121,NP_944490

	7790														
Ezr	194;1482;1992;5839	1.0102	1.0703	0.062887	0.091897	0.091277	MGI:98931	2235	NM_009510	NP_033536	5574	HGNC:12691	7430	NM_001111077, NM_003379	NP_003370,NP_001104547,XP_011534412
Pds5a	13781;14844;25200;95955	1.0093	1.0702	0.063017	0.091797	0.091277	MGI:1918771	7152 1	NM_001081321|XM_006504118|XR_001784747|XR_001784748|XM_006504117|XM_006504115	XP_006504180|NP_001074790|XP_006504178|XP_006504181	22877	HGNC:29088	234 4	NM_015200,NM_001100400,NM_001100399	XP_011511974,NP_001093870,NP_001093869,XP_016863417
Sharpin	91841;14887;88411;94844	1.0078	1.0782	0.063220	0.091778	0.091277	MGI:1913331	10625	NM_025340|XR_383966|XM_011245399|XM_011245398|XM_006520263	XP_006520326|XP_011243701|NP_079616|XP_011243700	11918	HGNC:25321	8185 8	NM_030974	XP_016869377,XP_016869376,NP_112236
Tmed1	14131;14900;52622;6	1.0064	1.0724	0.063440	0.091777	0.091277	MGI:1062001	1708 3	NR_136911|NM_001324510|NM_010744|NR_136912	NP_034874|NP_001311439	21360	HGNC:17291	1101 8	NM_006858	XP_006722694,NP_006849

Gstm2	4233129;14955;65733;74199	1.0073360400	0.0637193	0.0919127	0.0	MGI:958611	148633	NM_008183	NP_032209	12149	HGNC:46322	294	NM_000561,NM_146421	NP_666533,XP_005270839,NP_000552
Anxa2	7014;14977;26877;52722	1.0031031	0.0638584	0.0918427	0.0	MGI:882462	12306	NM_007585|XM_006510796	NP_031611|XP_006510859	20857	HGNC:537	302	NM_004039,NM_001002857,NM_001136015,NM_001002858	NP_001002858,NP_004030,NP_001129487,NP_001002857,XP_016877581,XP_016877582,XP_016877580,XP_011519779,XP_016877579
Mier1	5414;14988;29050;74500	1.0026766	0.0639265	0.0916527	0.0	MGI:1918398	7114 8	XM_006503398|NM_001286221|XM_006503402|NM_001286223|XM_017320386|NM_001039081|NM_001286222|NM_027696|XM_006503399|XM_006503401	XP_006503464|XP_006503461|XP_017175875|NP_001273150|NP_001273152|NP_001273151|XP_006503462|XP_006503465|NP_001034170|NP_081972	13617	HGNC:29657	57708	NM_001077700,NM_001077703,NM_001146110,NM_001146113,NM_001077702,NM_001146112,NM_001146111,NM_020948,NM_001278215,NM_001077701,NM_001077704,NM_001350530	XP_016857423,XP_011540166,NP_001265144,XP_016857419,XP_016857408,NP_001071170,NP_001071171,XP_016857416,XP_016857422,XP_016857415,NP_001071172,NP_001071169,NP_001337459,NP_001139584,XP_005271133,XP_016857418,XP_016857412,NP_001139582,XP_016857420,XP_016857411,XP_016857414,XP_016857413,XP_016857417,XP_016857409,NP_001139583,NP_065999,XP_011540167,XP_016857410,XP_016857421,NP_001139585,NP_001071168
Map3	466;	1.0089	0.0644	0.0911	0.0	MGI:	264	XM_011249037|NM_011947	NP_036077|XP_011247339	691	HGNC	4215	NM_203351,NM_001330431,NM_002401	NP_001317360,XP_005257434,NP_002392,NP_976226,XP_005

k3	150;2775;8259	16	43	04	55	27	13468774	06			10	:6855			257433,XP_005257435
Adck2	726;1505;3694;49800	0.99351	0.8151	0.643975	0.91727	0.91727	MGI:1889336	5769	XM_006506425|NM_178873	XP_006506488|NP_849204	49103	HGNC:19039	9056	NM_052853	XP_006716233,NP_443085,XP_011514977
Mapk7	532;1506;3259;;61113	0.99888	0.9868	0.643945	0.91556	0.91227	MGI:1346347	2393	XM_006533284|NM_011841|XM_006533281|NM_001291036|XM_006533277|NM_001291033|NM_001291034|XM_006533280|NM_001291037|NM_001291035|XM_006533285|XM_006533286	NP_001277963|XP_006533349|XP_006533344|XP_006533340|XP_006533343|XP_006533347|XP_006533348|NP_001277962|NP_001277966|NP_001277965|NP_001277964|NP_035971	2060	HGNC:6880	5598	NM_002749,NM_139034,NM_139032,NM_139033	XP_006721620,XP_006721621,NP_620602,XP_011522259,XP_006721622,NP_620601,NP_002740,NP_620603
Unc93b1	564;1507;6510;;68800	0.998583	0.9858	0.645237	0.91357	0.91227	MGI:1859307	5444	NM_019449|XM_006531798|NM_001161428	NP_062322|XP_006531861|NP_001154900	41325	HGNC:13481	8162	NM_030930	NP_112192,XP_011543592,XP_011543593
Adss	235;150	0.99740	0.10250	0.646527	0.91227	0.91227	MGI:879	1156	NM_007422|XR_001785476	NP_031448	875	HGNC:2	159	NM_001126	XP_011542410,NP_001117

	9;46900;92011						48					92			
Tcaf1	14773;15299;52222;83711	0.0.0.0.0.0.0	0.9.7.6.9.0.1	7.1.6.2.8.1	0.1.0.9.8.0	0.1.1.9.1.0	MGI:1914665	774	XM_006506753|XM_006506754|XM_006506756|XM_006506755|XM_006506751|XM_006506752|XM_017321830|XM_133096	XP_006506814|XP_006506819|XP_006506816|XP_006506818|XP_006506817|NP_084206|XP_017177319|XP_006506815	881	HGNC:22201	947	NM_014719,NM_001206941,NM_001206938	NP_055534,XP_006716254,XP_005250134,XP_016868325,XP_005250132,XP_016868324,NP_001193870,XP_006716255,XP_005250131,NP_001193867,XP_016868323,XP_016868322,XP_005250133
Mul1	807;15344;53700;79366	0.0.0.0.0.0.0	0.7.6.9.3.9.1	9.1.6.3.0.8.1	8.1.3.4.0.9.1	0.1.1.9.1.0.0	MGI:1915600	683	XM_006539134|NM_026689	NP_080965|XP_006539197	1157	HGNC:25762	795	NM_024544	XP_011540439,NP_078820
Acp1	14503;15355;27922;95699	0.0.0.0.0.0.0	0.9.7.6.9.0.1	8.1.6.4.2.9.1	5.6.4.2.0.8.1	2.0.2.0.1.0.1	MGI:1878811	1143	XR_381176|NM_001110239|NM_021330	NP_001103709|NP_067305	3827	HGNC:1222	52	NM_004300,NM_001040649,NM_007099,NM_177554	NP_001035739,NP_009030,NP_004291
Hexim1	832;15377	0.0.0.0.0.0.0	0.9.7.6.9.0.1	8.4.8.5.2.8.1	3.3.5.6.2.1.0	0.6.6.6.2.8.1	MGI:2385	1922	NM_138753	NP_620092	3138	HGNC:249	106	NM_006460	NP_006451

	;46255;85722						923				53				
Bbs7	990;15388;24689;45899	0.976591	0.066634	0.092641	0.09181	MGI:1918742	714 92	NM_027810|XM_006535536|XM_006535535	XP_006535599|XP_006535598|NP_082086	1239 5	HGNC:18758	55 21 2	NM_176824,NM_018190	XP_011530382, XP_005263163, XP_011530381, NP_789794,XP_016863847,XP_011530383,NP_060660,XP_016863846
Llgl1	751;15399;28222;65588	0.980161	0.066711	0.092461	0.09181	MGI:1026822	168 97	NM_001159404|NM_008502|XM_006532354|NM_001159405|XM_006532355	NP_032528|NP_001152877|XP_006532418|XP_006532417|NP_001152876	312 20	HGNC:6628	39 96	NM_004140	XP_011522154, XP_011522157, XP_011522158, NP_004131,XP_011522155,XP_011522153,XP_011522156,XP_011522152,XP_011522151
Tk2	823;15400;46588;69666	0.982896	0.066787	0.092271	0.09181	MGI:1913266	57 813	NM_021028|XM_011248461|XM_006531233|XM_006531235|XM_006531234|NR_045642|XM_017312925	XP_017168414|XP_006531296|XP_006531297|NP_066356|XP_006531298|XP_011246763	332	HGNC:11831	70 84	NM_001172645, NM_001172643, NM_001272050, NM_001172644, NM_001271935, NM_001271934, NM_004614	NP_001258979, NP_001166115, NP_001258864, NP_001166116, NP_004605,NP_001166114,NP_001258863
Mast2	1395;15411;2	0.982545	0.066844	0.092091	0.09181	MGI:1894676	177 76	NM_008641|NM_001042743|XM_006502840|XM_006502835|XM_006502836|XM_006502833|XM_006502839|XM_017320018|XM_006502834	XP_017175507|XP_006502897|XP_006502903|NP_001036208|XP_006502896|XP_006502899|XP_006502898|XP_006502902|NP_032667	7428	HGNC:19035	23 13 9	NM_001324321, NM_015112,NM_001319245,NM_001324320	NP_001306174, XP_016856242, XP_016856241, XP_011539364, XP_005270713, NP_001311249, XP_011539371, XP_016856243, NP_001311250, XP_011539361, XP_011539365,

	906;4363														XP_006710540, XP_011539366, XP_011539367, XP_011539370, XP_011539363, XP_016856244, XP_005270712, XP_011539369, NP_055927
Mtmr14	1416;1542;2298;7783	0.9820	0.7125	0.6691	0.9911	0.9811	MGI:1916075	9728 7	XM_006506827|XR_001785185|XM_006506826|XR_377503|XM_006506824|XM_006506825|NM_026849|XM_006506823	XP_006506887|XP_006506886|NP_081125|XP_006506890|XP_006506888|XP_006506889	1203	HGNC:26190	6419	NM_001077526, NM_001077525, NM_022485	NP_001070993, NP_001070994, XP_016862525, XP_011532314, XP_016862529, XP_016862533, XP_011532315, XP_016862531, XP_016862523, XP_016862528, NP_071930,XP_016862527,XP_005265457,XP_016862526,XP_016862534,XP_016862532,XP_016862524,XP_016862530
Nfkb1	1344;1544;2096;3061	0.9811	0.7179	0.6705	0.9181	0.9181	MGI:973112	18033	NM_008689|XM_006501107|XM_006501106	NP_032715|XP_006501169|XP_006501170	2971	HGNC:7794	4790	NM_003998,NM_001319226,NM_001165412	XP_011530308, NP_001158884, NP_001306155, NP_003989,XP_011530310
Ugt1a10	1331;1550;5381;6424	0.9784	0.7176	0.6747	0.9211	0.9193	MGI:3580642	39443 0	NM_201641	NP_964003	13281	#N/A	54575	NM_019075	NP_061948
Slc16a1	424;1551;	0.9779	0.9000	0.6753	0.9193	0.9193	MGI:1060	2050 1	NM_009196	NP_033222	2062	HGNC:109	656 6	NM_003051,NM_001166496	XP_011540328, NP_001159968, XP_011540329, NP_003042

	23688;31377						13				22				
Cdk9	26969;15555;56711;94887	0.976173	0.987379	0.679200	0.920000	0.920000	MGI:1328368	107951	XM_011239001|NM_130860	XP_011237303|NP_570930	55566	HGNC:17800	102 5	NM_001261	XP_016869673,NP_001252
Ube2d3	11897;15588;42166;95144	0.997295	0.972900	0.680001	0.920001	0.920001	MGI:1913355	66105	XM_006501874|XM_006501873|XM_006501875|NM_025356	XP_006501937|XP_006501936|XP_006501938|NP_079632	12391 4	HGNC:12476	73 23	NM_181889,NM_181890,NM_181886,NM_181887,NM_181892,NM_181888,NM_181893,NM_181891,NM_001300795,NM_003340	XP_016864073,NP_003331,NP_871621,NP_871620,NP_871619,NP_001287724,NP_871618,NP_871615,NP_871622,NP_871616,NP_871617
Vrk3	10611;15688;22766;48966	0.970225	0.974255	0.686866	0.926648	0.924848	MGI:2182465	10158	XM_006540538|NM_133945	XP_006540601|NP_598706	9509	HGNC:18996	51 23 1	NM_016440,NM_001308420,NM_001025778	NP_001020949,XP_006723301,XP_011525325,NP_057524,NP_001295349,XP_005259029,XP_005259028,XP_006723300
Trpc4ap	41056;15692;2	0.996983	0.990233	0.687548	0.924848	0.924848	MGI:1930707	56407	NM_001163452|NM_019828	NP_001156924|NP_062802	9224	HGNC:16181	26 13 3	NM_015638,NM_199368	NP_955400,XP_011527074,NP_056453,XP_016883290,XP_011527076,XP_016883288,XP_016883289

	164;6982						51								
Mef2a	18;1573;4032;5146	0.9683680	1.0634	0.0690257	0.0925956	MGI:995332	1725 8	XM_011250814|XM_006540685|NM_001291191|XM_017322011|NM_001291196|NM_001033713|NM_001291195|XM_006540686|XM_006540684|NM_001291192	NP_001278121|NP_001028885|NP_001278120|NP_001278124|NP_001278125|XP_006540748|XP_006540749|XP_006540747|XP_011249116|XP_017177500	4080	HGNC:6993	4205	NM_001171894,NM_001130928,NM_005587,NM_001352614,NM_001319206,NM_001130927,NM_001130926,NM_001352617,NM_001352616,NM_001352615,NM_001352618	XP_016877681,XP_011519884,XP_016877692,NP_001306135,NP_001339544,XP_011519874,XP_011519887,XP_011519875,NP_001165365,XP_011519885,XP_005254973,NP_001124400,XP_016877683,XP_016877687,NP_001339545,XP_011519880,XP_016877691,NP_001339546,XP_016877680,XP_016877685,XP_011519892,XP_011519878,XP_016877686,NP_001124398,XP_016877684,XP_016877682,XP_011519873,XP_016877693,XP_005254972,XP_011519888,XP_016877688,XP_011519883,XP_016877679,XP_016877689,XP_005254971,NP_001339543,XP_011519881,NP_001339547,NP_001124399,XP_016877690,XP_011519889,NP_005578,XP_011519879
Nme4	18;1579;5275;5494	0.9653	1.0552444	0.0694587	0.0928256	MGI:1931148	5652 0	XM_006524677|NM_019731	NP_062705|XP_006524740	3673	HGNC:7852	4833	NM_001286439,NM_005009,NM_001286436,NM_001286440,NM_001286438,NM_001286433,NM_001286435	NP_001273365,NP_001273362,NP_001273369,NP_001273367,NP_001273364,NP_001273368,NP_005000
Pvrl3	1521;15	0.9631	0.0695156	0.0697905	0.0930556	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

	84;42366;94522														
Cmkl1	9988;15855;32855;39966	0.9626	0.7473	0.6986	0.9287	0.9256	MGI:1096003	147	XM_006530165|XM_006530164|NM_008153|XM_006530166	XP_006530229|NP_032179|XP_006530228|XP_006530227	129967	HGNC:21211	1240	NM_001142344,NM_001142345,NM_001142343,NM_004072	NP_004063,NP_001135817,NP_001135815,NP_001135816,XP_016874309
Macf1	17979;15866;27111;70388	0.9622	0.1062	0.6994	0.9271	0.9256	MGI:1085559	1142	XM_011240417|NM_001199137|XM_011240414|XM_011240416|XM_011240415|XM_011240411|NM_001199136|XM_017319920|XM_011240418	XP_017175409|XP_011238720|NP_001186066|NP_001186065|XP_011238717|XP_011238716|XP_011238719|XP_011238713|XP_011238718	136191	#N/A	#N/A	#N/A	#N/A
Cd109	23737;15888;27722;55022	0.9613	0.1005	0.7009	0.9262	0.9256	MGI:2445221	2355055	NM_153098	NP_694738	251833	HGNC:21685	1352288	NM_133493,NM_001159587,NM_001159588	XP_011533775,XP_005248716,NP_001153059,XP_016865772,NP_598000,NP_001153060
Ncam1	10947;15911	0.9603002	0.7730296	0.7902646	0.9256	0.9256	MGI:97281	179167	XM_006510066|XM_006510075|XM_006510064|XM_006510061|NM_001081445|XM_006510069|XM_006510060|XM_017313195|XM_006510063|	XP_006510136|XP_006510121|XP_017168690|XP_017168681|XP_006510133|XP_006510134|XP_017168682|XP_011240717|XP_006510137|	407554	HGNC:76556	468464	NM_000615,NM_001242607,NM_181351,NM_001076682,NM_001242608	NP_851996,NP_001229536,NP_001070150,NP_000606,NP_001229537

	;3321;5893							XM_017313197|XM_006510062|XM_006510055|XM_006510057|XM_017313201|XM_017313199|XM_006510070|NM_010875|NM_001311065|XM_017313200|XM_017313193|XM_006510058|XM_006510059|XM_017313198|XM_006510065|XM_017313194|XM_011242415|XM_006510071|XM_011242416|XM_006510073|NM_001113204|XM_006510056|XM_006510068|XM_017313192|XM_017313196|XM_011242414|XM_006510067|XM_006510074|XM_011242413	XP_006510126|XP_006510123|XP_011240718|XP_017168688|XP_017168685|XP_017168684|XP_017168687|XP_017168683|XP_006510118|XP_011240716|XP_006510128|XP_006510130|NP_001106675|XP_006510129|XP_006510119|XP_011240715|XP_017168689|XP_006510124|XP_006510131|NP_001297994|XP_006510127|XP_006510132|XP_006510122|XP_006510125|NP_001074914|NP_035005|XP_017168686|XP_006510120|XP_006510138				
Sdcbp	94;15933;26922;738888	0.95911	0.75345	0.70446	0.92556	0.92556	MGI:1337026	5378	XM_006538084|NM_001098227|NM_016807	XP_006538147|NP_001091697|NP_058087	410	HGNC:10662	6386	NM_001348340, NM_001007067, NM_001330537, NM_001348339, NM_001348341, NM_005625, NM_001007068, NM_001007069, NM_001007070	NP_001007071, XP_016869216, NP_001007069, NP_001335270, NP_001335268, NP_001335269, NP_001007070, NP_001317466, NP_001007068, XP_011515873, XP_016869217, NP_005616
Ocrl	910;16066;27447;32799	0.95334	0.75663	0.71335	0.93449	0.92888	MGI:1095889	3206344	NM_177215|XM_011251008|XM_017318524	NP_796189|XP_017174013|XP_011249310	233	HGNC:8108	4952	NM_001587,NM_001318784,NM_000276	XP_005262479, NP_001305713, XP_011529647, NP_001578,XP_016885043,XP_011529646,NP_000267
Gadd45g	112;16074;	0.95330	1.15555	0.71441	0.93308	0.92888	MGI:1346463	23882	NM_011817	NP_035947	21334	HGNC:4097	10912	NM_006705	NP_006696,XP_011516465

	723;5327					25									
Casp3	12177;16088;54000;80833	0.952525	0.715515	0.714813	0.931338	0.92888	MGI:1077739	12367	XM_017312543|NM_001284409|NM_009810	NP_033940|XP_017168032|NP_001271338	37912	HGNC:15044	836	NM_004346,NM_032991	NP_004337,XP_011530603,NP_116786
Npc1	15701;16099;46433;81299	0.952121	0.683771	0.715515	0.929636	0.92888	MGI:1097712	18145	XM_017317849|NM_008720	NP_032746|XP_017173338	228	HGNC:7897	4864	NM_000271	XP_005258336, XP_006722542, XP_016881275, XP_016881274, XP_005258334, XP_016881276, XP_005258335, NP_000262,XP_016881273,XP_011524317
Stk17b	14301;16133;23799;32033	0.950303	0.695056	0.718484	0.930707	0.92888	MGI:2138162	98267	NM_133810|XM_006496359	NP_598571|XP_006496422	31231	HGNC:11396	9262	NM_004226	XP_011510472, XP_011510471, XP_011510473, XP_011510470, NP_004217
Cnep1r1	60961;16166;6	0.949090	0.819099	0.720406	0.930608	0.92888	MGI:1921929	38203	XM_011248421|XM_011248420|XM_356102	XP_011246723|XP_011246722|NP_083350	14472	HGNC:26759	25591	NM_001281789, NM_153261	NP_001268718, NP_694993

	707:7339					81									
Mphosph9	320;1617;5489;6331	0.0.0.0.0.0	0.9486	0.9394	0.7211	0.9288	0.9288	MGI:2443138	269702	NR_102690|NM_001277867|XM_006530362|XM_011248205|XM_011248206|XM_011248207|XM_006530361|NM_001081323|XR_001784704|XM_006530366|XM_006530365|XM_006530364|XR_878687	XP_006530429|NP_001264796|XP_006530428|NP_001074792|XP_006530427|XP_011246508|XP_006530425|XP_011246509|XP_006530424|XP_011246507	112556	HGNC:7215	10198	NM_022782	XP_016874162, XP_016874169, XP_016874165, XP_016874166, XP_016874167, XP_011536042, XP_016874163, XP_011536043, XP_016874164, NP_073619,XP_016874168,XP_016874170
Tipr1	139;1623;7645;9740	0.1.0.0.0.0	0.9460	1.0692	0.7253	0.9316	0.9299	MGI:1915087	2265911	XM_011238792|NM_145513|XM_006496779|XM_006496780	XP_006496843|XP_006496842|NP_663488|XP_011237094	71400	HGNC:30231	261726	NM_001031800, NM_152902	NP_001026970, NP_690866
Cpne3	1039;1624;3535;6027	0.0.0.0.0.0	0.9456	0.7331	0.7260	0.9299	0.9299	MGI:1917818	705688	NM_027769|XM_017320384	NP_082045|XP_017175873	208391	HGNC:23166	88955	NM_003909	XP_005251150, NP_003900,XP_016869434
Rab39b	209;1629;234	0.1.0.0.0.0	0.9435	0.1021	0.7295	0.9318	0.9315	MGI:1915040	677790	NM_175122	NP_780331	62377	HGNC:16449	116442	NM_171998	NP_741995

	8;4469														
Tbc1d10b	78;1632;7844;8858	0.942264	1.2.7317	0.0.9320	0.0.9315	MGI:1915699	6849	NM_144522	NP_653105	917	HGNC:24510	260 0	NM_015527	XP_011544091, XP_011544092, NP_056342	
Zfand6	1183;1641;5853;8772	0.938383	0.7.7123	0.0.9378	0.0.9315	MGI:1929510	6509 8	XM_006508105| XM_006508106| XM_017312218| NM_022985|XM_006508109|XM_006508110|XM_006508108|XM_006508107	XP_006508168| XP_017167707| NP_075361|XP_006508172|XP_006508171|XP_006508173|XP_006508169|XP_006508170	1037 2	HGNC:30164	54 69	NM_001242912, NM_001242911, NM_001242916, NM_001242915, NM_001242914, NM_001242918, NM_001242913, NM_001242919, NM_001242917, NM_019006	NP_001229845, NP_001229846, NP_001229844, NP_061879,NP_001229840,NP_001229842,NP_001229841,NP_001229843,NP_001229847,XP_011519986,NP_001229848	
Rab11a	420;1643;3746;6992	0.938175	0.8.7396	0.0.9369	0.0.9315	MGI:1858202	5386 9	NM_017382	NP_059078	3790 3	HGNC:9760	87 66	NM_004663,NM_001206836	NP_004654,NP_001193765	
Fig4	1043;1648;8340;	0.934545	0.7.7433	0.0.9389	0.0.9315	MGI:2143585	1031 99	NM_133999	NP_598760	6713	HGNC:16873	98 96	NM_014845	XP_016867082, XP_011534583, XP_016867081, NP_055660,XP_016867080	

	94677														
Sfi1	78;16527;27269;74899	0.9337	0.7692	0.7461	0.9399	0.9315	MGI:1926137	787	XM_006514900|XM_006514894|XM_017314846|XM_011243798|XM_011243794|XM_006514899|XR_001780076|XR_380988|XM_006514904|XM_017314842|XM_011243792|XM_006514897|XM_017314843|XM_006514908|XM_017314847|XM_017314841|XR_872210|XR_380989|XM_006514903|XM_006514902|XM_011243797|XM_011243795|XM_006514901|XM_006514898|XR_001780077|XR_380990|XM_017314844|XM_006514896|NM_030207|XM_017314845|XR_001780078	XP_017170332|XP_006514971|XP_006514966|NP_084483|XP_017170334|XP_017170333|XP_011242097|XP_006514960|XP_006514965|XP_017170336|XP_006514962|XP_006514967|XP_017170331|XP_006514961|XP_006514964|XP_011242099|XP_006514963|XP_011242094|XP_006514959|XP_017170335|XP_017170330|XP_011242096|XP_011242100|XP_006514957	127	HGNC:29064	98 14	NM_001258327,NM_014775,NM_001258325,NM_001007467,NM_001258326	XP_016884647,XP_011528881,XP_016884649,XP_011528883,XP_016884629,XP_016884636,XP_016884645,XP_016884650,XP_016884633,XP_011528889,XP_011528873,XP_016884639,XP_016884630,XP_011528882,XP_016884642,XP_016884637,NP_001245256,XP_016884632,XP_011528885,XP_011528884,XP_016884631,XP_011528872,XP_016884635,XP_016884644,NP_055590,XP_011528879,NP_001245254,XP_016884646,XP_005261925,XP_011528876,XP_016884641,XP_016884648,NP_001007468,XP_016884634,XP_011528878,XP_016884640,XP_016884643,XP_006724453,XP_016884628,XP_016884651,XP_016884638,XP_011528877,NP_001245255
Frmd6	84;16554;61386;89977	0.9327	0.7576	0.7392	0.9315	MGI:2442579	3197 10	XM_006515977|XM_006515979|NM_028127|XM_006515978	XP_006516041|XP_006516042|NP_082403|XP_006516040	12449	HGNC:19839	12 27 8 6	NM_001267047,NM_001042481,NM_001267046,NM_152330	XP_016876456,XP_011534726,XP_011534725,NP_689543,NP_001253976,XP_006720093,XP_006720092,XP_016876457,NP_001253975,NP_001035946
Enpp4	35;16552;2	0.9124	0.7483	0.9375	0.9315	MGI:2682626	22479 4	XM_006524130|XM_006524134|NM_199016|XM_017317438|XM_006524133	XP_006524193|XP_006524197|XP_006524196|XP_017172927|NP_950181	28264	HGNC:33559	22 28 75	NM_014936	NP_055751

	239;6135					34									
Slc9a3r1	693;1656;3797;7668	0.9320	0.7892	0.7490	0.9358	0.9315	MGI:1349482	2641	NM_012030	NP_036160	3137	HGNC:11075	9368	NM_004252	NP_004243
Ceacam2	1481;1657;2331;6562	0.9316	0.6826	0.7497	0.9340	0.9315	MGI:1347246	2636	NM_001113368|NM_007543|NM_001113369	NP_031569|NP_001106840|NP_001106839	12863	HGNC:18144	634	NM_001024912, NM_001205344, NM_001184813, NM_001184816, NM_001712,NM_001184815	NP_001020083, NP_001192273, XP_011525508, NP_001171742, NP_001171744, NP_001171745, NP_001703
Slc6a6	1530;1661;4622;9245	0.9299	0.6785	0.7528	0.9353	0.9315	MGI:984888	2136	XR_001785116|XR_001785117|XR_001785114|XM_011241279|XM_006505871|XM_006505870|NM_009320|XR_377434|XR_001785115	XP_006505934|NP_033346|XP_006505933|XP_011239581	2291	HGNC:11052	6533	NM_001134367, NM_001134368, NM_003043	XP_006713370, NP_001127840, XP_011532332, NP_001127839, NP_003034,XP_011532333
Cep152	1597;1662;6	0.9295	0.6742	0.7534	0.9336	0.9315	MGI:2139083	9910	XM_006500473|XM_017319354|XM_011239871|XR_001783212|XR_001783214|NM_001081091|XR_001783213|XM_006500474|XM_011239870	XP_011238172|XP_017174843|XP_006500536|NP_001074560|XP_011238173|XP_006500537	37159	HGNC:29298	2295	NM_014985,NM_001194998	NP_001181927, NP_055800,XP_011519681,XP_011519677,XP_011519683,XP_016877503,XP_006720500,XP_016877504,XP_011519676,XP_011519675,XP_

	712;707														011519680,XP_016877505
Rat1e	1058;1666;2493;9374	0.9272179	0.7216	0.7534	0.9315	MGI:2675273	3790433	XM_006512780|XM_011243178|XM_006512779|XM_006512777|XM_011243179|XM_006512782|NM_198193	XP_006512842|XP_006512840|XP_011241481|XP_006512843|NP_937836|XP_006512845|XP_011241480	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Tyh3	1060;1667;3160;7410	0.9274	0.7212	0.7533	0.9315	MGI:1925589	7833439	NM_001308040|XM_006504769|NM_175274|XM_006504772|XM_017321177	NP_780483|XP_017176666|XP_006504832|XP_006504835|NP_001294969	18431	HGNC:22222	80727	NM_025250	XP_016868144, XP_011513837, XP_016868145, NP_079526
Reps1	9083;1670;2501;8706	0.9262	0.7431	0.7591	0.9315	MGI:1196373	19707	NM_009048|XM_017313852|NM_001111065|XM_006512621|XM_017313853	XP_006512684|XP_017169342|NP_001104535|XP_017169341|NP_033074	75155	HGNC:15578	85021	NM_001286612, NM_001128617, NM_031922,NM_001286611	NP_001273541, NP_001122089, XP_005267236, XP_016866878, XP_016866877, XP_005267234, XP_005267235, XP_016866876, NP_001273540, NP_114128,XP_011534504
Gpc4	710;1671;45	0.9258	0.7821	0.7599	0.9315	MGI:1049022	14735	NM_008150|XM_011250978	XP_011249280|NP_032176	55582	HGNC:44522	22339	NM_001448	NP_001439

	60;5095													
Slco3a1	2853;1675;;2758;;4583	0.0924149	0.0949926	0.0762828	0.0932656	0.0932656	MGI:1351867	108116	NM_001038643|NM_023908	NP_076397|NP_001033732	40862	HGNC:10952	2823 2	NM_013272,NM_001145044	XP_011519758,NP_001138516,NP_037404,XP_005254948,XP_005254946
Ephb4	1559;1684;;7774;;7958	0.0920404	0.0671949	0.0769393	0.0938080	0.0935657	MGI:1047557	138446	NM_001159571|NM_010144	NP_034274|NP_001153043	20939	HGNC:33955	2050	NM_004444	NP_004435,XP_016867305
Ets1	4533;1685;;3044;;6296	0.0920007	0.0858707	0.0770064	0.0936457	0.0935657	MGI:954555	23871	NM_011808|NM_001038642|XM_006510269	NP_035938|XP_006510332|NP_001033731	38837	HGNC:34888	213	NM_005238,NM_001330451,NM_001143820,NM_001162422	XP_016872806,NP_001155894,XP_016872805,XP_011540953,NP_005229,XP_011540954,XP_016872804,XP_011540951,XP_016872803,NP_001317380,XP_011540952,NP_001137292
Cdc42ep3	4733;1687;;3324	0.0919202	0.0850303	0.0771616	0.0935757	0.0935757	MGI:2384718	26040 9	NM_026514|XM_006524295	XP_006524358|NP_080790	4708	HGNC:16943	1060 2	NM_001270436,NM_001270438,NM_001270437,NM_006449	NP_001257366,NP_001257365,NP_006440,XP_011530784,NP_001257367

	;4619														
Btn2a2	7069;16944;30266;32229	0.0916383	0.0778369	0.0793997	0.0939797	MGI:3606486	2385555	NM_175938|NM_001289615|XM_006516664|XM_017315508|NM_001289614|XR_001780781	XP_006516727|NP_001276543|NP_787952|NP_001276544|XP_017170997	56012	HGNC:11137	10385	NM_001197240, NM_001197238, NM_001197239, NM_001197237, NM_006995,NM_181531	XP_016865658, XP_006715016, XP_016865656, NP_001184166, NP_001184168, XP_016865657, XP_011512531, XP_006715018, XP_016865655, NP_001184167, XP_005248854, NP_001184169, XP_011512530, XP_005248855, XP_011512533, NP_008926,NP_853509
Ssh2	31069;16977;40377;50522	0.0915188	0.0928891	0.0773991	0.0939399	MGI:2679255	2378600	XM_006533228|NM_177710|XM_006533227|NM_001291190|XM_006533229	XP_006533290|NP_001278119|NP_808378|XP_006533291|XP_006533292	14116	HGNC:30580	85464	NM_001282130, NM_001282129, NM_033389,NM_001282131	NP_001269060, XP_016880743, XP_005258116, XP_016880741, NP_203747,XP_011523709,XP_005258117,XP_016880740,NP_001269058,NP_001269059,XP_006722212,XP_011523707,XP_011523708,XP_005258115,XP_016880742,XP_016880744,XP_011523706,XP_011523704
Serinc1	16188;17088;80000;85622	0.0910707	0.0663676	0.0787373	0.0947272	0.0945757	MGI:1926228	5644 2	NM_019760	NP_062734	41334	HGNC:134644	57515	NM_020755	NP_065806
Pkn2	17474;17099;65377;9	0.0910303	0.1042636	0.0788181	0.0945757	0.0945757	MGI:1092111	1093 3 3	NM_178654	NP_848769	20544	HGNC:94066	55586	NM_001320707, NM_001320708, NM_006256,NM_001320709	NP_001307637, XP_016857271, NP_006247,XP_016857272,NP_001307636,NP_001307638,XP_011540074

	651														
Fam168b	16925;17165;60651;84777	0.0.0.0.0.0	0906758	0793394	0794494	0.9.4.9.4.4	MGI:2448487	21469	XM_006495845|NM_001160236|NM_001160235|NM_174997	XP_006495908|NP_001153707|NP_778162|NP_001153708	18390	HGNC:27016	13074	NM_001321743,NM_001321746,NM_001321745,NM_001321744,NM_001009993,NM_001321748,NM_001321747	NP_001308675,NP_001009993,NP_001308672,XP_011508896,NP_001308673,NP_001308674,NP_001308676,XP_016858816,NP_001308677,XP_016858817
Gnb2l1	43617;17191;42851;79277	0.9.0.8.7.9.4.9.4.6 0.5.9.5.9.6 0.6.3.0.5.5					#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Glmn	40173;17255;35622;50855	0.9.0.8.7.3.9.6	0.8.0.0.2.5	0.9.5.2.2.5	0.9.5.2.2.5	MGI:2141180	17082 3	XM_011249410|XR_001784631|XM_006534800|NM_001161738|NM_001161739|XM_017320694|NM_133248	NP_001155210|XP_017176183|XP_006534863|NP_573511|NP_001155211|XP_011247712	14239	HGNC:14373	11146	NM_001319683,NM_007070,NM_053274	XP_006710372,XP_016855629,NP_444504,XP_005270458,XP_016855630,XP_016855633,XP_016855626,NP_001306612,XP_016855628,XP_016855631,XP_016855632,XP_016855627,XP_011538848
Fyn	67673;17345;52600;72	0.9.0.7.0.0.3 0.7.8.0.7.6 0.9.5.8.9.2				0.9.5.8.9.2	MGI:9560 2	14360	NM_001122893|XM_006512539|NM_001122892|XM_011243117|NM_008054|XM_006512540	XP_006512602|NP_001116364|NP_032080|NP_001116365|XP_006512603|XP_011241419	48068	HGNC:40377	25334	NM_002037,NM_153047,NM_153048,NM_001242779	NP_694593,XP_016866142,XP_016866139,XP_005266949,NP_002028,XP_016866144,NP_694592,XP_016866143,XP_005266947,XP_016866140,XP_016866141

Tdg	43494;17500;70888;95188	0.894118	0.829818	0.819001	0.970194	0.969404	MGI:1082477	2165	XM_006513577|NM_172552|NM_011561	NP_766140|XP_006513640|NP_035691	2415	HGNC:11700	6996	NM_003211,NM_001008411	XP_011537017, XP_011537016, NP_003202,XP_005269182
Rab21	32617;17522;48466;67599	0.893331	0.908106	0.820694	0.969404	0.969404	MGI:8943088	2163444	XM_006513537|NM_024454	NP_077774|XP_006513600	8991	HGNC:18263	23011	NM_014999	NP_055814
Ppp1r2	38417;17573;91035;93566	0.891313	0.875535	0.824343	0.971313	0.971313	MGI:1914099	6684 49	NM_025800	NP_080076	4546	HGNC:9288	5504	NM_006241,NM_001291504,NM_001316325,NM_001291505	NP_001278434, XP_006713745, NP_006232,NP_001303254,NP_001278433
Zpr1	36917;17633;19893;75433	0.888200	0.882090	0.829020	0.974343	0.972727	MGI:1330262	22687	NM_011752	NP_035882	2900	HGNC:13051	8882	NM_003904,NM_001317086	NP_001304015, NP_003895

Nfe2l2	149;1764;6777;9047	0.8866029	0.8829727	0.9727	MGI:1084204	180	NM_010902|NR_132727	NP_035032	241	HGNC:7782	478	NM_001313901, NM_001145413, NM_001145412, NM_001313900, NM_001313902, NM_001313904, NM_001313903, NM_006164	NP_001138884, NP_001300833, NP_001300829, NP_006155,NP_001300832,NP_001300831,NP_001300830,NP_001138885
Map2k2	154;1767;4327;7508	0.8875	0.1056420	0.9728	MGI:1346867	263	NM_023138|XM_006513684|NM_001347144|XM_006513682|XM_006513683	NP_001334073|XP_006513746|XP_006513747|NP_075627|XP_006513745	4859	HGNC:6842	560	NM_030662	XP_016882480, XP_016882478, XP_016882479, XP_006722862, NP_109587
Enah	268;1770;5922;9720	0.8863	0.9434329	0.9729	MGI:1083600	138	XM_006496652|XM_006496646|XM_006496644|XM_006496647|NM_001083120|XM_006496648|XM_006496650|XM_006496645|XR_001780490|NM_008680|NM_001083121|XM_006496643|NM_010135|XM_006496649|XM_006496651	XP_006496706|XP_006496710|XP_006496709|XP_006496714|NP_034265|NP_032706|NP_001076590|XP_006496712|NP_001076589|XP_006496707|XP_006496711|XP_006496713|XP_006496715|XP_006496708	1340	HGNC:18271	5570	NM_001008493, NM_018212	XP_016857238, XP_016857241, XP_016857243, XP_005273244, XP_016857236, XP_016857239, XP_016857245, XP_016857240, XP_016857242, XP_011542531, NP_001008493, NP_060682,XP_016857244,XP_016857237,XP_016857235,XP_016857246
Cdc42ep4	1469;1775;4272;8322	0.8844	0.6598	0.8374981	MGI:1929760	569	XM_006533815|XM_006533817|XM_006533819|XM_006533818|XM_017314686|NM_020006|NM_001163346	XP_006533878|XP_017170175|NP_001156818|XP_006533880|XP_006533881|XP_006533882|NP_064390	810	HGNC:17147	2358	NM_012121	XP_005257239, NP_036253

Rasa2	29;17800;52667;57667	0.8819625	0.9184167	0.9767	0.9767	MGI:2149960	114713	XM_006510777|NM_053268|XM_017313108|XM_006510775|XM_006510776	XP_017168597|XP_006510840|XP_006510839|NP_444498|XP_006510838	4745	HGNC:9872	592	NM_006506,NM_001303245,NM_001303246	XP_016862460,NP_001290174,NP_006497,XP_011511361,NP_001290175,XP_016862461,XP_016862459,XP_016862458,XP_016862457
Twf2	15483;17833;33888;66533	0.8814	0.6531	0.8441	0.9769	0.9769	MGI:1346078	2399	NM_011876	NP_036006	5272	HGNC:96211	1134	NM_007284	NP_009215
Prpsap1	17847;17877;82455;88966	0.8799	0.6403	0.8472	0.9780	0.9769	MGI:1915013	6763	XM_181343|XM_011249196|XM_006534018|XM_006534017	NP_080640|XP_011247498|XP_006534080|XP_006534081	55687	HGNC:94666	5635	NM_001330503,NM_002766	NP_002757,XP_011523336,NP_001317432
Gpatch2	9603;17902;26599;91966	0.8717	0.8419	0.9781	0.9769	MGI:1915019	6769	NM_026367|XM_006497200|XM_006497199|XM_006497196|XM_006497197|XM_006497198|XM_006497195|XM_011238923|XR_373774|XM_006497201	NP_080643|XP_006497263|XP_011237225|XP_006497262|XP_006497261|XP_006497259|XP_006497264|XP_006497260|XP_006497258	9976	HGNC:25499	55105	NM_001297754,NM_018040	XP_011507992,NP_001284683,XP_011507995,XP_011507993,XP_011507996,NP_060510,XP_016857082,XP_016857081,XP_011507991

Hipk3	15673;17933;54605;55355	0.8776	0.6500	0.8518	0.9784	0.969	MGI:3148482	1529	NM_001145824|NM_010434	NP_034564|NP_001139296	55923	HGNC:49155	10114	NM_001278162, NM_001278163, NM_001048200, NM_005734	XP_005252786, NP_001041665, NP_005725,XP_016872566,NP_001265091,NP_001265092,XP_016872565
Cdc42ep5	13633;17944;66977;83300	0.8772	0.6643	0.8526	0.9769	0.969	MGI:1929745	5804	XM_006540250|NM_021454|XM_006540249	XP_006540313|XP_006540312|NP_067429	10984	HGNC:174408	14817 0	NM_145057	NP_659494
Chrm3	12083;18055;56822;86999	0.8731	0.6767	0.8614	0.9844	0.9801	MGI:883981	1267	XM_006516468|NM_033269	NP_150372|XP_006516531	20191	HGNC:1952	11311	NM_001347716, NM_000740	XP_016855648, XP_016855652, XP_016855645, XP_005273089, XP_016855641, XP_016855650, XP_016855651, XP_011542348, XP_016855649, XP_016855643, XP_011542345, XP_011542346, XP_016855647, XP_016855646, XP_011542347, XP_011542349, XP_016855644, NP_001334645, NP_000731,XP_016855642,XP_011542343
Actr6	17453;18066;43522;8	0.8727	0.6383	0.8622	0.9829	0.9801	MGI:1914269	6701	9	XM_006513967|XM_017314062|XM_017314063|XM_006513965|XM_006513966|NM_025914|XM_011243532	XP_006514030|NP_080190|XP_006514028|XP_006514029|XP_017169552|XP_011241834|XP_017169551	64511	HGNC:240255	64431	NM_022496	NP_071941,XP_016875310

Slc8b1	659402;180808;308335;504040	0.0.8720	0.0.8571	0.0.8638	0.0.9823	0.0.9801	MGI:2180781	170756	XM_006530174|XM_006530175|NM_001177594|XM_017320692|NM_133221|NM_001177595	XP_006530237|NP_001171065|XP_017176181|NP_573484|XP_006530238|NP_001171066	41602	HGNC:26175	80024	NM_024959,NM_001330466	NP_079235,XP_011537051,XP_011537052,NP_001317395,XP_011537054,XP_016875467,XP_006719670
Coro1c	17862;18099;23133;81466	0.0.8716	0.0.8636	0.0.8645	0.0.9806	0.0.9801	MGI:1345964	23790	NM_011779	NP_035909	56537	HGNC:22254	23603	NM_001105237,NM_014325,NM_001276471	XP_016874611,NP_055140,XP_016874612,XP_016874610,NP_001098707,XP_011536427,NP_001263400
Ankrd27	39882;18142;25033;52711	0.0.8697	0.0.8579	0.0.8685	0.0.9828	0.0.9801	MGI:2441403	245886	NM_145633|XM_017322266|XR_881721|XM_006539986|XM_006539985|XM_017322264|NM_178263	NP_839994|XP_006540048|XP_017177753|XP_006540049|NP_663608|XP_017177755	12956	HGNC:25310	84079	NM_032139	XP_006723475,NP_115515,XP_016882838
Gadd45b	90182;18173;34311;84	0.0.8686	0.0.7155	0.0.8710	0.0.9831	0.0.9801	MGI:1077766	17873	NM_008655	NP_032681	74433	HGNC:40966	46116	NM_015675	NP_056490,XP_016882311

Scn8a	62 18 5; 18 18; 48 57; 66 18	0. 8 6 8 3	1. 0 0 9 0	0. 8 7 1 8	0. 9 8 1 6	0. 8 0 1	MGI: 1031 69	203 27 3	XM_006520651| XM_006520656| XM_017316514| XM_017316515| XM_017316516| XM_017316519| NM_001077499| XM_006520655| XM_017316512| XM_017316517| XM_017316513| NM_011323|XM _017316518	NP_001070967| XP_006520714| XP_017172007| XP_017172003| XP_017172001| XP_017172002| XP_017172006| XP_017172005| XP_006520718| NP_035453|XP_ 006520719|XP_ 017172004|XP_ 017172008	79 27	HGNC: 10596	63 34	NM_001330260, NM_175894,NM _014191,NM_00 1177984	NP_055006,XP_ 016875284,XP_ 006719619,XP_ 011536953,XP_ 011536952,NP_ 001317189,NP_ 001171455,XP_ 016875283,XP_ 016875285
Sec16a	11 22 6; 18 19 ; 57 41 ; 58 92	0. 8 6 7 9	0. 6 8 3 7	0. 8 7 2 6	0. 9 8 0 1	0. 9 8 0 1	MGI: 2139 207	227 648	XM_006497910| XM_006497912| XM_011239073| NM_153125|XM _006497913|XM _006497914|XM _006497909|XM _006497911	XP_006497972| XP_006497976| XP_006497974| XP_011237375| XP_006497977| XP_006497973| NP_694765|XP_ 006497975	10 53 3	HGNC: 29006	99 19	NM_001276418, NM_014866	NP_055681,XP_ 011517550,XP_ 011517563,XP_ 011517565,XP_ 011517561,XP_ 011517551,XP_ 011517557,XP_ 016870852,XP_ 011517564,XP_ 011517558,XP_ 011517562,XP_ 011517549,XP_ 005266191,NP_ 001263347,XP_ 011517560,XP_ 011517555,XP_ 011517548,XP_ 011517566,XP_ 016870853,XP_ 011517554,XP_ 011517552,XP_ 011517559,XP_ 011517556,XP_ 011517553
Sgms2	17 61 ; 18 24 ; 42 74 ; 58 63	0. 8 6 6 0	0. 6 3 4 3	0. 8 7 6 5	0. 9 8 2 0	0. 9 8 1 1	MGI: 1192 169 2	744 42	XM_011240249| XM_006502196| XM_006502193| XM_006502194| XM_006502199| NM_028943|XM _006502197|XM _011240250	XP_011238551| XP_006502260| XP_006502256| NP_083219|XP_ 011238552|XP_ 006502262|XP_ 006502257|XP_ 006502259	32 70 5	HGNC: 28395	16 69 29	NM_152621,NM _001136258,NM _001136257	XP_016863328, XP_011530002, NP_001129729, XP_011530000, XP_011530003, XP_016863329, NP_001129730, NP_689834,XP_ 011530004,XP_ 016863330,XP_ 011530001
Flot1	56 5; 18 30 ; 35 3	0. 8 6 3 8	0. 7 9 0 5	0. 8 8 1 1	0. 9 8 4 8	0. 9 8 1 1	MGI: 1100 500 0	142 51	XM_006523657| NM_008027|XM _006523656	XP_006523719| XP_006523720| NP_032053	31 33 37	HGNC: 37557	10 21 1	NM_005803,NM _001318875	NP_001305804, XP_016865646, XP_005248837, XP_006715010, NP_005794,XP_ 016865647

	1;8212														
Syt4	16955;18311;57266;63866	0.863560	0.636019	0.881933	0.983311	0.981183	MGI:1017559	20983	XM_017317852|NM_009308	NP_033334|XP_017173341	7559	HGNC:11512	6860	NM_020783	NP_065834
Pard	9871;18322;22955;60866	0.863192	0.692727	0.882718	0.981178	0.981184	MGI:1018844	19015	NM_011145	NP_035275	45444	HGNC:9235	54677	NM_006238,NM_177435,NM_001171818,NM_001171820,NM_001171819	XP_006715186,NP_001165290,XP_005249250,XP_016866460,XP_011513012,NP_803184,XP_011513011,NP_001165291,XP_011513009,XP_016866464,XP_016866462,XP_006715183,NP_001165289,XP_016866463,NP_006229,XP_016866461
Fzd2	712;18344;39306;65599	0.862449	0.749943	0.884311	0.981181	0.981181	MGI:1888513	57265	NM_020510	NP_065256	20377	HGNC:4040	2535	NM_001466	NP_001457
Plat	421;18411;73322;	0.859880	0.842337	0.889748	0.981393	0.981393	MGI:976100	18791	NM_008872	NP_032898	717	HGNC:90511	5327	NM_000931,NM_033011,NM_001319189,NM_000930	NP_127509,NP_001306118,NP_000921

	73533													
Dab2ip	29447;184847;218917;388811	0.8570576	0.9105	0.894687	0.98713	0.98113	MGI:1916851	691601	XM_011239173|XM_011239174|NM_001290639|XM_011239172|XM_011239175|XM_017319251|NM_001290640|NM_001290641|XM_006498304|XM_006498311|NM_001114125|XM_006498307|NM_001290637|XM_006498305|NM_001114124|XM_130206	NP_001277570|XP_011237475|NP_006498367|XP_006498370|NP_001107597|NP_001107596|XP_011237477|NP_001277568|XP_006498368|XP_017174740|XP_011237476|XP_011237474|NP_001277569|NP_001001602|XP_006498374|NP_001277566	13058	HGNC:17294	1530910	NM_138709,NM_032552	XP_011516573,XP_011516568,XP_011516572,XP_011516569,XP_005251781,XP_016869789,NP_115941,XP_011516567,XP_005251776,XP_005251778,XP_011516566,XP_016869788,XP_016869787,NP_619723
Smpd1	39048;184848;327070;379798	0.8573555	0.8553	0.898561	0.98113	MGI:1983257	20597	NM_011421	NP_035551	457	HGNC:11120	660910	NM_001318087,NM_001007593,NM_000543,NM_001318088	NP_001007594,NP_001305016,NP_000534,XP_011518605,XP_011518606,NP_001305017
Lman2	12653;184849;656969;717474	0.8566969	0.8962961	0.898446	0.98113	MGI:1914140	66890	NM_025828	NP_080104	49624	HGNC:16986	10960	NM_006816	NP_006807
Cdk15	67979;185151;468881;81	0.8756282	0.8989770	0.898440	0.98113	MGI:3583944	271697	XM_006496048|XM_006496050|XM_006496049|XM_011238531|XR_373255|XM_194683	XP_006496112|XP_006496111|NP_001028545|XP_006496113|XP_011236833	64641	HGNC:14434	650611	NM_001261436,NM_001261435,NM_139158	XP_011509952,NP_631897,XP_005246839,XP_011509954,NP_001248364,NP_001248365,XP_011509957,XP_011509959,XP_011509956,XP_011509958,XP_005246838

Igsf3	79144;18577;68822;81225	0.854062	0.642402	0.990868	0.990868	0.98113	MGI:1926158	7908	XM_006502343|XM_006502342|XM_194109|XM_011240287	NP_997088|XP_006502405|XP_011238589|XP_006502406	1182	HGNC:5950	331	NM_001542,NM_001007237	XP_011539617,XP_011539618,XP_006710656,XP_005270850,NP_001533,XP_005270851,NP_001007238
Sped2	18433;18600;67466;70008	0.853045	0.624549	0.990487	0.987232	0.98113	MGI:2150019	11471	XM_006514456|NM_033523|XM_006514457|XM_006514458	XP_006514519|XP_006514520|NP_277058|XP_006514521	24918	HGNC:17722	20073	NM_001128210,NM_181784	XP_005264258,NP_861449,XP_016859065,XP_005264257,NP_001121682,XP_005264259
Lat2	38813;18613;25500;82199	0.852676	0.857705	0.905705	0.985705	0.98113	MGI:1926479	56743	XM_006504452|XM_006504451|XM_006504455|NM_020044|NM_022964|XM_006504456|XM_006504453|XM_006504450	XP_006504518|XP_006504513|XP_006504516|NP_075253|XP_006504514|NP_064428|XP_006504519|XP_006504515	11297	HGNC:12749	74662	NM_032464,NM_014146,NM_032463	XP_011514860,NP_115852,NP_115853,NP_054865
Myof	16863;15154;65	0.851907	0.630773	0.990851	0.990851	0.98113	MGI:1919192	22610	XM_006526995|XM_006526994|NM_001302140|XM_283556	XP_006527058|XP_006527057|NP_001289069|NP_001093104	40882	HGNC:36556	26509	NM_013451,NM_133337	XP_016871559,NP_579899,XP_005269750,XP_005269751,NP_038479,XP_016871558,XP_011537934,XP_016871557

Sos1	1424;1868;7101;8028	0.849017	0.941712	0.987013	0.98133	MGI:983554	2062	NM_009231	NP_033257	411	HGNC:11187	665	NM_005633	XP_011531366, XP_011531364, NP_005624,XP_011531368,XP_005264572
Hmg20a	795;1871;4464;8890	0.849002	0.913571	0.987113	0.98133	MGI:1914117	6687	XM_006511368|NM_025812	XP_006511431|NP_080088	3239	HGNC:50001	1063	NM_001304504, NM_001304505, NM_018200	NP_060670,NP_001291434,XP_011519460,NP_001291433
Klra6	353;1874;2526;62611	0.848000	0.870059	0.987413	0.98133	MGI:1019022	1637	NM_008464|XM_017321417|XM_006505650|XM_006505649	XP_006505713|XP_006505712|NP_032490|XP_017176906	#N/A	#N/A	#N/A	#N/A	#N/A
Zdhhc20	1193;1878;2521;40433	0.846565	0.665091	0.985813	0.98133	MGI:1923215	7596	XM_006519660|XM_006519659|XM_006519661|NM_029492|XM_006519657|XR_001781166|XM_006519658|XR_001781165	XP_006519723|XP_006519720|NP_083768|XP_006519724|XP_006519721|XP_006519722	5710	HGNC:20749	2538	NM_001330059, NM_001286638, NM_153251	XP_011533332, XP_016876014, NP_001273567, XP_006719860, NP_001316988, XP_006719859, XP_006719858, XP_016876015, XP_016876016, NP_694983

Nox1	980;1879;6555;6914	0.8462	0.6918	0.9199	0.9870	0.9813	MGI:2450016	23703 8	XM_006528515|NM_172203	XP_006528578|NP_757340	4849 5	HGNC:7889	27035	NM_001271815,NM_013955,NM_013954,NM_007052	XP_016884896,NP_039249,NP_001258744,NP_008983
Ppp1r21	10522;18800;25043;39311	0.8458	0.6815	0.9208	0.9857	0.9813	MGI:1921075	73825	NM_028658|XM_017317677	NP_082934|XP_017173166	4481 1	HGNC:30595	12928 5	NM_001135629,NM_152994,NM_001193475,NM_001135630	NP_001180404,NP_001129101,XP_016858791,NP_694539,XP_016858790
Krit1	12944;18811;27772;7232	0.8455	0.6545	0.9216	0.9842	0.9813	MGI:1930618	79264	XM_006503617|NR_033173|NM_030675|NM_001170552|XM_006503618	NP_001164023|XP_006503680|NP_109600|XP_006503681	1274 6	HGNC:1573	889	NM_001350684,NM_001350696,NM_001350693,NM_001350673,NM_001350670,NM_001350671,NM_001350687,NM_194454,NM_001350677,NM_004912,NM_001350678,NM_001350680,NM_001350688,NM_001350689,NM_001350676,NM_001350685,NM_001350697,NM_194456,NM_001350691,NM_001350683,NM_001350682,NM_001350672,NM_001350694,NM_001013406,NM_001350690,NM_001350675,NM_001350674,NM_001350692,NM_001350695,NM_001350669,NM_194455,NM_001350679,NM_001350686,NM_001350681	NP_001337612,NP_919436,XP_011514960,NP_001337624,NP_001337610,NP_001337619,XP_011514959,NP_004903,XP_011514957,XP_011514963,NP_001337603,XP_006716226,NP_001337617,XP_006716225,XP_011514956,NP_001337605,XP_011514958,NP_001337622,XP_011514962,XP_005250726,NP_001337618,XP_016868244,NP_001337609,XP_005250717,NP_001337607,XP_005250719,NP_919438,XP_016868247,XP_005250723,NP_001337599,NP_001337621,NP_001337608,NP_001337602,NP_001337614,NP_001337626,XP_016868248,NP_001337623,XP_005250724,NP_001337

														625,XP_016868246,NP_001337611,XP_011514961,XP_016868245,XP_011514953,NP_001013424,NP_001337600,NP_001337615,NP_001337606,XP_005250725,XP_011514955,XP_005250722,XP_006716224,NP_001337601,NP_001337620,NP_001337604,NP_001337613,NP_001337598,NP_919437,NP_001337616
Syt12	18701;18867;37495;73599	0.0843789	0.0618957	0.0925762	0.0984813	0.0981	MGI:1933366	836711	NM_001040088|XM_006508356|NM_001289585|XM_006508359|NM_001040087|XM_006508360|NM_001289586|NM_001040085|NM_001289583|NR_110348|NM_031394|NM_001289584|XM_006508357|XM_006508358|XM_006508355	XP_006508423|NP_001035177|NP_001276512|XP_006508422|NP_001276513|NP_001035174|XP_006508421|XP_006508420|NP_113571|NP_001276514|NP_001276515|XP_006508418|NP_001035176|XP_006508419	131343	HGNC:15585	54843	NM_001162953,NM_206929,NM_001162952,NM_001289608,NM_206928,NM_032379,NM_206927,NM_032943,NM_001289610,NM_001162951,NM_206930,NM_001289609	XP_005274118,NP_001156425,XP_011543412,XP_005274114,NP_001156424,XP_005274123,XP_016873424,XP_011543411,XP_005274120,XP_016873429,XP_011543417,XP_011543410,XP_016873428,NP_996812,XP_016873426,XP_011543408,NP_001276537,XP_016873425,XP_011543414,XP_011543409,XP_005274119,NP_996813,XP_016873427,XP_016873423,NP_001156423,XP_011543418,NP_001276539,XP_016873422,NP_116561,XP_005274124,NP_001276538,XP_011543416,XP_011543407,XP_005274117
Gpr143	12391;18887;30466;43733	0.0843434	0.0658687	0.0926669	0.0984849	0.0981313	MGI:1071933	18241	NM_010951|XM_006528746	NP_035081|XP_006528809	230	HGNC:20145	49335	NM_000273	XP_005274598,NP_000264

Wdr6	13755;18899;56988;75699	0.84271	0.64611	0.992882	0.984383	0.98113	MGI:1930140	8369	NM_031392	NP_113569	11768	HGNC:12758	1180	NM_001320546, NM_018031,NM_001320547	NP_001307475, NP_060501,NP_001307476
Casp9	64;18911;89933;95799	0.842020	0.751414	0.992998	0.983838	0.98113	MGI:1277950	12371	NM_001277932|NM_015733|XM_017319928	NP_056548|XP_017175417|NP_001264861	31024	HGNC:15111	842	NM_001229,NM_032996,NM_001278054	NP_001220,XP_011540575,XP_005246071,NP_127463,NP_001264983
Nrbp2	9781;18999;24111;49833	0.839226	0.688666	0.936636	0.988666	0.98113	MGI:2385017	22364	NM_144847|XM_006520772	XP_006520835|NP_659096	13564	#N/A	#N/A	#N/A	#N/A
Gpsm1	935;19033;34588;51655	0.837878	0.694545	0.939898	0.989898	0.98113	MGI:1915089	6783	NM_153410|NM_001199147|NM_001199146|XM_006498255|XM_017319226|XM_006498253	NP_700459|NP_001186076|XP_017174715|XP_006498316|XP_006498318|NP_001186075	16987	HGNC:17858	26086	NM_001145639, NM_001200003, NM_015597,NM_001145638	NP_001139111, XP_016870087, NP_001139110, XP_016870088, NP_001186932, NP_056412,XP_011516800

Plcb4	174;1904;3599;6810	0.836209407	0.983813	MGI:107464	187918	XM_006498942|XM_006498939|XM_017316414|XM_006498951|NM_013829|XM_006498936|XM_006498937|XM_006498948|XM_006498947|XM_017316368|XM_011239357|XM_006498943|XM_006498950|XM_006498941|XM_006498945|XM_006498944|XM_006498940|XM_011239359|XM_006498946|XM_006498938|XM_011239358	XP_006499010|XP_006499002|XP_006499000|NP_038857|XP_006499004|XP_006499006|XP_017171857|XP_017171903|XP_006498999|XP_011237661|XP_006499003|XP_006499005|XP_006499011|XP_006499001|XP_006499007|XP_006499014|XP_006499013|XP_006499008|XP_011237659|XP_011237660|XP_006499009	847 1	HGNC:9059	533 2	NM_000933,NM_001172646,NM_182797	NP_877949,XP_016883370,XP_006723631,NP_001166117,XP_016883373,XP_016883374,NP_000924,XP_016883371,XP_005260785,XP_016883369,XP_016883372,XP_005260781,XP_016883375,XP_011527556,XP_006723632
Phka1	1768;1905;24600;28445	0.837195916	0.981303	MGI:97576	186779	NM_173021|XM_006527894|NM_008832|XM_017318427|XM_006527895	NP_032858|NP_766609|XP_006527957|XP_006527958|XP_017173916	1981	HGNC:8925	525 5	NM_001172436,NM_002637,NM_001122670	NP_001165907,NP_002628,NP_001116142,XP_006724724
Pkd2	1531;1906;64054;74300	0.836317	0.981356	MGI:1098188	187644	XR_001784633|NM_008861|XM_006534815	XP_006534878|NP_032887	2010 4	HGNC:9009	531 1	NM_000297	XP_011530332,NP_000288,XP_011530330,XP_011530331
Smarcd1	103;1910;38386	0.836789549	0.981303	MGI:1933623	837977	NM_031842	NP_114030	2067 0	HGNC:11106	662	NM_139071,NM_003076	NP_620710,NP_003067,XP_005269164,XP_011536997

Prdx3	7988331;19133;21800;78996	0.0.0.0.0.0	0.8343	0.8756	0.9482	0.9872	0.9813	MGI:880344	117557	NM_007452	NP_031478	4944	HGNC:93544	109351	NM_001302272, NM_006793,NM_014098	NP_006784,NP_001289201
S1pr1	1199;19145;58762;78622	0.0.0.0.0.0	0.8340	0.6581	0.9491	0.9859	0.9813	MGI:1096355	136091	NM_007901	NP_031927	1071	HGNC:31655	19011	NM_001320730, NM_001400	NP_001307659, NP_001391
Hdac3	4311;19155;62062;73122	0.0.0.0.0.0	0.8336	0.8248	0.9500	0.9845	0.9813	MGI:1343091	151183	NM_010411|XR_385976	NP_034541	48250	HGNC:48544	88411	NM_003883	XP_011535999, NP_003874
Tob1	1001;19199;21947;37	0.0.0.0.0.0	0.8323	0.6817	0.9533	0.9857	0.9813	MGI:1349721	220057	NM_009427	NP_033453	3133 4	HGNC:11979	10140	NM_001243885, NM_005749,NM_001243877	NP_005740,NP_001230814,NP_001230806

Cdc25c	617392;19206765;;9656	0.8319	0.6182	0.954	0.9844	0.913	MGI:1883502	1532	XM_011246819|XM_006525551|NM_009860	XP_011245121|XP_006525614|NP_033990	1356	HGNC:1727	995	NM_001287582,NM_001790,NM_022809,NM_001287583,NM_001318098	NP_001781,XP_011542063,XP_011542062,NP_001274512,XP_011542066,XP_011542064,XP_005272202,NP_073720,XP_016865590,XP_006714802,XP_011542065,NP_001274511,NP_001305027,XP_011542061
Ak1	1236;19211;;311102;62911	0.8316	0.6531	0.9550	0.9830	0.913	MGI:1879777	1163	NM_001198791|NM_021515|XM_006497624|NM_001198790|XM_017315020|NM_001198792	XP_006497687|NP_001185719|XP_017170509|NP_001185720|NP_067490|NP_001185721	20135	HGNC:3611	203	NM_001318121,NM_000476,NM_001318122	NP_001305050,XP_016869916,NP_001305051,XP_016869917,NP_000467
Bcl3	1917;19222;58288;60155	0.8312	0.6111	0.9559	0.9817	0.913	MGI:1881400	1205 1	XM_006539487|NM_033601	XP_006539550|NP_291079	8173 8	HGNC:998	602	NM_005178	XP_016882599,NP_005169,XP_011525500,XP_011525499,XP_016882598,XP_011525502
Rhoj	273;19244;60933;;71	0.8305	0.9116	0.9576	0.9813	0.913	MGI:1931551 1	8083 7	NM_023275	NP_075764	5689 4	HGNC:6888	5738 1	NM_020663	NP_065714,XP_006720277,XP_011535295

	91														
Lrrc8c	26;1927;42299;77899	0.89208	0.99603	0.98188	MGI:2140839	106041	XM_017320573|NM_133897|XM_006534685|XM_006534686	NP_598658|XP_006534748|XP_017176062|XP_006534749	1299	HGNC:25075	843	NM_032270	NP_115646,XP_016857993,XP_011540585,XP_011540584,XP_016857992,XP_006711023
Gak	645;19365;20900;92900	0.82656	0.98743	0.98333	MGI:2442153	231580	XM_132229|XM_006534907|XM_017320853|XR_001784677|XR_001784678|XR_389271|NM_001282052|XR_880392|XM_006534905|NM_001282051	NP_001268980|NP_001268981|XP_017176342|XP_006534968|NP_705797|XP_006534970	3846	HGNC:41133	2580	NM_005255,NM_001286833,NM_001318134	XP_011511733,XP_016863480,XP_011511731,XP_011511727,XP_005272325,XP_011511734,XP_011511730,XP_016863483,NP_001305063,NP_005246,XP_005272327,XP_016863481,XP_011511729,XP_016863482,XP_011511728,XP_011511736,XP_016863484,XP_011511732
Irf7	674;19374;24433;69160	0.82610	0.74106	0.98633	MGI:1859212	541123	NM_016850|NM_001252601|XM_006536214|NM_001252600	NP_001239529|NP_001239530|XP_006536277|NP_058546	12862	HGNC:6122	3665	NM_004029,NM_004030,NM_001572,NM_004031	NP_001563,XP_011518368,XP_005252964,NP_004020,XP_005252963,NP_004022,XP_005252966,XP_016873163
Tapbpl	161;19381;48043;92333	0.82581	0.62196	0.98433	MGI:2384853	213233	XR_001785113|NM_145391|XR_001785112	NP_663366	9958	HGNC:30683	5508	NM_018009,NM_001351355	XP_016875034,XP_005253757,NP_001338284,NP_060479,XP_016875035

Sp140	85;1939;4288;9819	0.8254	0.7027	0.9703	0.9833	0.9833	MGI:3702467	434484	XM_017321619|XM_017321615|XR_001785136|XR_001785139|XM_017321620|XM_017321613|XM_017321617|NM_001013817	XP_017177109|XP_017177102|XP_017177106|NP_001013839|XP_017177108|XP_017177104	12839 1	HGNC:17133	1162	NM_001278452,NM_001278453,NM_007237,NM_001278451,NM_001005176	XP_005246312,XP_016858738,XP_016858739,XP_016858730,NP_001265381,XP_005246311,XP_011508817,XP_016858731,XP_005246313,XP_011508821,XP_006712286,XP_016858733,XP_016858735,XP_016858728,NP_001265380,XP_016858729,NP_001005176,XP_005246309,XP_016858740,XP_016858737,NP_001265382,XP_016858741,XP_011508820,XP_005246310,NP_009168,XP_011508822,XP_011508819,XP_016858736,XP_016858734,XP_011508818,XP_016858732,XP_016858742
Ahi1	189;1944;5553;83522	0.8237	0.9824	0.9744	0.9852	0.9852	MGI:8797171	529006	XR_380069|XM_006512798|XR_001779556|NM_001177776|NM_026203|XR_001779555	NP_080479|NP_001171247|XP_006512861	9762	HGNC:21575	5480 6	NM_001350503,NM_001134832,NM_017651,NM_001134831,NM_001350504,NM_001134830	XP_016866471,XP_016866470,XP_016866466,NP_001128304,XP_016866469,NP_001128303,XP_011534213,XP_016866467,NP_060121,XP_016866472,NP_001337433,XP_016866468,XP_016866473,XP_011534212,NP_001337432,NP_001128302
Amotl1	67;1947;7345;75844	0.8227	0.1989	0.9769	0.9855	0.9855	MGI:1922973	757 23	XM_006510669|XM_006510667|NM_001081395|XM_006510668|XM_006510666|XM_006510670	XP_006510732|XP_006510733|NP_001074864|XP_006510729|XP_006510730|XP_006510731	43977	HGNC:17811	1548 10	NM_130847,NM_001301007	XP_006718835,NP_570899,XP_005273855,XP_011540930,XP_005273858,NP_001287936,XP_011540928
Fas	318;1953	0.8207	0.8767	0.9821	0.9886	0.9886	MGI:9554	1411 02	XM_011247141|NM_007987|NM_001146708	NP_001140180|NP_032013|XP_011245443	27	HGNC:119	3555	NM_152876,NM_152873,NM_152874,NM_152875,NM_001320619,NM_152872,NM_152871,NM_000043,NM_152877	XP_011538066,XP_011538068,NP_000034,NP_001307548,NP_690610,XP_011538069,XP_006717882,XP_011

	;45943;49333					84					20				538067,NP_690611
Ghr	145;1962;5246;;87922	0.8176778	0.6268942	0.9898942	0.9942	0.9942	MGI:95708	1460	NM_001048178|NM_001286370|NM_010284	NP_001041643|NP_034414|NP_001273299	134	HGNC:4263	269	NM_001242402,NM_001242401,NM_001242403,NM_000163,NM_001242460,NM_001242399,NM_001242461,NM_001242462,NM_001242404,NM_001242406,NM_001242405,NM_001242400	NP_001229334,NP_000154,NP_001229332,NP_001229335,NP_001229329,NP_001229391,NP_001229330,NP_001229333,NP_001229389,NP_001229328,NP_001229331
Cadm1	623;1968;73191;91356	0.8157493	0.7499571	0.9979965	0.9965	0.9965	MGI:1889272	5472	NM_001025600|XM_006510497|XM_017313488|NM_207676|XM_017313489|NM_001310841|NM_207675|XM_017313487|NM_018770	NP_997559|XP_006510560|XP_017168977|XP_017168978|XP_017168976|NP_061240|NP_001297770|NP_001020771|NP_997558	8641	HGNC:5951	2370 5	NM_014333,NM_001301043,NM_001301044,NM_001098517,NM_001301045	XP_016872946,NP_001287974,XP_016872950,XP_016872949,XP_016872948,NP_001287972,NP_001287973,NP_055148,XP_005271551,NP_001091987,XP_016872947
Cactin	515;1970;27388;95962	0.8151517	0.7827	0.9966	0.9965	0.9965	MGI:1917562	7032	NM_027381	NP_081657	69553	HGNC:29938	5850 9	NM_001080543,NM_021231	XP_011526462,NP_001074012,XP_011526463,NP_067054

Part VI Genes enriched in TCRα KO mice without treatment against the *in vitro* controls

p-value=0 means <3.7400e-05, FDR=0 means <0.000522423296101

Gene Symbol	Rank of per turbations	STARS Score	Average Score	p-value	FDR	q-value	Mouse Marker ID	Mouse NCBI Entrez ID	Mouse NCBI RefSeq Transcript ID	Mouse NCBI RefSeq Protein ID	Homolog eneID	HGNC ID	Human NCBI Entrez ID	Human NCBI RefSeq Transcript ID	Human NCBI RefSeq Protein ID
Nf2	1;2;4;16	11.1611	7.6844	0.000000	0.000000	0.000000	MGI:97307	18016	XM_006514572|NM_010898|XM_017314334|XM_006514569|XM_006514574|XM_011243669|XM_006514573|NM_001252252|NM_001252253|XM_011243670|NM_001252250|XM_006514570|NM_001252251|XM_006514571|XM_017314335	XP_006514633|XP_011241971|NP_001239180|XP_006514635|XP_006514634|NP_001239182|NP_001239179|NP_035028|XP_011241972|XP_017169823|XP_006514636|XP_017169824|XP_006514637|NP_001239181|XP_006514632	2180	HGNC:7773	4771	NM_181826,NM_016418,NM_181829,NM_181835,NM_181828,NM_181830,NM_181825,NM_181831,NM_181833,NM_181834,NM_181827,NM_181832,NM_000268	NP_861971,NP_861967,NP_861966,XP_016884298,NP_861546,NP_057502,NP_861969,NP_000259,NP_861968,NP_861970,XP_016884299
Chp1	5;8;12;18	10.9565	6.8000	0.000000	0.000000	0.000000	MGI:1927185	56398	NM_019769	NP_062743	5235	HGNC:17433	11261	NM_007236	NP_009167,XP_016877368
Pon2	17;21;22;264	7.35499	5.094600	0.000000	0.000000	0.000000	MGI:1066887	33026 0	XM_006505122|NM_183308	XP_006505185|NP_899131	385	HGNC:9205	5445	NM_000305,NM_001018161	XP_016867846,XP_016867847,XP_005250510,NP_001018171,NP_000296
Kirrel	24;29;45;152	7.25024	4.994400	0.000000	0.000000	0.000000	MGI:1891396	170643	XM_017319471|XM_011240029|NM_001170985|XM_006501076|NM_130867|XM_011240028	NP_570937|XP_011238330|XP_006501139|XP_017174960|NP_001164456|XP_011238331	1089	HGNC:15734	55243	NM_018240,NM_001286349	NP_060710,XP_005245362,NP_001273278
Plxn	109;1	6.177	3.710	0.000	0.000	0.000	MGI:1	18444	NM_008881	NP_032907	56426	HGNC:	53611	NM_032242	XP_011511211,XP_011511210,NP_115618

a1	816;185;;282	66	13	00	04	04	07685					9099			
Dgkz	11;51;65;;354	54.9460	0000	0000	0009	MGI:1278339	104118	XM_006498542|XM_006498543|XM_006498537|XM_006498538|XM_017314878|XM_006498540|XM_011239241|XM_017314875|XR_374381|XM_011239244|XM_011239240|NM_138306|XM_006498541|NM_001166597|XM_006498539|XM_017314867|XR_866203	XP_011237543|NP_612179|XP_017170356|NP_001160069|XP_006498600|XP_017170364|XP_006498603|XP_006498604|XP_006498605|XP_006498601|XP_017170367|XP_006498606|XP_011237542|XP_006498602|XP_011237546	378	HGNC:28571	852	NM_201533,NM_001199267,NM_001199268,NM_201532,NM_001105540,NM_003646,NM_001199266	NP_003637,XP_005253239,XP_006718418,XP_011518724,XP_016873945,NP_001186196,XP_011518725,NP_001099010,NP_001186195,NP_001186197,NP_963290,XP_005253238,XP_016873946,XP_006718417,NP_963291,XP_016873944
Tox4	142;210;;273;;335	58774515	3000	0000	0009	MGI:1915389	2687441	NM_023434	NP_075923	8889	HGNC:20161	9878	NM_014828,NM_001303523	NP_055643,NP_001290452	
Ak2	60;67;88;4663	5.5571616	0000	0001	0010	MGI:879788	116637	NM_001033966|NR_138540|NM_016895|XR_376293	NP_001029138|NP_058591	1227	HGNC:362	204	NM_013411,NM_001319140,NM_001319141,NM_001319139,NM_001199199,NM_001625,NM_001319142,NM_001319143	NP_001306069,NP_037543,NP_001186128,NP_001306072,NP_001306071,NP_001306070,NP_001306068,NP_001616	
Cdk12	53;102;;175;;437	5.4157383	0000	0001	0014	MGI:1098802	691131	XM_011249225|NM_001109628|NM_001109626|XM_006534108|XM_011249224|NM_026952|XM_011249226	NP_081228|XP_011247527|XP_006534171|XP_011247528|NP_001103098|XP_011247526|NP_001103096	1286322	HGNC:24224	51755	NM_016507,NM_015083	XP_011523197,XP_011523203,XP_016880238,XP_011523202,XP_016880237,XP_011523196,XP_005257513,XP_005257515,XP_016880240,XP_011523207,XP_016880234,NP_057591,XP_011523201,XP_011523198,XP_016880235,XP_016880242,XP_011523194,XP_011523208,NP_055898,XP_016880233,XP_016	

															880236,XP_011523209,XP_011523205,XP_016880241,XP_016880239,XP_011523204,XP_011523195,XP_011523199,XP_011523200
Rer1	15;46;101;4475	53.382677	0.000017	0.0015	MGI:1915080	6783	NM_026395|XM_006539133|XM_006539131|XM_006539130|XM_006539132|XM_011250328	XP_011248630|XP_006539193|NP_080671|XP_006539196|XP_006539195|XP_006539194	5468	HGNC:30309	1107 9	NM_007033	XP_005244770,XP_016855623,XP_016855620,XP_006710369,XP_011538845,XP_016855621,XP_016855624,XP_016855622,NP_008964,XP_011538844
Elin2	7;99;104;586	5.330472	0.000015	0.0015	MGI:2387215	2433	NM_153592|XM_006509116|XM_006509115|XM_006509114|XM_006509117	XP_006509179|NP_705820|XP_006509180|XP_006509177|XP_006509178	5193	HGNC:13556	1116 0	NM_001003791,NM_001003790,NM_007175	NP_001003791,NP_009106,XP_006716343,NP_001003790,XP_016868489,XP_005273449
Nf1	50;55;130;2004	5.045133	0.000357	0.0035	MGI:973006	1801 5	XM_006532442|XM_006532441|NM_010897|XM_006532436|XM_006532439|XM_006532438|XM_006532437|XM_006532440	XP_006532500|XP_006532504|XP_006532502|XP_006532499|XP_006532505|XP_006532501|NP_035027|XP_006532503	226	HGNC:77665	4763	NM_001128147,NM_000267,NM_001042492	XP_005258041,XP_011523159,NP_000258,XP_006721985,NP_001035957,XP_011523154,XP_016880179,XP_006721988,XP_005258040,XP_016880178,XP_006721989,XP_006721987,NP_001121619
Psph	28;80;1911;572	4.948038	0.000035	0.0035	MGI:977788	1006 78	NM_133900|XM_006504275|XM_006504274|XM_017320574	XP_006504337|XP_017176063|XP_006504338|NP_598661	31245	HGNC:9577	5723	NM_004577	XP_005271832,XP_011513763,XP_005271830,XP_016867957,XP_016867955,NP_004568,XP_006715824,XP_006715823,XP_016867956,XP_005271833,XP_005271831,XP_016867958
G3bp1	36;135;541;;5	4.876614	0.000140	0.0040	MGI:1351465	2704 1	XM_006533444|NM_013716	XP_006533507|NP_038744	38096	HGNC:30292	1046	NM_198395,NM_005754	NP_005745,NP_938405,XP_016864412,XP_006714812,XP_016864411,XP_006714813

Ptpn12	962;5556;6466;6511	4.7.2.3.3	2.6.2.4.7	0.0.0.0.2	0.0.0.5.0	0.0.5.0	MGI:1046773	1924	XM_017320733|NM_011203|XM_017320731|XM_006535642|XM_017320732	XP_006535705|NP_035333|XP_017176221|XP_017176220|XP_017176222	3769	1	HGNC:9645	5782	NM_002835,NM_001131008,NM_001131009	XP_005250575,NP_002826,NP_001124481,XP_006716136,XP_016867963,NP_001124480,XP_011514746
Slc38a2	64;1556;172;774	4.6.8.2.2	3.3.8.4.4	0.0.0.0.2	0.0.0.5.5	0.0.5.5	MGI:1915010	6776	NM_175121|XM_006521300	NP_780330|XP_006521363	2313	2	HGNC:134488	5440	NM_001307936,NM_018976	NP_001294865,NP_061849
Ptpn14	272;330;454;701	4.5.9.4.7	2.8.0.5.6	0.0.0.0.2	0.0.0.6.3	0.0.6.3	MGI:1024677	1925	XM_006497131|XM_006497133|XM_006497129|XM_006497130|NM_008976|XM_006497134	XP_006497197|XP_006497194|XP_006497193|XP_006497192|XP_006497196|NP_033002	3941	H	GNC:96477	5784	NM_005401	NP_005392,XP_016857430
Vapa	193;250;291;708	4.5.7.7.5	3.0.3.7.4	0.0.0.0.3	0.0.0.6.3	0.0.6.3	MGI:1353561	3096	XM_017317500|NM_013933|XM_006524385	XP_017172989|NP_038961|XP_006524448	37824	H	GNC:126488	9218	NM_194434,NM_003574	NP_919415,NP_003565,XP_011524071,XP_016881568
Zfyve27	93;131;206;46	4.4.8.7	2.9.5.7.5	0.0.0.0.5	0.0.1.0.9	0.0.1.0.8	MGI:1916022	3197	NM_177319|NM_001164531	NP_796293|NP_001158003	16939	H	GNC:26559	1181	NM_001174119,NM_001174121,NM_001002262,NM_001174120,NM_001174122,NM_001002261,NM_144588	XP_016871141,XP_005269566,XP_005269567,XP_016871133,XP_005269568,XP_016871144,XP_016871134,XP_016871136,XP_005269561,XP_005269562,XP_016871135,XP_016871140,NP_001002262,XP_011537555,

	36														XP_016871139, XP_011537557, XP_016871137, NP_001167590, XP_005269560, NP_001167593, NP_653189,NP_001167591,XP_016871142,NP_001002261,XP_005269563,XP_011537554,XP_005269559,XP_016871143,XP_011537556,XP_016871138,XP_005269565,NP_001167592
Pard3	105;166;395;772	4.4272	3.0516	0.0005	0.0109	0.0108	MGI:2135608	93742	NM_033620|NM_001309391|XM_006531528|NM_001013580|XM_006531526|XM_006531533|XM_006531530|XM_006531527|XM_006531521|XM_006531532|XM_006531529|NM_001309392|XM_006531524|XM_006531523|NM_001122850|XM_006531531|NM_001013581|XM_006531520	XP_006531590|XP_006531593|XP_006531584|XP_006531589|XP_006531594|NP_001296321|XP_006531592|XP_006531596|NP_001116322|XP_006531586|NP_296369|XP_006531587|XP_006531591|XP_006531595|NP_001013598|NP_001296320|NP_001013599|XP_006531583	10489	HGNC:16051	56288	NM_001184785, NM_001184791, NM_001184789, NM_001184790, NM_001184794, NM_001184793, NM_001184786, NM_001184788, NM_019619,NM_001184792,NM_001184787	XP_011517883, XP_005252593, XP_011517875, XP_011517885, NP_001171721, XP_011517880, NP_001171715, XP_005252592, XP_011517873, NP_001171720, XP_005252587, XP_011517878, XP_005252589, XP_016871919, NP_001171719, XP_011517871, XP_011517886, XP_005252588, NP_062565,XP_005252591,NP_001171714,NP_001171723,NP_001171718,XP_011517872,XP_011517874,NP_001171716,XP_011517881,XP_011517879,XP_005252585,NP_001171717,XP_011517877,NP_001171722
Ambra1	20;178;213;4510	4.4055	3.0750	0.0005	0.0111	0.0108	MGI:2443564	228361	NM_172669|XM_006499252|NM_001080754|XM_006499253	XP_006499316|NP_766257|XP_006499315|NP_001074223	18204	HGNC:25990	55626	NM_001300731, NM_001267782, NM_017749,NM_001267783	XP_006718323, NP_001254712, XP_005253068, XP_016873497, XP_005253071, XP_005253066, NP_001287660, NP_001254711, XP_016873496, XP_006718322, NP_060219
Calm1	75;149;632	4.3915	2.9510	0.0005	0.0108	0.0108	MGI:88251	12313	NM_009790|NM_001313934	NP_001300863|NP_033920	116117	#N/A	#N/A	#N/A	#N/A

	;7888														
Efr3a	74;2544;4333;8811	4.19714	2.9100965	0.0010165	0.0010165	MGI:1923990	7674	XM_006521529|XM_006521530|NM_133766	NP_598527|XP_006521593|XP_006521592	442222	HGNC:28970	23167	NM_015137,NM_001323554,NM_001323555,NM_001323556,NM_001323557,NM_001323553,NM_001323558	NP_001310482,NP_055952,NP_001310487,NP_001310483,NP_001310484,NP_001310485,NP_001310486
Abl1	38;422;1220;;32005	3.9679	2.6549	0.0016	0.0029	0.0029	MGI:878559	1135	NM_001112703|NM_001283045|NM_001283046|NM_009594|XM_006497621|NM_001283047	NP_001269976|NP_033724|NP_001269975|XP_006497684|NP_001269974|NP_001106174	3783	HGNC:76	25	NM_005157,NM_007313	NP_005148,NP_009297
Cdk2	134;438;452;;10466	3.8995	2.6464	0.0018	0.0325	0.0325	MGI:1047722	1256	XM_011243321|NM_016756|NM_183417|XM_006513162	NP_058036|NP_904326|XP_011241623|XP_006513225	74409	HGNC:17711	1017	NM_001798,NM_052827,NM_001290230	XP_011536034,NP_001789,NP_439892,NP_001277159
Ppp6c	202;277;;348;;18622	3.7732	2.5335	0.0025	0.0422	0.0421	MGI:1915107	6785	XM_006498256|XM_017319227|NM_024209	XP_006498319|XP_017174716|NP_077171	68273	HGNC:93223	5537	NM_001123369,NM_002721,NM_001123355	XP_011517149,NP_002712,NP_001116827,NP_001116841
Seph s1	3;;161;;668;	3.7500	3.1035	0.0026	0.0432	0.0421	MGI:1923579	1079	XM_006497309|XM_017314904|NM_175400	XP_006497372|XP_017170393|NP_780609	56558	HGNC:19685	2292	NM_001195602,NM_012247,NM_001195604	XP_016871431,XP_016871432,XP_016871433,NP_001182531,NP_001182533,NP_036379,XP_016871434

	114080						80													
Ric8	94;30555;74299	3.7464	2.4825	0.0026	0.0421	0.0421	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Ckb	13;73;48279;97211	3.4905	2.8853	0.0047	0.0726	0.0726	MGI:88407	127091	NM_021273	NP_067248	37530	HGNC:19911	1152	NM_001823	XP_016876440, NP_001814,XP_016876441					
Bub1b	216;231;479;;143111	3.3617	2.5769	0.0062	0.0928	0.0899	MGI:1333889	12236	NM_009773|XM_006498622	NP_033903|XP_006498685	933	HGNC:11449	7001	NM_001211	NP_001202					
Ern1	33;369;;88;;142727	3.3599	2.4003	0.0062	0.0899	0.0899	MGI:1930134	78943	NM_023913	NP_076402	55580	HGNC:34449	2081	NM_152461,NM_001433	NP_001424,XP_016879837,XP_016879836					
Glmn	325;340;;4	3.3353	2.1004	0.0067	0.0938	0.0931	MGI:2141411	17082	XM_011249410|XR_001784631|XM_006534800|NM_001161738|NM_001161739|XM_017320694|NM_133248	NP_001155210|XP_017176183|XP_006534863|NP_573511|NP_001155211|XP_011247712	14239	HGNC:143	11146	NM_001319683, NM_007070,NM_053274	XP_006710372, XP_016855629, NP_444504,XP_005270458,XP_016855630,XP_016855633,XP_016855626,NP_001306612,XP_016855628,XP_					

	89;3247					80					73				016855631,XP_016855632,XP_016855627,XP_011538848
Rab12	721;1139;1164;1456	3.3250	1.8500	0.0069	0.0931	0.0931	MGI:3819428 4	1938	XM_006523888|XM_006523889|XR_876464|NM_024448	XP_006523951|XP_006523952|NP_077768	10387 9	HGNC:31332	2014 75	NM_001025300	XP_006722363,NP_001020471
Amotl2	6493;7473;1033;1506	3.2663	1.9636	0.0079	0.1039	0.1005	MGI:1929286	5632	XM_006511771|XM_006511772|XM_006511773|NM_019764	XP_006511834|XP_006511836|XP_006511835|NP_062738	9420 0	HGNC:17812	5142 1	NM_016201,NM_001278683,NM_001278685	XP_006713717,XP_011511183,NP_001265612,NP_057285,XP_016862071,XP_016862069,NP_001265614,XP_016862070
Dusp6	3647;3777;5188;5899	3.2616	2.0779	0.0080	0.1025	0.1005	MGI:1914853	6760 3	NM_026268	NP_080544	55621	HGNC:30722	1848	NM_022652,NM_001946	NP_001937,NP_073143
Ppp6r1	337;1239;1311;15	3.2560	1.8493	0.0081	0.1005	0.1005	MGI:2442163	2438 19	NM_172894|XM_011250556	XP_011248858|NP_766482	86982	HGNC:29195	2287 0	NM_014931	NP_055746

Spta n1	15221;801;1210;15855	3.1.1.1	1.9.7.4	0.0.0.8	0.1.9.8	0.1.8.6	MGI:983866	207401	XM_006497812|XM_006497813|NM_001177668|XM_006497815|NM_001309460|XM_006497809|XM_006497814|NM_001177667|XM_006497810|XM_006497816	XP_006497873|XP_006497875|NP_001171139|NP_001296389|XP_006497872|NP_001171138|XP_006497879|XP_006497878|XP_006497877|XP_006497876	2353	HGNC:11273	6709	NM_001130438,NM_001195532,NM_003127	XP_006717314,NP_001182461,XP_006717315,XP_006717317,XP_016870550,XP_006717316,XP_006717308,XP_006717311,XP_016870548,XP_006717313,XP_016870549,XP_006717312,XP_006717310,XP_006717309,NP_003118,NP_001123910
Rvbl2	48;123;568;9488	3.1.4.3.8	2.6.3.4.3	0.0.1.0.6	0.1.2.5.3	0.1.2.5.3	MGI:1342299	201741	XM_006540722|XM_006540723|NM_011304	NP_035434|XP_006540785|XP_006540786	4856	HGNC:10475	1085 6	NM_001321191,NM_006666,NM_001321190	NP_001308119,NP_006657,NP_001308120,XP_011524632
Marcks	173;642;997;;16644	3.0.9.3.0	2.0.8.8.9	0.0.1.1.9	0.1.3.6.7	0.1.3.6.2	MGI:969907	171181	NM_008538	NP_032564	0	#N/A	#N/A	#N/A	#N/A
Pdcd10	83;117;;11164;47400	3.0.8.4.6	2.0.8.6.4	0.0.1.2.3	0.1.3.7.3	0.1.3.6.2	MGI:1928396	564261	NM_019745	NP_062719	10505	HGNC:87611	1123 5	NM_007217,NM_145860,NM_145859	XP_005247144,XP_005247145,XP_011510671,NP_009148,XP_006713548,NP_665859,XP_016861134,XP_005247143,NP_665858,XP_016861133,XP_011510670
Itgav	167;308;;6	3.0.6.7.6	2.1.7.3.5	0.0.1.2.8	0.1.3.9.1	0.1.3.6.2	MGI:966088	164101	XM_006498807|NM_008402	NP_032428|XP_006498870	20510	HGNC:61500	3685	NM_002210,NM_001145000,NM_001144999	NP_001138472,NP_001138471,NP_002201

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	4														
	8														
	9														
Pcbp2	1	3	2	0	0	0	MGI:	1	XM_011245498|	XP_011243805|	7	H	5	NM_001128912,	NP_001092090,
	1	.	.	.	.	.		8	XM_017316500|	XP_011243806|	4	G	0	NM_001128914,	NP_114366,NP_
	3	0	3	0	1	1		5	XM_006520583|	XP_011243811|	5	N	9	NM_001128911,	001122386,NP_
	;	6	1	1	3	3		2	XM_006520586|	XP_011243801|	3	C	4	NM_031989,NM	001122383,NP_
	4	5	3	2	6	6		1	XM_006520582|	XP_006520647|	6	:		_001128913,NM	005007,NP_001
	1	5	9	8	2	2		1	XM_011245509|	XP_017171988|		8		_005016,NM_00	122384,NP_001
	4							0	XM_011245496|	XP_011243803|		6		1098620	122385
	;							8	NM_001103166|	XP_017171987|		4			
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									XM_011245499|	001167544|NP_					
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									XM_011245495|	011243804|XP_					
									NM_001174073|	011243798|XP_					
									NM_011042|XM	011243802|XP_					
									_011245505	011243797					
Magi1	1	2	2	0	0	0	MGI:	1	XM_006505588|	XP_006505644|	3	H	9	NM_004742,NM	XP_006713473,
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	4	7	0	6	0	7		4	XM_006505594|	XP_006505652|		9			XP_016862996,
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	9							2	_001083321|XM	XP_006505661|					XP_016862991,
	6							2	_006505596|NM	XP_017176889|					XP_006713470,
	;								_001286784|XM	XP_006505646|					XP_016862989,
	2								_006505600|XM	XP_011239525|					XP_011532542,
	3								_017321400|XM	XP_006505655|					XP_016862990,
	9								_006505584|XM	NP_001025021|					NP_001028229,
	7								_006505595|XM	XP_017176888|					XP_006713474,
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									6505581|NM_00	XP_006505648|					XP_016862988,
									1286785|XM_00	NP_001273717|					XP_005265625,
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									1029850|XM_00	XP_006505650|					XP_005265623,
									6505597|XM_00	NP_034497|XP_					XP_005265628,
									6505601|NM_00	006505653|XP_					XP_005265620,
									1286788|NM_00	006505656|XP_					XP_006713472,
									1286786|XM_00	006505649|NP_					XP_006713475,
									6505589|XM_00	001273715|NP_					NP_056335,NP_
									6505580|XR_37	001076790|XP_					004733
									7424|XM_00650	006505664					
									5585|XM_01124						
									1223						
Ppp5	1	2	1	0	0	0	MGI	5	XM_006524619|	XP_006524679|	2	H	5	NM_002714	NP_002705,XP_
	1	.	.	.	.	.		2	XM_006524616|	XP_006524681|	0	G	5		011513024,XP_
	5	9	9	0	1	1		0	XM_006524618|	XP_006524680|		N			

1r10	;147;1852;6590	0674	1836	8072	:1289273	40	XM_006524617|NM_001163818	NP_001157290|XP_006524682	33	C:9284	14			006715193,XP_016866484
Wnk1	203;647;916;1854	2.9052506	2.0018404	0.1825	0.1807	MGI:2442092	23241	XM_017321555|XM_017321548|XM_017321550|XM_017321556|XM_017321554|XM_017321545|XM_017321543|NM_001199084|XM_017321552|XM_017321547|XM_011241320|NM_001185021|XM_017321549|XM_017321542|XM_017321544|NM_001199083|XM_017321553|NM_001185020|XM_017321546|XM_017321557|NM_198703	NP_941992|XP_017177031|XP_017177038|XP_017177039|XP_017177043|XP_017177046|NP_001171950|XP_017177044|XP_017177037|XP_011239622|XP_017177034|XP_017177036|XP_017177032|XP_017177045|NP_001186012|XP_017177033|XP_017177035|NP_001186013|NP_001171949|XP_017177041|XP_017177042	14253	HGNC:14540	651225	NM_213655,NM_014823,NM_018979,NM_001184985	XP_011519309,XP_011519303,XP_016875328,XP_011519308,XP_006719066,XP_016875325,XP_011519304,NP_055638,NP_998820,XP_011519301,XP_016875323,XP_011519306,XP_016875327,XP_011519307,XP_016875324,XP_016875326,NP_061852,NP_001171914,XP_011519299,XP_011519310,XP_011519305,XP_011519302,XP_011519300,XP_011519311
Ptpn11	417;418;1812;1859	2.9005	1.9857	0.0186	0.1807	MGI:9951147	19247	NM_011202|NM_001109992	NP_035332|NP_001103462	2122	HGNC:9644	5781	NM_080601,NM_002834,NM_001330437	XP_006719589,NP_002825,NP_001317366,XP_016875211,XP_011536915,NP_542168
Ank2	956;1105;1225;1879	2.8817019	1.8701945	0.1823	0.1823	MGI:8802567	10967	XM_011239987|XM_011239989|XM_006500899|XM_017319431|XM_006500900|XR_001783641|XM_017319436|XM_017319434|XM_006500888|XM_017319428|NM_001034168|XM_006500881|XM_017319429|XM_006500906|XM_017319437|XM_006500894|XM_006500904|XM_011239986|XM_017319433|XM_017319432|	XP_006500953|XP_011238290|XP_011238294|XP_011238292|XP_006500963|XP_011238293|XP_017174917|XP_017174925|XP_006500965|XP_017174927|XP_017174916|XP_011238288|XP_006500950|XP_006500948|XP_017174922|XP_006500954|XP_011238296|XP_006500958|XP_017174920|XP_006500967|	0	#N/A	#N/A	#N/A	#N/A

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Ube2d3	403;12332;17222;18977	2.8654	1.6521	0.0202	0.1881	0.1823	MGI:1913555	6610 5	XM_006501874|XM_006501873|XM_006501875|NM_025356	XP_006501937|XP_006501936|XP_006501938|NP_079632	12391 4	HGNC:12476	7323	NM_181889,NM_181890,NM_181886,NM_181887,NM_181892,NM_181888,NM_181893,NM_181891,NM_001300795,NM_003340	XP_016864073,NP_003331,NP_871621,NP_871620,NP_871619,NP_001287724,NP_871618,NP_871615,NP_871622,NP_871616,NP_871617
Ahr	671;896;917;;19044	2.8590	1.8603	0.0205	0.1871	0.1823	MGI:1050443	1162 2	NM_001314027|NM_013464	NP_038492|NP_001300956	1224	HGNC:348	196	NM_001621	NP_001612
Acly	19;6012;132	2.8580	2.1904	0.0205	0.1836	0.1823	MGI:1032511	1041 12	NM_001199296|NM_134037	NP_001186225|NP_598798	854	HGNC:115	47	NM_001303274,NM_001096,NM_198830,NM_001303275	XP_005257452,NP_001087,XP_016880177,NP_001290204,NP_942127,NP_001290203

	2;1905													
Top1	68;2977;7148;;2048	2.8527	2.2377	0.0208	0.1823	0.1823	MGI:98788	2169	NM_009408	NP_033434	2467	HGNC:11986	7150	NM_003286	NP_003277
Cd2ap	267;7705;18105;;19502	2.8175	1.7558	0.0225	0.1935	0.1932	MGI:1330281	1248	XM_011246264|XM_011246263|NM_009847|XM_011246265|XR_001782031	XP_011244567|NP_033977|XP_011244565|XP_011244566	7663	HGNC:14258	2360 7	NM_012120	NP_036252,XP_005249033,XP_011512751,XP_016866130
Sped1	382;6133;7382;;42582	2.8107	1.7879	0.0229	0.1932	0.1932	MGI:2150016	1147 15	NM_001277256|NM_033524	NP_277059|NP_001264185	24919	HGNC:20249	1617 422	NM_152594	XP_011519591,NP_689807,XP_005254259
Atp5o	402;6788;7566;;91622	2.7802	1.7442	0.0242	0.2005	0.2005	MGI:1063411	2808 0	NM_138597	NP_613063	1283	HGNC:8500	5359	NM_001697	NP_001688
Nbn	143;1	2.7 2	1.9 8	0.0 2	0.2 1	0.2 1	MGI:1	2735 4	XM_006537971|NM_013752|XM_006537970	XP_006538033|XP_006538034|NP_038780	1858	HGNC:	4683	NM_001024688,NM_002485	NP_001019859,NP_002476,XP_016868951,XP_016868950,XP_016868949,XP_

	79;7674;9736	08466594	35162							7652					011515347,XP_011515348
Akap8	247;3518;7983;9916	2.7118	1.9653	0.0269	0.2145	0.2144	MGI:1928488	563	XM_006524663|XM_006524665|XR_001782093|NM_019774|XM_006524664|NR_131219|XM_006524666|NR_131218	XP_006524726|XP_006524727|XP_006524728|NP_062748|XP_006524729	428	HGNC:378	10	NM_005858	NP_005849,XP_011525926,XP_016881630
Stil	132;1833;1013;2406	2.7020	2.1342	0.0273	0.2144	0.2144	MGI:107477	204	XM_017320088|NM_001304555|NM_001304559|XM_006502907|XM_006502905|XM_006502906|NM_001304551|NM_009185|NM_001304553	NP_033211|XP_017175577|XP_006502970|NP_001291482|XP_006502968|NP_001291488|XP_006502969|NP_001291484|NP_001291480	283	HGNC:10879	641	NM_001282937,NM_001048166,NM_003035,NM_001282939,NM_001282938,NM_001282936	XP_016857616,XP_016857615,XP_016857613,XP_011540293,XP_011540300,XP_011540296,XP_006710897,XP_011540294,NP_001269867,XP_011540303,NP_001041631,NP_001269866,XP_011540298,XP_016857614,NP_001269865,XP_016857612,NP_003026,NP_001269868
Smek2	456;5922;8355;9098	2.6545	1.7231	0.0229	0.2281	0.2281	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Wbp4	133;396;8702;	2.6027	1.9779	0.0323	0.2449	0.2449	MGI:1095688	2238	NM_018765	NP_061235	3828	HGNC:12739	1193	NM_007187	NP_009118,XP_016875869,XP_005266302

Mphosph10	915;4758;4580;9188;9638	2.5350	2.0639	0.0364	0.2711	0.2680	MGI:1915223	6793	NM_026483	NP_080759	13741	HGNC:7213	1019	NM_005791	NP_005782
Smg8	3216;6366;9211;43799	2.5309	1.7071	0.0366	0.2668	0.2680	MGI:1921383	7413	NM_024262	NP_077224	32393	HGNC:25551	5518	NM_018149	NP_060619
Sptbn1	4623;8733;9433;28977	2.5012	1.5616	0.0386	0.2785	0.2785	MGI:983888	2074	XM_006514601|XR_001779935|NM_009260|XM_006514599|NM_175836|XM_006514600	NP_033286|XP_006514664|XP_006514663|XP_006514662|NP_787030	2354	HGNC:11275	671	NM_003128,NM_178313	NP_003119,XP_006712150,XP_016860269,XP_016860268,NP_842565,XP_005264575,XP_005264574,XP_016860270
Slc22a5	6882;9522;9588;53111	2.4481	1.4906	0.0401	0.2844	0.2796	MGI:1329012	2052	XM_017314397|XM_006532651|XR_001779933|XM_006532650|XR_001779934|XM_006532652|NM_011396	XP_006532713|NP_035526|XP_006532715|XP_017169886|XP_006532714	68295	HGNC:10969	654	NM_001308122,NM_003060	NP_001295051,XP_016865267,NP_003051,XP_011541892
Snx4	2228;2392;1	2.4752	1.9123	0.0405	0.2830	0.2796	MGI:191964	6915	NM_080557	NP_542124	36143	HGNC:111	8723	NM_003794	XP_016862903,NP_003785

	2003;9872					00					75			
Mpzl1	7203;8255;9655;8718	2.4722	1.5198	0.0407	0.2796	0.2796	MGI:1915731	6848 1	NM_001347128|XM_129565|XM_006496974|NM_001083897	XP_006497037|NP_001001880|NP_001334057|NP_001077366	293 9	HGNC:7226	9019	NM_003953,NM_001146191,NM_024569	NP_001139663,NP_078845,NP_003944
Golph3	1693;2611;2400;3739	2.4007	1.7938	0.0468	0.3172	0.3164	MGI:1913879	6662 9	NM_025673|XM_006520143	XP_006520206|NP_079949	5694 2	HGNC:15452	6408 3	NM_022130	XP_016865176,NP_071413,XP_016865175
Nme2	611;2633;3996;4915	2.3942	2.0046	0.0474	0.3164	0.3164	MGI:97356	1810 3	NM_008705|NM_001077529	NP_001070997|NP_032731	1338 79	HGNC:7850	4831	NM_002512,NM_001018137,NM_001018139,NM_001018138,NM_001198682	NP_001018147,NP_002503,NP_001185611,NP_001018148,NP_001018149
Safb	460;986;1061;21488	2.3534	1.4865	0.0511	0.3359	0.3334	MGI:2146974	2249 03	NM_001163300|XM_006524160|XM_017317445	XP_006524223|NP_001156772|XP_017172934	2229	HGNC:10520	6294	NM_001320572,NM_001201340,NM_001320571,NM_001201338,NM_002967,NM_001201339	NP_001307501,XP_016882605,XP_016882607,NP_001188268,XP_016882604,NP_002958,NP_001307500,NP_001188269,NP_001188267,XP_016882606,XP_016882603

Cep250	89;895;1067;4028	2.3463	1.4339	0.0516	0.3345	0.3334	MGI:1080844	163	XM_358344|NM_001129999|NM_177217|NM_001130000|XM_006498797|XM_006498802|XM_017315701|XM_006498799|XM_006498798|XM_006498796	XP_006498862|NP_001123472|XP_006498865|NP_001123471|XP_006498861|XP_006498859|XP_017171190|NP_796191|NP_032409|XP_006498860	3826	HGNC:1859	1190	NM_001035518, NM_001318219, NM_007186	XP_005260321, XP_016883106, XP_006723756, XP_016883108, XP_005260319, XP_016883107, NP_009117,XP_006723754,XP_011526819,XP_006723755,XP_005260320,XP_011526821,NP_001305148,XP_006723753,XP_006723757,XP_011526820
Atxn10	91;2804;5477;7025	2.3413	1.8934	0.0522	0.3334	0.3334	MGI:1859293	54138	NM_016843	NP_058539	40858	HGNC:10549	25814	NM_013236,NM_001167621	NP_037368,NP_001161093
Smg7	241;283;2638;4207	2.3323	1.6874	0.0531	0.3342	0.3342	MGI:2682317	2265	XM_017319981|XM_006529451|XM_006529452|XM_017319979|XM_017319978|NM_001160256|XM_006529450|NM_001005507|NM_001160257	XP_006529513|XP_006529514|NP_001005507|XP_017175468|NP_001153728|NP_001153729|XP_017175467|XP_017175470|XP_006529515	32235	HGNC:16792	9887	NM_001174061, NM_001350222, NM_001350219, NM_001350221, NM_001331007, NM_201568,NM_014837,NM_201569,NM_173156,NM_001350220	NP_001337150, NP_001167532, XP_016858455, XP_016858457, XP_005245710, XP_011508510, XP_016858456, XP_011508509, XP_011508512, NP_963863,XP_005245709,XP_006711741,NP_001337149,NP_963862,XP_006711739,NP_775179,XP_016858460,XP_016858459,NP_001317936,NP_001337151,NP_001337148,XP_005245706,XP_011508508,XP_011508511,XP_005245705,XP_011508507,XP_016858458
Clk2	187;293;2020;65	2.3031	1.7243	0.0560	0.3475	0.3475	MGI:1098669	1274 8	NM_001163432|NM_007712	NP_031738|NP_001156904	3303	HGNC:2069	1196	NM_003993,NM_001291,NM_001294339,NM_001294338	XP_016855732, NP_001281268, XP_011507446, XP_011507445, XP_011507449, XP_016855731, NP_001281267, XP_016855733, XP_016855730, XP_005244935, NP_003984

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Stag2	51;963;1125;5309	21.2805823	10.4058585	00.3585	MGI:109583	208443	XM_011250983|NM_021465|NM_001290713|XM_011250987|XM_011250984|XM_017318446|NM_001077712|XM_011250986|XM_011250985|XM_011250988|XM_011250989	NP_001277642|XP_011249286|XP_011249289|XP_011249290|XP_017173935|XP_011249291|NP_067440|XP_011249285|NP_001071180|XP_011249287|XP_011249288	382062	HGNC:11355	1073 5	NM_001282418,NM_006603,NM_001042749,NM_001042750,NM_001042751	XP_005262416,NP_001269347,XP_016884724,NP_001036215,XP_016884721,XP_005262415,XP_006724791,XP_005262418,XP_016884722,NP_006594,NP_001036216,XP_011529555,XP_005262414,XP_016884723,XP_006724790,XP_005262417,NP_001036214
Otub1	56;7;1092;1136;9662	21.2681	00.4067	00.3619	MGI:2147616	1072 60	NM_134150	NP_598911	9772	#N/A	#N/A	#N/A	#N/A
Chd8	37;10;1158;67511	21.2442	10.4063931	00.3745	MGI:191502 22	677712	XM_017316171|XM_006519476|XM_017316172|XM_011245165|XM_017316170|NM_201637	XP_017171660|XP_006519539|XP_017171659|XP_017171661|XP_011243467|NP_963999	72405	HGNC:20153	5760 80	NM_020920,NM_001170629	NP_001164100,NP_065971
Ptpn9	25;9663;1163;59188	21.2385389	10.4056367	00.3745	MGI:192837 6	562 94	NM_019651	NP_062625	21211	HGNC:9661	5780	NM_002833	NP_002824
Aip	148;;;	21.2273	10.4067	00.3737	MGI:	116	XM_006531641|NM_001276284|XM_006531642|NM_016666	NP_001263213|XP_006531704|NP_057875|XP_006531705	29559	HGNC	904 9	NM_001302959,NM_001302960,NM_003977	NP_001289888,NP_003968,NP_001289889

	320;5850;9187	904	541	577	777	1096222	32				:3588				
Gsk3b	1883;7199;1178;5986	2.2.2.29	1.6.4.30	0.0.6.59	0.3.7.77	0.3.7.77	MGI:1861437	563	XM_006522426|XM_006522425|NM_019827|NM_001347232	NP_001334161|XP_006522489|NP_062801|XP_006522488	5562	HGNC:4617	293	NM_002093,NM_001146156	NP_001139628,XP_006713673,XP_006713674,NP_002084
Rab23	3223;3288;8376;8469	2.2.0.83	1.5.6.80	0.0.3.47	0.3.7.82	MGI:998333	193	35	NM_008999|XM_006495802|NM_001159729|XM_006495801	XP_006495864|NP_001153201|NP_033025|XP_006495865	7503	HGNC:14263	517	15	NM_016277,NM_001278668,NM_001278667,NM_183227,NM_001278666	NP_057361,NP_001265597,NP_899050,NP_001265595,NP_001265596
Ewsr1	59;3297;7851;7871	2.2.0.57	1.9.7.75	0.0.6.84	0.3.8.21	0.3.7.82	MGI:996060	140	30	NM_001283063|NM_007968|XM_017314255|NM_001283062|XM_006514508|NM_001283061|XM_006514512|XM_006514509|XR_001779874|XM_006514510|XM_006514511	NP_031994|NP_001269991|XP_006514573|NP_001269990|XP_006514574|XP_017169744|NP_001269992|XP_006514575|XP_006514572|XP_006514571	1346	#N/A	#N/A	#N/A	#N/A
Arhgap21	704;8611;1196	2.2.0.40	1.4.2.17	0.0.6.85	0.3.7.82	0.3.7.82	MGI:1918685	714	35	XM_006497541|XM_006497544|XM_011238986|XM_006497538|XM_017319263|XR_373945|XM_006497545|XR_373946|XM_017319262|XM_006497540|NM_001128084|XM_006497539|XM_006	XP_006497608|NP_001121556|NP_001074833|XP_006497606|XP_006497601|XP_006497605|XP_006497607|XP_006497602|XP_017174751|XP_006497604|XP_006497603|	1082	HGNC:2372	575	84	NM_020824	XP_016871948,XP_016871950,XP_011517906,XP_011517907,XP_005252599,NP_065875,XP_016871949,XP_011517904,XP_005252601,XP_011517909,XP_011517905,XP_011517908

	;37878							497542|NM_001081364|XM_006497543	XP_017174752|XP_011237288					
Casc5	459;10800;12120;42006	2.1875	1.4082	0.07009	0.38633	0.38447	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Wwc2	230;339;2330;47122	2.18066	1.16210	0.07188	0.38666	0.38447	MGI:1261872	52357	NM_133791	NP_598552	32618	HGNC:24148	80014	NM_024949	NP_079225,XP_011530571
Ctdspl2	367;8766;12232;;28288	2.17863	1.14866	0.07223	0.38447	0.38447	MGI:1964055	32950	XM_283758|XR_001783138|XM_017319053|XM_011239627|XM_006499776|NM_001290992|NM_001290991|XR_374482	XP_006499839|NP_001277920|NP_001277921|NP_997615|XP_017174542|XP_011237929	32311	HGNC:26936	51496	NM_016396	XP_006720628,NP_057480,XP_011519967,XP_016877795,XP_016877796,XP_005254498
Acox1	327;3466;21444;;64244	2.16345	1.54266	0.07455	0.39166	0.39166	MGI:1330812	11430	XM_006532002|NM_001271898|NM_015729	XP_006532065|NP_001258827|NP_056544	38299	HGNC:119	51	NM_004035,NM_007292,NM_001185039	XP_011523170,NP_001171968,NP_009223,NP_004026,XP_011523171

Akr1b3	27;350;3373;8985	2.1539	2.0592	0.0761	0.0.3958	0.0.3946	MGI:1353494	116 777	NM_009658	NP_033788	13374 3	HGNC:3811	231	NM_001628,NM_001346142	NP_001333071, NP_001619,XP_005250291
Tipr1	794;8722;12511;29911	2.1482	1.3867	0.0770	0.0.3958	0.0.3946	MGI:1915087	226 591	XM_011238792|NM_145513|XM_006496779|XM_006496780	XP_006496843|XP_006496842|NP_663488|XP_011237094	7140	HGNC:30231	261 726	NM_001031800, NM_152902	NP_001026970, NP_690866
Ppp1cb	607;1051;12599;31266	2.1403	1.3658	0.0783	0.0.3978	0.0.3946	MGI:1048871	1904 6	NM_172707|XM_006503780	NP_766295|XP_006503843	37659	HGNC:92822	550 0	NM_206877,NM_206876,NM_002709	NP_002700,NP_996759
Axin1	342;605;12607;61133	2.1393	1.5819	0.0786	0.0.3946	0.0.3946	MGI:1096327	1200 5	NM_001159598|XM_006523515|XM_128515|XM_006523516	XP_006523579|NP_033863|XP_006523578|NP_001153070	2614	HGNC:9033	831 2	NM_003502,NM_181050	XP_016879234, XP_016879232, XP_016879236, XP_016879233, XP_011520985, XP_016879235, XP_011520986, XP_011520988, NP_003493,NP_851393,XP_016879237,XP_011520984
Pcif1	498;6311	2.1325	1.5210	0.0797	0.0.3960	0.0.3960	MGI:24486	2288 6	XM_011239494|NM_146129|XM_011239495	NP_666241|XP_011237797|XP_011237796	1134	HGNC:16	639 35	NM_022104	XP_011527282, XP_011527283, XP_016883503, XP_016883502, NP_071387

	;12667;28022					3858				2000					
Ppp1ca	6932;7533;13055;41755	21.095928	1.042285	0.085917	0.042117	0.042117	MGI:1030116	1045	NM_031868	NP_114074	10526	HGNC:92811	549	NM_002708,NM_206873,NM_001008709	NP_002699,NP_996756,NP_001008709
Gpx4	129;3844;30188;44733	21.076857	1.068771	0.089130	0.043086	0.043086	MGI:1047667	6252 49	NM_008162|NM_001037741|NR_110342	NP_032188|NP_001032830	13438	HGNC:45556	2879	NM_002085,NM_001039848,NM_001039847	NP_001034936,NP_001034937,NP_002076
Flcn	761;1094;13266;70388	21.076288	1.308892	0.042887	0.042886	MGI:2442184	2161805	NR_073164|XR_879567|NM_146018|NM_001271356|XM_011248905|NM_001271357	NP_001258285|NP_666130|XP_011247207|NP_001258286	14583	HGNC:27310	20116 3	NM_144606,NM_144997	XP_011522021,NP_659434,XP_016879795,XP_011522016,XP_011522023,XP_016879798,XP_016879794,XP_016879797,XP_016879793,XP_016879796,XP_011522018,NP_653207,XP_011522020
Srebf1	227;3877;25563;	21.070083	1.056803	0.090161	0.042886	0.042886	MGI:1076066	2077 87	XM_006532714|XM_006532715|XM_006532717|NM_001313979|XM_006532716|XM_011248845|NM_011480	XP_006532779|XP_006532778|NP_035610|XP_006532777|XP_011247147|XP_006532780|NP_001300908	3079	HGNC:11289	6720	NM_001321096,NM_001005291,NM_004176	NP_001308025,XP_016880460,NP_004167,NP_001005291,XP_005256829,XP_016880459

	25711														
Dlst	62;39141;48377;74177	2.0.6.148	1.8.3.48	0.0.9.19	0.0.4.322	0.0.4.322	MGI:1926170	78920	XM_006516392|NM_030225|XM_017315247	NP_084501|XP_006516455|XP_017170736	1456	HGNC:29111	1743	NM_001933,NM_001244883	NP_001231812,NP_001924
Acvr2b	52;58;13;53;60	2.0.4.95	1.5.0.88	0.0.4.411	0.0.4.381	0.0.4.381	MGI:879122	1148 1	NM_001313757|XM_006511926|XR_379846|NM_007397	NP_031423|NP_001300686|XP_006511989	863	HGNC:174	93	NM_001106	NP_001097,XP_016863004,XP_016863005,XP_016863003,XP_005265640
Stk24	138;399;16;87;51;79	2.0.4.45	1.6.9.89	0.0.9.51	0.0.4.382	0.0.4.382	MGI:2385007	22325 5	XM_011245043|NM_145465|XM_006518918|XM_017315988	XP_006518981|XP_017171477|XP_011243345|NP_663440	2079 3	HGNC:11403	8428	NM_003576,NM_001032296,NM_001286649	XP_005254136,XP_016876283,XP_016876284,NP_003567,NP_001027467,NP_001273578
Msn	810;968;13;73;67;54	2.0.3.332	1.3.1.90	0.0.9.72	0.0.4.434	0.0.4.434	MGI:971667	1769 8	NM_010833	NP_034963	1833	HGNC:7373	4478	NM_002444	NP_002435,XP_005262326,XP_016885035,XP_016885034,XP_011529261
Pkd2	878;	2.0.1	1.2.1	0.0.1	0.0.4	0.0.4	MGI:	187	XR_001784633|NM_008861|XM_006534815	XP_006534878|NP_032887	201	HGNC	531 1	NM_000297	XP_011530332,NP_000288,XP_011530330,XP_011530331

	995;1397;;3380	18	64	19	00	98	1099818	64			04	:9009			
Plec	352;1325;1402;;2763	2.0743	1.0307	1.0299	0.4598	0.4598	MGI:1277961	1810	NM_201394|NM_001163542|NM_201392|NM_201390|NM_001164203|NM_201386|NM_001163540|NM_011117|NM_201387|NM_201388|NM_201393|NM_001163549|NM_201389|NM_201385|NM_201391	NP_958796|NP_958793|NP_958794|NP_958788|NP_001157021|NP_001157014|NP_958790|NP_035247|NP_958789|NP_958792|NP_958787|NP_001157675|NP_958791|NP_001157012|NP_958795	384	HGNC:9069	539	NM_201378,NM_201382,NM_000445,NM_201380,NM_201383,NM_201379,NM_201381,NM_201384	XP_006716653,XP_005251040,NP_958784,XP_005251036,XP_011515432,XP_005251037,XP_006716651,XP_006716652,NP_958780,XP_005251039,NP_958783,NP_000436,XP_005251033,XP_005251038,XP_011515434,XP_005251041,XP_011515433,XP_005251035,NP_958781,NP_958786,NP_958785,NP_958782
Ppap2c	243;7505;;14163;9183	1.9952	1.5212	1.0555	0.4668	0.4663	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Mapk14	1268;1360;;14322;2154	1.9814	1.1740	1.0861	0.4761	0.4663	MGI:1346865	2641	NM_001168513|NM_011951|NM_001168514|XM_017317480|NM_001168508	NP_001161986|NP_036081|XP_017172969|NP_001161985|NP_001161980	3177	HGNC:68776	1432	NM_139012,NM_139014,NM_139013,NM_001315	XP_011512612,XP_006715061,NP_001306,XP_016865793,XP_016865789,NP_620581,XP_016865792,XP_016865791,NP_620582,NP_620583,XP_016865790,XP_016865788
Rnf125	243;435	1.9805	1.5090	1.0930	0.4730	0.4663	MGI:19	67664	NM_026301|XM_006526188	XP_006526251|NP_080577	0	#N/A	#N/A	#N/A	#N/A

	1;20800;20900					14914									
Epm2a	7;13118;14341;79811	1.19797	1.5303	0.1091	0.4689	0.4663	MGI:1341085	138533	NM_010146	NP_034276	38087	HGNC:34133	795 7	NM_005670,NM_001018041	NP_005661,XP_006715627,XP_016866789,XP_016866791,NP_001018051,XP_016866790,XP_011534418,XP_011534415
Atp1b3	118;43232;17951;94388	1.19786	1.6736	0.1095	0.4663	0.4663	MGI:1077888	119331	XM_011242658|XM_017313113|NM_007502|XM_017313112	NP_031528|XP_017168602|XP_011240960|XP_017168601	37510	HGNC:8066	483	NM_001679	NP_001670
Mcph1	41;16582;14422;72688	1.19728	1.4803	0.1006	0.4665	0.4665	MGI:2443308	243291	XM_017312789|XM_011242056|NM_173189|XM_017312792|XM_011242059|XM_017312791|XM_006508786|XM_006508790|XM_017312788|XM_011242057|XM_017312790|XM_011242058	XP_011240358|XP_011240359|XP_017168279|NP_775281|XP_011240360|XP_006508853|XP_011240361|XP_017168278|XP_006508849|XP_017168277|XP_017168281|XP_017168280	32586	HGNC:6954	796 48	NM_024596,NM_001322042,NM_001322043,NM_001172574,NM_001322045,NM_001172575	NP_001308971,NP_078872,XP_016869320,XP_016869319,NP_001166045,XP_011533060,XP_016869323,XP_016869318,XP_011533059,XP_011533061,XP_016869321,NP_001308974,XP_011533062,NP_001308972,XP_016869322,XP_011533058,NP_001166046,XP_011533057
Bckdk	29283;14577	1.19601	1.4143	0.1136	0.4744	0.4744	MGI:1276121	12041	NM_009739	NP_033869	37642	HGNC:16902	1029 5	NM_005881,NM_001122957,NM_001271926	NP_005872,XP_016878348,NP_001258855,NP_001116429

;340202															
Rassf3	119595;124271;149784	11.9484	1.1902	0.1165	0.4824	0.4763	MGI:2178972	192678	XM_006513379|NM_138956|XM_011243388	NP_620406|XP_006513442|XP_011241690	16365	HGNC:14271	28349	NM_178169	NP_835463,XP_016874671,XP_011536497,XP_006719408
Sgol1	82;45012;151212;197575	1.9448	1.7830	0.1174	0.4814	0.4763	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Capn1	610;962;148012;470606	1.9409	1.3215	0.1184	0.4812	0.4763	MGI:882633	12333	NM_007600|NM_001110504	NP_031626|NP_001103974	3800	HGNC:1476	823	NM_001198868, NM_005186,NM_001198869	XP_006718761, NP_005177,NP_001185798,XP_011543594,NP_001185797
H2-Ab1	394;455;;231212;;392121	1.9356	1.3928	0.1198	0.4826	0.4763	MGI:1030700	14961	NM_207105	NP_996988	1603	HGNC:49444	3119	NM_001243961, NM_001243962, NM_002123	NP_001230891, NP_002114,NP_001230890

Plk4	6;8448;14911;6087	1.9318	1.9941	0.1209	0.4825	0.4763	MGI:1017833	208	NM_011495|XM_006500770|NR_045576|NM_173169|XM_011239968|XM_006500768	NP_775261|NP_035625|XP_006500833|XP_011238270|XP_006500831	7962	HGNC:11397	107 33	NM_001190801, NM_014264,NM_001190799	XP_016863151, XP_016863152, NP_055079,XP_005262758,NP_001177728,NP_001177730
Wdr6	11466;13166;14933;47033	1.9302	1.1735	0.1214	0.4802	0.4763	MGI:1930140	836 69	NM_031392	NP_113569	11768 2	HGNC:12758	111 80	NM_001320546, NM_018031,NM_001320547	NP_001307475, NP_060501,NP_001307476
Il15	10102;10788;14944;21299	1.9294	1.2354	0.1215	0.4763	0.4763	MGI:1030144	168	XM_006530709|XM_011248314|NM_008357|XM_006530711|XM_006530705|XM_006530708|XM_006530712|XM_006530713|XM_006530714|XM_006530707|NM_001254747|XM_011248312|XM_006530706|XM_006530715|XM_011248313|XM_006530710	XP_006530770|XP_011246615|XP_006530769|XP_006530768|XP_006530771|XP_011246616|XP_006530773|NP_032383|XP_011246614|XP_006530776|XP_006530774|XP_006530775|XP_006530778|NP_001241676|XP_006530777|XP_006530772	487	HGNC:5977	360 0	NM_000585,NM_172175,NM_172174	NP_000576,NP_751915
Dusp4	28964;31414;97299	1.9144	1.4448	0.1244	0.4826	0.4826	MGI:2442191	319 520	NM_176933	NP_795907	1065	HGNC:30700	184 6	NM_001394,NM_057158	NP_476499,NP_001385,XP_011542730
Cdk9	1904;4	1.902	1.512	0.1249	0.4848	0.4848	MGI:1	107 9	XM_011239001|NM_130860	XP_011237303|NP_570930	5566	HGNC:	102 5	NM_001261	XP_016869673, NP_001252

	73;2516;9747	36	12	83	44	90	3283688	51				1780			
Psme1	66;4800;20399;911188	1.891565	1.7365	0.1316	0.5028	0.4890	MGI:1096367	186	NM_011189	NP_035319	460	HGNC:9568	570	NM_001281529, NM_001281528, NM_006263,NM_176783	NP_001268458, NP_788955,NP_006254,NP_001268457
Exo1	819;12499;15444;67748	1.8891	1.2053	0.1324	0.5015	0.4890	MGI:1349427	2690 9	XM_006496863| XM_006496862| NM_012012	XP_006496926| XP_006496925| NP_036142	3135 2	HGNC:35111	916	NM_006027,NM_003686,NM_001319224,NM_130398	XP_011542625, XP_016858282, NP_006018,XP_011542624,XP_011542627,XP_006711903,NP_001306153,NP_569082,XP_011542623,NP_003677,XP_011542626
Ccnl2	120;8555;15455;26222	1.8883	1.5476	0.1325	0.4978	0.4890	MGI:1927119	5603 6	XM_011250305| XR_001784166| XM_017320328| XR_881434|NM_207678|XM_017320327|XR_001784165|XM_011250304	XP_017175817| XP_017175816| XP_011248607| NP_997561|XP_011248606	6947 7	HGNC:20570	816 69	NM_001320155, NM_001350497, NM_001039577, NM_001350498, NM_001350500, NM_030937,NM_001144867,NM_001350499,NM_001320153,NM_001144868	XP_016857909, NP_001337426, NP_112199,XP_011540518,XP_016857910,XP_011540521,NP_001337429,NP_001337427,XP_016857911,NP_001307084,NP_001307082,XP_016857912,NP_001337428,NP_001034666,XP_011540523
Gna11	116;4833;16600	1.8863	1.6768	0.1332	0.4962	0.4890	MGI:957662	1467 2	NM_010301	NP_034431	2047 4	HGNC:43779	2767	NM_002067	NP_002058

	;4275														
Srpk1	341;1167;1551;4076	1.8835	1.3249	0.1339	0.4946	0.4890	MGI:1106908	20815	XM_006523958|NM_016795|XM_011246337|XR_385308	XP_006524021|NP_058075|XP_011244639	110962	HGNC:11305	6732	NM_003137	NP_003128
Rnf41	1154;1347;1552;4231	1.8828	1.1514	0.1342	0.4917	0.4890	MGI:1914838	67588	NR_104289|NM_001164237|NR_104290|NR_104288|NM_026259	NP_001157709|NP_080535	4226	HGNC:18401	10193	NM_194359,NM_005785,NM_001242826,NM_194358	NP_919339,XP_005268618,XP_011536036,NP_005776,NP_919340,XP_011536037,NP_001229755
Ppp2r1a	86;486;7324;7460	1.8812	1.6752	0.1346	0.4890	0.4890	MGI:1926334	51792	NM_016891	NP_058587	68559	HGNC:9302	5518	NM_014225	XP_016882418, NP_055040
Ptpn23	180;1174;1577;22	1.8632	1.4019	0.1398	0.5040	0.5040	MGI:2144837	104831	NM_001081043|XM_011242931	NP_001074512|XP_011241233	135706	HGNC:14406	25930	NM_001304482, NM_015466	NP_001291411, NP_056281,XP_005265088

Elp3	7720;5000;3967;5987	1.8568	1.4681	0.1415	0.5062	0.5062	MGI:1921445	741	NR_045599|NM_001253812|NM_028811	NP_083087|NP_001240741	7105	HGNC:20696	551	NM_001284222, NM_001284225, NM_001284224, NM_001284226, NM_001284220, NM_018091	NP_001271154, NP_060561,XP_016869093,NP_001271149,NP_001271153,NP_001271151,XP_006716417,NP_001271155
Elavl1	1920;5133;2000;2152	1.8368	1.4857	0.1483	0.5263	0.5203	MGI:1100851	1558	XM_006508698|NM_010485	NP_034615|XP_006508761	2036	HGNC:33112	194	NM_001419	NP_001410
Fam132a	186;5144;4600;9031	1.8352	1.4914	0.1489	0.5240	0.5203	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Kidins220	434;864;1614;3049	1.8350	1.8355	0.1490	0.5200	0.5203	MGI:1924730	774810	XM_006515256|XM_006515249|XM_006515251|XM_017315243|XM_006515253|NM_001081378|XM_006515259|XM_006515257|XM_006515252|XM_006515254|XM_006515258|XM_006515255|XM_006515250|XM_017315244|XM_006515260	XP_006515320|NP_001074847|XP_006515318|XP_006515316|XP_006515317|XP_006515323|XP_006515315|XP_017170733|XP_006515312|XP_006515322|XP_006515319|XP_006515313|XP_006515314|XP_017170732|XP_006515321	14254	HGNC:29508	57498	NM_020738,NM_001348732,NM_001348736,NM_001348739,NM_001348734,NM_001348745,NM_001348729,NM_001348742,NM_001348738,NM_001348741,NM_001348731,NM_001348740,NM_001348743,NM_001348735	NP_001335663, NP_001335667, NP_001335660, NP_001335665, NP_001335668, NP_001335672, NP_001335658, NP_001335669, NP_001335674, NP_001335664, NP_001335661, NP_001335670, NP_065789,NP_001335671
Lmbr	582;1	1.82	1.117	0.1153	0.5353	0.5353	MGI:1	68421	NM_026719|XM_017322292|NM_001310483	XP_017177781|NP_001297412|NP_080995	10156	HGNC:88	557	NM_018368	NP_060838,XP_011534243

d1	501;1632;;8463	15	64	33	13	13	9156711				2303038				
Stxbp5	63;10364;;16444;;23889	1.8125431265	1.2415648	0.1535780	0.5350	0.5350	MGI:1926058	7880	XR_380096|NM_001081344|XM_006512928|XM_006512927|XM_011243236|XR_001779636|XM_006512926|XR_380094|XR_380092|XM_011243237|XM_011243238	XP_006512990|XP_006512989|XP_011241538|XP_011241540|XP_006512991|XP_011241539|NP_001074813	1640 2	HGNC:19665	13495 7	NM_001127715, NM_139244	XP_016865757, XP_006715402, XP_016865756, NP_001121187, NP_640337,XP_011533755
Dcakd	519;529;;66601;;71116	1.8171796	1.2715668	0.1535350	0.5350	0.5350	MGI:1915337	6808 7	XM_006534038|NM_026551	XP_006534101|NP_080827	5652	HGNC:26238	7987 7	NM_001321326, NM_024819,NM_001288655,NM_001128631,NM_001288654	NP_001308255, XP_005257745, NP_001275583, XP_016880594, XP_016880591, XP_016880593, XP_016880592, NP_079095,XP_016880595,NP_001122103,NP_001275584,XP_011523564
Enpp4	1483;1606;;16702;;76822	1.7930 5	1.0601 2	0.1632 7	0.5527	0.5527	MGI:2682634	2247 94	XM_006524130|XM_006524134|NM_199016|XM_017317438|XM_006524133	XP_006524193|XP_006524197|XP_006524196|XP_017172927|NP_950181	2826 4	HGNC:33559	2287 5	NM_014936	NP_055751
Zeb2	97;547;;1	1.7842	1.7613	0.1664	0.5599	0.5599	MGI:1344	2411 36	NM_015753|XM_017318063|NM_001289521|XM_017318065|XM_017318061|XM_006498042|XM_011239102|XM_006498043	XP_006498106|XP_006498105|NP_056568|NP_001276450|XP_017173550|XP_017173552|XP_017173554|XP_011237404	8868	HGNC:148	9839	NM_001171653, NM_014795	NP_001165124, XP_016860904, XP_016860903, XP_011510534, NP_055610,XP_006712945,XP_006712944

	789;6698					407					81					
Smek1	286;550;4016;9821	1.7797	1.3770	0.1684	0.5618	0.5610	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Pfkfb1	288;553;6274;81177	1.7753	1.3734	0.1701	0.5633	0.5610	MGI:1078166	1639	NM_008824|XM_011247791|XM_006528755|XM_006528756|XM_006528757	XP_006528820|XP_011246093|XP_006528819|XP_006528818|NP_032850	1056554	HGNC:8872	5207	NM_001271805,NM_002625,NM_001271804	NP_002616,XP_016885066,NP_001258733,XP_016885065,NP_001258734,XP_016885067
Haus7	217;554;3428;39333	1.7738	1.4293	0.1707	0.5610	0.5610	MGI:1920988	7378	NM_028633|NM_207104	NP_996987|NP_082909	125613	HGNC:32979	5559	NM_017518,NM_207106,NM_207107	NP_059988
Daxx	253;598;17082;22	1.7662	1.5003	0.1736	0.5664	0.5662	MGI:1197015	1163	XM_006523582|NM_001199733|XM_006523580|XM_006523581|NM_007829|XR_385278	XP_006523644|NP_031855|XP_006523643|NP_001186662|XP_006523645	1033	HGNC:26881	161	NM_001350,NM_001254717,NM_001141969,NM_001141970	NP_001241646,NP_001135442,NP_001341,XP_005248917,NP_001135441

Xbp1	20 47 6; 108 7; 1713 ; 6671	1 . 7 6 2 7	1 . 2 6 0 4	0 . 1 7 4 8	0 . 5 6 6 2	0 . 5 6 6 2	MGI: 989 70	224 33	NM_001271730|NM_013842	NP_038870|NP_001258659	372 2	HGNC: 1280 1	74 94	NM_001079539,NM_005080	NP_001073007,NP_005071
Bag6	47 0; 569 ; 619 7; 7147	1 . 7 5 2 0	1 . 2 6 7 9	0 . 1 7 9 1	0 . 5 7 5 8	0 . 5 7 3 9	MGI: 1914 39	224 727	XM_006524111|XM_006524115|NM_057171|XM_017317434|XM_006524110|XM_006524116|XM_006524113|XM_006524114|XM_006524117|XM_006524118|XM_006524109|XM_006524119|NM_001252468|XM_017317432|XM_006524112|NM_001252469|XM_017317433|XM_017317431|XM_017317436|XM_017317435	XP_006524178|XP_006524177|XP_006524182|XP_006524175|XP_017172924|XP_017172920|XP_006524174|XP_017172925|NP_001239398|XP_006524176|NP_001239397|XP_006524179|NP_476512|XP_006524173|XP_017172922|XP_006524181|XP_017172921|XP_017172923|XP_006524172|XP_006524180	340 9	HGNC: 1391 9	79 17	NM_001199697,NM_001098534,NM_001199698,NM_080702,NM_080703,NM_004639	XP_016866778,XP_016866784,XP_016866765,XP_016866785,XP_016866779,XP_016866777,NP_542433,XP_016866787,XP_016866786,NP_004630,XP_016866764,XP_016866781,XP_016866768,XP_016866770,NP_001186627,NP_001186626,XP_016866771,XP_016866773,XP_016866774,XP_016866775,XP_016866766,XP_016866780,XP_016866767,XP_016866783,NP_542434,XP_016866782,XP_016866776,XP_016866769,XP_016866772,NP_001092004,XP_011513194
Cdk13	78 5; 113 4; 1731 ; 5060	1 . 7 5 0 0	1 . 1 8 7 6	0 . 1 7 9 7	0 . 5 7 3 9	0 . 5 7 3 9	MGI: 1916 812	695 62	NM_027118|XM_011244344|XM_006516767|XM_127221|XM_017315593|XM_006516766	NP_001074527|NP_081394|XP_017171082|XP_006516829|XP_006516830|XP_011242646	135 707	HGNC: 1733	86 21	NM_031267,NM_003718	NP_112557,XP_011513899,XP_016868240,NP_003709,XP_016868239
Clcf1	449 ; 114	1 . 7 4 0 2	1 . 1 9 1 0	0 . 1 8 3 7	0 . 5 8 2 4	0 . 5 7 9 9	MGI: 19	567 08	NM_001310038|NM_001310039|NM_019952	NP_064336|NP_001296967|NP_001296968	829 9	HGNC: 1	23 52 9	NM_001166212,NM_013246	NP_037378,NP_001159684

	38;17455;82588					3008					7412				
Mipp1	365;5788;29811;91778	1.7392	1.3092	0.1842	0.5799	0.579	MGI:133615	1730	NM_010799	NP_034929	37980	HGNC:71102	9562	NM_001178117, NM_001178118, NM_004897	NP_004888,XP_006718141,XP_016872455,XP_011538681,NP_001171588,XP_016872454,NP_001171589
Ddx23	1515;5911;32667;89333	1.7211	1.4773	0.1919	0.5957	0.5867	MGI:1921601	74351	XM_006521493| NM_001080981	XP_006521556| NP_001074450	3542	HGNC:17347	9416	NM_004818	NP_004809
Coro1c	5705;8556;17733;41300	1.7210	1.2865	0.1920	0.5920	0.5867	MGI:1345964	2379	NM_011779	NP_035909	56537	HGNC:2254	2360	NM_001105237, NM_014325,NM_001276471	XP_016874611, NP_055140,XP_016874612,XP_016874610,NP_001098707,XP_011536427,NP_001263400
Slc7a11	559;5933;57488	1.7184	1.2196	0.1929	0.5907	0.5867	MGI:1347355	2657	XM_017319590| XM_006500777| XM_006500776| XM_006500778| NM_011990	XP_006500841| NP_036120|XP_006500839|XP_006500840|XP_017175079	22684	HGNC:110599	2365	NM_014331	NP_055146,XP_011530104

	;6877														
Rab28	4575;12441;17786;63588	1.1.1.1.1.1	7121.1.1.1	0.2.9.5.6.6	0.1.3.8.7.7	0.7.3.6.6.7	MGI:1917285	102	NM_001310590|XM_017320585|XM_006503651|XM_132086|NR_132325|NM_001310592|NM_001310589	NP_081571|XP_017176074|NP_001297521|XP_006503714|NP_001297519|NP_001297518	3135	HGNC:9768	9364	NM_001159601, NM_001017979, NM_004249	NP_001017979, XP_011512213, NP_001153073, XP_016864339, XP_011512214, XP_005248275, NP_004240
Nedd4l	6355;11481;17813;37088	1.1.1.1.1.1	7119.1.1.1	0.1.9.5.6.6	0.5.4.8.6.7	0.8.2.7.7.7	MGI:1933754	8381 4	XM_006526380|XM_011247044|XM_017318015|XR_001782406|XM_006526373|XM_006526371|XM_006526377|XM_011247047|XM_006526370|XM_006526382|XM_006526374|NM_001114386|XM_006526378|NM_031881|XM_006526376|XM_006526379|XM_017318016	XP_006526437|XP_006526445|XP_006526439|NP_001107858|XP_017173505|XP_006526434|XP_011245349|XP_006526441|XP_006526443|XP_006526440|XP_006526433|XP_011245346|XP_006526442|NP_114087|XP_017173504|XP_006526436	8698 6	HGNC:7728	2337	NM_001144970, NM_001144969, NM_001144971, NM_001144964, NM_001144967, NM_001144968, NM_001144965, NM_001144966, NM_015277,NM_001243960	NP_001138437, NP_001138441, XP_006722487, XP_016881168, XP_016881167, NP_001138443, XP_016881166, NP_001230889, XP_005266715, XP_016881165, XP_011524189, XP_006722488, XP_006722491, XP_006722489, NP_001138439, NP_001138442, NP_001138440, XP_016881170, NP_001138438, XP_016881169, XP_006722484, XP_006722493, XP_005266720, NP_056092,NP_001138436,XP_005266717
Unc119	4722;5993;39488;72444	1.1.1.1.1.1	7121.1.1.1	0.4.9.5.8.9	0.6.6.8.9.1	0.2.4.9.1.1	MGI:1328357	2242 48	NM_001313986|NM_001313985|NM_011676|NM_001313987|NM_001313988	NP_001300917|NP_001300914|NP_001300915|NP_001300916|NP_035806	3778	HGNC:12565	9094	NM_054035,NM_005148,NM_001330166	NP_473376,XP_016880778,XP_011523761,NP_001317095,NP_005139
Tollip	1201;1424	1.1.1.1.1.1	6822.1.1.1	0.6.7.0.2.3	0.0.6.9.3.0	0.2.6.1.3.0	MGI:1891 8	5447 3	NM_001347562|XM_006508631|NM_023764	NP_076253|NP_001334491|XP_006508694	1075	HGNC:164	5447 2	NM_001318514, NM_001318515, NM_019009,NM_001318516,NM_001318512	NP_001305444, NP_001305443, XP_016873420, NP_001305445, NP_061882,NP_001305441

	;18311;58488					08					76				
Smarca5	211;623;93700;94533	1.6783	1.3873	0.2109	0.6242	0.6242	MGI:1935129	9762	NM_053124	NP_444354	55764	HGNC:11101	8467	NM_003601	NP_003592
Cap1	89;6266;5940;70855	1.6744	1.5646	0.2127	0.6255	0.6255	MGI:882622	1231	NM_007598|NM_001301067|XM_006502697|XM_006502695	XP_006502758|NP_001287996|NP_031624|XP_006502760	74572	HGNC:20040	1047	NM_001350477, NM_001350485, NM_001330502, NM_001350481, NM_001350480, NM_001105530, NM_001350475, NM_001350478, NM_001350484, NM_006367,NM_001350476,NM_001350479,NM_001350483,NM_001350482	XP_011538813, XP_016855558, NP_001337410, NP_001337407, NP_001337408, NP_001337412, NP_006358,XP_016855560,NP_001337406,XP_011538815,XP_011538814,NP_001099000,NP_001317431,XP_005270425,XP_016855562,NP_001337413,NP_001337404,XP_011538817,NP_001337409,XP_016855561,NP_001337405,XP_011538812,NP_001337414,XP_016855556,XP_016855557,NP_001337411,XP_016855559,XP_011538811,XP_011538816
Abl2	515;1538;1868;45333	1.6581	1.1308	0.2005	0.6442	0.6442	MGI:87860	1152	XM_006496621|XM_011238738|NM_001136104|XM_011238737|XM_006496622|XM_006496617|NM_009595|XM_006496614|XM_006496616|XM_006496615|XM_006496613|XM_006496620	XP_006496676|XP_011237039|XP_006496677|XP_006496684|XP_006496679|XP_006496678|XP_011237040|XP_006496680|NP_001129576|XP_006496685|NP_033725|XP_006496683	52778	HGNC:77	27	NM_001168239, NM_001168237, NM_001168236, NM_001136000, NM_001136001, NM_007314,NM_001168238,NM_005158	NP_001161709, NP_001161711, NP_001161710, NP_009298,NP_005149,XP_005245145,NP_001161708,NP_001129472,NP_001129473,XP_016856524

Gpr143	14;15725;18755;57225	1.6536	1.0219	0.2229	0.6470	0.6470	MGI:1071933	18241	NM_010951|XM_006528746	NP_035081|XP_006528809	230	HGNC:20145	4935	NM_000273	XP_005274598, NP_000264
Ppp6r3	83;18661;18873;19933	1.64600	1.1350	0.2268	0.6540	0.6540	MGI:1921807	52036	XM_017318249|NM_001164159|XR_001782603|XR_001782602|XM_017318248|XM_006531792|XM_006531796|XM_017318250|XM_011248641|NM_029456|XR_001782601|XM_011248642|NM_028999|XM_006531794|XR_001782600|XM_006531797|XM_011248640|XM_006531789	NP_001157631|XP_011246944|XP_011246942|XP_017173739|XP_017173737|XP_006531855|NP_083275|XP_006531860|XP_006531859|XP_017173738|XP_011246943|NP_083732|XP_006531857|XP_006531852	11591 1	HGNC:1173	5529 1	NM_001352357, NM_001352349, NM_001352376, NM_001352375, NM_001164161, NM_001352365, NM_001352366, NM_001164160, NM_001352367, NM_001352364, NM_001352363, NM_001164163, NM_001164162, NM_001352380, NM_001352359, NM_001352360, NM_001352373, NM_001352379, NM_001164164, NM_001352351, NM_001352370, NM_018312,NM_001352361,NM_001352352,NM_001352377,NM_001352355,NM_001352368,NM_001352358,NM_001352348,NM_001352378,NM_001352353,NM_001352374,NM_001352371,NM_001352354,NM_001352362,NM_001352350,NM_001352372,NM_001352347,NM_001352356,NM_001352369	XP_011543438, XP_016873461, NP_001339299, XP_006718675, XP_016873454, XP_006718686, XP_011543437, NP_001339295, XP_016873465, NP_001339305, XP_016873459, NP_001157635, XP_016873455, NP_001339287, XP_016873453, XP_006718684, XP_016873466, NP_001339280, XP_016873457, XP_006718671, XP_016873460, XP_006718677, NP_001339308, NP_001339291, NP_001339292, NP_001339285, NP_001339309, NP_001339294, NP_001339300, XP_016873469, NP_001339298, NP_001339302, XP_016873470, XP_016873456, XP_016873472, XP_006718676, NP_001339276, XP_011543442, NP_001339301, XP_016873458, NP_001157634, XP_016873451, XP_016873462, NP_001339283, NP_001339297, NP_001339293, XP_011543445, XP_016873452, NP_001339296, NP_001157633, NP_001339289, NP_001339277, NP_001339282, XP_016873471, XP_011543443, XP_016873464,

														XP_011543439, XP_011543441, NP_001339290, XP_006718685, NP_001157636, XP_011543447, NP_001339284, NP_001339288, XP_006718687, NP_060782,NP_001339307,NP_001339278,NP_001339279,NP_001339304,NP_001339306,XP_016873463,NP_001157632,XP_016873468,XP_006718690,NP_001339303,XP_016873467,XP_011543440,NP_001339286,XP_011543444,XP_006718681,XP_016873473,NP_001339281
Aldh18a1	35;654;2398;;2613	1.1.1.63908	1.2.1.62628	0.2.3.02303	0.6.5.09858	0.6.5.09858	MGI:1888908	5645 54	NM_153554|NM_019698	NP_062672|NP_705782	2142	HGNC:9722	583 2	NM_001323418, NM_001323412, NM_001323415, NM_001323413, NM_001323419, NM_001323414, NM_001323417, NM_001017423, NM_002860,NM_001323416	NP_001310345, NP_001310347, NP_001310344, NP_001017423, NP_001310348, NP_002851,NP_001310346,NP_001310342,NP_001310341,NP_001310343
Rab8a	380;680;3777;;8616	1.1.2.60765	1.2.3.72357	0.2.4.07372	0.7.0.03837	0.6.9.06833	MGI:969960	17274	NM_023126	NP_075615	10934	HGNC:7007	4218	NM_005370	NP_005361,XP_011526322
Atf4	63;681;;2664;;83	1.1.6.06649	1.6.0.36039	0.2.4.07478	0.7.0.07099	0.6.9.06833	MGI:880966	11911 1	NM_001287180|NM_009716	NP_033846|NP_001274109	1266	HGNC:7866	468	NM_001675,NM_182810	NP_001666,XP_016884296,NP_877962

	96														
Stk19	154;682;4912;7245	1.6053	1.4153	0.2484	0.6983	0.6983	MGI:1860085	5402	NM_019442	NP_062315	1049	HGNC:11398	859	NM_032454,NM_004197	NP_004188,NP_115830
Cebpg	404;1823;1957;9204	1.6023	1.1023	0.2500	0.6986	0.6986	MGI:1049822	1261	NM_009884	NP_034014	1368	HGNC:18377	1054	NM_001252296, NM_001806	NP_001797,NP_001239225
Stk11ip	205;705;4556;6466	1.5786	1.3433	0.2596	0.7209	0.7207	MGI:1918978	7178	NM_027886	NP_082162	1406	HGNC:19184	11479	NM_052902	XP_011508828, XP_011508831, XP_011508830, NP_443134,XP_011508829
Slc4a1ap	421;710;4576;9363	1.5730	1.1989	0.2612	0.7207	0.7207	MGI:1196608	2053 4	NM_009206|XM_006503811|NM_001347328|XM_006503809|XM_017320752|XM_006503808|XM_006503810	XP_006503873|XP_006503872|XP_017176241|NP_033232|NP_001334257|XP_006503871|XP_006503874	7543	HGNC:13813	2295 0	NM_018158	NP_060628
Fgfr	278;	1.5676	1.2727	0.2626	0.7227	0.7227	MGI:	752	NM_201230|XM_006523356|XM_006523355|XM	XP_006523419|XP_006523420|NP_001183975|	5116	HGNC	1111	NM_194429,NM_001278690,NM_007045	NP_919410,NP_008976,NP_001265619

1op	718:2522:2939	40	48	36	29	29	1922546	96	_006523357|NM_001197046	XP_006523418|NP_957682		:17012	16		
Acin1	501;739;215;3839	1.5410	1.1507	0.2703	0.7367	0.7311	MGI:1891824	562 15	XM_006519299|XM_006519308|XM_006519298|NM_023190|NM_001085472|NM_001242606|NM_019567|NM_001242605|NM_001085473|XM_006519296|XM_006519301|XM_006519297|XM_006519300|XM_006519304	XP_006519364|XP_006519363|XP_006519361|NP_001229534|NP_075679|XP_006519360|XP_006519367|NP_062513|XP_006519359|NP_001229535|XP_006519362|NP_001078942|NP_001078941|XP_006519371	22853	HGNC:17066	229 85	NM_001164817, NM_001164815, NM_001164814, NM_014977,NM_001164816	NP_001158289, NP_001158286, XP_011534872, NP_055792,XP_005267475,NP_001158288,XP_005267473,XP_005267472,XP_006720144,NP_001158287
Abcb1b	163;7404;27048324;4839	1.5399	1.3709	0.2703	0.7331	0.7331	MGI:9756	1869	NM_011075	NP_035205	#N/A	#N/A	#N/A	#N/A	#N/A
Arpp19	310;752;6992;8235	1.5270	1.2348	0.2744	0.7385	0.7385	MGI:1891691	590 46	XM_006511327|NM_021548|NM_001142655	XP_006511390|NP_001136127|NP_067523	21318	HGNC:16967	107 76	NM_001306196, NM_001306191, NM_001330309, NM_001306195, NM_006628	XP_016877358, NP_001293120, XP_016877359, NP_006619,XP_016877357,NP_001293125,XP_016877360,NP_001317238,NP_001293124
Dvl2	560;759;305	1.5197	1.1200	0.2765	0.7400	0.7394	MGI:1066133	1354 3	NM_007888	NP_031914	20927	HGNC:30866	1856	NM_004422	NP_004413,XP_005256559,XP_016879787

	4;7646														
Pgp	728;763;5121;6130	11.5155	10.0277	00.7739	00.7394	MGI:1914328	670	NM_025954	NP_080230	551	HGNC:8909	283871	NM_001042371	NP_001035830	
Rbp7	725;782;24887;81622	11.4959	10.0638	00.7844	00.7522	MGI:1194910	2456	NM_009031	NP_033057	5570	HGNC:9890	5931	NM_002893,NM_001198719	NP_001185648,NP_002884	
Stk11	722;795;91232;92822	11.4829	10.0578	00.7589	00.7548	MGI:1341870	2089	NR_126043|XM_006513443|XM_006513442|NM_011492|XM_006513439|NM_001301853|NM_001301854|XM_006513441	NP_001288782|XP_006513504|XP_006513506|NP_001288783|XP_006513505|XP_006513502|NP_035622	393	HGNC:11389	6794	NM_000455	XP_005259674,NP_000446,XP_011526511,XP_005259675	
Ppp2r4	41;802;71441;72766	11.4759	10.6304	00.2914	00.7617	##N/A	##N/A	#N/A	#N/A	##N/A	##N/A	##N/A	#N/A	#N/A	
Pi	72	11.	10.	00.	00.	MG	11	XM_006513120|XM_011243288|	XP_017169257|XP_006513183|	23	HG	79	NM_001146259,NM_001146260,	NP_079055,NP_001139731,XP_	

p42c	3;806;1999;4164	47201	052128	761048	7548	I:21522144	7150	XM_017313768|NM_054097|XR_871695|XM_006513121|XM_011243289	NP_473438|XP_006513184|XP_011241591|XP_011241590	484	NC:23786	837	NM_024779,NM_001146258	011537049,XP_016875462,XP_005269209,NP_001139730,NP_001139732
Gjc3	362;808;4519;620606	1.47002	1.17622	0.29335	0.75848	0.7548	MGI:2153041	11844 6	NM_080450|XR_001784599	NP_536698	15399	HGNC:17495	349149	NM_181538	NP_853516
Arfgef2	240;809;3500;427 1	1.46900	1.25666	0.29338	0.75448	0.7548	MGI:2139354	99371	XM_011239875|XM_006500484|XM_006500483|NM_001085495	XP_006500546|XP_011238177|XP_006500547|NP_001078964	11880	HGNC:158553	10564	NM_006420	NP_006411,XP_005260309
Ets1	709;814;3287;647 9	1.46422	1.05155	0.29557	0.75554	0.7554	MGI:954555	2387 1	NM_011808|NM_001038642|XM_006510269	NP_035938|XP_006510332|NP_001033731	38337	HGNC:3488	2113	NM_005238,NM_001330451,NM_001143820,NM_001162422	XP_016872806,NP_001155894,XP_016872805,XP_011540953,NP_005229,XP_011540954,XP_016872804,XP_011540951,XP_016872803,NP_001317380,XP_011540952,NP_001137292
Psenen	126;823;3	1.45555	1.38211	0.29090	0.75994	0.7594	MGI:191355	66340	NM_025498	NP_079774	11952	HGNC:3011	558511	NM_172341,NM_001281532	NP_001268461,NP_758844

	113;5964	90										00			
Trib1	271;8299;8156;9096	1.4497	1.2227	0.3012	0.7606	0.7606	MGI:2443397	2170	NM_144549	NP_653132	75216	HGNC:16891	102 21	NM_001282985, NM_025195	NP_079471,NP_001269914
Ercc6l	57;8367;49029;78900	1.4422	1.5431	0.3041	0.7636	0.7614	MGI:2654144	2369300	NM_146235	NP_666347	44945	HGNC:20794	548 21	NM_001009954, NM_017669	NP_060139,NP_001009954
Nadk	90;8436;5577;71000	1.4365	1.4333	0.3063	0.7649	0.7614	MGI:2183149	19218 5	NM_001159637| XM_006538665| XM_006538663| XM_006538662| XM_006538664| NM_138671	XP_006538727| NP_619612|NP_001153109|XP_006538728|XP_006538725|XP_006538726	49724	HGNC:29831	65220	NM_023018,NM_001198994,NM_001198995,NM_001198993	XP_011540309, XP_016857634, XP_016857632, XP_005244835, XP_016857633, XP_006710900, XP_011540311, XP_006710901, XP_011540310, NP_075394,XP_011540308,NP_001185922,NP_001185924,NP_001185923,XP_006710902,XP_016857635
Stxbp1	158;8533;7624;87474	1.4273	1.3210	0.3100	0.7698	0.7614	MGI:1073663	20910	NM_009295|NM_001113569	NP_033321|NP_001107041	2382	HGNC:11444	6812	NM_003165,NM_001032221	NP_001027392, NP_003156

Dusp12	52 5;8 54;5 491 ;;6 084	1 1. .4 263	1 0 8 4 9	0 0 3 1 0 4	0 0 7 6 6 5	0 . 7 6 1 4	MGI:1890614	80915	XR_373626|NM_023173|XM_006497042	NP_075662|XP_006497105	52 38	HGNC:30667	11266	NM_007240	NP_009171,XP_005244919
Nvl	19 9;8 62;3 309 ;;7 645	1 1. .4 190	1 2 6 9 5	0 0 3 1 3 4	0 0 7 6 9 6	0 . 7 6 1 4	MGI:1914709	67459	XM_011238856|NM_026171|XM_011238857|XR_373614|XM_006496965|XR_001785531|XM_006496964	XP_011237158|NP_080447|XP_011237159|XP_006497027|XP_006497028	19 02	HGNC:8070	49 31	NM_206840,NM_001243147,NM_002533,NM_001243146	XP_016856873,XP_011542498,XP_016856871,XP_016856874,XP_016856868,XP_011542500,XP_011542501,XP_016856870,NP_002524,NP_001230076,XP_016856872,XP_016856875,XP_016856869,XP_011542502,NP_996671,NP_001230075,XP_016856867
Ntpcr	63 3;8 65;3 114 ;;6 768	1 1. .4 163	1 0 4 6 8	0 0 3 1 4 3	0 0 7 6 7 8	0 . 7 6 1 4	MGI:1913816	66566	NM_025636|XM_006531283|NM_001310688|XM_006531286|XM_006531287|XM_006531285	NP_001297617|NP_079912|XP_006531349|XP_006531350|XP_006531346|XP_006531348	11 98 9	HGNC:28204	84 284	NM_001329452,NM_001329453,NM_032324	NP_001316382,NP_115700,NP_001316381
Csnk1g3	48 8;8 66;6 839 ;;9 419	1 1. .4 154	1 0 9 2 7	0 0 3 1 4 4 6	0 0 7 6 4 6	0 . 7 6 1 4	MGI:1917675	70425	XM_006526235|XM_006526231|XM_006526237|XM_006526230|XM_006526236|XM_006526234|NM_152809|XM_006526232|XM_006526233	XP_006526297|XP_006526295|XP_006526296|XP_006526293|XP_006526294|XP_006526299|XP_006526298|XP_006526300|NP_690022	12 16 50	HGNC:2456	14 56	NM_001270572,NM_004384,NM_001044723,NM_001270574,NM_001044722,NM_001270573,NM_001031812	XP_016864552,XP_016864559,XP_016864557,XP_016864549,XP_016864558,XP_005271952,XP_016864555,XP_016864548,XP_016864547,XP_016864550,NP_004375,XP_005271953,XP_016864553,NP_001026982,XP_016864551,XP_005271951,XP_005271949,NP_001257503,XP_016864546,NP_001257501,XP_016864554,NP_001257502,XP_005271948,XP_

														016864556,NP_001038188
Prkci	29;867;3191;3480	1.4145	1.1863	0.3151	0.7614	0.7614	MGI:992660	1759	NM_008857|XM_006535411	NP_032883|XP_006535474	3767	HGNC:9404	554	NM_002740	XP_016862349, NP_002731
Sra1	62;874;4868;8930	1.4082	1.0460	0.3178	0.7638	0.7638	MGI:1344414	2406	NR_028355|NM_025291|NM_001164406	NP_001157878|NP_079567	1190	HGNC:11281	100	NM_001253764, NM_001035235	NP_001240693, NP_001030312
Gtpbp4	34;8903;2677;3035	1.3939	1.6297	0.3240	0.7744	0.7725	MGI:1916487	6923	XM_017315592|NM_027000	XP_017171081|NP_081276	7100	HGNC:21535	2356	NM_012341	NP_036473
Slc41a3	70;903;2832;3346	1.3826	1.0122	0.3291	0.7824	0.7725	MGI:1918949	7169	NM_001037493|XM_132686|XM_006506627|XM_006506626|XM_006506625	XP_006506689|NP_001032570|XP_006506688|XP_006506690|NP_082144	2305	HGNC:3104	549	NM_001164475, NM_001008487, NM_001008486, NM_001008485, NM_017836	XP_011511247, XP_005247616, NP_001008485, NP_001008487, NP_001157947, XP_016862196, XP_016862197, XP_006713744, NP_060306,XP_016862194,XP_005247622,XP_016862198,XP_005247619,NP_001008486,XP_005247620,XP_005247621,XP_016862195
Taok3	746;90	1.3809	1.0014	0.3299	0.7902	0.7725	MGI:3307	3301	XM_011248221|XM_006530385|XM_011248219|NM_001199685|NM_001081308|	NP_899129|NP_001074777|XP_011246521|XP_011246523|NP_001186614|XP_	8327	HGNC:1	513	NM_001346495, NM_016281,NM_001346488,NM_001346496,NM_001346487,NM_001346489,NM	XP_005253954, XP_016874902, NP_001333417, NP_001333421, NP_001333416, NP_001333419,

	5;3104;8708					411177	XM_011248220|NM_183306	011246522|XP_006530448		81333	_001346490,NM_001346492,NM_001346497,NM_001346494,NM_001346491,NM_001346493	NP_001333425,NP_001333420,NP_057365,XP_005253955,NP_001333418,XP_016874900,NP_001333423,XP_016874897,NP_001333426,NP_001333424,XP_016874899,XP_011536741,XP_016874901,NP_001333422,XP_016874898,XP_011536739,XP_006719508
Erbb2ip	882;9063;23655;44066	1.3800	0.9744	0.3303	0.7770	0.7725	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Slc26a11	881;9073;42566;78777	1.3792	0.9857	0.3307	0.7739	0.7725	MGI:2444589	26851 2	XM_006533419|XM_006533421|XM_006533418|XM_006533420|NM_178743	XP_006533483|XP_006533481|XP_006533482|XP_006533484|NP_848858	13685	HGNC:14471	28412 9	NM_001166349,NM_001166348,NM_001166347,NM_173626	XP_016879996,XP_006721896,XP_011522954,XP_016879995,NP_775897,XP_011522956,NP_001159819,XP_016879994,NP_001159821,XP_011522955,NP_001159820
Jade1	885;9105;28354;82144	1.3766	0.9722	0.3312	0.7725	0.7725	MGI:1925835	26942 4	XM_006500784|NM_001130186|NM_172303|NM_001130184|NM_001130185	NP_001123657|NP_758507|NP_001123656|XP_006500847|NP_001123658	18162	HGNC:30027	79960	NM_001287442,NM_024900,NM_001287441,NM_001287437,NM_199320,NM_001287440,NM_001287439,NM_001287443	NP_001274371,NP_001274370,NP_955352,XP_016864116,NP_001274366,NP_001274368,NP_079176,NP_001274369,XP_005263289,NP_001274372,XP_016864115
Pvrl3	106;9199	1.3689	1.3750	0.3354	0.7768	0.7768	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

	;;3183;6921													
Kctd7	666;937;4898;5626	1.3538	1.0068	0.034265	0.078959	0.078339	MGI:2442265	2129	NM_172509|XM_006504401	NP_766097|XP_006504464	17687	HGNC:21957	15481	NM_153033,NM_001167961	NP_694578,NP_001161433
Col4a3bp	625;938;3767;9556	1.3530	1.0173	0.034330	0.078362	0.078339	MGI:1915268	6801	XM_011244694|NM_023420|NM_001164222	XP_011242996|NP_075909|NP_001157694	4173	HGNC:22005	1087	NM_031361,NM_005713,NM_001130105	XP_011541393,NP_112729,XP_016864408,NP_001123577,XP_011541392,XP_006714576,NP_005704
Slc22a18	571;940;5341;8882	1.3513	1.0323	0.034337	0.078339	0.078339	MGI:1336884	1840	XM_006508513|XM_006508514|NM_008767|XM_006508512|NM_001042760|XM_006508511|XM_006508515|XM_006508510	NP_001036225|XP_006508576|XP_006508573|NP_032793|XP_006508575|XP_006508574|XP_006508577|XP_006508578	1918	HGNC:10964	5002	NM_001315501,NM_183233,NM_002555,NM_001315502	NP_001302430,XP_011518444,NP_001302431,NP_002546,NP_899056,XP_011518443
Mdp1	85;953;;2914;;33	1.3407	1.4074	0.034907	0.079185	0.078339	MGI:1915131	6781	XM_017316173|NR_028316|NM_023397	NP_075886|XP_017171662	5846	HGNC:28781	14553	NM_001199821,NM_001199822,NM_138476	NP_612485,NP_001186751,NP_001186750

	34														
Gpc6	634;955;4682;8568	1.3309709	10.3497895	0.7895	MGI:1346322	238	NM_001079844|NM_011821|XM_006518929	NP_035951|XP_006518992|NP_001073313	5592	HGNC:4454	10	NM_005708	XP_016875790, NP_005699,XP_011519346,XP_016875791,XP_016875789,XP_016875787,XP_016875788
Sbf2	702;964;2847;5417	1.3389189	0.3537939	0.7939	MGI:1921831	319	XM_011241830|XR_001785572|XM_006507926|NM_177324|XM_006507924|XM_006507925|XM_006507927	NP_796298|XP_006507987|XP_006507988|XP_006507989|XP_011240132|XP_006507990	4810	HGNC:2135	81846	NM_030962	XP_005253211, XP_011518698, XP_011518696, XP_016873864, XP_016873865, XP_005253212, XP_011518697, NP_112224,XP_016873866,XP_016873861,XP_016873863,XP_016873862
Lima1	914;9700;3614;5594	1.3270	0.3425	0.7955	MGI:1920992	659	NM_023063|XR_001781560|NM_001113545|XM_006521245	NP_001107017|NP_075550|XP_006521308	9484	HGNC:2466	5147	NM_001243775, NM_016357,NM_001113546,NM_001113547	NP_001230704, XP_011536757, NP_057441,XP_016874918,NP_001107019,NP_001107018,XP_016874919
Stk38l	496;9811;5592;6917	1.3182	0.3041	0.7933	MGI:1922250	233	XM_017321560|XM_006507029|XR_001785124|XM_006507032|XM_006507034|XM_006507027|XM_006507031|NM_172734|NM_001346666|XM_006507033	XP_006507097|XP_006507090|XP_006507092|XP_017177049|XP_006507096|XP_006507095|NP_766322|XP_006507094|NP_001333595	5629	HGNC:1784	23012	NM_015000	XP_006719122, XP_016874525, XP_011518915, XP_005253399, XP_006719121, NP_055815
Nisch	527;9	1.3129	0.3609	0.79	MGI:1	6465 2	NM_022656|XM_017316115|XM_017316116|XM_006519354|XM	XP_017171605|XP_017171604|XP_006519417|XP_006519416|	1361	#N/A	#N/A	#N/A	#N/A

	85;5767;6141	51	85	21	14	93	92832323		_006519353|NM_001347583	NP_001334512|NP_073147	61				
Slc39a14	27;9875;6222;7390	1.31535	1.15530	0.36309	0.79933	0.7993	MGI:2384851	213053	XM_006518789|XM_006518787|XM_006518786|NM_001135151|XM_006518791|NM_144808|NM_001135152|XM_006518788	NP_001128624|XP_006518852|XP_006518849|NP_001128623|XP_006518851|XP_006518854|NP_659057|XP_006518850	150371	HGNC:20858	23516	NM_001351656,NM_001135153,NM_001351655,NM_001351658,NM_001351660,NM_001128431,NM_015359,NM_001351659,NM_001351657,NM_001135154	XP_011542780,XP_016868783,XP_006716386,XP_016868782,XP_005273522,NP_001338586,XP_016868784,NP_056174,XP_005273523,XP_006716387,NP_001128626,NP_001338587,NP_001338584,NP_001338588,NP_001121903,NP_001338585,NP_001128625,NP_001338589,XP_016868781
Tmx3	69;9965;4288;87288	1.30650	0.97506	0.36699	0.80399	0.80199	MGI:2442418	67988	NM_198295	NP_938037	10381	HGNC:24718	54495	NM_001350512,NM_001350517,NM_001350515,NM_001350516,NM_001350514,NM_001350513,NM_019022	NP_001337442,NP_001337446,NP_001337443,NP_001337441,XP_011524335,XP_011524337,NP_001337445,NP_001337444,XP_005266771,XP_011524336,NP_061895
Trim28	58;1005;41999;98411	1.29961	1.46810	0.37048	0.80446	0.80446	MGI:1092744	21849	NM_011588	NP_035718	21175	HGNC:16384	10155	NM_005762	NP_005753
Ricb8b	249;10162;3	1.29102	1.16703	0.37555	0.81080	0.80744	MGI:2682823	23742212	NM_183172|XR_380393|XM_006513625|XR_380394|XR_380392|NM_001013441	NP_898995|NP_001013459|XP_006513688	23080	HGNC:25555	55188	NM_001351361,NM_001330145,NM_001330147,NM_001351362,NM_001351367,NM_001351363,NM_018157,NM_001330146,NM_001351366,NM_001351364	NP_001317076,XP_011536830,NP_001317074,NP_001317075,NP_001338290,XP_011536829,XP_011536828,NP_001338291,XP_016875037,NP_001338296,

	352;557;676					07									XP_011536831, NP_001338295, XP_005269055, NP_060627,XP_016875038,NP_001338293,NP_001338292
Nap1l1	669;1017;2558;3820	1.2905	0.9744	0.3759	0.0780	0.0774	MGI:1855693	536 05	XR_001779557|XM_006513893|NM_015781|XR_001779558|XM_006513890|NM_001146707	NP_001140179|XP_006513953|NP_056596|XP_006513956	1292118	HGNC:7637	4673	NM_001330232, NM_001307924, NM_139207,NM_001330231,NM_004537	NP_001317161, NP_001317160, XP_011536692, XP_016874828, NP_001294853, NP_004528,XP_016874827,XP_011536695,XP_016874829,XP_006719488,NP_631946
Nudt18	999;1023;5057;7906	1.2859	0.9089	0.3785	0.0809	0.0744	MGI:2385853	213 484	XM_006518793|XM_006518792|NM_153136	XP_006518855|XP_006518856|NP_694776	32604	HGNC:26194	7987 3	NM_024815	XP_011542952, NP_079091
Cd63	563;1025;4699;95000	1.2844	1.0014	0.3793	0.0774	0.0744	MGI:995299	125 12	NM_007653|NM_001282966|NM_001042580	NP_001269895|NP_001036045|NP_031679	37526	HGNC:1692	967	NM_001257389, NM_001257401, NM_001267698, NM_001257390, NM_001040034, NM_001257391, NM_001780,NM_001257400,NM_001257392	NP_001244319, NP_001244329, NP_001244330, NP_001244318, NP_001771,NP_001244320,NP_001254627,NP_001244321
Fam84b	589;1030;2774	1.2807	0.9915	0.3815	0.0881	0.0811	MGI:3026924	396 03	XR_384024|NM_001162926	NP_001156398	18379	HGNC:24166	1576 38	NM_174911	XP_016868597, NP_777571,XP_016868596

	;4985														
Csnk1e	8920;10037;40833;68988	1.2755	0.9204	0.3844	0.8105	0.805	MGI:1351660	2737	XM_011245652|XM_011245651|NM_013767|XM_011245654|XM_006521043|XM_011245649|XM_017316657|XM_017316658|XM_017316659|XM_011245653|NM_001289898|NM_001289899|XM_011245650|XM_017316660	NP_001276828|XP_011243952|XP_011243956|XP_006521106|XP_017172149|XP_017172148|XP_011243954|XP_011243951|XP_011243955|XP_017172147|XP_017172146|NP_001276827|XP_011243953|NP_038795	12169	HGNC:24533	1454	NM_152221,NM_001894	NP_001885,NP_689407
Jak1	7345;10045;27099;;30466	1.2696	0.9482	0.3879	0.8141	0.823	MGI:9662851	1645	NM_146145|XM_011240451|XM_006502812	NP_666257|XP_006502875|XP_011238753	1678	HGNC:6190	3716	NM_001321857,NM_001321852,NM_001320923,NM_002227,NM_001321853,NM_001321856,NM_001321855,NM_001321854	NP_001308783,NP_001308781,NP_001307852,NP_001308784,NP_001308785,NP_001308786,NP_001308782,NP_002218,XP_016856701
Bmp2	4200;10047;;38147;84771	1.2681	1.0469	0.3889	0.8123	0.823	MGI:881777	1215 6	NM_007553|XM_006498619	NP_031579|XP_006498682	926	HGNC:10699	650	NM_001200	XP_011527625,NP_001191
Pja2	6480;10555;;49622;;75	1.2623	0.9658	0.3925	0.8160	0.860	MGI:2159342	2249 38	NM_144859|NM_001025309	NP_001020480|NP_659108	32233	HGNC:17481	9867	NM_014819	XP_016865588,NP_055634

Bfsp2	32;150;1066;3826;4125	1.2.2.5.4.4	1.4.5.3	0.3.9.7.7	0.8.2.3.1	0.8.1.6.1	MGI:1338288	107993	XM_356180	NP_001002896	20791	HGNC:10411	8419	NM_003571	XP_016862804, NP_003562
Fam126a	30;1069;4449;8839	1.2.5.2.3	1.0.1.2	0.3.9.2.2	0.8.2.2.1	0.8.1.6.1	MGI:2149839	84652	NM_001310471|NM_053090|XM_011249798|XM_006535822|XM_017321188	NP_444320|NP_001297400|XP_017176677|XP_006535885|XP_011248100	57175	HGNC:24587	84668	NM_032581	XP_011513892, XP_011513891, XP_005249951, NP_115970,XP_005249952
Ywhag	44;1071;3023;4044	1.2.5.0.8	1.5.0.2.8	0.4.0.0.1	0.8.2.0.4	0.8.1.6.1	MGI:1081109	226228	NM_018871	NP_061359	22725	HGNC:12852	75332	NM_012479	NP_036611
Ulk4	984;1072;3959;9061	1.2.5.0.1	0.8.9.3.1	0.4.0.7.8	0.8.1.6.1	MGI:1921622	20912	XM_006512022|XM_006512024|NM_177589|XM_006512023|XM_017313263|XM_006512025|XM_011242952|XM_006512026	XP_006512086|XP_011241254|XP_006512085|XP_006512087|XP_006512089|NP_808257|XP_006512088|XP_017168752	41205	HGNC:15784	54986	NM_001322501, NM_001322500, NM_017886	NP_060356,XP_011532182,XP_011532176,NP_001309429,NP_001309430,XP_016862200,XP_016862201

Adam10	98;108;344;497	1.2488.4057.8244.811	0.0.0.0	MGI:1095488	117	XM_011242657|NM_007399	NP_031425|XP_011240959	865	HGNC:188	102	NM_001110,NM_001320570	NP_001101,NP_001307499,XP_016877350
Actr6	146;1084;8122;8875	1.2441.4062.8161.811	0.0.0.0	MGI:1914269	679	XM_006513967|XM_017314062|XM_017314063|XM_006513965|XM_006513966|NM_025914|XM_011243532	XP_006514030|NP_080190|XP_006514028|XP_006514029|XP_017169552|XP_011241834|XP_017169551	6451	HGNC:24025	644 3 1	NM_022496	NP_071941,XP_016875310
Pdcd6	104;1086;2647;4069	1.2488.4071.8197.811	0.0.0.0	MGI:1092883	1857 0	NM_011051|XM_006517156	NP_035181|XP_006517219	7880	HGNC:87665	1001 6	NM_001267556,NM_001267558,NM_001267559,NM_013232,NM_001267557	NP_001254488,NP_001254485,NP_037364,NP_001254487,NP_001254486
Prpsap1	536;1088;3316;5821	1.2388.4081.811	0.0.0.0	MGI:1915013	6763	XM_181343|XM_011249196|XM_006534018|XM_006534017	NP_080640|XP_011247498|XP_006534080|XP_006534081	55687	HGNC:94665	563 5	NM_001330503,NM_002766	NP_002757,XP_011523336,NP_001317432
Cd	73	1.	0.0.0.0	MG	67	NM_026410	NP_080686	49	HG	11	NM_080668	XP_016872647,XP_005273791,

cas5	1;1090;45822;45833	2374	9330	40900	81611	81611	I:19150999	849				860	NC:14626	3130	XP_011543049, XP_005273790, XP_011543051, XP_011543050, XP_011543045, NP_542399
Acvr1b	1029;1100;20009;36322	1.23059	0.87699	0.41382	0.82222	0.81888	MGI:1338944	1149	NM_007395	NP_031421	20906	HGNC:172	91	NM_020328,NM_004302,NM_020327	XP_011537269, XP_011537268, XP_016875690, NP_064733,NP_004293,NP_064732,XP_016875688,XP_016875689
Lppr2	428;11108;32275;53555	1.22510	0.02178	0.41792	0.82658	0.81888	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Krit1	435;11100;67033;8833	1.22361	0.01881	0.41894	0.82488	0.81888	MGI:1930618	7926	XM_006503617|NR_033173|NM_030675|NM_001170552|XM_006503618	NP_001164023|XP_006503680|NP_109600|XP_006503681	12746	HGNC:1573	889	NM_001350684, NM_001350696, NM_001350693, NM_001350673, NM_001350670, NM_001350671, NM_001350687, NM_194454,NM_001350677,NM_004912,NM_001350678,NM_001350680,NM_001350688,NM_001350689,NM_001350676,NM_001350685,NM_001350697,NM_194456,NM_001350691,NM_001350683,NM_001350682,NM_001350672,NM_001350	NP_001337612, NP_919436,XP_011514960,NP_001337624,NP_001337610,NP_001337619,XP_011514959,NP_004903,XP_011514957,XP_011514963,NP_001337603,XP_006716226,NP_001337617,XP_006716225,XP_011514956,NP_001337605,XP_011514958,NP_001337622,XP_011514962,XP_005250726,NP_001337618,XP_016868244,NP_001

													0694,NM_00101 3406,NM_00135 0690,NM_00135 0675,NM_00135 0674,NM_00135 0692,NM_00135 0695,NM_00135 0669,NM_19445 5,NM_00135067 9,NM_00135068 6,NM_00135068 1	337609,XP_005 250717,NP_001 337607,XP_005 250719,NP_919 438,XP_016868 247,XP_005250 723,NP_001337 599,NP_001337 621,NP_001337 608,NP_001337 602,NP_001337 614,NP_001337 626,XP_016868 248,NP_001337 623,XP_005250 724,NP_001337 625,XP_016868 246,NP_001337 611,XP_011514 961,XP_016868 245,XP_011514 953,NP_001013 424,NP_001337 600,NP_001337 615,NP_001337 606,XP_005250 725,XP_011514 955,XP_005250 722,XP_006716 224,NP_001337 601,NP_001337 620,NP_001337 604,NP_001337 613,NP_001337 598,NP_919437, NP_001337616
Tsc2	749;1111;7507;8143	1.22.219	0.92.198	0.41.92	0.82.19	0.81.88	MGI:1025548	2204	XM_017317390|NM_001286714|XM_017317391|XM_017317393|XM_017317386|XM_017317385|XR_001782063|NM_001286720|XM_006524044|NM_001286718|XM_017317384|XM_017317388|NM_001286713|NM_001286716|XR_001782062|NM_001039363|NM_011647|XM_017317389|XM_017317392|XM_017317387|XM_006524040	XP_006524103|XP_017172874|XP_017172877|XP_017172873|NP_001273642|NP_001273647|XP_017172875|XP_017172879|NP_001273643|NP_035777|XP_006524107|XP_017172882|NP_001034452|NP_001273645|NP_001273649|XP_017172880|XP_017172876|XP_017172881|XP_017172878	462	HGNC:12363	7249	NM_021056,NM_021055,NM_000548,NM_001318832,NM_001318831,NM_001077183,NM_001318827,NM_001318829,NM_001114382	NP_001107854, XP_011520941, XP_011520938, NP_001305761, XP_005255588, NP_001305760, XP_016879107, XP_011520940, XP_016879105, XP_005255586, NP_001305756, NP_000539,NP_001305758,XP_011520942,XP_011520939,NP_001070651,XP_016879106,XP_016879104
Sucl g1	833;1112;2977;4606	1.22.223	0.90.44	0.41.97	0.81.93	0.81.88	MGI:1927234	56451	NM_019879	NP_063932	55785	HGNC:11449	8802	NM_003849	NP_003840

Gng13	33;115;2526;7842	1.2202	1.5492	0.4213	0.8188	0.8188	MGI:1925616	6433	NM_022422|XM_006524779	XP_006524842|NP_071867	8189	HGNC:14131	5176	NM_016541	NP_057625
Map3k15	110;114;5117;6351	1.2008	1.2832	0.4355	0.8428	0.8423	MGI:2448588	2706	NM_001163085	NP_001156557	5040	HGNC:31689	3840	NM_001001671	XP_011543809, XP_011543812, XP_011543813, NP_001001671, XP_011543810, XP_016885000
Riok3	849;1147;4777;9102	1.1988	0.1887	0.4372	0.8423	0.8423	MGI:1914128	6687	XR_001782391|XR_001782389|NM_024182|XM_017317969|XR_001782390	NP_077144|XP_017173458	2843	HGNC:11451	8780	NM_145906,NM_001348193,NM_003831	XP_011524545, XP_011524544, NP_001335122, NP_003822
Dis3l	212;115;2;4196;9364	1.1955	1.1449	0.4397	0.8436	0.8435	MGI:2143272	2135	NM_172519|NM_001001295|NM_001177784|XM_006510983|XM_011242700|XM_006510982	XP_006511045|NP_766107|NP_001171255|NP_001001295|XP_006511046|XP_011241002	15797	HGNC:28698	1152	NM_001323937, NM_133375,NM_001323945,NM_001323946,NM_001323943,NM_001143688,NM_001323940,NM_001323939,NM_001323941,NM_001323938,NM_001323936,NM_001323944,NM_001323948	NP_001310867, NP_001310868, NP_001310866, NP_001310877, NP_001310873, NP_001310865, NP_588616,XP_005254203,NP_001310872,NP_001310875,NP_001137160,NP_001310870,NP_001310869,NP_001310874
Tpx2	392;	1.18	1.102	0.444	0.884	0.84	MGI:	721	XM_006500215|NM_001141978|XM_006500213|NM_028109|NM	NP_001135450|XP_006500276|NP_001135449|XP_006500278|	807	HGNC	229	NM_012112	XP_011526999, NP_036244,XP_011527001,XP_011527002

	116;207;316	904	4897	35	1919369	19	_001141977|NM_001141976|XM_006500214|NM_001141975	NP_001135447|NP_082385|NP_001135448|XP_006500277		:1249	74			
Ehbp1	950;116;685;2985;6797	1.18651	0.4478	0.8517	0.8435	MGI:2665252	216565	XM_011243688|XM_011243687|XM_017314439|XM_011243692|XM_011243683|XM_011243689|XM_011243681|XM_017314440|XM_011243691|XM_011243693|XM_011243684|NM_001252515|XM_017314438|XM_011243682|NM_153078|XM_011243686|XM_011243690|XM_017314437|XM_011243685	XP_017169927|XP_017169926|XP_017169929|XP_011241992|XP_011241991|XP_011241985|XP_011241989|NP_694718|XP_017169928|XP_011241983|XP_011241990|XP_011241988|XP_011241987|XP_011241995|XP_011241984|NP_001239444|XP_011241994|XP_011241986|XP_011241993	2280	HGNC:29144	23301	NM_001142614,NM_015252,NM_001142616,NM_001142615	XP_016859144,NP_001136088,XP_016859134,XP_005264285,XP_011531019,XP_016859143,XP_016859137,XP_016859132,XP_016859138,XP_016859135,XP_011531017,XP_011531018,XP_016859133,XP_006712034,XP_005264284,XP_016859142,NP_001136086,XP_005264282,XP_016859141,XP_016859136,XP_011531020,XP_005264283,NP_001136087,XP_011531015,XP_016859139,XP_011531016,NP_056067,XP_016859140
Trim25	811;172;3845;7126	1.18826	0.4499	0.8521	0.8435	MGI:1027499	21706 9	XM_126545|XM_017314476	XP_017169965|NP_033572	48325	HGNC:12932	7706	NM_005082	NP_005073
Tgif1	39;117;5980;;79	1.18194	1.4945	0.8494	0.8435	MGI:1944977	21815	XM_006524031|XM_006524032|NM_001164077|XM_011246363|NM_001164076|NM_001164075|NM_009372|NM_001164074	NP_001157548|XP_006524095|NP_033398|XP_011244665|NP_001157546|NP_001157547|NP_001157549|XP_006524094	7574	HGNC:11776	7050	NM_173210,NM_001278684,NM_174886,NM_001278682,NM_173208,NM_173209,NM_173211,NM_170695,NM_003244,NM_173207,NM_001278686	NP_001265613,NP_775301,NP_001265611,NP_003235,XP_011524037,NP_775300,XP_016881447,NP_001265615,NP_775303,NP_775299,NP_733796,NP_777480,XP_016881448,NP_775302

Trip10	01841;11801;86211;90233	1.1775	0.1880	0.0453	0.0484	0.0435	MGI:2146901	1062	NM_134125|XM_006523401|XM_006523400|NM_001242390|NM_001242391|NM_001242389	NP_001229318|NP_001229320|NP_001229319|XP_006523464|NP_598886|XP_006523463	9978	HGNC:12304	932	NM_004240,NM_001288963,NM_001288962	NP_001275891, XP_005259740, NP_001275892, XP_006723003, NP_004231
Zdhhc13	10971;11822;46422;86062	1.1762	0.1840	0.0454	0.0484	0.0435	MGI:1919227	2439	XM_006540898|NM_028031|XM_006540896	NP_082307|XP_006540959|XP_006540961	75106	HGNC:18413	545	NM_019028,NM_001001483	NP_001001483, XP_011518497, NP_061901,XP_011518495,XP_011518496,XP_005253053
Rrp8	31871;11889;31643;78999	1.1718	0.1052	0.0458	0.0850	0.0435	MGI:1914251	1018	XR_378204|NM_025897|NM_133951	NP_080173|NP_598712	5621	HGNC:29030	2337	NM_015324	NP_056139,XP_011518257,XP_016872912
Comt	89711;46371;73977	1.1705	0.1867	0.0459	0.0848	0.0435	MGI:884700	1246	NM_001111062|NM_001111063|NM_007744	NP_001104532|NP_031770|NP_001104533	30982	HGNC:22288	132	NM_007310,NM_001135161,NM_000754,NM_001135162	XP_016884083, XP_016884084, NP_001128634, NP_000745,NP_009294,NP_001128633,XP_011528188

Rrp1b	107;119;122;407;2;806;8	1.16991	0.8459	0.8460	0.8435	MGI:1911712	7462	XR_001782117|XM_006524974|NM_028244|XM_006524973|XM_006524971|XM_006524972|NM_001163734	NP_001157206|XP_006525037|XP_006525035|XP_006525036|NP_082520|XP_006525034	5708	HGNC:23818	2307	6	NM_015056	NP_055871
Aldh3b1	38;119;3;579;9;97811	1.16920	0.8460	0.8435	0.8435	MGI:1914939	6768	NM_026316|XM_006531830	XP_006531893|NP_080592	7390	HGNC:410	2	21	NM_001161473,NM_000694,NM_001290059,NM_001290058,NM_001030010	NP_001276988,NP_001154945,NP_000685,NP_001025181,NP_001276987
Uhrf1	113;119;8;738;6;973;7	1.16611	0.8463	0.8450	0.8440	MGI:1338889	1810	NM_001111079|NM_010931|XM_006523800|NM_001111078|NM_001111080|XM_006523799	NP_035061|NP_001104550|XP_006523863|NP_001104549|XP_006523862|NP_001104548	7866	HGNC:12556	2918	28	NM_001290051,NM_001290050,NM_001048201,NM_001290052,NM_013282	NP_001041666,XP_011526244,NP_037414,NP_001276981,NP_001276979,NP_001276980
Lats2	830;120;2;317;5;;4771	1.16366	0.8765	0.8454	0.8440	MGI:1354386	5052	XM_006519224|NM_015771|XM_006519225|NM_153382	NP_700431|NP_056586|XP_006519288|XP_006519287	5667	HGNC:6515	2654	24	NM_014572	NP_055387,XP_016876031,XP_011533344,XP_016876030,XP_005266399

Pak1ip1	784;12093;75977;96887	1...1593	0...8826	0...4691	0...8489	0...8440	MGI:1915333	683	NM_026550	NP_080826	3957	HGNC:20882	55	NM_017906	XP_011513023, XP_011513022, XP_005249261, NP_060376
Itch	712;12155;69677;70188	1...1556	0...4721	0...8509	0...8440	MGI:1202301	1639	XM_192925|XR_001781069|NM_001243712|XR_001781068	NP_032421|NP_001230641	8842	HGNC:13890	837	NM_001324197, NM_001324198, NM_001257138, NM_031483,NM_001257137	NP_001244066, XP_016883581, NP_001311126, NP_113671,NP_001244067,XP_016883579,XP_005260627,XP_016883580,NP_001311127,XP_016883578,XP_011527381
Ldlr	787;12177;65453;90100	1...1544	0...4787	0...8493	0...8440	MGI:967765	1683	NM_001252659|NM_010700|NM_001252658	NP_001239588|NP_001239587|NP_034830	5546	HGNC:65477	394	NM_000527,NM_001195802,NM_001195798,NM_001195803,NM_001195799,NM_001195800	NP_001182727, NP_000518,XP_011526312,NP_001182732,NP_001182729,NP_001182728
Ino80c	122;12193;23589;4	1...1537	1...2374	0...8479	0...8440	MGI:2443014	2252280	NM_172625	NP_766213	45426	HGNC:26994	1254776	NM_194281,NM_001308064,NM_001098817	XP_005258254, XP_005258253, XP_011524114, NP_001294993, XP_016881038, NP_919257,NP_001092287
Pik1	971	1...11	0...84	0...88	0...88	MGI	187	XM_006495782|NM_011086|XM_006495776|XM	NP_035216|XP_006495844|XP_006495839|XP_	321	HGN	200	NM_015040,NM_152671,NM_00	XP_011509083, XP_011509086, XP_016859057,

fyve	;123;4118;4350	44837817	44127540	:1335106	11	_006495781|XM_006495779|NM_001310624|XM_006495777|XM_011238454	006495842|NP_001297553|XP_011236756|XP_006495845|XP_006495840	15	C:2378	576	1178000,NM_001002881	XP_016859061, XP_011509094, XP_011509088, XP_011509085, NP_001171471, XP_011509090, XP_011509091, XP_016859063, XP_016859060, XP_011509087, XP_016859058, XP_011509080, XP_011509084, NP_055855,NP_689884,XP_016859062,XP_011509089,XP_011509082,XP_016859059,XP_011509081,XP_011509092
Ctdsp2	630;12314;19974;4283	1.14588	0..91240	0..48032	0..85200	0..84400	MGI:1098748	524	NM_001113470|XM_017314028|NM_146012	XP_017169517|NP_001106941|NP_666124	128791	HGNC:17077	106	NM_005730	NP_005721,XP_005268613
Cch1	54;12336;75777;78111	1.14465	0..44059	0..48510	0..84400	MGI:1913921	666711	NM_001347587|XM_006517325|NM_023243|NM_001347588|XM_006517324	NP_001334517|XP_006517388|NP_001334516|XP_006517387|NP_075732	946	HGNC:1594	902	NM_001199189, NM_001239	XP_005248684, XP_016865503, XP_005248686, NP_001186118, XP_011542008, NP_001230
Ggta1	11;1712344;56025;76055	1.14420	0..48219	0..84480	0..84400	MGI:957044	14594	XM_011239027|NM_001308300|NM_010283|NM_001308299|XM_011239029|XM_011239028|XM_006497720|NM_001145821|XM_011239026	NP_001295228|XP_011237329|NP_001295229|XP_011237330|XP_006497783|NP_034413|XP_011237328|XP_011237331|NP_001139293	7730	#N/A	#N/A	#N/A	#N/A

Smarca2	76;1423628;6837;7975	1.1.48430	0.3.8467	0.0.8440	0.0.0	MGI:9960 3	671 55	XM_006527281|XM_017318278|XR_386502|XM_006527288|XM_017318276|XM_017318277|XM_006527284|XM_006527282|XM_006527283|NM_001347439|XM_358329|XM_006527286|XM_017318275|XM_006527285|XM_006527291|XM_006527289	XP_006527354|XP_017173765|XP_006527347|XP_006527344|NP_080279|XP_006527345|XP_017173766|NP_035546|XP_006527349|XP_006527348|NP_001334368|XP_006527351|XP_017173767|XP_006527352|XP_017173764|XP_006527346	2308	HGNC:1109 8	6595	NM_001289399,NM_001289396,NM_139045,NM_003070,NM_001289397,NM_001289400,NM_001289398	NP_003061,NP_001276326,NP_001276327,NP_620614,NP_001276329,NP_001276325,NP_001276328
Cactin	11;1238;6480;8303	1.1.48416	0.1.8413	0.0.8442	0.0.0	MGI:1917562	703 12	NM_027381	NP_081657	69553	HGNC:29938	585 09	NM_001080543,NM_021231	XP_011526462,NP_001074012,XP_011526463,NP_067054
Pi4ka	37;1240;4766;9167	1.1.40456	0.0.4852	0.0.8440	0.0.0	MGI:2448506	224 020	XM_006522037|NM_001001983|XM_006522036|XM_006522034	NP_001001983|XP_006522097|XP_006522099|XP_006522100	1171	HGNC:8983	529 7	NM_002650,NM_058004	XP_005261691,NP_477352,XP_011528530,XP_016884319,XP_011528528,XP_016884318,XP_005261692
Lrpap1	12;1248;4825;;72588	1.1.13569	0.0.8069	0.0.4895	0.0.8481	0.0.8467	MGI:9682 9	169 76	NM_013587	NP_038615	3761 2	HGNC:6701	404 3	NM_002337	NP_002328
En	79	1.	0.	0.	0.	0.	MG	56	NM_001026212|NM_019561	NP_062507|NP_001021383	37	HG	20	NM_207043,NM_207046,NM_20	NP_996928,NP_997051,NP_004

sa	3;1250;3303;6947	13448	86833	49006	84467	84467	IC:18911189	205			924	NC:3360	29	7045,NM_207044,NM_207168,NM_207047,NM_207042,NM_004436	427,NP_996927,NP_996926,NP_996925,NP_996930,NP_996929
Tax1bp3	52113;12663;44277;73433	1.1268	0.9365	0.4977	0.8557	0.8557	MGI:1923531	7628 1	NM_029564	NP_083840	8749	HGNC:30684	30851	NM_014604,NM_001204698	NP_055419,NP_001191627
Slc16a3	7971;12779;35721;41155	1.1740	0.8506	0.8671	0.8666	0.8666	MGI:1933438	8087 9	NM_001038653|NM_030696|XM_011249321|NM_001038654|XM_011249322	XP_011247624|NP_001033743|NP_001033742|NP_109621|XP_011247623	3790 0	HGNC:10924	91 23	NM_001042422,NM_001206951,NM_001206950,NM_001206952,NM_001042423,NM_004207	XP_011521909,NP_001193880,NP_001193879,NP_004198,NP_001193881,NP_001035888,NP_001035887
Pik3r1	11183;12855;60700;80811	1.1140	0.7990	0.5098	0.8699	0.8666	MGI:975 83	187 08	NM_001024955|XM_006517569|NM_001077495|XM_006517570	NP_001070963|XP_006517633|NP_001020126|XP_006517632	7889	HGNC:8979	52 95	NM_181523,NM_181524,NM_181504,NM_001242466	XP_011541795,NP_852556,NP_852665,NP_001229395,XP_016865074,XP_005248599,NP_852664,XP_016865075
Sos1	11911	1.110	0.518	0.866	0.866	MGI:	206	NM_009231	NP_033257	4117	HGNC	6654	NM_005633	XP_011531366,XP_011531364,NP_005624,XP_	

	;128;3312;3647	23	63	15	93	66	983542				:11187				011531368,XP_005264572
Trps1	1003;1290;4589;7208	1.1182109	0.0.5.1.2.6	0.0.8.6.8.0	0.0.8.6.6.6	MGI:1927616	835	XM_011245777|NM_001310481|NM_032000|NM_001310485|XM_011245780|XM_006521560|XM_006521563|XM_011245776|XM_011245778	XP_011244078|XP_006521623|XP_011244082|NP_001297414|XP_011244079|XP_006521626|XP_011244080|NP_001297410|NP_114389	856	HGNC:12340	72	NM_001282903,NM_014112,NM_001282902,NM_001330599	XP_011515568,XP_011515569,XP_005251106,NP_054831,XP_011515566,XP_016869290,XP_006716688,NP_001269831,NP_001317528,NP_001269832,XP_011515570
Nme3	846;1292;3466;3588	1.1.1.1.0.0	0.0.5.1.3.8	0.0.8.6.6.6	0.0.8.6.6.6	MGI:1930182	790	NM_019730	NP_062704	2056	HGNC:7851	48	NM_002513	XP_011520806,NP_002504,XP_005255389,XP_011520805
Map2k1	416;1298;6225;9366	1.1.0.6.6	0.0.9.6.7.9	0.0.5.1.7.1	0.0.8.6.8.9	0.0.8.6.8.6	MGI:1346866	263	NM_008927|XM_006511196	NP_032953|XP_006511259	2063	HGNC:6840	56	NM_002755	NP_002746,XP_016877901,XP_016877900,XP_011520085,XP_016877902
Mmp2	783;1	1.1.0	0.0.8.5	0.0.5.1	0.0.8.6	MGI:90	173	NM_008610|XM_006530751	NP_032636|XP_006530814	3329	HGNC:	43	NM_001302510,NM_001302509,NM_001127891,NM_001302508,NM_004530	NP_001121363,NP_001289437,NP_001289438,NP_004521,NP_001289439

	3043;4180;42663	53	94	96	86	7009				7166					
Map4k4	57;1306;2219;2732	1.1020	0.9058	0.5216	0.8700	0.8686	MGI:1349394	269211	XM_017321021|XM_006496043|XR_001784729|XM_006496045|XM_017321016|XR_001784730|XM_017321002|XM_006496042|XM_017321018|XM_017321001|XM_017321013|XM_006496041|XM_011238530|XM_017320998|XM_017321011|XM_017321004|NM_001252201|NM_008696|NM_001252202|XM_017320994|XM_006496044|XM_006496046|NM_001252200|XM_017321010	NP_001239129|XP_017176483|XP_017176500|NP_001239130|XP_017176505|XP_017176493|XP_017176507|NP_032722|XP_006496107|NP_001239131|XP_006496104|XP_006496106|XP_017176510|XP_017176487|XP_006496108|XP_017176491|XP_006496105|XP_011236832|XP_006496109|XP_017176502|XP_017176490|XP_017176499	744 2	HGNC:6866	9448	NM_145686,NM_145687,NM_001242559,NM_004834,NM_001242560	XP_016860845,XP_005264116,XP_005264119,XP_006712932,XP_016860851,XP_016860860,XP_016860849,XP_016860852,XP_005264107,XP_006712928,XP_016860848,XP_005264122,XP_005264120,XP_016860841,XP_005264117,XP_016860859,XP_016860850,NP_001229488,XP_016860839,NP_663720,XP_005264126,XP_016860857,XP_005264114,XP_016860854,XP_016860861,XP_016860846,XP_016860855,XP_005264123,NP_001229489,XP_016860864,XP_005264125,NP_004825,XP_016860856,XP_005264109,XP_016860840,XP_005264115,XP_016860844,XP_016860842,XP_016860863,XP_016860862,XP_016860858,XP_016860853,XP_016860838,XP_005264121,XP_005264128,XP_016860847,NP_663719,XP_006712931,XP_016860843,XP_005264105
Trim56	1165;1308;49	1.1009	0.7953	0.5227	0.8686	0.8686	MGI:2685298	384309	NM_201373|XM_011240883|XM_006504441	XP_006504504|NP_958761|XP_011239185	12812	HGNC:19028	8184 4	NM_030961	NP_112223,XP_011514891

	96;8473													
Gpr149	7893;13133;52422;;77344	1.0981	0.8509	0.5257	0.8703	0.8691	MGI:2443628	22935 7	NM_177346|XM_011240076|XM_006501322	XP_006501385|XP_011238378|NP_796320	16359	HGNC:23627	34475 8	NM_001038705	NP_001033794
H2-D1	4133;13155;45299;;74799	1.0970	0.9645	0.5269	0.8691	0.8691	MGI:958966	14964	NM_010380	NP_034510	12835 2	HGNC:49311	3105	NM_002116,NM_001242758	XP_005275388,NP_002107,NP_001229687,XP_016885777
Dusp2	34;13277;37633;;93006	1.0990 3	0.9962	0.5338	0.8772	0.8730	MGI:1019111	13537	NM_010090	NP_034220	3255	HGNC:3068	1844	NM_004418	XP_016859035,NP_004409
Pi4k2a	374;13311;80542;;	1.0881	0.9789	0.5362	0.8779	0.8730	MGI:1934031	84095	XR_877696|XM_011247405|XM_011247406|NM_145501	XP_011245707|XP_011245708|NP_663476	10168 1	HGNC:30031	55361	NM_018425	NP_060895

	9276														
Ifnar1	12929;13333;28722;84133	1.0870	0.0781573	0.0876630	0.0873030	MGI:1076588	15975	NM_010508|XR_384931	NP_034638	524	HGNC:54332	3454	NM_000629	XP_011527854, NP_000620,XP_005261021
Hmgb3	26533;13344;29111;83477	1.0864	0.0845579	0.0874430	0.0873030	MGI:1098219	15354	NM_001293624|XM_006527842|NM_008253|NM_001293623|NM_001293625	NP_001280552|NP_001280554|NP_032279|NP_001280553|XP_006527905	13426	#N/A	#N/A	#N/A	#N/A
Adcy7	67933;13366;55495;79588	1.0853	0.0869330	0.0873030	0.0873030	MGI:1028911	11513	XM_011248281|XR_878769|XM_011248278|NM_001109756|NM_007406|NM_001037723|XM_006530580|XM_011248277|XM_011248282|XM_011248280|NM_001037724|XM_011248279|XR_878770|XM_011248283	XP_006530643|XP_011246579|XP_011246583|XP_011246580|NP_001032812|NP_001032813|XP_011246585|NP_031432|XP_011246582|NP_001103226|XP_011246581|XP_011246584	866	HGNC:238	113	NM_001286057, NM_001114	XP_011521140, XP_011521142, XP_016878386, XP_016878388, XP_016878387, NP_001272986, XP_011521144, XP_011521141, XP_016878384, XP_016878385, XP_011521137, XP_011521138, NP_001105,XP_011521139
Park7	12307;13488;53865;5	1.0778	0.0773	0.0546315	0.0879330	MGI:2135637	57320	NM_020569	NP_065594	38295	HGNC:16369	11315	NM_001123377, NM_007262	NP_001116849, NP_009193,XP_005263481

Gas1	92178613499;198703	1.078316	0841668	0.0879333	0.087933	MGI:95655	144511	NM_008086	NP_032112	1548	HGNC:41655	26199	NM_002048	NP_002039
Xrn1	467;13549;519520892	1.075569	0.0930999	0.0548810	0.088100	MGI:891964	24127	XM_006511156|NM_011916|NM_001311130|XM_006511154|XR_001778898|XM_011242743|XM_006511155	NP_001298059|NP_036046|XP_006511219|XP_006511217|XP_011241045|XP_006511218	5894	HGNC:30654	54644	NM_001282859,NM_019001,NM_001282857,NM_001042604	XP_011511224,XP_011511221,NP_001269786,XP_016862131,NP_001269788,XP_006713736,XP_016862129,XP_011511222,NP_061874,XP_016862130
Pp1r2	6403;13663;68833;;72144	1.069113	0.0871713	0.0558971	0.088480	MGI:1914099	66849	NM_025800	NP_080076	4546	HGNC:92888	55044	NM_006241,NM_001291504,NM_001316325,NM_001291505	NP_001278434,XP_006713745,NP_006232,NP_001303254,NP_001278433
Cd248	11288;13688;;31781;;71	1.068811	0.0783112	0.0558820	0.088800	MGI:1917695	70445	NM_054042	NP_473383	10699	HGNC:18219	57124	NM_020404	NP_065137

	86														
Ppp21r51c	12.1067588813;1952866637;3472;3415;5478	1	0	0	0	0	MGI:1134947517	26991	XM_006515919|XM_017315083|XM_017315084|XM_006515922|NM_001135001|XM_017315081|XM_006515921|NM_001081457|NM_012023|XM_017315086|XM_006515923|XM_006515918|XM_006515924|XM_017315085|NM_001081458|XM_006515920|XM_017315082|XM_006515917	XP_017170571|NP_001074927|XP_017170573|XP_006515987|XP_006515982|XP_006515981|NP_001128473|XP_017170570|XP_017170574|XP_017170575|XP_006515983|XP_017170572|XP_006515985|XP_006515986|XP_006515980|XP_006515984|NP_001074926|NP_036153	12865	#N/A	#N/A	#N/A	#N/A
	78														
Sipa1l1	21.5067;1125478;3541;7593	1	1	0	0	0	MGI:2432	17692	XM_011244069|XM_011244067|XM_017315029|XM_011244060|XM_011244066|XM_011244064|XM_011244062|XM_017315027|XM_017315026|XM_011244063|XM_011244068|XM_017315028|NM_001167983|XM_006515684|NM_172579|XM_017315025|XM_011244061	XP_011242370|XP_011242362|XP_017170515|XP_017170517|XP_011242363|XP_017170516|XP_011242366|XP_011242365|NP_766167|XP_011242369|NP_001161455|XP_011242364|XP_017170514|XP_011242371|XP_006515747|XP_017170518|XP_011242368	91820:284	HGNC:26037	NM_015556,NM_001284245,NM_001284246,NM_001284247	XP_016876668,XP_016876686,XP_011534937,XP_011534934,XP_016876682,XP_016876675,XP_016876650,XP_016876688,XP_016876659,XP_016876658,XP_016876669,XP_016876649,NP_001271174,XP_016876681,XP_016876680,XP_016876672,NP_056371,XP_011534933,XP_016876671,XP_016876651,XP_016876654,XP_016876683,XP_016876673,XP_016876656,XP_016876648,XP_016876687,XP_016876676,XP_011534940,XP_016876661,XP_016876665,XP_016876679,XP_016876662,NP_001271175,XP_016876670,XP_016876653,XP_016876660,XP_016876663,XP_016876667,NP_001271176,XP_016876689,XP_016876657,XP_006720174,XP_016876666,XP_016876674,XP_011534932,XP_016876685,XP_016876652,XP_016876678,XP_016876677,XP_016876664,XP_005267573,XP_016876684,XP_016876655

Tmem150a	84;1379;3954;9251	10.0822.1822	0.5648	0.8890	0.8890	MGI:2385244	2320	NM_144916	NP_659165	16378	HGNC:24677	129	NM_001031738, NM_153342	NP_001026908, XP_011530809, XP_016858796, XP_016858794, XP_011530810, XP_006711995, XP_006711993, XP_006711994, XP_016858795, XP_011530807
Eps15	1024;1389;3558;5150	10.0570.8	0.5708	0.8953	0.8932	MGI:1045833	1358	NM_007943|XM_006502739|NM_001159964|XM_017319956|XM_006502738|XM_006502740	NP_031969|XP_006502802|XP_006502803|XP_006502801|NP_001153436|XP_017175445	12835	HGNC:34199	206	NM_001981,NM_001159969	XP_016856106, NP_001972,XP_016856107,NP_001153441,XP_005270675,XP_016856104,XP_016856108,XP_016856105,XP_016856109
Ankle2	1121;1390;4020;4551	10.0564	0.5715	0.8932	0.8932	MGI:1261856	7178	NM_001253814|NM_027922	NP_001240743|NP_082198	35424	HGNC:29101	231	NM_015114	XP_005266217, XP_005266216, XP_011533089, XP_006719798, XP_016874565, NP_055929,XP_011533090
Evc	1304;1395;6666;8742	10.0538	0.5745	0.8948	0.8948	MGI:1890596	5056	XM_017321049|XR_868290|NM_021292|XR_376820|XM_006504042|XM_011240761|XM_006504043	XP_006504106|XP_011239063|XP_017176538|XP_006504105|NP_067267	10949	HGNC:34977	2121	NM_001306090, NM_014556,NM_153717,NM_001306092	NP_001293021, XP_006713928, XP_006713929, XP_011511721, NP_714928,NP_001293019,XP_016863372

42449	3863;14033;42811;48100	1.0497	0.95377	0.57943	0.89933	0.8993	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Ulk3	3443;14116;25063;48366	1.0456	0.97443	0.58445	0.90441	0.9041	MGI:1918992	717422	XR_379457|XR_001779013|XR_870766|XR_379456|XR_379459|XR_379458|NM_027895|XR_870767|XR_001779012	NP_082171	6842	HGNC:19703	2589	NM_001099436, NM_001284365, NM_001284364	XP_016877561, XP_016877560, XP_016877559, XP_005254346, XP_016877558, NP_001092906, NP_001271294, XP_016877557, NP_001271293
Dusp3	5553;14200;35166;75566	1.0410	0.88202	0.59009	0.90940	0.9080	MGI:1919599	72349	NM_028207|XM_006534305|XM_006534306	XP_006534369|NP_082483|XP_006534368	20870	HGNC:30699	1845	NM_004090	NP_004081
Mphosph9	6503;14222;31333;88344	1.0400	0.85401	0.59013	0.90833	0.9080	MGI:2443138	269702	NR_102690|NM_001277867|XM_006530362|XM_011248205|XM_011248206|XM_011248207|XM_006530361|NM_001081323|XR_001784704|XM_006530366|XM_006530365|XM_006530364|XR_878687	XP_006530429|NP_001264796|XP_006530428|NP_001074792|XP_006530427|XP_011246508|XP_006530425|XP_011246509|XP_006530424|XP_011246507	11256	HGNC:7215	1098	NM_022782	XP_016874162, XP_016874169, XP_016874165, XP_016874166, XP_016874167, XP_011536042, XP_016874163, XP_011536043, XP_016874164, NP_073619,XP_016874168,XP_016874170
H2-44	446	1.09	0.95	0.99	MGI	1449	NM_013543	NP_038571	5665	HGN	79	NM_014234	NP_055049		

Ke6	;14255;30122;44955	384	208	9310	0800	:9591 1	79				88	C:3554	23		
Inpp11	445;14292;28047;31288	1.039364	092026	0059056	0090866	MGI:1337887	163 32	NM_010567|NM_001122739|XM_017321991|XM_011241682|XM_006507392|XR_378218|XM_006507391	NP_001116211|XP_006507454|XP_006507455|XP_017177480|NP_034697|XP_011239984	1204	HGNC:6080	3636	NM_001567	XP_011543301, XP_016873162, NP_001558,XP_005274036,XP_005274035,XP_011543302
Dlgap5	235;14377;55788;70644	1.032445	1042507	0060102	0090900	MGI:2183453	2189 77	XM_006518834|XM_006518833|XM_006518835|NM_144553	NP_653136|XP_006518896|XP_006518897|XP_006518898	8840	HGNC:16864	9787	NM_001146015, NM_014750	NP_001139487, XP_016877329, NP_055565
Pls cr1	502;14399;26322;34700	1.038955	0601900	0090900	MGI:893575	2203 8	NM_011636|XM_006511052	NP_035766|XP_006511115	4141 8	HGNC:9092	5359	NM_021105	XP_016862117, XP_011511209, XP_011511206, XP_005247595, XP_011511207, NP_066928,XP_011511208,XP_016862118	
Trad	883;14	1.020042	0794264	0617277	0914343	MGI:109	7160 9	XM_134502	NP_001028333	2807	HGNC:1	8717	NM_153425,NM_001323552,NM_003789	XP_005256270, NP_001310481, NP_003780,XP_016879304

	62;29753;31433					9200					2030				
Npc1	12541;14633;62866;77800	10.0193	107453	06171	09256	0914	MGI:1097712	1845	XM_017317849|NM_008720	NP_032746|XP_017173338	228	HGNC:7897	4864	NM_000271	XP_005258336, XP_006722542, XP_016881275, XP_016881274, XP_005258334, XP_016881276, XP_005258335, NP_000262,XP_016881273,XP_011524317
Sspn	4931;14643;30955;81115	10.0190	108926	06178	09236	0914	MGI:1353511	1651	NM_010656|XM_006506916|NM_001310837	XP_006506979|NP_034786|NP_001297766	3727	HGNC:11322	8082	NM_005086,NM_001135823	XP_011519156, XP_011519155, NP_005077,NP_001129295,XP_011519157
Plgrkt	10991;14662;45620;66500	10.0180	107616	06191	09225	0914	MGI:1915009	6775 9	XM_017318284|NM_026362|XM_017318287|XM_017318285|XM_011247325|XM_011247326|XM_017318283|XM_017318286	XP_017173774|XP_017173773|XP_017173776|XP_011245627|NP_080638|XP_017173772|XP_011245628|XP_017173775	10213	HGNC:23633	5584 8	NM_018465	XP_011516262, XP_005251569, XP_005251567, NP_060935
Ncl	485;146	10.0175	108949	06198	09205	0914	MGI:9722	1795	XM_006529238|NM_010880	NP_035010|XP_006529301	13648	HGNC:76	4691	NM_005381	NP_005372

	7;4958;9431					86					67				
Atpif1	93;14772;619473;627	10.0.0.0.0.0 1078362309211433	MGI:1196457	119	NM_007512	NP_031538	405811	HGNC:8711	93974	NM_016311,NM_178191,NM_178190	NP_835498,NP_835497,NP_057395				
Psmd10	137;14744;492373;764	10.0.0.0.0.0 1073162439211433	MGI:1858898	5380	NM_016883|NM_001164177	NP_058579|NP_001157649	945177	HGNC:9555	5716	NM_170750,NM_002814	NP_002805,NP_736606				
Sharpin	1346;14753;34589;441919	10.0.0.0.0.0 1073134062509043	MGI:1913331	1025	NM_025340|XR_383966|XM_011245399|XM_011245398|XM_006520263	XP_006520326|XP_011243701|NP_079616|XP_011243700	11918	HGNC:25321	8185	NM_030974	XP_016869377,XP_016869376,NP_112236				
Agpat3	53;14777	10.0.0.0.0.0 1087462678343	MGI:1336	289	XM_006513718|XM_006513723|XM_006513720|XM_006513716|XM_006513717|NM_053014|XM_006513719|XM	NP_443747|XP_006513781|XP_006513786|XP_006513785|XP_006513780|XP_006513783|XP_006513784|XP_	10591	HGNC:326	5689	NM_020132,NM_001037553	XP_016883899,XP_005261217,XP_016883900,XP_011527966,XP_016883898,XP_006724093,XP_016883902,XP_011527965,				

	;235061					186	_006513721|XM_006513722	006513782|XP_006513779					XP_016883897, XP_011527963, XP_006724092, XP_016883903, NP_001032642, XP_006724094, XP_011527967, XP_011527964, XP_011527962, NP_064517,XP_016883901
Syt9	269;147;463;922	1.010117	1.005171	0.062775	0.091666	0.091443	MGI:1926373	60510	XR_378262|XM_006508099|NM_021889	XP_006508162|NP_068689	11062	HGNC:19265	143425	NM_175733	XP_011518208, XP_011518209, XP_011518206, XP_011518203, NP_783860,XP_011518202,XP_011518204
Xpr1	113;1485;2093;3788	1.008826	0.075263	0.063112	0.091660	0.091443	MGI:97932	19775	NM_011273	NP_035403	134226	HGNC:12827	92139	NM_001135669, NM_001328662, NM_004736	NP_001315591, NP_001129141, NP_004727
Cfp	119;1488;3295;7863	1.007474	0.074533	0.063320	0.091660	0.091443	MGI:975455	18636	XM_135820	NP_032849	1969	HGNC:8864	51919	NM_001145252, NM_002621	NP_002612,NP_001138724,XP_016885064
Diap1	105;149	1.003506	0.076086	0.063886	0.092083	0.091443	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

	6;32190;58200													
Cep152	37;14988;76188;77960	1.00257	0.0935	0.0639	0.0917	0.0143	MGI:2139083	99100	XM_006500473|XM_017319354|XM_011239871|XR_001783212|XR_001783214|NM_001081091|XR_001783213|XM_006500474|XM_011239870	XP_011238172|XP_017174843|XP_006500536|NP_001074560|XP_011238173|XP_006500537	3715	HGNC:29298	229 5	NM_014985,NM_001194998	NP_001181927,NP_055800,XP_011519681,XP_011519677,XP_011519683,XP_016877503,XP_006720500,XP_016877504,XP_011519676,XP_011519675,XP_011519680,XP_016877505
Rap2b	5513;15022;72078;90866	1.00734	0.0864	0.0627	0.0920	0.0143	MGI:1921262	74012	NM_028712	NP_082988	5570 1	HGNC:9862	5912	NM_002886	NP_002877
Tnfrsf1a	769;15044;63321;71155	0.99957	0.0805	0.0643	0.0919	0.0143	MGI:1314884	21937	NM_011609	NP_035739	828	HGNC:11916	713 2	NM_001346091,NM_001065,NM_001346092	NP_001333020,NP_001333021,NP_001056
Ankrd13a	1844;15053;7	0.99393	0.0756	0.0646	0.0917	0.0143	MGI:1915156	68420	NM_026718|XM_006530454	NP_080994|XP_006530517	23814	HGNC:21268	884 55	NM_033121	XP_016875650,XP_016875652,XP_005254037,XP_005254038,XP_016875646,XP_005254041,XP_016875647,XP_016875648,XP_005254039,NP_149112,XP_

	628;879					70								011537239,XP_016875651,XP_016875649,XP_011537240
Ippk	3061;15092;23522;75252	0.99745	0.97255	0.64713	0.91843	0.91443	MGI:1922928	7567 8	NR_075085|XM_017315628|XR_001780827|NM_001276399|NM_199056	XP_017171117|NP_001263328|NP_951011	4149 5	HGNC:14645	6476 8	NM_022755	NP_073592,XP_016870530
Ppp2r3c	1391;15102;24611;76988	0.99689	0.11324	0.64788	0.91633	0.91443	MGI:1930009	5903 2	NM_021529|XR_381536	NP_067504	9915	HGNC:17485	5501 2	NM_001305155, NM_001305156, NM_017917	XP_016876878, NP_001292085, NP_001292084, XP_016876877, NP_060387,XP_005267839
Mapk6	4411;15111;63999;73000	0.99641	0.99019	0.64844	0.91443	0.91443	MGI:1354946	5077 2	NM_027418|NM_015806|XM_011242767	NP_081694|XP_011241069|NP_056621	5568 3	HGNC:6879	5597	NM_002748	NP_002739,XP_005254595,XP_011520084,XP_005254596,XP_005254594
Hacd3	1022;15144;58000	0.99501	0.97601	0.65044	0.91443	0.91443	MGI:1889341	5787 4	XR_001778950|NM_021345	NP_067320	9494	HGNC:24175	5149 5	NM_016395	XP_011519966, NP_057479

	6;7293														
Atrnl1	52;1524;4162;8391	0.0986570	0.0865707	0.0652070	0.0920796	0.0916796	MGI:2147749	225	XM_006527051|XM_006527049|XM_006527052|XM_006527053|NM_181415|XR_001782587|XM_011247244	XP_006527112|XP_006527116|XP_011245546|NP_852080|XP_006527114|XP_006527115	458	HGNC:29063	263	NM_207303,NM_001276282	XP_011537891,XP_016871527,NP_001263211,XP_011537893,XP_016871526,XP_011537890,XP_011537889,XP_016871529,NP_997186,XP_011537892,XP_016871525,XP_016871524,XP_016871528
Ppp2r2d	13;1526;4563;5992	0.0982393	0.0725844	0.0651897	0.0919796	0.0919796	MGI:1289252	524	XM_017322351|XM_017322352|NM_001347618|XM_006508019|XM_017322350|XM_006508016|XM_006508015|XM_006508020|NM_026391	XP_017177840|NP_001334547|XP_006508079|NP_080667|XP_006508083|XP_017177841|XP_006508078|XP_006508082|XP_017177839	819	HGNC:23732	554	NM_018461,NM_001291310,NM_001003656	XP_016871895,XP_016871897,NP_060931,XP_006717977,XP_016871896,XP_006717978,NP_001278239
Gjc1	81;1534;5950;7774	0.0985007	0.0796039	0.0662457	0.0919796	0.0919796	MGI:957718	146	XM_006532226|NM_008122|NM_001159383|XM_006532227|XM_011248736|NM_001159382	NP_032148|XP_006532289|NP_001152855|NP_001152854|XP_011247038|XP_006532290	401	HGNC:4280	105	NM_001080383,NM_005497	NP_005488,XP_005256978,XP_005256977,NP_001073852
Tbcd	67;1536;2793;	0.0984813	0.0821532	0.0662434	0.0919796	0.0919796	MGI:1919686	108	XR_388323|XM_006531974|XR_879503|XM_017314220|XR_879504|XM_006531973|NM_029878|XR_001779860|XR_001779861|XR_001779859|XM_006531971|XM_006531975	XP_006532036|NP_084154|XP_017169709|XP_006532038|XP_006532034|XP_006532037	436	HGNC:11581	690	NM_001033052,NM_005993	XP_005256461,XP_016880479,XP_016880478,XP_005256453,XP_006722353,XP_011521896,XP_005256456,XP_011521901,XP_011521895,XP_011521902,XP_011521900,XP_011521891,XP_011521892,NP_005984,XP_

	8082													016880476,XP_006722354,XP_016880477,XP_006722355,XP_011521899,XP_011521893,XP_011521897
Fez1	33;1547;3452;;5634	0.97983	0.94833	0.67207	0.93097	0.9196	MGI:2670976	2351180	XM_017313312|XM_006510227|NM_183171|XM_006510229|XM_017313313|XM_006510228	XP_006510292|XP_017168801|NP_898994|XP_006510291|XP_017168802|XP_006510290	2106 3	HGNC:36599	9638	NM_005103,NM_022549	NP_005094,NP_072043,XP_005271791,XP_005271792
Mif	1073;1550;8085;8630	0.97844	0.97450	0.67466	0.93096	0.9196	MGI:969822	17319	NM_010798	NP_034928	55655	HGNC:7097	4282	NM_002415	NP_002406
S100a13	692;1553;4871;;6230	0.97700	0.81200	0.67666	0.93096	0.9196	MGI:1095811	20196	NM_009113|XM_011240046	XP_011238348|NP_033139	7523	HGNC:10490	6284	NM_001024210,NM_001024213,NM_005979,NM_001024211,NM_001024212	XP_005245491,XP_016857524,NP_001019383,XP_016857525,NP_001019384,NP_001019381,XP_016857523,XP_011508165,NP_005970,XP_011508164,NP_001019382,XP_011508166
Bcl2	15;1555;6552	0.97611	1.0.0944	0.67779	0.92996	0.9196	MGI:881438	12043	NM_177410|NM_009741	NP_803129|NP_033871	527	HGNC:990	5996	NM_000657,NM_000633	NP_000648,NP_000624,XP_011524437,XP_016881406

	;8145													
Tk2	170;1557;40080;52600	0.9752	0.1079798	0.0679393	0.0928686	0.0919696	MGI:1913266	578113	NM_021028|XM_011248461|XM_006531233|XM_006531235|XM_006531234|NR_045642|XM_017312925	XP_017168414|XP_006531296|XP_006531297|NP_066356|XP_006531298|XP_011246763	339 2	HGNC:11831	704	NM_001172645, NM_001172643, NM_001272050, NM_001172644, NM_001271935, NM_001271934, NM_004614	NP_001258979, NP_001166115, NP_001258864, NP_001166116, NP_004605,NP_001166114,NP_001258863
Zfp36	49;15600;45911;;82644	0.9738	0.0870479	0.0681486	0.0928686	0.0919696	MGI:991800	226955	NM_011756	NP_035886	2558	HGNC:12862	7538	NM_003407	NP_003398
Rab4b	954;15611;;21887;;40966	0.9734	0.0759393	0.0682121	0.0926767	0.0919696	MGI:1050771	193422	NM_029391	NP_083667	10063 2	HGNC:9782	53916	NM_016154	NP_057238
Psen2	590;15622;;25327;;	0.9729	0.0837373	0.0682848	0.0924949	0.0919696	MGI:1092844	191165	XR_373599|NM_001128605|NM_011183|XM_011238776|XM_006496712	XP_006496775|XP_011237078|NP_001122077|NP_035313	386	HGNC:9509	5664	NM_000447,NM_012486	NP_036618,XP_005273256,NP_000438,XP_016857324,XP_016857325

Mfsd3	44104163;27000;83744	0.9725	0.7463	0.6834	0.9229	0.9196	MGI:1916822	6957	NM_027122	NP_081398	12318	HGNC:25157	113655	NM_138431	XP_011515108, NP_612440,XP_016868494
Ip6k1	14211;15644;37199;45799	0.9720	0.7071	0.6841	0.9211	0.9196	MGI:1351633	2739	NM_013785	NP_038813	56602	HGNC:18360	9807	NM_001242829, NM_153273,NM_001006115	NP_001006115, NP_001229758, NP_695005
Hectd1	76262;15699;67911;93899	0.9698	0.7924	0.6878	0.9205	0.9196	MGI:2384768	2073 04	XM_011244050| XM_011244051| NM_144788|XM_011244049|XM_017315008	XP_011242351| XP_011242352| XP_017170497| XP_011242353| NP_659037	91155	HGNC:20157	25831	NM_015382	XP_016876637, XP_016876640, NP_056197,XP_016876641,XP_011534923,XP_005267559,XP_016876638,XP_011534921,XP_011534924,XP_016876639,XP_016876642
Mapkap1	21919;15711;48119;67	0.9689	0.6850	0.6892	0.9196	0.9196	MGI:2444554	2217743	XM_011239083| NM_177345|XM_017317446|XM_011239085|XM_006497975|XM_006497980|XM_011239084|XM_006497978|XM_017317443|XM_011239082|XM_006497983|NM_001290625|XM_006497982|NM_001290626	XP_011237386| NP_001277555| XP_006498046| XP_011237387| NP_796319|XP_006498045|XP_006498043|NP_001277554|XP_011237385|XP_011237384|XP_017172932|XP_006498041|XP_017172935|XP_006498038	11473	HGNC:18752	791 09	NM_001006620, NM_024117,NM_001006619,NM_001006621,NM_001006617,NM_001006618	XP_016870616, XP_011517309, XP_011517311, XP_011517308, NP_001006618, XP_016870615, NP_001006622, XP_011517307, XP_011517310, NP_001006619, NP_001006621, NP_001006620, XP_011517312, NP_077022

Mapk8ip3	60 13 14; 15 76; 49 35; ; 84 32	0 . 9 6 6 6	0 . 7 1 3 2	0 . 6 9 2 6	0 . 9 2 1 4	0 . 9 2 0 4	MGI:1353598	309 57	NM_001163447|NM_001163448|NM_001163449|NM_013931|NM_001163450|NM_001163453|NM_001163451	NP_001156921|NP_001156922|NP_038959|NP_001156923|NP_001156920|NP_001156925|NP_001156919	227 90	HGNC:6884	23 16 2	NM_015133,NM_001040439,NM_001318852	NP_001035529,NP_055948,XP_005255247,NP_001305781,XP_011520734,XP_011520731,XP_011520735,XP_011520733,XP_016878570,XP_016878569,XP_011520732,XP_006720932,XP_016878568
Hatip2	10 59 ; 15 78 ; 22 23 ; 72 89	0 . 9 6 5 7	0 . 7 4 0 5	0 . 6 9 3 9	0 . 9 2 0 4	0 . 9 2 0 4	MGI:1859271	53 41 5	NM_001146050|NM_016865|NM_001146052|NM_001146049|XM_006540989|XM_006540992|XM_006540988|XM_006540990|XM_006540991|NM_001146053	NP_001139521|XP_006541052|NP_001139524|NP_001139522|XP_006541055|NP_001139525|XP_006541051|XP_006541054|XP_006541053|NP_058561	467 6	HGNC:16637	1 0 5 3	NM_001098521,NM_001098520,NM_001098522,NM_001098523,NM_006410	NP_006401,NP_001091993,NP_001091992,NP_001091990,NP_001091991
Aplp2	15 19 ; 15 92 ; 28 64 ; 46 56	0 . 9 5 9 5	0 . 6 9 4 0	0 . 7 0 3 9	0 . 9 3 0 9	0 . 9 3 0 9	MGI:1880447	11 80 4	NM_001102456|NM_001102455|XM_006509951|NM_009691|XM_006509952	XP_006510015|NP_001095925|NP_033821|NP_001095926|XP_006510014	203 96	HGNC:598	33 34	NM_001328685,NM_001328682,NM_001142276,NM_001243299,NM_001142278,NM_001328684,NM_001642,NM_001142277,NM_001328686	NP_001315615,NP_001135750,NP_001230228,NP_001135748,NP_001315613,NP_001135749,NP_001315614,NP_001315611,NP_001633
Amigo2	28 5 ; 15 97 ; 76 91 ; 87	0 . 9 5 7 3	0 . 9 6 6 5	0 . 7 0 7 3	0 . 9 3 2 7	0 . 9 3 2 7	MGI:2145995	10 58 27	NM_178114|NM_001164563|NM_001164602	NP_001158035|NP_835215|NP_001158074	186 49	HGNC:240773	34 79 02	NM_001143668,NM_181847	XP_005268894,NP_001137140,NP_862830

Limk1	41256;16001;66377;93466	0.9556	0.9870	0.7102	0.9337	0.9337	MGI:1045722	1685	XM_006504396|NM_010717|NM_001305875|NR_131247	NP_001292804|XP_006504459|NP_034847	1738	HGNC:6613	3984	NM_001204426,NM_002314,NM_016735	NP_002305,NP_001191355
Dagla	38816;75111;89244	0.9516	0.9037	0.7165	0.9393	0.9388	MGI:2677061	2690	NM_198114|XM_017318213|XM_006527114	NP_932782|XP_017173702|XP_006527177	4468	HGNC:11165	7447	NM_006133	NP_006124,XP_016873729,XP_016873728,XP_016873727
Polr3f	37;16155;21833;86511	0.9495	0.1389	0.7202	0.9413	0.9388	MGI:1924086	7040	NM_029763	NP_084039	4722	HGNC:15763	10621	NM_001282526,NM_006466	XP_011527443,NP_006457,NP_001269455,XP_016883085
Ppme1	539;16161;45699;56644	0.9490	0.8415	0.7209	0.9394	0.9388	MGI:1919840	7250	NM_028292	NP_082568	6099	HGNC:30178	51400	NM_001271593,NM_016147	NP_057231,XP_016873402,NP_001258522

Ikbke	10;11;16;21;38;81;132	0.9469	0.7376	0.7242	0.9411	0.9388	MGI:1929612	5648	XM_006529762|XM_011248052|XM_006529764|XM_017321843|XR_387186|XM_006529763|NM_019777	XP_006529826|XP_006529827|XP_017177332|NP_062751|XP_006529825|XP_011246354	2316	HGNC:14552	9641	NM_001193322,NM_001193321,NM_014002	NP_001180250,NP_001180251,NP_054721,XP_016858357,XP_005273413
Grn	69;162;8;442;1;885;6	0.9439	0.7956	0.7290	0.9445	0.9388	MGI:958332	14824	NM_008175	NP_032201	1577	HGNC:46001	2896	NM_002087,NM_001012479	NP_002078,XP_005257310
Rabepk	23;163;0;567;948;4	0.9430	1.0030	0.7304	0.9436	0.9388	MGI:2139530	22746	XM_006497985|XM_006497987|NM_145522|XM_006497986|XM_006497989|XM_006497988|XM_006497984|XM_017317453	XP_017172942|XP_006498051|XP_006498047|NP_663497|XP_006498052|XP_006498048|XP_006498050|XP_006498049	4872	HGNC:16896	1024	NM_001174152,NM_005833,NM_001174153	XP_016869667,XP_005251701,XP_011516422,XP_005251699,XP_005251698,NP_001167624,NP_001167623,XP_016869669,NP_005824,XP_016869666,XP_005251697,XP_016869671,XP_016869668,XP_016869670,XP_016869672
Bag5	14;90;163;8;823;;948;3	0.9396	0.6860	0.7366	0.9481	0.9388	MGI:1917619	7036	XM_127149|XM_006516217|NM_001324480|NM_001324481|XM_017315180|NM_001324482	NP_001311410|XP_006516280|NP_001311409|NP_081680|XP_017170669|NP_001311411	3584	HGNC:941	9529	NM_004873,NM_001015048,NM_001015049	NP_001015048,NP_001015049,NP_004864

Twist1	38;163;5048;96488	0.939899	0.897367	0.946338	0.938	MGI:98872	221160	NM_011658	NP_035788	402	HGNC:12428	7291	NM_000474	XP_011513798, NP_000465
Zfp622	87;1641;4516;50788	0.938383	0.120147	0.738227	0.945455	0.938	MGI:1289282	52521	NM_144523	NP_653106	74377	HGNC:30958	90441	NM_033414	NP_219482
B3galt3	128;1642;4485;74522	0.937379	0.970193	0.739038	0.943888	0.938	MGI:1919977	727	NM_024256	NP_077218	56554	HGNC:9223	2629	NM_001288721, NM_001288723, NM_001288722, NM_012200	NP_001275652, NP_001275651, NP_036332,NP_001275650
Ptpn3	778;1645;6076;64933	0.936725	0.977250	0.741037	0.943888	0.938	MGI:1053077	5456222	XM_006538097|NM_011207|XM_006538100|XM_006538101|XM_006538099|XM_006538098	XP_006538161|XP_006538164|NP_035337|XP_006538163|XP_006538160|XP_006538162	74451	HGNC:9655	5774	NM_002829,NM_001145369,NM_001145368,NM_001145371,NM_001145370,NM_001145372	XP_006717260, XP_006717267, XP_011517191, NP_001138842, XP_016870445, NP_001138840, NP_001138844, XP_011517190, XP_016870444, XP_016870446, XP_006717266, NP_001138843, NP_002820,XP_006717265,XP_006717264,NP_001138841,XP_006717262
Slc	157	0.96	0.67	0.99	0.9	MGI	269	XM_006499607|XM_006499604|NM_001081162	NP_001074631|XP_006499670|XP_006499667	129	HGN	8339	NM_032034,NM_001174090,NM_001174089	XP_016883586, XP_005260913, XP_011527685,

4a11	3;164;282;3434	3588	7884	4225	4299	3888	:2138987	356				31	C:16438	59		NP_114423,XP_011527686,XP_005260914,XP_016883585,XP_016883582,XP_016883583,NP_001167561,XP_016883584,XP_011527687,NP_001167560
Dab2	766;1649;;807215;8615	0.93502	0.77439	0.79420	0.93888	MGI:1091755	131132	NM_001037905|NM_001310446|NM_023118|NM_001008702|XM_017316424|XM_011245324|NM_001102400	NP_001032994|NP_001008702|XP_011243626|NP_001297375|NP_001095870|XP_017171913|NP_075607	1026	HGNC:2662	160 1	NM_001244871,NM_001343		NP_001231800,NP_001334
Cd74	1607;1652;;2081;;93011	0.93378	0.67458	0.79462	0.93888	MGI:965344	161149	NM_010545|NM_001042605	NP_034675|NP_001036070	3209	HGNC:16977	97 2	NM_001025159,NM_001025158,NM_004355		XP_016865579,NP_004346,XP_016865578,NP_001020329,NP_001020330
Iqgap3	1106;1657;;7011;;70521	0.93165	0.71756	0.74936	0.94388	MGI:3028642	401471 0	NM_001033484|XM_006501643	NP_001028656|XP_006501706	26400	HGNC:20669	12 8 23 9	NM_178229		XP_011507503,XP_016855806,XP_016855807,NP_839943,XP_011507502,XP_011507500
Slc	533	0.98	0.87	0.79	0.99	MGI	527	XM_006521151|NM_029643	XP_006521214|NP_083919	569	HGN	795	NM_001253816,NM_024531,NM_001253815		XP_006716722,XP_006716723,XP_016869309,

52a2	;1658;6437;8327	312	346	502	420	388	:128928	10			94	C:3022 4	81		XP_016869308, XP_011515602, XP_006716721, XP_016869311, NP_078807,NP_ 001240745,XP_ 016869310,NP_ 001240744
Sgip1	194;1663;5339;8392	0.92291	1.0298	0.7538	0.9438	0.9388	MGI:1920344	734	XR_376365|XR_ 376364|XR_376 361|XR_376370| XR_376362|XM_ 017320403|XR_ 376366|NM_001 285860|XM_017 320402|XR_001 784209|XM_006 503427|NM_001 285859|XR_376 363|XR_376360| XR_867892|XM_ 017320404|NM_ 001285852|XR_ 376359|XR_376 369|XR_001784 208|NM_144906 |XM_017320401| NM_001285862| XR_376368|XR_ 001784206|XR_ 001784207|XM_ 006503429|XM_ 006503428|XM_ 017320400|XM_ 006503430	NP_001272789| XP_017175891| XP_006503493| XP_017175889| NP_001272788| XP_006503490| XP_017175890| XP_017175893| NP_001272781| XP_006503492| XP_006503491| NP_659155|NP_ 001272791|XP_ 017175892	1300 1	HGNC:2541 2	842 51	NM_001350217, NM_032291,NM _001308203,NM _001350218	XP_016858021, XP_016858016, XP_016858010, XP_016858014, XP_016858002, XP_016858018, XP_006711035, NP_115667,XP_ 005271325,XP_ 016858011,XP_ 016857994,XP_ 016858008,XP_ 016858020,XP_ 016858012,XP_ 016858022,NP_ 001337146,XP_ 016857998,XP_ 006711037,XP_ 006711030,XP_ 011540593,XP_ 006711032,XP_ 006711036,XP_ 016858017,XP_ 016858003,XP_ 016858025,XP_ 016858023,XP_ 016858007,XP_ 016858019,XP_ 011540594,XP_ 006711034,XP_ 016858015,XP_ 011540595,XP_ 016857995,XP_ 005271321,NP_ 001337147,XP_ 016858006,XP_ 016858026,XP_ 006711024,XP_ 016857997,XP_ 016858009,XP_ 016858001,XP_ 016858005,XP_ 016858004,XP_ 006711029,NP_ 001295132,XP_ 016858000,XP_ 016858013,XP_ 005271327,XP_ 016857999,XP_ 016857996,XP_ 016858024
Dusp1	124;1665	0.928 3	0.706	0.755 3	0.943 1	0.938 8	MGI:1051	925 2	NM_013642	NP_038670	325 4	HGNC:3064	184 3	NM_004417	NP_004408

	;3946;7892						20								
Psd3	99.0;16767;2873;7921	0.0.7.9.3.2.7.4	0.0.7.4.2.9.0.9	0.0.5.2.8.7.6.7	0.0.4.2.8.8.2.2	0.0.3.8.9.1.8.1	MGI:1917821	23435	NM_027626|XM_017312706|XM_006509621|NM_177698|XM_017312709|XM_017312711|NM_030263|XM_017312708|XM_006509611|XM_017312710|XM_017312704|XM_011242288|XM_006509619|XM_006509620|XM_017312700|XM_017312703|XM_017312701|XM_017312702|XM_017312707|XM_017312705	XP_017168192|XP_017168200|NP_081902|XP_017168195|XP_011240590|XP_006509674|NP_084539|XP_006509684|XP_017168196|XP_017168198|XP_017168199|NP_808366|XP_017168197|XP_017168189|XP_006509683|XP_006509682|XP_017168194|XP_017168190|XP_017168191|XP_017168193	87.2.5.7	HGNC:19093	23.36.2	NM_206909,NM_015310	XP_011542769,XP_016868747,XP_011542771,XP_011542773,XP_016868748,NP_056125,XP_016868752,XP_011542775,XP_016868750,XP_016868749,NP_996792,XP_016868751,XP_016868754,XP_011542770,XP_016868753
Tlcd1	12.9.2.7.0;16.6.8;70.5.5;9470	0.0.6.9.5.7.0.2	0.0.7.5.7.0.6.5	0.0.9.4.0.8.8.5	0.0.3.8.8.1.5.2	MGI:1915572	63.8.5	NM_001291235|XM_011249203|NM_001291237|NM_001291236|XM_006534054|NM_026708	NP_001278165|NP_001278164|NP_080984|NP_001278166|XP_006534117|XP_011247505	12.26.3	HGNC:25177	11.62.38	NM_138463,NM_001160407	NP_001153879,XP_006721734,XP_011522580,NP_612472
Cdc6	37.8;16.6.9;35.4.9;9770	0.0.9.8.2.6.6.6	0.0.7.5.8.8.8.2	0.0.9.3.8.8.8.8	0.0.3.8.4.5.1.0	MGI:1345150	23.83.4	XM_017314546|XR_001780004|NM_001025779|XM_017314547|XR_879651|NM_011799	NP_001020950|XP_017170036|XP_017170035|NP_035929	68.17.2	HGNC:17444	99.0	NM_001254	XP_011523843,NP_001245,XP_011523844
Akap9	40.1;16.7.2	0.0.1.9.2.5.4.3	0.0.7.8.4.0.4.9	0.0.6.3.0.8.3.9	0.0.3.8.9.2.1.8	MGI:2178	10.98.16	XM_006503521|XM_006503519|XM_017320586|XM_006503523|XM_017320587|NM_194462|XM_006503524|XM_006503518|XM	XP_017176075|XP_006503585|XP_006503582|XP_006503587|XP_006503583|NP_919444|XP_006503581|XP_006503584|XP_	13.4.5.83	#N/A	#N/A	#N/A	#N/A

	;78669;;79233						217	_006503520|XM_006503522|XM_017320588	017176076|XP_006503586|XP_017176077						
Mbd3	15081;16822;29106;;60633	0.92125	0.67567	0.79451	0.94390	MGI:1333812	17192	XM_006513301|NM_001306143|NM_013595|XM_006513303	NP_001293072|XP_006513364|XP_006513366|NP_038623	2917	HGNC:6918	536155	NM_001281453,NM_003926,NM_001281454	NP_001268383,NP_001268382	
Ly96	82416;16833;;25895;;61225	0.92088	0.75544	0.76811	0.94333	0.93390	MGI:1341909	17087	NM_016923|NM_001159711	NP_001153183|NP_058619	9109	HGNC:17156	23643	NM_015364,NM_001195797	NP_056179,NP_001182726,XP_011515810,XP_016868789,XP_016868788
Smarce1	54040;16844;49669;;80155	0.92048	0.82668	0.76889	0.94170	0.93390	MGI:1927347	57376	NM_020618|XM_006533827|XM_011249158|XM_006533828	XP_006533890|XP_006533891|XP_011247460|NP_065643	37727	HGNC:11109	66055	NM_003079	NP_003070
Rab5c	10091;16888;	0.91888	0.72399	0.77118	0.94260	0.93390	MGI:1053062	19345	NM_001305003|NM_024456	NP_001291932|NP_077776	55533	HGNC:9785	58778	NM_201434,NM_004583,NM_001252039	XP_011523392,NP_001238968,NP_004574,NP_958842,XP_011523393

	5142;8180														
Gpi1	4360;16900;19900;65555	0.0.9.1.8.0	0.0.8.6.4.8	0.0.7.7.3.2	0.0.9.4.1.8	0.0.9.3.9.0	MGI:957977	147511	NM_008155	NP_032181	145	HGNC:4458	281	NM_001329909, NM_001289789, NM_001329910, NM_001329911, NM_001289790, NM_000175,NM_001184722	NP_001171651, NP_001276718, XP_005258821, NP_001316838, XP_011525056, XP_006723211, NP_001276719, NP_001316839, NP_000166,NP_001316840
Irf7	1522;16911;37473;46900	0.0.9.1.7.6	0.0.6.7.2.8	0.0.7.7.3.9	0.0.9.4.0.1	0.0.9.3.9.0	MGI:1859212	54123	NM_016850|NM_001252601|XM_006536214|NM_001252600	NP_001239529|NP_001239530|XP_006536277|NP_058546	128624	HGNC:61222	3665	NM_004029,NM_004030,NM_001572,NM_004031	NP_001563,XP_011518368,XP_005252964,NP_004020,XP_005252963,NP_004022,XP_005252966,XP_016873163
Mphosph8	8155;16955;20077;47422	0.0.9.1.5.9	0.0.7.5.4.7	0.0.7.7.7.0	0.0.9.4.1.3	0.0.9.3.9.0	MGI:1922589	753391	XR_383218|XM_006519640|XR_383217|NM_023773	NP_076262|XP_006519703	11380	HGNC:29810	54737	NM_017520	NP_059990,XP_011533426
Cd34	1651;16977;;	0.0.9.1.5.1	0.0.6.6.4.1	0.0.7.7.8.4	0.0.9.4.0.4	0.0.9.3.9.0	MGI:883299	124900	NM_133654|NM_001111059	NP_598415|NP_001104529	1343	HGNC:16622	947	NM_001025109, NM_001773	NP_001020280, NP_001764

	193;857														
Mpl42	217;1699;4002;5437	0.914443	1.044679	0.779937	0.939700	0.939000	MGI:1333774	6727	NM_026065|XM_006513979	XP_006514042|NP_080341	1210	HGNC:14493	2897	NM_172178,NM_172177,NM_014050	NP_751917,NP_054769
Gjb2	119;1702;2464;;5575	0.913120	0.702200	0.782200	0.939700	0.939000	MGI:957200	1469	NM_008125	NP_032151	2975	HGNC:4284	2706	NM_004004	XP_011533351,NP_003995
Antxr1	345;1706;3057;;96822	0.911515	0.910622	0.784906	0.940600	0.939000	MGI:1916788	6958	NM_054041|XM_006506564	NP_473382|XP_006506627	1297	HGNC:21014	8416	NM_032208,NM_018153,NM_053034	NP_444262,NP_060623,XP_016860566,XP_016860564,NP_115584,XP_016860565
Maea	684;1707;876	0.911110	0.781056	0.793900	0.939000	0.939000	MGI:1891748	5903	XM_006504041|NM_021500	XP_006504104|NP_067475	4298	HGNC:13731	1029	6	NM_001297432,NM_001017405,NM_005882,NM_001297431,NM_001297433,NM_001297430	NP_005873,NP_001284361,XP_016863126,XP_006713912,XP_006713913,NP_001284362,XP_011511679,XP_011511678,NP_001284360,XP_016863125,NP_001284359,NP_001017405

	6;9711														
Pdpk1	14480;17105313;80466	0.0907991	0.0674178	0.0793911	0.0939111	MGI:1338068	186077	XM_017317320|XM_017317323|NM_001286662|NM_011062|XM_017317327|XM_017317325|NM_001080773|XM_017317321|XM_017317324|XM_017317322|XM_017317326	XP_017172815|XP_017172809|NP_001074242|NP_035192|XP_017172816|NP_001273591|XP_017172813|XP_017172810|XP_017172811|XP_017172812|XP_017172814	37643	HGNC:8816	517070	NM_031268,NM_002613,NM_001261816	XP_016878765,XP_016878761,NP_112558,XP_016878766,XP_011520823,NP_001248745,XP_016878764,XP_016878760,XP_011520825,XP_016878763,NP_002604,XP_016878762
Hmgcs1	13037;17209;92904;98444	0.0905959	0.0683955	0.0794557	0.0943433	MGI:1075922	208715	XM_006517578|NM_001291439|NM_145942	XP_006517641|NP_001278368|NP_666054	1609	HGNC:5007	315757	NM_002130,NM_001324222,NM_001324223,NM_001098272,NM_001324224,NM_001324219,NM_001330663,NM_001324220	NP_001311152,NP_001311151,NP_002121,NP_001091742,NP_001311148,XP_011512338,XP_016864901,NP_001317592,NP_001311153,NP_001311149
Pim2	37121;17211;48022;68866	0.0905552	0.0889622	0.0794413	0.0943433	MGI:975887	187155	NM_138606	NP_613072	17098	HGNC:8987	1104040	NM_006875	NP_006866
Cyld	67623;17223;82222	0.0904787	0.0797733	0.0794333	0.0943433	MGI:1921506	74256	XM_006531416|XM_006531414|XM_006531419|XM_006531420|XM_011248524|NM_001276279|NM_001128170|XM_006531417|XM_011248523|NM_001128171|XM_006531415|XM_006531418|NM_173369|XM	XP_006531480|XP_006531481|XP_011246827|XP_011246826|XP_006531479|XP_006531477|NP_001121643|NP_775545|XP_006531478|XP_006531482|NP_001121642|XP_011246825|NP_001263208|XP_	90699	HGNC:25844	1540	NM_001042355,NM_015247,NM_001042412	XP_016878466,NP_001035877,XP_005255869,XP_016878470,XP_016878469,XP_016878468,NP_001035814,NP_056062,XP_011521213,XP_006721212,XP_011521209,XP_016878467,XP_011521210

	;98173								_011248525|XM_017312989	006531483|XP_017168478				
Cops	248;17277;44043;86233	0.903171	0.967108	0.804454	0.943433	MGI:1913673	664233	XM_006508848|NM_025556|XM_011242070	XP_006508911|NP_079832|XP_011240372	10180	HGNC:28848	5535 2	NM_001330176, NM_018405	NP_060875,NP_001317105,XP_005258057
Rnf135	201;17733;46035;57011	0.900783	0.100852	0.804722	0.943433	MGI:1919206	719561	NM_028019	NP_082295	12427	HGNC:211158	8428 2	NM_001184992, NM_032322,NM_197939	NP_922921,NP_115698,XP_005258100,XP_016880712,NP_001171921
Nme7	1224;17366;42699;44099	0.898955	0.683074	0.804733	0.943433	MGI:2449121	1715671	XM_006496692|NM_138314|NM_178071|NM_001293313|XM_006496693	XP_006496755|NP_835172|NP_001280242|NP_612187|XP_006496756	8344	HGNC:204611	2992 2	NM_197972,NM_013330	NP_932076,XP_016856588,NP_037462,XP_005245163,XP_016856589
Tnfrsf23	532;17377;19777;7	0.899 2	0.881 89	0.808 11	0.943 3	MGI:1930269	792011	NM_001308111|XM_006508661|NR_131763|NM_024290|XM_006508660	XP_006508724|XP_006508723|NP_001295040|NP_077252	#N/A	#N/A	#N/A	#N/A	#N/A

	5 3 5														
Lpar1	13581738;42098737	0.089885	0.067585	0.089441	0.094433	0.094433	MGI:1084299	145	XM_011249930|XM_011249929|XM_011249935|XM_011249931|NM_172989|XM_011249928|NM_010336|NM_001290486|XM_011249934|XM_011249933|XM_011249932	XP_011248233|NP_034466|XP_011248235|XP_011248234|XP_011248237|NP_766577|XP_011248232|XP_011248236|NP_001277415|XP_011248230|XP_011248231	107 2	HGNC:3166	190 2	NM_001351409,NM_001351414,NM_001351403,NM_001351412,NM_001351402,NM_001351397,NM_001351415,NM_001351416,NM_001351404,NM_001351408,NM_001401,NM_001351398,NM_001351417,NM_001351405,NM_001351419,NM_001351418,NM_001351420,NM_001351413,NM_001351400,NM_001351407,NM_001351406,NM_001351401,NM_057159,NM_001351411,NM_001351410,NM_001351399	NP_001338342,NP_001338326,XP_016869888,XP_016869876,NP_001338332,XP_016869881,NP_001338340,NP_001338338,XP_016869892,NP_001338336,NP_001338347,XP_016869886,NP_001338346,XP_016869877,NP_001338341,XP_016869890,NP_001338331,XP_016869887,NP_001338327,NP_001338334,XP_016869878,NP_001338335,NP_001338337,NP_001338328,XP_016869873,NP_476500,XP_005251838,XP_016869889,NP_001338333,NP_001338348,XP_016869874,NP_001338345,XP_016869893,NP_001338343,NP_001338339,NP_001392,XP_016869885,XP_005251839,XP_016869896,NP_001338349,XP_016869895,XP_016869883,XP_016869894,XP_016869882,XP_016869880,NP_001338330,XP_016869884,XP_016869879,NP_001338344,XP_016869872,XP_016869891,NP_001338329,XP_016869875
Tgfbr3	16313;17400;;79733;95544	0.089880	0.065606	0.081003	0.094333	0.094333	MGI:1046367	214	NM_011578	NP_035708	243 6	HGNC:11774	704 9	NM_001195683,NM_001195684,NM_003243	XP_006710931,NP_001182613,NP_001182612,XP_006710930,NP_003234

Tfg	70;1743;2770;43811	0.8967	0.8926	0.8126	0.9434	0.9434	MGI:133804	2177	XM_006521980|XM_006521983|XM_006521981	XP_006522043|NP_001239372|NP_062652|XP_006522044|XP_006522045|XP_006522046	4426	HGNC:11758	103412	NM_006070,NM_001195479,NM_001007565,NM_001195478	XP_011510636,XP_006713535,NP_006061,XP_005247123,XP_016861016,NP_001182407,XP_016861017,NP_001182408,NP_001007566,XP_016861019,XP_016861018,XP_006713536
Rpap2	14689;17522;49411;94288	0.8963	0.8614	0.8493	0.9441	0.9441	MGI:2141142	2315711	NM_001163461|NM_001289570|XM_006534897|NM_001289569|XM_006534902|NM_144911|XM_011249440|XM_006534901|XM_006534903|NM_001163462|XM_006534900	NP_001276498|NP_001156934|XP_006534963|NP_001276499|XP_006534965|XP_006534966|XP_006534960|XP_011247742|XP_006534964|NP_001156933|NP_659160	11733	HGNC:25791	798711	NM_024813	XP_011540469,XP_016857852,XP_016857853,NP_079089,XP_016857851,XP_005271280
Scyl3	15981;17543;29022;56777	0.8925	0.8650	0.8208	0.9440	0.9441	MGI:1921385	2401808	XM_006496849|XM_006496845|NM_001286002|XM_017320572|XM_006496847|XM_006496846|NM_001286003|NM_028776	XP_006496912|XP_006496910|NP_001272932|XP_006496908|XP_006496909|XP_017176061|NP_083052|NP_001272931	10706	HGNC:19285	571447	NM_181093,NM_020423	NP_851607,XP_006711528,XP_016857351,XP_016857352,NP_065156,XP_011508103,XP_016857353,XP_016857354,XP_011508105,XP_011508104
Mob1b	90475;17557;52077;62433	0.8913	0.8726	0.8230	0.9448	0.9441	MGI:1915723	6847	XM_284098	NP_081011	61676	HGNC:29801	925597	NM_001244767,NM_173468,NM_001244766	XP_005265766,XP_011530714,NP_775739,NP_001231696,XP_016864326,NP_001231695

Msh2	36;175;248;8949	0.8910	0.8861	0.8238	0.9466	0.9441	MGI:1018166	1785	NM_008628	NP_032654	210	HGNC:7325	443	NM_001258281, NM_000251	XP_011531169, XP_005264389, NP_001245210, NP_000242
Tf1	110;176;214;8187	0.8902	0.8967	0.8253	0.9459	0.9441	MGI:1050444	2210	XR_374069|NM_009442|XR_374068|XM_006497852|XR_374070|XM_006497851	XP_006497915| XP_006497914| NP_033468	13723	#N/A	#N/A	#N/A	#N/A
Smarca4	268;176;461;9605	0.8844	0.8486	0.8283	0.9446	0.9441	MGI:881922	2058	XM_006510122| XM_011242434| XM_011242438| NM_001174079| XM_017313235| XM_017313234| XM_006510120| XM_017313232| XM_011242436| XM_011242437| XM_011242435| XM_017313233| NM_011417|NM_001174078|XM_006510117|XM_006510119	XP_006510185| XP_017168721| XP_006510180| XP_011240736| XP_006510182| XP_006510183| NP_001167550| NP_001167549| XP_017168723| NP_035547|XP_011240738|XP_011240739|XP_011240740|XP_011240737|XP_017168724|XP_017168722	13592	HGNC:1100	657	NM_001128844, NM_003072,NM_001128848,NM_001128849,NM_001128847,NM_001128845,NM_001128846	XP_016882650, XP_006722908, XP_016882652, NP_001122316, XP_016882653, XP_016882649, XP_016882656, XP_016882655, NP_001122317, NP_001122321, NP_001122318, XP_006722909, XP_016882654, NP_003063,NP_001122319,NP_001122320,XP_016882657,XP_016882651,XP_011526500
Sec16a	595;1765;2335;3310	0.8883	0.8793	0.8239	0.9454	0.9441	MGI:2139207	2764	XM_006497910| XM_006497912| XM_011239073| NM_153125|XM_006497913|XM_006497914|XM_006497909|XM_006497911	XP_006497972| XP_006497976| XP_006497974| XP_011237375| XP_006497977| XP_006497973| NP_694765|XP_006497975	10533	HGNC:2900 6	991	NM_001276418, NM_014866	NP_055681,XP_011517550,XP_011517563,XP_011517565,XP_011517561,XP_011517551,XP_011517557,XP_016870852,XP_011517564,XP_011517558,XP_011517562,XP_011517549,XP_005266191,NP_001263347,XP_011517560,XP_011517555,XP_011517548,XP_011517566,XP_016870853,XP_

															011517554,XP_011517552,XP_011517559,XP_011517556,XP_011517553
Dusp11	15253;17771;41488;51288	0.8860	0.6668	0.8338	0.9483	0.9441	MGI:1919352	7212	NM_028099|XM_011241476|XM_017321754|XR_001785172	XP_017177243|XP_011239778|NP_082375	31183	HGNC:30666	8446	NM_003584	NP_003575
Sparc	11717;17722;37228;55800	0.8856	0.6869	0.8345	0.9467	0.9441	MGI:98373	2069 2	NM_001290817|NM_009242	NP_001277746|NP_033268	31132	HGNC:11219	6678	NM_001309444, NM_001309443, NM_003118	NP_001296373, NP_001296372, NP_003109
Osmr	10032;17747;54877;84011	0.8848	0.7037	0.8361	0.9462	0.9441	MGI:1330819	1841 4	NM_011019|XM_006519973|XM_006519976|NM_001310469|XM_006519977	NP_001297398|XP_006520039|XP_006520040|XP_006520036|NP_035149	29725	HGNC:8507	9180	NM_001323506, NM_001323504, NM_003999,NM_001323507,NM_001323505,NM_001168355	NP_001161827, NP_001310436, XP_005248444, XP_005248441, XP_005248443, XP_016865509, XP_011512463, XP_016865508, NP_001310435, NP_001310433, NP_001310434, NP_003990
Mapk12	13693;17754;29 4	0.8844	0.6674	0.8370	0.9448	0.9441	MGI:1353438	2985 7	XM_006521060|XM_006521061|XM_006521059|XM_006521058|NM_013871	XP_006521123|NP_038899|XP_006521121|XP_006521124|XP_006521122	55705	HGNC:6874	6300	NM_001303252, NM_002969	NP_001290181, NP_002960

	0;3149														
Ubxn2b	93;1777;4817;5588	0.883779	0.717985	0.838541	0.944141	0.944141	MGI:1915303	6805	NM_026534	NP_080810	2358	HGNC:27035	13788 6	NM_001077619, NM_001330535	NP_001071087, NP_001317464, XP_005251223, XP_005251222
Nr3c1	223;1786;2676;3715	0.880202	0.897054	0.845495	0.944960	0.944960	MGI:958244	14815	XM_017317837|XM_006525666|XM_006525660|XM_017317835|XM_006525663|XM_006525665|XM_006525662|XM_017317838|XM_006525664|XM_006525659|XM_006525658|NM_008173|XM_006525661|XM_017317836	XP_006525725|XP_006525723|XP_017173325|XP_006525721|XP_017173327|XP_017173326|XP_017173324|XP_006525726|XP_006525728|XP_006525727|NP_032199|XP_006525729|XP_006525722|XP_006525724	3096 0	HGNC:7978	29 08	NM_001024094, NM_001020825, NM_000176,NM_001204263,NM_001204259,NM_001204264,NM_001018074,NM_001018077,NM_001204261,NM_001204258,NM_001204265,NM_001018076,NM_001204260,NM_001018075,NM_001204262	NP_001191188, NP_001018086, NP_001018085, XP_016864887, XP_016864886, XP_005268479, XP_005268480, NP_001191191, NP_001018661, NP_001191194, XP_005268477, XP_011535939, NP_001191189, XP_005268476, NP_001191190, NP_001191187, NP_001018087, NP_001191193, NP_001191192, NP_001019265, NP_001018084, NP_000167
Adam17	309;1788;4187;7333	0.879515	0.911717	0.846969	0.944880	0.944880	MGI:1096335	11491	NM_001277266|NM_001291871|NR_102380|NM_009615|NR_120376	NP_001264195|NP_001278800|NP_033745	2395	HGNC:195	6868	NM_003183	XP_011508678, XP_016860274, XP_011508679, XP_011508677, NP_003174,XP_016860275
Kdm5a	516;1790;;19	0.878742	0.814842	0.844841	0.944860	0.944860	MGI:2136980	21499	XM_011241281|NM_145997|XR_001785118|XR_377436	XP_011239583|NP_666109	3419	HGNC:9886	5927	NM_005056,NM_001042603	NP_001036068

	83;45811														
Rab13	730;17922;74233;;80006	0.8780	0.7535	0.8500	0.9475	0.9460	MGI:1927232	6832	NM_001293741|XR_375571|NM_026677	NP_001280670|NP_080953	113822	HGNC:9762	5872	NM_002870,NM_001272038	NP_001258967,NP_002861,XP_016857448
Mcc	1286;17933;60233;;71666	0.8776	0.6713	0.8508	0.9460	0.9460	MGI:969300	3289	XM_006526023|NM_001085373|XM_006526026|NM_001085374|XM_006526025|XM_006526024	XP_006526088|XP_006526089|XP_006526087|XP_006526086|NP_001078843|NP_001078842	20539	HGNC:69355	4163	NM_002387,NM_001085377	XP_016864963,NP_001078846,XP_016864962,NP_002378,XP_005272048
Frmd6	775;17965;41811;;47477	0.8765	0.7430	0.8531	0.9462	0.9462	MGI:2442579	3197	XM_006515977|XM_006515979|NM_028127|XM_006515978	XP_006516041|XP_006516042|NP_082403|XP_006516040	12449	HGNC:19839	12786	NM_001267047,NM_001042481,NM_001267046,NM_152330	XP_016876456,XP_011534726,XP_011534725,NP_689543,NP_001253976,XP_006720093,XP_006720092,XP_016876457,NP_001253975,NP_001035946
Acsl3	1176;18133;78447	0.8701	0.6787	0.8665	0.9587	0.9572	MGI:1921455	7420	NM_001033606|XM_129894|NM_001136222	NP_083093|NP_001129694|NP_001028778	32781	HGNC:35700	2181	NM_004457,NM_203372	NP_976251,XP_016859073,NP_004448

	6;7876														
Wtip	225;18140;22211;26166	0.086970	0.097086733	0.095722	0.095722	MGI:2141920	101543	XM_017321909|XR_001785463|NM_207212	XP_017177398|NP_997095	643533	HGNC:20964	12637	NM_001080436	NP_001073905, XP_006723077, XP_011524755, XP_011524754
Kat2b	16094;18200;57688;69899	0.086675	0.064260	0.087200	0.096001	0.095887	MGI:1343094	1851	XM_006523820|XR_385299|NM_001190846|NM_020005|XR_001782056	XP_006523883|NP_001177775|NP_064389	208334	HGNC:86388	8850	NM_003884	XP_016862913, XP_016862912, XP_005265585, NP_003875
Efna5	16541;18211;48644;83522	0.086711	0.063999	0.087229	0.095887	0.095887	MGI:1074444	1364	NM_207654|XM_006523598|NM_010109	XP_006523661|NP_997537|NP_034239	14822	HGNC:32225	1946	NM_001962	XP_006714628, XP_016864694, XP_011541552, NP_001953,XP_011541553
Gpc4	18241;18255;29511	0.086557	0.101159	0.087559	0.095596	0.095900	MGI:1049022	1473	NM_008150|XM_011250978	XP_011249280|NP_032176	55582	HGNC:44522	2239	NM_001448	NP_001439

	;8337													
Angpt1	1763;18827;37324;46244	0.8649	0.6337	0.8775	0.9590	0.9590	MGI:1084488	1160	NM_001286062|XM_006520323|NM_009640	XP_006520386|NP_001272991|NP_033770	37447	HGNC:4844	284	NM_001314051,NM_139290,NM_001199859,NM_001146	NP_001300980,NP_001186788,NP_001137
Foxo1	9443;18838;29699;70877	0.8609	0.7046	0.8861	0.9660	0.9645	MGI:1890077	5645 58	NM_019739	NP_062713	15277	HGNC:38199	2308	NM_002015	NP_002006,XP_011533310,XP_011533312
Rangrf	1300;18399;72506;82699	0.8606	0.6615	0.8868	0.9645	0.9645	MGI:1889073	5778 5	NM_021329|NM_001285441|NM_001285442|NM_001285443	NP_067304|NP_001272372|NP_001272371|NP_001272370	41138	HGNC:17679	2908	NM_001177801,NM_001330127,NM_001177802,NM_016492	NP_001171273,XP_005256675,NP_001171272,NP_057576,NP_001317056
Ccne2	3933;18448;58122;	0.8573	0.8541	0.8942	0.9701	0.9701	MGI:1329034	1244 8	XM_006537573|XM_011249913|NM_001282943|NM_009830|NM_001037134|XM_006537574|XM_006537575	NP_033960|XP_006537637|NP_001032211|NP_001269872|XP_006537636|XP_011248215|XP_006537638	7660	HGNC:1590	9134	NM_004702,NM_057749,NM_057735	XP_011515668,NP_477097,XP_016869446,XP_016869448,XP_016869447

Ccnb2	8128813806;18577;27211;73966	0.8540	0.6513	0.9017	0.9759	0.9744	MGI:883111	12442	NM_007630	NP_031656	74359	HGNC:15800	9133	NM_004701	NP_004692
Lamtor3	619;18581;83599;97455	0.8537	0.7694	0.9025	0.9744	0.9744	MGI:1929467	56692	NM_019920	NP_064304	10539	HGNC:15606	8649	NM_021970,NM_001243736	NP_001230665, NP_068805
Stat2	3599;18611;24288;65644	0.8526	0.8691	0.9049	0.9744	0.9747	MGI:1030399	20847	XM_006513433|XM_006513435|NM_019963|XM_006513436	XP_006513498|NP_064347|XP_006513496|XP_006513499	39522	HGNC:11363	6773	NM_198332,NM_005419	XP_016875393, XP_011537000, XP_011536999, XP_011537002, NP_938146,NP_005410,XP_011537001,XP_005269168
Ppp1r35	284;18655;26377;95	0.8512	0.9141	0.9080	0.9757	0.9756	MGI:1922853	69871	XM_006504615|NM_027242	XP_006504678|NP_081518	12337	HGNC:28320	22190 8	NM_145030,NM_001346938	NP_659467,NP_001333867,XP_011514216

Gnaq	84372;18697;35233;62266	0.8497	0.8608	0.91155	0.97711	0.97556	MGI:957766	1468 2	NM_008139	NP_032165	1566	HGNC:4390	2776	NM_002072	XP_016870117, NP_002063
Casp8	7652;18700;61888;67005	0.8494	0.7316	0.91236	0.97556	0.97556	MGI:1261423	1370	NM_001277926|NM_009812|NM_001080126|XM_006495634	NP_001073595|XP_006495697|NP_033942|NP_001264855	7657	HGNC:1509	841	NM_001080125, NM_033356,NM_033358,NM_001080124,NM_001228,NM_033355,NM_033357	XP_005246943, XP_005246950, XP_005246947, NP_203520,XP_006712853,XP_006712856,NP_001219,XP_005246944,XP_005246952,XP_005246949,XP_005246948,NP_203522,NP_203519, XP_006712852, XP_005246942, XP_005246951, XP_011510271, NP_001073594, NP_001073593, XP_005246946, XP_005246945
Csnp2	12455;18800;31573;33044	0.8458	0.6593	0.92006	0.98222	0.98222	MGI:2386852	2077 85	NM_153407|XM_006520683	XP_006520746|NP_700456	32743	HGNC:16006	8156 6	NM_030809	XP_006719684, NP_110436,XP_016875480
Fyn	189;18926;47633;71	0.8416	0.9913	0.93064	0.99042	0.99042	MGI:956022	1436 0	NM_001122893|XM_006512539|NM_001122892|XM_011243117|NM_008054|XM_006512540	XP_006512602|NP_001116364|NP_032080|NP_001116365|XP_006512603|XP_011241419	4806 8	HGNC:4037	2534	NM_002037,NM_153047,NM_153048,NM_001242779	NP_694593,XP_016866142,XP_016866139,XP_005266949,NP_002028,XP_016866144,NP_694592,XP_016866143,XP_005266947,XP_016866140,XP_016866141

H2-T22	01149;18955;22900;74166	0.8406	0.6306	0.9933	0.9906	0.9892	MGI:95956	150-39	NM_010397|XM_006523701|XM_006523702|XM_017317264|NM_001347382	NP_001334311|XP_006523764|NP_034527|XP_017172753|XP_006523765	#N/A	#N/A	#N/A	#N/A	#N/A
Fnip2	13619;18966;47611;81600	0.8402	0.6406	0.9933	0.9898	0.9892	MGI:2683054	3296-79	NM_001162999|XM_017319622|XM_017319620|XM_017319621|XM_006501594	NP_001156471|XP_017175109|XP_017175111|XP_017175110|XP_006501657	46417	HGNC:29280	576-00	NM_020840,NM_001323916,NM_001346043	XP_005263213, XP_005263217, NP_001332972, NP_001310845, XP_016863976, XP_005263215, XP_011530456, NP_065891
Nck1	94493;18999;24954;54422	0.8392	0.6930	0.9936	0.9898	0.9896	MGI:1096011	179-73	NM_001324530|NM_010878|XM_006510840	NP_001311459|XP_006510903|NP_035008	38148	HGNC:76644	469-00	NM_001291999, NM_001190796, NM_006153	NP_006144,NP_001177725,NP_001278928
Tprkb	17143;19077;24308	0.8364	0.0093	0.9943	0.9944	0.9944	MGI:1917036	697-86	XM_006506568|NM_176842|XM_006506567|NM_001170488|XM_017321732|XM_006506569	XP_006506630|NP_001163959|NP_789812|XP_017177221|XP_006506631|XP_006506632	41096	HGNC:24259	510-02	NM_001330387, NM_001330390, NM_001330388, NM_001330389, NM_001330392, NM_016058,NM_001330391,NM_001330386	NP_001317319, NP_001317321, NP_001317316, NP_001317318, XP_016859721, XP_005264400, NP_001317320, XP_011531182, XP_011531179, NP_001317315, NP_057142,XP_006712089,XP_016859724,XP_011531181,XP_011531180,XP_016859723,XP_006712090,XP_

	28														016859722,NP_001317317
Oas3	820;19111;36675;42544	0.83503	0.71333	0.94644	0.99954	0.99951	MGI:2180850	2467	NM_145226	NP_660261	4510	HGNC:80888	490	NM_006187	XP_016874852,NP_006178,XP_005253946
Dgkd	144;19153;22533;44081	0.83362	0.63628	0.94986	0.99951	0.99951	MGI:2138334	2273	NM_177646|XM_006529473|XM_006529474|XM_006529472|XM_011247988|XR_001784183|XM_017320352|XM_006529471	XP_017175841|XP_011246290|XP_006529536|XP_006529537|XP_006529534|XP_006529535|NP_808314	10054	HGNC:28551	8527	NM_152879,NM_003648	XP_005246167,XP_016860628,XP_005246165,XP_011510335,XP_011510330,XP_011510334,XP_011510332,XP_011510337,NP_003639,XP_011510331,XP_011510333,XP_011510342,XP_011510339,XP_005246164,XP_011510341,NP_690618,XP_016860629,XP_016860627
Inpp5b	1391;19173;42605;51051	0.83299	0.63995	0.95140	0.99960	0.99951	MGI:1032557	1630	XM_006502809|XM_011240450|NM_008385|XM_006502805|XR_001784096|XM_006502804|XR_867812|NR_126474	XP_006502867|XP_011238752|NP_032411|XP_006502872|XP_006502868	69021	HGNC:60777	3633	NM_005540,NM_001350227,NM_001350228,NM_001297434	XP_011539694,XP_006710684,NP_001337157,XP_016856695,XP_011539695,NP_005531,NP_001337156,XP_016856698,NP_001284363,XP_016856696,XP_016856697
Dact3	851;19222;37111;66	0.83122	0.70555	0.95566	0.99980	0.99951	MGI:3654828	6293	NM_001081655	NP_001075124	77340	HGNC:307445	14790	NM_145056,NM_001301046	NP_001287975,XP_016881823,XP_011524802,NP_659493,XP_011524801

Npm2	17594;19233;48334;54211	0.8309	0.7651	0.9564	0.9965	0.9951	MGI:1890811	3284 0	XM_006519146|XM_006519143|XM_006519147|XM_017316061|XM_006519145|XM_011245091|NM_181345	XP_006519209|XP_017171550|XP_006519208|XP_006519210|XP_011243393|XP_006519206|NP_851990	15349	HGNC:7930	10361	NM_001286681,NM_001286680,NM_182795	XP_016868436,XP_011542662,NP_001273610,XP_016868439,XP_011542666,XP_016868438,XP_016868437,NP_001273609,XP_011542665,XP_011542664,NP_877724
Mcts1	13811;19244;26244;51887	0.8305	0.6395	0.9572	0.9951	0.9951	MGI:1916245	68995	NM_026902|XM_006541536|XM_006541535	XP_006541598|NP_081178|XP_006541599	58033	HGNC:23357	28985	NM_014060,NM_001137554	NP_001131026,NP_054779
Ppargc1b	18677;19273;35322;71555	0.8295	0.6119	0.9598	0.9955	0.9955	MGI:2444934	170826	NM_133249|XM_006525698	XP_006525761|NP_573512	15776	HGNC:30022	13352	NM_001172699,NM_133263,NM_001172698	XP_011535855,XP_011535857,XP_011535856,NP_573570,NP_001166169,NP_001166170,XP_011535859,XP_011535858,XP_005268429
Etnk1	15391;19322;52768;68	0.8278	0.6269	0.9642	0.9977	0.9960	MGI:1922570	75320	XM_006507012|XM_006507011|NM_029250	NP_083526|XP_006507074|XP_006507075	10240	HGNC:24649	55500	NM_001039481,NM_018638	XP_016875070,NP_061108,NP_001034570,XP_016875069,XP_005253477

	23														
Gak	95;19335;35142;67822	0.8268567	0.6859980	0.9667160	0.9880160	0.9960	MGI:2442153	2311580	XM_132229|XM_006534907|XM_017320853|XR_001784677|XR_001784678|XR_389271|NM_001282052|XR_880392|XM_006534905|NM_001282051	NP_001268980|NP_001268981|XP_017176342|XP_006534968|NP_705797|XP_006534970	3846	HGNC:41133	2580	NM_005255,NM_001286833,NM_001318134	XP_011511733, XP_016863480, XP_011511731, XP_011511727, XP_005272325, XP_011511734, XP_011511730, XP_016863483, NP_001305063, NP_005246,XP_005272327,XP_016863481,XP_011511729,XP_016863482,XP_011511728,XP_011511736,XP_016863484,XP_011511732
Anapc4	576;19338;44817;97677	0.8258580	0.8768933	0.9698360	0.9983360	0.9960	MGI:1098673	52206	NM_024213	NP_077175	4087	HGNC:19990	2945	NM_013367,NM_001286756	XP_005248216, NP_037499,NP_001273685,XP_011512140,XP_011512141,XP_016863627
Idnk	208;19411;34097;61266	0.8248480	0.9634340	0.9719190	0.9987160	0.9960	MGI:1922981	75731	NM_198004|NM_001048060	NP_001041525|NP_932121	5666	HGNC:31367	4143280	NM_001190727, NM_001351535, NM_001001551, NM_001256915	XP_006717173, XP_016870211, XP_016870212, XP_006717174, XP_016870210, XP_016870208, XP_016870214, XP_016870213, NP_001001551, NP_001243844, NP_001338464, XP_016870209
Vav3	1294;19422;73077;81988	0.8244480	0.6439960	0.9727720	0.9976040	0.9960	MGI:1888518	57257	NM_146139|XM_006501819|XM_006501820|NM_020505	NP_065251|XP_006501883|NP_666251|XP_006501882	38143	HGNC:12659	1045180	NM_006113,NM_001079874	NP_001073343, XP_016855542, NP_006104,XP_005270417,XP_016855544,XP_016855545,XP_005270418,XP_016855543

Lats1	11903;19466;27722;54399	0.823136	0.653616	0.976262	0.998585	0.999600	MGI:1338383	1679	XM_006512567|NM_010690	NP_034820|XP_006512630	5584	HGNC:6514	913	NM_004690,NM_001350340,NM_001350392,NM_001270519,NM_001350339	NP_001257448, NP_001337269, NP_001337268, XP_016866965, XP_006715666, XP_016866964, XP_016866971, NP_004681,XP_016866963,XP_016866966,XP_016866970,NP_001337321,XP_016866967,XP_011534554,XP_016866968,XP_016866969
Adipor1	75858;19477;67422;83933	0.822278	0.719780	0.977071	0.999600	MGI:1919924	7267 4	NM_028320|NM_001306069	NP_082596|NP_001292998	6919 9	HGNC:24040	5109 4	NM_001290629, NM_001290553, NM_015999,NM_001290557	XP_016856896, NP_001277558, NP_001277486, NP_001277482, NP_057083
Exoc2	42449;42388;47433	0.822211	0.822187	0.979655	0.999600	MGI:1913732	6648 2	XM_017315564|NM_025588|XM_011244327|XM_006516726|XM_011244328|XM_017315565|XM_011244326	XP_011242628|XP_017171053|NP_079864|XP_011242630|XP_011242629|XP_017171054|XP_006516789	10122	HGNC:24968	5570	NM_018303	XP_016866515, NP_060773,XP_016866509,XP_016866508,XP_016866513,XP_016866511,XP_016866510,XP_016866514,XP_016866512,XP_016866507
H2-M3	13533;19511;;61887;;95088	0.821414	0.637204	0.980460	0.999600	MGI:9591515	1491 1	NM_013819	NP_038847	13255	HGNC:4964	3135	NM_002127	NP_002118,XP_016866305,XP_016866307,XP_016866306

Rps6kb2	52;1960;3474;7985	0.8184	1.2508	0.9880	0.1000	0.9084	MGI:1927343	589 8	XR_388261|XM_006531812|XM_017318266|XM_006531813|NM_021485|XR_388263|XR_879445|XM_017318267|XM_006531814|XR_879446|XR_388267|XR_879447|XR_001782607	XP_017173756|XP_006531876|XP_006531875|XP_006531877|NP_067460|XP_017173755	6837 4	HGNC:10437	619 9	NM_003952,NM_001007071	XP_006718720,XP_005274222,XP_016873597,XP_006718719,NP_003943,XP_006718718,XP_005274221
Cdk1	56;1964;7054;97705	0.8171	0.7683	0.9915	0.1000	0.9084	MGI:8835 51	125 34	NM_007659	NP_031685	6820 3	HGNC:17222	983	NM_001170406,NM_001130829,NM_001320918,NM_001786,NM_001170407,NM_033379	NP_001163877,NP_001307847,NP_001777,NP_001163878,NP_203698,XP_005270360
Pi4kb	14;1965;4492;66669	0.8167	0.6276	0.9924	0.1000	0.9084	MGI:1334433	1076 50	NM_001293715|NM_001293716|NM_175356	NP_001280644|NP_780565|NP_001280645	6741	HGNC:8984	529 8	NM_001198775,NM_001198774,NM_001198773,NM_002651,NM_001330721	XP_016856980,NP_001185703,XP_011507937,XP_011507940,XP_005245321,XP_011507936,XP_016856979,XP_011507938,NP_001185702,XP_016856976,XP_016856978,NP_001185704,XP_011507939,XP_016856977,NP_002642,XP_016856981,XP_016856975,NP_001317650
Wnt6	207;1966;21733;69521	0.8164	0.9602	0.9932	0.1000	0.9084	MGI:9896 0	224 20	XM_006495887|XM_006495888|NM_009526|XM_006495889	XP_006495951|NP_033552|XP_006495950|XP_006495952	4756	HGNC:12785	745	NM_006522	NP_006513
Hn1	35	0.8	0.6	0.9	0.9	0.9	MGI	520	NM_198937	NP_945175	169	HGNC	908	NM_144570	NP_653171

11	6;19682;27960;82360	1573420	9509944	9849	:1196260	09				34	C:14137	61			
Add1	56;19701;27609;31090	0.8161558	0.7699567	0.9998894	0.9984	MGI:1887918	115118	XM_006503679|XM_017320615|XM_006503674|XM_006503676|NM_001331081|NM_001331085|XM_017320616|XM_006503670|NM_001331083|XM_006503678|XM_006503669|XM_006503677|XM_006503675|NM_001331087|XM_006503681|XM_006503680|XM_006503672|XM_006503671|XM_017320614|NM_001331086|NM_001102444|NM_001331084|XM_006503668|NM_001331080|XM_017320617|NM_001331082|NM_013457|NM_001024458|XM_006503673|XM_017320613	NP_001318010|XP_017176106|XP_001318015|XP_006503744|XP_017176102|XP_006503740|XP_006503739|XP_006503736|XP_006503734|NP_001318014|XP_006503732|XP_006503731|XP_006503738|NP_001318013|NP_001318009|XP_006503733|XP_017176105|XP_006503741|XP_017176103|NP_001318011|NP_001318012|XP_006503737|NP_001318016|XP_006503742|XP_017176104|XP_006503743|NP_001095914|NP_038485|NP_001019629|XP_006503735	22754;2435	HGNC:2443	11818	NM_176801,NM_001286645,NM_014190,NM_001119,NM_014189	XP_016863193,NP_054909,XP_005247992,XP_005247993,XP_016863198,XP_016863196,XP_016863199,XP_016863197,XP_016863195,XP_005247990,NP_001110,XP_016863192,NP_054908,XP_016863194,XP_005247994,XP_005247991,NP_001273574,NP_789771
Rapgef4	18;19721;34905;65511	0.8144	0.8106848	0.9984	0.9984	MGI:1917723	5658	NM_001204165|XM_011239711|XM_017319138|NM_019688|NM_001204167|XM_006499938|XM_017319139|NM_001204166	NP_062662|XP_017174627|XP_006500001|XP_017174628|XP_011238013|NP_001191095|NP_001191096|NP_001191094	44;51	HGNC:16626	11069	NM_001282900,NM_007023,NM_001282899,NM_001282901,NM_001100397	NP_001093867,XP_011508807,NP_001269830,XP_016858686,XP_016858685,NP_001269829,XP_005246303,NP_008954,XP_006712268,NP_001269828

* The nucleic acid and polypeptide sequences of the biomarkers of the present invention listed in Table 1 have been submitted at GenBank under the unique identifier provided

herein and each such uniquely identified sequence submitted at GenBank is hereby incorporated in its entirety by reference.

* Included in Table 1 are RNA nucleic acid molecules (*e.g.*, thymines replaced with uredines), nucleic acid molecules encoding orthologs of the encoded proteins, as well as DNA or RNA nucleic acid sequences comprising a nucleic acid sequence having at least 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.5%, or more identity across their full length with the nucleic acid sequence of any SEQ ID NO listed in Table 1, or a portion thereof. Such nucleic acid molecules can have a function of the full-length nucleic acid as described further herein.

* Included in Table 1 are orthologs of the proteins, as well as polypeptide molecules comprising an amino acid sequence having at least 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.5%, or more identity across their full length with an amino acid sequence of any SEQ ID NO listed in Table 1, or a portion thereof. Such polypeptides can have a function of the full-length polypeptide as described further herein.

* Included in Table 1 are any known components of the inhibition of kinase signaling pathway, including PTPN2 and SOCS1, as well as orthologs of the pathway components and nucleic acid and amino acid variants having the recited homology described in the immediately preceding paragraphs and elsewhere herein.

* Included in Table 1 are any known components of the activation of kinase signaling pathway. In some embodiments, their agonists are used to activate the kinase signaling pathway as described herein. For example, such agonists include any natural or non-natural agent prepared, synthesized, manufactured, and/or purified by human that is capable of increasing, promoting, enhancing, and/or inducing the biological ability of a biomarker in Table 1, which activates kinase signaling pathway (and its fragments, domains, and/or motifs thereof, discussed herein). In one embodiment, such agonists may increase or enhance the binding/interaction between a biomarker in Table 1 and its substrates or other binding partners. In another embodiment, such agonists may increase or enhance at least one biomarker functions. In still another embodiment, such agonists may decrease or

inhibit the turnover rate, increase or enhance the expression and/or the stability (*e.g.*, the half-life), and/or change the cellular localization of at least one biomarker in Table 1, resulting in at least an increase in the biomarker levels and/or activity. Such agonists may be any molecule, including but not limited to small molecule compounds, antibodies or intrabodies, polypeptides or fusion proteins (which comprise, *e.g.*, full-length biomarker, or biologically active fragments thereof, with or without any mutations or modifications to maintain or enhancing biomarker expression levels or biological functions. Such agonists may be specific to at least one biomarker or also enhance the copy number, amount, and/or activity of at least one of other proteins having a common domain/motif with the at least one biomarker. These embodiments can also be equally applied to other biomarkers of Table 1 that results in an sgRNA enrichment in the sgRNA screens described herein.

* The nucleic acid and amino acid sequences corresponding to the reference ID numbers (*e.g.*, Mouse Marker ID, Mouse NCBI RefSeq Transcript ID, Mouse NCBI RefSeq Protein ID, Human NCBI RefSeq Transcript ID, and Human NCBI RefSeq Protein ID) in Table 1 available to the public as of a particular date, *e.g.*, the application filing date, is necessarily and readily confirmed using the public availability date shown in the Gene Locus header information for each ID on the NCBI website available at ncbi.nlm.nih.gov.

II. Subjects

In one embodiment, the subject for whom predicted likelihood of efficacy of an inhibitor of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and an immunotherapy combination treatment is determined, is a mammal (*e.g.*, mouse, rat, primate, non-human mammal, domestic animal, such as a dog, cat, cow, horse, and the like), and is preferably a human. In another embodiment, the subject is an animal model of cancer. For example, the animal model can be an orthotopic xenograft animal model of a human-derived cancer.

In another embodiment of the methods of the present invention, the subject has not undergone treatment, such as chemotherapy, radiation therapy, targeted therapy, and/or immunotherapies. In still another embodiment, the subject has undergone treatment, such as chemotherapy, radiation therapy, targeted therapy, and/or immunotherapies.

In certain embodiments, the subject has had surgery to remove cancerous or precancerous tissue. In other embodiments, the cancerous tissue has not been removed,

e.g., the cancerous tissue may be located in an inoperable region of the body, such as in a tissue that is essential for life, or in a region where a surgical procedure would cause considerable risk of harm to the patient.

The methods of the present invention can be used to determine the responsiveness to inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatment of many different cancers in subjects such as those described herein.

III. Sample Collection, Preparation and Separation

In some embodiments, biomarker amount and/or activity measurement(s) in a sample from a subject is compared to a predetermined control (standard) sample. The sample from the subject is typically from a diseased tissue, such as cancer cells or tissues. The control sample can be from the same subject or from a different subject. The control sample is typically a normal, non-diseased sample. However, in some embodiments, such as for staging of disease or for evaluating the efficacy of treatment, the control sample can be from a diseased tissue. The control sample can be a combination of samples from several different subjects. In some embodiments, the biomarker amount and/or activity measurement(s) from a subject is compared to a pre-determined level. This pre-determined level is typically obtained from normal samples. As described herein, a "pre-determined" biomarker amount and/or activity measurement(s) may be a biomarker amount and/or activity measurement(s) used to, by way of example only, evaluate a subject that may be selected for treatment (*e.g.*, based on the number of genomic mutations and/or the number of genomic mutations causing non-functional proteins for DNA repair genes), evaluate a response to an inhibitor of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and an immunotherapy combination treatment, and/or evaluate a response to such inhibitor and an immunotherapy combination treatment with one or more additional anti-cancer therapies. A pre-determined biomarker amount and/or activity measurement(s) may be determined in populations of patients with or without cancer. The pre-determined biomarker amount and/or activity measurement(s) can be a single number, equally applicable to every patient, or the pre-determined biomarker amount and/or activity measurement(s) can vary according to specific subpopulations of patients. Age, weight, height, and other factors of a subject may affect the pre-determined biomarker amount and/or activity measurement(s) of the individual.

Furthermore, the pre-determined biomarker amount and/or activity can be determined for each subject individually. In one embodiment, the amounts determined and/or compared in a method described herein are based on absolute measurements.

In another embodiment, the amounts determined and/or compared in a method described herein are based on relative measurements, such as ratios (*e.g.*, biomarker copy numbers, level, and/or activity before a treatment vs. after a treatment, such biomarker measurements relative to a spiked or man-made control, such biomarker measurements relative to the expression of a housekeeping gene, and the like). For example, the relative analysis can be based on the ratio of pre-treatment biomarker measurement as compared to post-treatment biomarker measurement. Pre-treatment biomarker measurement can be made at any time prior to initiation of anti-cancer therapy. Post-treatment biomarker measurement can be made at any time after initiation of anti-cancer therapy. In some embodiments, post-treatment biomarker measurements are made 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 weeks or more after initiation of anti-cancer therapy, and even longer toward indefinitely for continued monitoring. Treatment can comprise anti-cancer therapy, such as a therapeutic regimen comprising one or more inhibitor of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatment alone or in combination with other anti-cancer agents, such as with immune checkpoint inhibitors.

The pre-determined biomarker amount and/or activity measurement(s) can be any suitable standard. For example, the pre-determined biomarker amount and/or activity measurement(s) can be obtained from the same or a different human for whom a patient selection is being assessed. In one embodiment, the pre-determined biomarker amount and/or activity measurement(s) can be obtained from a previous assessment of the same patient. In such a manner, the progress of the selection of the patient can be monitored over time. In addition, the control can be obtained from an assessment of another human or multiple humans, *e.g.*, selected groups of humans, if the subject is a human. In such a manner, the extent of the selection of the human for whom selection is being assessed can be compared to suitable other humans, *e.g.,* other humans who are in a similar situation to the human of interest, such as those suffering from similar or the same condition(s) and/or of the same ethnic group.

In some embodiments of the present invention the change of biomarker amount and/or activity measurement(s) from the pre-determined level is about 0.1, 0.2, 0.3, 0.4, 0.5,

0.6, 0.7, 0.8, 0.9, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, or 5.0 fold or greater, or any range in between, inclusive. Such cutoff values apply equally when the measurement is based on relative changes, such as based on the ratio of pre-treatment biomarker measurement as compared to post-treatment biomarker measurement.

Biological samples can be collected from a variety of sources from a patient including a body fluid sample, cell sample, or a tissue sample comprising nucleic acids and/or proteins. "Body fluids" refer to fluids that are excreted or secreted from the body as well as fluids that are normally not (*e.g.*, amniotic fluid, aqueous humor, bile, blood and blood plasma, cerebrospinal fluid, cerumen and earwax, cowper's fluid or pre-ejaculatory fluid, chyle, chyme, stool, female ejaculate, interstitial fluid, intracellular fluid, lymph, menses, breast milk, mucus, pleural fluid, pus, saliva, sebum, semen, serum, sweat, synovial fluid, tears, urine, vaginal lubrication, vitreous humor, vomit). In a preferred embodiment, the subject and/or control sample is selected from the group consisting of cells, cell lines, histological slides, paraffin embedded tissues, biopsies, whole blood, nipple aspirate, serum, plasma, buccal scrape, saliva, cerebrospinal fluid, urine, stool, and bone marrow. In one embodiment, the sample is serum, plasma, or urine. In another embodiment, the sample is serum.

The samples can be collected from individuals repeatedly over a longitudinal period of time (*e.g.*, once or more on the order of days, weeks, months, annually, biannually, etc.). Obtaining numerous samples from an individual over a period of time can be used to verify results from earlier detections and/or to identify an alteration in biological pattern as a result of, for example, disease progression, drug treatment, *etc.* For example, subject samples can be taken and monitored every month, every two months, or combinations of one, two, or three month intervals according to the present invention. In addition, the biomarker amount and/or activity measurements of the subject obtained over time can be conveniently compared with each other, as well as with those of normal controls during the monitoring period, thereby providing the subject's own values, as an internal, or personal, control for long-term monitoring.

Sample preparation and separation can involve any of the procedures, depending on the type of sample collected and/or analysis of biomarker measurement(s). Such procedures include, by way of example only, concentration, dilution, adjustment of pH, removal of high abundance polypeptides (*e.g.*, albumin, gamma globulin, and transferrin, etc.), addition of preservatives and calibrants, addition of protease inhibitors, addition of

denaturants, desalting of samples, concentration of sample proteins, extraction and purification of lipids.

The sample preparation can also isolate molecules that are bound in non-covalent complexes to other protein (*e.g.*, carrier proteins). This process may isolate those molecules bound to a specific carrier protein (*e.g.*, albumin), or use a more general process, such as the release of bound molecules from all carrier proteins via protein denaturation, for example using an acid, followed by removal of the carrier proteins.

Removal of undesired proteins (*e.g.*, high abundance, uninformative, or undetectable proteins) from a sample can be achieved using high affinity reagents, high molecular weight filters, ultracentrifugation and/or electrodialysis. High affinity reagents include antibodies or other reagents (*e.g.*, aptamers) that selectively bind to high abundance proteins. Sample preparation could also include ion exchange chromatography, metal ion affinity chromatography, gel filtration, hydrophobic chromatography, chromatofocusing, adsorption chromatography, isoelectric focusing and related techniques. Molecular weight filters include membranes that separate molecules on the basis of size and molecular weight. Such filters may further employ reverse osmosis, nanofiltration, ultrafiltration and microfiltration.

Ultracentrifugation is a method for removing undesired polypeptides from a sample. Ultracentrifugation is the centrifugation of a sample at about 15,000-60,000 rpm while monitoring with an optical system the sedimentation (or lack thereof) of particles. Electrodialysis is a procedure which uses an electromembrane or semipermable membrane in a process in which ions are transported through semi-permeable membranes from one solution to another under the influence of a potential gradient. Since the membranes used in electrodialysis may have the ability to selectively transport ions having positive or negative charge, reject ions of the opposite charge, or to allow species to migrate through a semipermable membrane based on size and charge, it renders electrodialysis useful for concentration, removal, or separation of electrolytes.

Separation and purification in the present invention may include any procedure known in the art, such as capillary electrophoresis (*e.g.*, in capillary or on-chip) or chromatography (*e.g.*, in capillary, column or on a chip). Electrophoresis is a method which can be used to separate ionic molecules under the influence of an electric field. Electrophoresis can be conducted in a gel, capillary, or in a microchannel on a chip. Examples of gels used for electrophoresis include starch, acrylamide, polyethylene oxides,

agarose, or combinations thereof. A gel can be modified by its cross-linking, addition of detergents, or denaturants, immobilization of enzymes or antibodies (affinity electrophoresis) or substrates (zymography) and incorporation of a pH gradient. Examples of capillaries used for electrophoresis include capillaries that interface with an electrospray.

Capillary electrophoresis (CE) is preferred for separating complex hydrophilic molecules and highly charged solutes. CE technology can also be implemented on microfluidic chips. Depending on the types of capillary and buffers used, CE can be further segmented into separation techniques such as capillary zone electrophoresis (CZE), capillary isoelectric focusing (CIEF), capillary isotachophoresis (cITP) and capillary electrochromatography (CEC). An embodiment to couple CE techniques to electrospray ionization involves the use of volatile solutions, for example, aqueous mixtures containing a volatile acid and/or base and an organic such as an alcohol or acetonitrile.

Capillary isotachophoresis (cITP) is a technique in which the analytes move through the capillary at a constant speed but are nevertheless separated by their respective mobilities. Capillary zone electrophoresis (CZE), also known as free-solution CE (FSCE), is based on differences in the electrophoretic mobility of the species, determined by the charge on the molecule, and the frictional resistance the molecule encounters during migration which is often directly proportional to the size of the molecule. Capillary isoelectric focusing (CIEF) allows weakly-ionizable amphoteric molecules, to be separated by electrophoresis in a pH gradient. CEC is a hybrid technique between traditional high performance liquid chromatography (HPLC) and CE.

Separation and purification techniques used in the present invention include any chromatography procedures known in the art. Chromatography can be based on the differential adsorption and elution of certain analytes or partitioning of analytes between mobile and stationary phases. Different examples of chromatography include, but not limited to, liquid chromatography (LC), gas chromatography (GC), high performance liquid chromatography (HPLC), etc.

IV. Biomarker Nucleic Acids and Polypeptides

One aspect of the present invention pertains to the use of isolated nucleic acid molecules that correspond to biomarker nucleic acids that encode a biomarker polypeptide or a portion of such a polypeptide. As used herein, the term "nucleic acid molecule" is intended to include DNA molecules (*e.g.*, cDNA or genomic DNA) and RNA molecules

(*e.g.*, mRNA) and analogs of the DNA or RNA generated using nucleotide analogs. The nucleic acid molecule can be single-stranded or double-stranded, but preferably is double-stranded DNA.

An "isolated" nucleic acid molecule is one which is separated from other nucleic acid molecules which are present in the natural source of the nucleic acid molecule. Preferably, an "isolated" nucleic acid molecule is free of sequences (preferably protein-encoding sequences) which naturally flank the nucleic acid (*i.e.*, sequences located at the 5' and 3' ends of the nucleic acid) in the genomic DNA of the organism from which the nucleic acid is derived. For example, in various embodiments, the isolated nucleic acid molecule can contain less than about 5 kB, 4 kB, 3 kB, 2 kB, 1 kB, 0.5 kB or 0.1 kB of nucleotide sequences which naturally flank the nucleic acid molecule in genomic DNA of the cell from which the nucleic acid is derived. Moreover, an "isolated" nucleic acid molecule, such as a cDNA molecule, can be substantially free of other cellular material or culture medium when produced by recombinant techniques, or substantially free of chemical precursors or other chemicals when chemically synthesized.

A biomarker nucleic acid molecule of the present invention can be isolated using standard molecular biology techniques and the sequence information in the database records described herein. Using all or a portion of such nucleic acid sequences, nucleic acid molecules of the present invention can be isolated using standard hybridization and cloning techniques (*e.g.*, as described in Sambrook *et al.*, ed., *Molecular Cloning: A Laboratory Manual, 2nd ed.,* Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 1989).

A nucleic acid molecule of the present invention can be amplified using cDNA, mRNA, or genomic DNA as a template and appropriate oligonucleotide primers according to standard PCR amplification techniques. The nucleic acid molecules so amplified can be cloned into an appropriate vector and characterized by DNA sequence analysis. Furthermore, oligonucleotides corresponding to all or a portion of a nucleic acid molecule of the present invention can be prepared by standard synthetic techniques, *e.g.*, using an automated DNA synthesizer.

Moreover, a nucleic acid molecule of the present invention can comprise only a portion of a nucleic acid sequence, wherein the full length nucleic acid sequence comprises a marker of the present invention or which encodes a polypeptide corresponding to a marker of the present invention. Such nucleic acid molecules can be used, for example, as

a probe or primer. The probe/primer typically is used as one or more substantially purified oligonucleotides. The oligonucleotide typically comprises a region of nucleotide sequence that hybridizes under stringent conditions to at least about 7, preferably about 15, more preferably about 25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, or 400 or more consecutive nucleotides of a biomarker nucleic acid sequence. Probes based on the sequence of a biomarker nucleic acid molecule can be used to detect transcripts or genomic sequences corresponding to one or more markers of the present invention. The probe comprises a label group attached thereto, *e.g.*, a radioisotope, a fluorescent compound, an enzyme, or an enzyme co-factor.

A biomarker nucleic acid molecules that differ, due to degeneracy of the genetic code, from the nucleotide sequence of nucleic acid molecules encoding a protein which corresponds to the biomarker, and thus encode the same protein, are also contemplated.

In addition, it will be appreciated by those skilled in the art that DNA sequence polymorphisms that lead to changes in the amino acid sequence can exist within a population (*e.g.*, the human population). Such genetic polymorphisms can exist among individuals within a population due to natural allelic variation. An allele is one of a group of genes which occur alternatively at a given genetic locus. In addition, it will be appreciated that DNA polymorphisms that affect RNA expression levels can also exist that may affect the overall expression level of that gene (*e.g.*, by affecting regulation or degradation).

The term "allele," which is used interchangeably herein with "allelic variant," refers to alternative forms of a gene or portions thereof. Alleles occupy the same locus or position on homologous chromosomes. When a subject has two identical alleles of a gene, the subject is said to be homozygous for the gene or allele. When a subject has two different alleles of a gene, the subject is said to be heterozygous for the gene or allele. For example, biomarker alleles can differ from each other in a single nucleotide, or several nucleotides, and can include substitutions, deletions, and insertions of nucleotides. An allele of a gene can also be a form of a gene containing one or more mutations.

The term "allelic variant of a polymorphic region of gene" or "allelic variant", used interchangeably herein, refers to an alternative form of a gene having one of several possible nucleotide sequences found in that region of the gene in the population. As used herein, allelic variant is meant to encompass functional allelic variants, non-functional allelic variants, SNPs, mutations and polymorphisms.

The term "single nucleotide polymorphism" (SNP) refers to a polymorphic site occupied by a single nucleotide, which is the site of variation between allelic sequences. The site is usually preceded by and followed by highly conserved sequences of the allele (*e.g.*, sequences that vary in less than 1/100 or 1/1000 members of a population). A SNP usually arises due to substitution of one nucleotide for another at the polymorphic site. SNPs can also arise from a deletion of a nucleotide or an insertion of a nucleotide relative to a reference allele. Typically the polymorphic site is occupied by a base other than the reference base. For example, where the reference allele contains the base "T" (thymidine) at the polymorphic site, the altered allele can contain a "C" (cytidine), "G" (guanine), or "A" (adenine) at the polymorphic site. SNP's may occur in protein-coding nucleic acid sequences, in which case they may give rise to a defective or otherwise variant protein, or genetic disease. Such a SNP may alter the coding sequence of the gene and therefore specify another amino acid (a "missense" SNP) or a SNP may introduce a stop codon (a "nonsense" SNP). When a SNP does not alter the amino acid sequence of a protein, the SNP is called "silent." SNP's may also occur in noncoding regions of the nucleotide sequence. This may result in defective protein expression, *e.g.*, as a result of alternative spicing, or it may have no effect on the function of the protein.

As used herein, the terms "gene" and "recombinant gene" refer to nucleic acid molecules comprising an open reading frame encoding a polypeptide corresponding to a marker of the present invention. Such natural allelic variations can typically result in 1-5% variance in the nucleotide sequence of a given gene. Alternative alleles can be identified by sequencing the gene of interest in a number of different individuals. This can be readily carried out by using hybridization probes to identify the same genetic locus in a variety of individuals. Any and all such nucleotide variations and resulting amino acid polymorphisms or variations that are the result of natural allelic variation and that do not alter the functional activity are intended to be within the scope of the present invention.

In another embodiment, a biomarker nucleic acid molecule is at least 7, 15, 20, 25, 30, 40, 60, 80, 100, 150, 200, 250, 300, 350, 400, 450, 550, 650, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2200, 2400, 2600, 2800, 3000, 3500, 4000, 4500, or more nucleotides in length and hybridizes under stringent conditions to a nucleic acid molecule corresponding to a marker of the present invention or to a nucleic acid molecule encoding a protein corresponding to a marker of the present invention. As used herein, the term "hybridizes under stringent conditions" is intended to describe

conditions for hybridization and washing under which nucleotide sequences at least 60% (65%, 70%, 75%, 80%, preferably 85%) identical to each other typically remain hybridized to each other. Such stringent conditions are known to those skilled in the art and can be found in sections 6.3.1-6.3.6 of *Current Protocols in Molecular Biology*, John Wiley & Sons, N.Y. (1989). A preferred, non-limiting example of stringent hybridization conditions are hybridization in 6X sodium chloride/sodium citrate (SSC) at about 45°C, followed by one or more washes in 0.2X SSC, 0.1% SDS at 50-65°C.

In addition to naturally-occurring allelic variants of a nucleic acid molecule of the present invention that can exist in the population, the skilled artisan will further appreciate that sequence changes can be introduced by mutation thereby leading to changes in the amino acid sequence of the encoded protein, without altering the biological activity of the protein encoded thereby. For example, one can make nucleotide substitutions leading to amino acid substitutions at "non-essential" amino acid residues. A "non-essential" amino acid residue is a residue that can be altered from the wild-type sequence without altering the biological activity, whereas an "essential" amino acid residue is required for biological activity. For example, amino acid residues that are not conserved or only semi-conserved among homologs of various species may be non-essential for activity and thus would be likely targets for alteration. Alternatively, amino acid residues that are conserved among the homologs of various species (*e.g.*, murine and human) may be essential for activity and thus would not be likely targets for alteration.

Accordingly, another aspect of the present invention pertains to nucleic acid molecules encoding a polypeptide of the present invention that contain changes in amino acid residues that are not essential for activity. Such polypeptides differ in amino acid sequence from the naturally-occurring proteins which correspond to the markers of the present invention, yet retain biological activity. In one embodiment, a biomarker protein has an amino acid sequence that is at least about 40% identical, 50%, 60%, 70%, 75%, 80%, 83%, 85%, 87.5%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or identical to the amino acid sequence of a biomarker protein described herein.

An isolated nucleic acid molecule encoding a variant protein can be created by introducing one or more nucleotide substitutions, additions or deletions into the nucleotide sequence of nucleic acids of the present invention, such that one or more amino acid residue substitutions, additions, or deletions are introduced into the encoded protein. Mutations can be introduced by standard techniques, such as site-directed mutagenesis and PCR-mediated

mutagenesis. Preferably, conservative amino acid substitutions are made at one or more predicted non-essential amino acid residues. A "conservative amino acid substitution" is one in which the amino acid residue is replaced with an amino acid residue having a similar side chain. Families of amino acid residues having similar side chains have been defined in the art. These families include amino acids with basic side chains (*e.g.*, lysine, arginine, histidine), acidic side chains (*e.g.*, aspartic acid, glutamic acid), uncharged polar side chains (*e.g.*, glycine, asparagine, glutamine, serine, threonine, tyrosine, cysteine), non-polar side chains (*e.g.*, alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan), beta-branched side chains (*e.g.*, threonine, valine, isoleucine) and aromatic side chains (*e.g.*, tyrosine, phenylalanine, tryptophan, histidine). Alternatively, mutations can be introduced randomly along all or part of the coding sequence, such as by saturation mutagenesis, and the resultant mutants can be screened for biological activity to identify mutants that retain activity. Following mutagenesis, the encoded protein can be expressed recombinantly and the activity of the protein can be determined.

In some embodiments, the present invention further contemplates the use of anti-biomarker antisense nucleic acid molecules, *i.e.*, molecules which are complementary to a sense nucleic acid of the present invention, *e.g.*, complementary to the coding strand of a double-stranded cDNA molecule corresponding to a marker of the present invention or complementary to an mRNA sequence corresponding to a marker of the present invention. Accordingly, an antisense nucleic acid molecule of the present invention can hydrogen bond to (*i.e.* anneal with) a sense nucleic acid of the present invention. The antisense nucleic acid can be complementary to an entire coding strand, or to only a portion thereof, *e.g.*, all or part of the protein coding region (or open reading frame). An antisense nucleic acid molecule can also be antisense to all or part of a non-coding region of the coding strand of a nucleotide sequence encoding a polypeptide of the present invention. The non-coding regions ("5' and 3' untranslated regions") are the 5' and 3' sequences which flank the coding region and are not translated into amino acids.

An antisense oligonucleotide can be, for example, about 5, 10, 15, 20, 25, 30, 35, 40, 45, or 50 or more nucleotides in length. An antisense nucleic acid can be constructed using chemical synthesis and enzymatic ligation reactions using procedures known in the art. For example, an antisense nucleic acid (*e.g.*, an antisense oligonucleotide) can be chemically synthesized using naturally occurring nucleotides or variously modified nucleotides designed to increase the biological stability of the molecules or to increase the

physical stability of the duplex formed between the antisense and sense nucleic acids, *e.g.*, phosphorothioate derivatives and acridine substituted nucleotides can be used. Examples of modified nucleotides which can be used to generate the antisense nucleic acid include 5-fluorouracil, 5-bromouracil, 5-chlorouracil, 5-iodouracil, hypoxanthine, xanthine, 4-acetylcytosine, 5-(carboxyhydroxylmethyl) uracil, 5-carboxymethylaminomethyl-2-thiouridine, 5-carboxymethylaminomethyluracil, dihydrouracil, beta-D-galactosylqueosine, inosine, N6-isopentenyladenine, 1-methylguanine, 1-methylinosine, 2,2-dimethylguanine, 2- methyladenine, 2-methylguanine, 3-methylcytosine, 5-methylcytosine, N6-adenine, 7-methylguanine, 5-methylaminomethyluracil, 5-methoxyaminomethyl-2-thiouracil, beta-D-mannosylqueosine, 5'-methoxycarboxymethyluracil, 5-methoxyuracil, 2-methylthio-N6-isopentenyladenine, uracil-5-oxyacetic acid (v), wybutoxosine, pseudouracil, queosine, 2-thiocytosine, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-methyluracil, uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid (v), 5-methyl-2-thiouracil, 3-(3-amino-3-N-2-carboxypropyl) uracil, (acp3)w, and 2,6-diaminopurine. Alternatively, the antisense nucleic acid can be produced biologically using an expression vector into which a nucleic acid has been sub-cloned in an antisense orientation (*i.e.*, RNA transcribed from the inserted nucleic acid will be of an antisense orientation to a target nucleic acid of interest, described further in the following subsection).

The antisense nucleic acid molecules of the present invention are typically administered to a subject or generated *in situ* such that they hybridize with or bind to cellular mRNA and/or genomic DNA encoding a polypeptide corresponding to a selected marker of the present invention to thereby inhibit expression of the marker, *e.g.*, by inhibiting transcription and/or translation. The hybridization can be by conventional nucleotide complementarity to form a stable duplex, or, for example, in the case of an antisense nucleic acid molecule which binds to DNA duplexes, through specific interactions in the major groove of the double helix. Examples of a route of administration of antisense nucleic acid molecules of the present invention includes direct injection at a tissue site or infusion of the antisense nucleic acid into a blood- or bone marrow-associated body fluid. Alternatively, antisense nucleic acid molecules can be modified to target selected cells and then administered systemically. For example, for systemic administration, antisense molecules can be modified such that they specifically bind to receptors or antigens expressed on a selected cell surface, *e.g.*, by linking the antisense nucleic acid molecules to peptides or antibodies which bind to cell surface receptors or antigens. The antisense

nucleic acid molecules can also be delivered to cells using the vectors described herein. To achieve sufficient intracellular concentrations of the antisense molecules, vector constructs in which the antisense nucleic acid molecule is placed under the control of a strong pol II or pol III promoter are preferred.

An antisense nucleic acid molecule of the present invention can be an α-anomeric nucleic acid molecule. An α-anomeric nucleic acid molecule forms specific double-stranded hybrids with complementary RNA in which, contrary to the usual α-units, the strands run parallel to each other (Gaultier *et al.,* 1987, *Nucleic Acids Res.* 15:6625-6641). The antisense nucleic acid molecule can also comprise a 2'-o-methylribonucleotide (Inoue *et al.,* 1987, *Nucleic Acids Res.* 15:6131-6148) or a chimeric RNA-DNA analogue (Inoue *et al.,* 1987, *FEBS Lett.* 215:327-330).

The present invention also encompasses ribozymes. Ribozymes are catalytic RNA molecules with ribonuclease activity which are capable of cleaving a single-stranded nucleic acid, such as an mRNA, to which they have a complementary region. Thus, ribozymes (*e.g.*, hammerhead ribozymes as described in Haselhoff and Gerlach, 1988, *Nature* 334:585-591) can be used to catalytically cleave mRNA transcripts to thereby inhibit translation of the protein encoded by the mRNA. A ribozyme having specificity for a nucleic acid molecule encoding a polypeptide corresponding to a marker of the present invention can be designed based upon the nucleotide sequence of a cDNA corresponding to the marker. For example, a derivative of a *Tetrahymena* L-19 IVS RNA can be constructed in which the nucleotide sequence of the active site is complementary to the nucleotide sequence to be cleaved (see Cech *et al.* U.S. Patent No. 4,987,071; and Cech *et al.* U.S. Patent No. 5,116,742). Alternatively, an mRNA encoding a polypeptide of the present invention can be used to select a catalytic RNA having a specific ribonuclease activity from a pool of RNA molecules (see, *e.g.*, Bartel and Szostak, 1993, *Science* 261:1411-1418).

The present invention also encompasses nucleic acid molecules which form triple helical structures. For example, expression of a biomarker protein can be inhibited by targeting nucleotide sequences complementary to the regulatory region of the gene encoding the polypeptide (*e.g.*, the promoter and/or enhancer) to form triple helical structures that prevent transcription of the gene in target cells. See generally Helene (1991) *Anticancer Drug Des.* 6(6):569-84; Helene (1992) *Ann. N.Y. Acad. Sci.* 660:27-36; and Maher (1992) *Bioassays* 14(12):807-15.

In various embodiments, the nucleic acid molecules of the present invention can be modified at the base moiety, sugar moiety or phosphate backbone to improve, *e.g.*, the stability, hybridization, or solubility of the molecule. For example, the deoxyribose phosphate backbone of the nucleic acid molecules can be modified to generate peptide nucleic acid molecules (see Hyrup *et al.,* 1996, *Bioorganic & Medicinal Chemistry* 4(1): 5-23). As used herein, the terms "peptide nucleic acids" or "PNAs" refer to nucleic acid mimics, *e.g.*, DNA mimics, in which the deoxyribose phosphate backbone is replaced by a pseudopeptide backbone and only the four natural nucleobases are retained. The neutral backbone of PNAs has been shown to allow for specific hybridization to DNA and RNA under conditions of low ionic strength. The synthesis of PNA oligomers can be performed using standard solid phase peptide synthesis protocols as described in Hyrup *et al.* (1996), *supra*; Perry-O'Keefe *et al.* (1996) *Proc. Natl. Acad. Sci. USA* 93:14670-675.

PNAs can be used in therapeutic and diagnostic applications. For example, PNAs can be used as antisense or antigene agents for sequence-specific modulation of gene expression by, *e.g.*, inducing transcription or translation arrest or inhibiting replication. PNAs can also be used, *e.g.*, in the analysis of single base pair mutations in a gene by, *e.g.*, PNA directed PCR clamping; as artificial restriction enzymes when used in combination with other enzymes, *e.g.*, S1 nucleases (Hyrup (1996), *supra*; or as probes or primers for DNA sequence and hybridization (Hyrup, 1996, *supra*; Perry-O'Keefe *et al.,* 1996, *Proc. Natl. Acad. Sci. USA* 93:14670-675).

In another embodiment, PNAs can be modified, *e.g.*, to enhance their stability or cellular uptake, by attaching lipophilic or other helper groups to PNA, by the formation of PNA-DNA chimeras, or by the use of liposomes or other techniques of drug delivery known in the art. For example, PNA-DNA chimeras can be generated which can combine the advantageous properties of PNA and DNA. Such chimeras allow DNA recognition enzymes, *e.g.*, RNASE H and DNA polymerases, to interact with the DNA portion while the PNA portion would provide high binding affinity and specificity. PNA-DNA chimeras can be linked using linkers of appropriate lengths selected in terms of base stacking, number of bonds between the nucleobases, and orientation (Hyrup, 1996, *supra*). The synthesis of PNA-DNA chimeras can be performed as described in Hyrup (1996), *supra,* and Finn *et al.* (1996) *Nucleic Acids Res.* 24(17):3357-63. For example, a DNA chain can be synthesized on a solid support using standard phosphoramidite coupling chemistry and modified nucleoside analogs. Compounds such as 5'-(4-methoxytrityl)amino-5'-deoxy-

thymidine phosphoramidite can be used as a link between the PNA and the 5' end of DNA (Mag *et al.*, 1989, *Nucleic Acids Res.* 17:5973-88). PNA monomers are then coupled in a step-wise manner to produce a chimeric molecule with a 5' PNA segment and a 3' DNA segment (Finn *et al.*, 1996, *Nucleic Acids Res.* 24(17):3357-63). Alternatively, chimeric molecules can be synthesized with a 5' DNA segment and a 3' PNA segment (Peterser *et al.*, 1975, *Bioorganic Med. Chem. Lett.* 5:1119-11124).

In other embodiments, the oligonucleotide can include other appended groups such as peptides (*e.g.*, for targeting host cell receptors *in vivo*), or agents facilitating transport across the cell membrane (see, *e.g.*, Letsinger *et al.*, 1989, *Proc. Natl. Acad. Sci. USA* 86:6553-6556; Lemaitre *et al.*, 1987, *Proc. Natl. Acad. Sci. USA* 84:648-652; PCT Publication No. WO 88/09810) or the blood-brain barrier (see, *e.g.*, PCT Publication No. WO 89/10134). In addition, oligonucleotides can be modified with hybridization-triggered cleavage agents (see, *e.g.*, Krol *et al.*, 1988, *Bio/Techniques* 6:958-976) or intercalating agents (see, *e.g.*, Zon, 1988, *Pharm. Res.* 5:539-549). To this end, the oligonucleotide can be conjugated to another molecule, *e.g.*, a peptide, hybridization triggered cross-linking agent, transport agent, hybridization-triggered cleavage agent, *etc.*

Another aspect of the present invention pertains to the use of biomarker proteins and biologically active portions thereof. In one embodiment, the native polypeptide corresponding to a marker can be isolated from cells or tissue sources by an appropriate purification scheme using standard protein purification techniques. In another embodiment, polypeptides corresponding to a marker of the present invention are produced by recombinant DNA techniques. Alternative to recombinant expression, a polypeptide corresponding to a marker of the present invention can be synthesized chemically using standard peptide synthesis techniques.

An "isolated" or "purified" protein or biologically active portion thereof is substantially free of cellular material or other contaminating proteins from the cell or tissue source from which the protein is derived, or substantially free of chemical precursors or other chemicals when chemically synthesized. The language "substantially free of cellular material" includes preparations of protein in which the protein is separated from cellular components of the cells from which it is isolated or recombinantly produced. Thus, protein that is substantially free of cellular material includes preparations of protein having less than about 30%, 20%, 10%, or 5% (by dry weight) of heterologous protein (also referred to herein as a "contaminating protein"). When the protein or biologically active portion

thereof is recombinantly produced, it is also preferably substantially free of culture medium, *i.e.*, culture medium represents less than about 20%, 10%, or 5% of the volume of the protein preparation. When the protein is produced by chemical synthesis, it is preferably substantially free of chemical precursors or other chemicals, *i.e.*, it is separated from chemical precursors or other chemicals which are involved in the synthesis of the protein. Accordingly such preparations of the protein have less than about 30%, 20%, 10%, 5% (by dry weight) of chemical precursors or compounds other than the polypeptide of interest.

Biologically active portions of a biomarker polypeptide include polypeptides comprising amino acid sequences sufficiently identical to or derived from a biomarker protein amino acid sequence described herein, but which includes fewer amino acids than the full length protein, and exhibit at least one activity of the corresponding full-length protein. Typically, biologically active portions comprise a domain or motif with at least one activity of the corresponding protein. A biologically active portion of a protein of the present invention can be a polypeptide which is, for example, 10, 25, 50, 100 or more amino acids in length. Moreover, other biologically active portions, in which other regions of the protein are deleted, can be prepared by recombinant techniques and evaluated for one or more of the functional activities of the native form of a polypeptide of the present invention.

Preferred polypeptides have an amino acid sequence of a biomarker protein encoded by a nucleic acid molecule described herein. Other useful proteins are substantially identical (*e.g.*, at least about 40%, preferably 50%, 60%, 70%, 75%, 80%, 83%, 85%, 88%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99%) to one of these sequences and retain the functional activity of the protein of the corresponding naturally-occurring protein yet differ in amino acid sequence due to natural allelic variation or mutagenesis.

To determine the percent identity of two amino acid sequences or of two nucleic acids, the sequences are aligned for optimal comparison purposes (*e.g.*, gaps can be introduced in the sequence of a first amino acid or nucleic acid sequence for optimal alignment with a second amino or nucleic acid sequence). The amino acid residues or nucleotides at corresponding amino acid positions or nucleotide positions are then compared. When a position in the first sequence is occupied by the same amino acid residue or nucleotide as the corresponding position in the second sequence, then the molecules are identical at that position. The percent identity between the two sequences is

a function of the number of identical positions shared by the sequences (*i.e.*, % identity = # of identical positions/total # of positions (*e.g.*, overlapping positions) x100). In one embodiment the two sequences are the same length.

The determination of percent identity between two sequences can be accomplished using a mathematical algorithm. A preferred, non-limiting example of a mathematical algorithm utilized for the comparison of two sequences is the algorithm of Karlin and Altschul (1990) *Proc. Natl. Acad. Sci. USA* 87:2264-2268, modified as in Karlin and Altschul (1993) *Proc. Natl. Acad. Sci. USA* 90:5873-5877. Such an algorithm is incorporated into the NBLAST and XBLAST programs of Altschul, *et al.* (1990) *J. Mol. Biol.* 215:403-410. BLAST nucleotide searches can be performed with the NBLAST program, score = 100, wordlength = 12 to obtain nucleotide sequences homologous to a nucleic acid molecules of the present invention. BLAST protein searches can be performed with the XBLAST program, score = 50, wordlength = 3 to obtain amino acid sequences homologous to a protein molecules of the present invention. To obtain gapped alignments for comparison purposes, Gapped BLAST can be utilized as described in Altschul *et al.* (1997) *Nucleic Acids Res.* 25:3389-3402. Alternatively, PSI-Blast can be used to perform an iterated search which detects distant relationships between molecules. When utilizing BLAST, Gapped BLAST, and PSI-Blast programs, the default parameters of the respective programs (*e.g.*, XBLAST and NBLAST) can be used. See http://www.ncbi.nlm.nih.gov. Another preferred, non-limiting example of a mathematical algorithm utilized for the comparison of sequences is the algorithm of Myers and Miller, (1988) *Comput Appl Biosci,* 4:11-7. Such an algorithm is incorporated into the ALIGN program (version 2.0) which is part of the GCG sequence alignment software package. When utilizing the ALIGN program for comparing amino acid sequences, a PAM120 weight residue table, a gap length penalty of 12, and a gap penalty of 4 can be used. Yet another useful algorithm for identifying regions of local sequence similarity and alignment is the FASTA algorithm as described in Pearson and Lipman (1988) *Proc. Natl. Acad. Sci. USA* 85:2444-2448. When using the FASTA algorithm for comparing nucleotide or amino acid sequences, a PAM120 weight residue table can, for example, be used with a *k*-tuple value of 2.

The percent identity between two sequences can be determined using techniques similar to those described above, with or without allowing gaps. In calculating percent identity, only exact matches are counted.

The present invention also provides chimeric or fusion proteins corresponding to a biomarker protein. As used herein, a "chimeric protein" or "fusion protein" comprises all or part (preferably a biologically active part) of a polypeptide corresponding to a marker of the present invention operably linked to a heterologous polypeptide (*i.e.*, a polypeptide other than the polypeptide corresponding to the marker). Within the fusion protein, the term "operably linked" is intended to indicate that the polypeptide of the present invention and the heterologous polypeptide are fused in-frame to each other. The heterologous polypeptide can be fused to the amino-terminus or the carboxyl-terminus of the polypeptide of the present invention.

One useful fusion protein is a GST fusion protein in which a polypeptide corresponding to a marker of the present invention is fused to the carboxyl terminus of GST sequences. Such fusion proteins can facilitate the purification of a recombinant polypeptide of the present invention.

In another embodiment, the fusion protein contains a heterologous signal sequence, immunoglobulin fusion protein, toxin, or other useful protein sequence. Chimeric and fusion proteins of the present invention can be produced by standard recombinant DNA techniques. In another embodiment, the fusion gene can be synthesized by conventional techniques including automated DNA synthesizers. Alternatively, PCR amplification of gene fragments can be carried out using anchor primers which give rise to complementary overhangs between two consecutive gene fragments which can subsequently be annealed and re-amplified to generate a chimeric gene sequence (see, *e.g.*, Ausubel *et al.*, *supra*). Moreover, many expression vectors are commercially available that already encode a fusion moiety (*e.g.*, a GST polypeptide). A nucleic acid encoding a polypeptide of the present invention can be cloned into such an expression vector such that the fusion moiety is linked in-frame to the polypeptide of the present invention.

A signal sequence can be used to facilitate secretion and isolation of the secreted protein or other proteins of interest. Signal sequences are typically characterized by a core of hydrophobic amino acids which are generally cleaved from the mature protein during secretion in one or more cleavage events. Such signal peptides contain processing sites that allow cleavage of the signal sequence from the mature proteins as they pass through the secretory pathway. Thus, the present invention pertains to the described polypeptides having a signal sequence, as well as to polypeptides from which the signal sequence has been proteolytically cleaved (*i.e.*, the cleavage products). In one embodiment, a nucleic

acid sequence encoding a signal sequence can be operably linked in an expression vector to a protein of interest, such as a protein which is ordinarily not secreted or is otherwise difficult to isolate. The signal sequence directs secretion of the protein, such as from a eukaryotic host into which the expression vector is transformed, and the signal sequence is subsequently or concurrently cleaved. The protein can then be readily purified from the extracellular medium by art recognized methods. Alternatively, the signal sequence can be linked to the protein of interest using a sequence which facilitates purification, such as with a GST domain.

The present invention also pertains to variants of the biomarker polypeptides described herein. Such variants have an altered amino acid sequence which can function as either agonists (mimetics) or as antagonists. Variants can be generated by mutagenesis, *e.g.*, discrete point mutation or truncation. An agonist can retain substantially the same, or a subset, of the biological activities of the naturally occurring form of the protein. An antagonist of a protein can inhibit one or more of the activities of the naturally occurring form of the protein by, for example, competitively binding to a downstream or upstream member of a cellular signaling cascade which includes the protein of interest. Thus, specific biological effects can be elicited by treatment with a variant of limited function. Treatment of a subject with a variant having a subset of the biological activities of the naturally occurring form of the protein can have fewer side effects in a subject relative to treatment with the naturally occurring form of the protein.

Variants of a biomarker protein which function as either agonists (mimetics) or as antagonists can be identified by screening combinatorial libraries of mutants, *e.g.*, truncation mutants, of the protein of the present invention for agonist or antagonist activity. In one embodiment, a variegated library of variants is generated by combinatorial mutagenesis at the nucleic acid level and is encoded by a variegated gene library. A variegated library of variants can be produced by, for example, enzymatically ligating a mixture of synthetic oligonucleotides into gene sequences such that a degenerate set of potential protein sequences is expressible as individual polypeptides, or alternatively, as a set of larger fusion proteins (*e.g.*, for phage display). There are a variety of methods which can be used to produce libraries of potential variants of the polypeptides of the present invention from a degenerate oligonucleotide sequence. Methods for synthesizing degenerate oligonucleotides are known in the art (see, *e.g.*, Narang, 1983, *Tetrahedron*

39:3; Itakura *et al.,* 1984, *Annu. Rev. Biochem.* 53:323; Itakura *et al.,* 1984, *Science* 198:1056; Ike *et al.,* 1983 *Nucleic Acid Res.* 11:477).

In addition, libraries of fragments of the coding sequence of a polypeptide corresponding to a marker of the present invention can be used to generate a variegated population of polypeptides for screening and subsequent selection of variants. For example, a library of coding sequence fragments can be generated by treating a double stranded PCR fragment of the coding sequence of interest with a nuclease under conditions wherein nicking occurs only about once per molecule, denaturing the double stranded DNA, renaturing the DNA to form double stranded DNA which can include sense/antisense pairs from different nicked products, removing single stranded portions from reformed duplexes by treatment with S1 nuclease, and ligating the resulting fragment library into an expression vector. By this method, an expression library can be derived which encodes amino terminal and internal fragments of various sizes of the protein of interest.

Several techniques are known in the art for screening gene products of combinatorial libraries made by point mutations or truncation, and for screening cDNA libraries for gene products having a selected property. The most widely used techniques, which are amenable to high throughput analysis, for screening large gene libraries typically include cloning the gene library into replicable expression vectors, transforming appropriate cells with the resulting library of vectors, and expressing the combinatorial genes under conditions in which detection of a desired activity facilitates isolation of the vector encoding the gene whose product was detected. Recursive ensemble mutagenesis (REM), a technique which enhances the frequency of functional mutants in the libraries, can be used in combination with the screening assays to identify variants of a protein of the present invention (Arkin and Yourvan, 1992, *Proc. Natl. Acad. Sci. USA 8*9:7811-7815; Delgrave *et al.,* 1993, *Protein Engineering* 6(3):327- 331).

An isolated polypeptide or a fragment thereof (or a nucleic acid encoding such a polypeptide) corresponding to one or more biomarkers of the invention, including the biomarkers listed in Table 1 or fragments thereof, can be used as an immunogen to generate antibodies that bind to said immunogen, using standard techniques for polyclonal and monoclonal antibody preparation according to well-known methods in the art. An antigenic peptide comprises at least 8 amino acid residues and encompasses an epitope present in the respective full length molecule such that an antibody raised against the peptide forms a specific immune complex with the respective full length molecule. Preferably, the

antigenic peptide comprises at least 10 amino acid residues. In one embodiment such epitopes can be specific for a given polypeptide molecule from one species, such as mouse or human (*i.e.*, an antigenic peptide that spans a region of the polypeptide molecule that is not conserved across species is used as immunogen; such non conserved residues can be determined using an alignment such as that provided herein).

In some embodiments, the immunotherapy utilizes an inhibitor of at least one immune checkpoint, such as an antibody binds substantially specifically to an immune checkpoint, such as PD-1, and inhibits or blocks its immunoinhibitory function, such as by interrupting its interaction with a binding partner of the immune checkpoint, such as PD-L1 and/or PD-L2 binding partners of PD-1. In one embodiment, an antibody, especially an intrbody, binds substantially specifically to one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and inhibits or blocks its biological function, such as by interrupting its interaction with a substrate like STAT or JAK proteins. In another embodiment, an antibody, especially an intrbody, binds substantially specifically to a binding partner of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1), such as PTPN2 and/or SOCS1 substrates described herein, and inhibits or blocks its biological function, such as by interrupting its interaction to PTPN2 and/or SOCS1.

For example, a polypeptide immunogen typically is used to prepare antibodies by immunizing a suitable subject (*e.g.*, rabbit, goat, mouse or other mammal) with the immunogen. A preferred animal is a mouse deficeint in the desired target antigen. For example, a PD-1 knockout mouse if the desired antibody is an anti-PD-1 antibody, may be used. This results in a wider spectrum of antibody recognition possibilities as antibodies reactive to common mouse and human epitopes are not removed by tolerance mechanisms. An appropriate immunogenic preparation can contain, for example, a recombinantly expressed or chemically synthesized molecule or fragment thereof to which the immune response is to be generated. The preparation can further include an adjuvant, such as Freund's complete or incomplete adjuvant, or similar immunostimulatory agent. Immunization of a suitable subject with an immunogenic preparation induces a polyclonal antibody response to the antigenic peptide contained therein.

Polyclonal antibodies can be prepared as described above by immunizing a suitable subject with a polypeptide immunogen. The polypeptide antibody titer in the immunized subject can be monitored over time by standard techniques, such as with an enzyme linked

immunosorbent assay (ELISA) using immobilized polypeptide. If desired, the antibody directed against the antigen can be isolated from the mammal (*e.g.*, from the blood) and further purified by well-known techniques, such as protein A chromatography, to obtain the IgG fraction. At an appropriate time after immunization, *e.g.*, when the antibody titers are highest, antibody-producing cells can be obtained from the subject and used to prepare monoclonal antibodies by standard techniques, such as the hybridoma technique (originally described by Kohler and Milstein (1975) *Nature* 256:495-497) (see also Brown *et al.* (1981) *J. Immunol.* 127:539-46; Brown *et al.* (1980) *J. Biol. Chem.* 255:4980-83; Yeh *et al.* (1976) *Proc. Natl. Acad. Sci.* 76:2927-31; Yeh *et al.* (1982) *Int. J. Cancer* 29:269-75), the more recent human B cell hybridoma technique (Kozbor *et al.* (1983) *Immunol. Today* 4:72), the EBV-hybridoma technique (Cole *et al.* (1985) *Monoclonal Antibodies and Cancer Therapy*, Alan R. Liss, Inc., pp. 77-96) or trioma techniques. The technology for producing monoclonal antibody hybridomas is well-known (see generally Kenneth, R. H. in *Monoclonal Antibodies: A New Dimension In Biological Analyses*, Plenum Publishing Corp., New York, New York (1980); Lerner, E. A. (1981) *Yale J. Biol. Med.* 54:387-402; Gefter, M. L. *et al.* (1977) *Somatic Cell Genet.* 3:231-36). Briefly, an immortal cell line (typically a myeloma) is fused to lymphocytes (typically splenocytes) from a mammal immunized with an immunogen as described above, and the culture supernatants of the resulting hybridoma cells are screened to identify a hybridoma producing a monoclonal antibody that binds to the polypeptide antigen, preferably specifically. In some embodiments, the immunization is performed in a cell or animal host that has a knockout of a target antigen of interest (*e.g.*, does not produce the antigen prior to immunization).

Any of the many well-known protocols used for fusing lymphocytes and immortalized cell lines can be applied for the purpose of generating a monoclonal antibody against one or more biomarkers of the invention, including the biomarkers listed in Table 1, or a fragment thereof (see, *e.g.*, Galfre, G. *et al.* (1977) *Nature* 266:55052; Gefter *et al.* (1977) *supra*; Lerner (1981) *supra*; Kenneth (1980) *supra*). Moreover, the ordinary skilled worker will appreciate that there are many variations of such methods which also would be useful. Typically, the immortal cell line (*e.g.*, a myeloma cell line) is derived from the same mammalian species as the lymphocytes. For example, murine hybridomas can be made by fusing lymphocytes from a mouse immunized with an immunogenic preparation of the present invention with an immortalized mouse cell line. Preferred immortal cell lines are mouse myeloma cell lines that are sensitive to culture medium containing hypoxanthine,

aminopterin and thymidine ("HAT medium"). Any of a number of myeloma cell lines can be used as a fusion partner according to standard techniques, *e.g.*, the P3-NS1/1-Ag4-1, P3-x63-Ag8.653 or Sp2/O-Ag14 myeloma lines. These myeloma lines are available from the American Type Culture Collection (ATCC), Rockville, MD. Typically, HAT-sensitive mouse myeloma cells are fused to mouse splenocytes using polyethylene glycol ("PEG"). Hybridoma cells resulting from the fusion are then selected using HAT medium, which kills unfused and unproductively fused myeloma cells (unfused splenocytes die after several days because they are not transformed). Hybridoma cells producing a monoclonal antibody of the invention are detected by screening the hybridoma culture supernatants for antibodies that bind a given polypeptide, *e.g.*, using a standard ELISA assay.

As an alternative to preparing monoclonal antibody-secreting hybridomas, a monoclonal specific for one of the above described polypeptides can be identified and isolated by screening a recombinant combinatorial immunoglobulin library (*e.g.*, an antibody phage display library) with the appropriate polypeptide to thereby isolate immunoglobulin library members that bind the polypeptide. Kits for generating and screening phage display libraries are commercially available (*e.g.*, the Pharmacia *Recombinant Phage Antibody System*, Catalog No. 27-9400-01; and the Stratagene *SurfZAP*™ *Phage Display Kit*, Catalog No. 240612). Additionally, examples of methods and reagents particularly amenable for use in generating and screening an antibody display library can be found in, for example, Ladner *et al.* U.S. Patent No. 5,223,409; Kang *et al.* International Publication No. WO 92/18619; Dower *et al.* International Publication No. WO 91/17271; Winter *et al.* International Publication WO 92/20791; Markland *et al.* International Publication No. WO 92/15679; Breitling *et al.* International Publication WO 93/01288; McCafferty *et al.* International Publication No. WO 92/01047; Garrard *et al.* International Publication No. WO 92/09690; Ladner *et al.* International Publication No. WO 90/02809; Fuchs *et al.* (1991) *Biotechnology (NY)* 9:1369-1372; Hay *et al.* (1992) *Hum. Antibod. Hybridomas* 3:81-85; Huse *et al.* (1989) *Science* 246:1275-1281; Griffiths *et al.* (1993) *EMBO J.* 12:725-734; Hawkins *et al.* (1992) *J. Mol. Biol.* 226:889-896; Clarkson *et al.* (1991) *Nature* 352:624-628; Gram *et al.* (1992) *Proc. Natl. Acad. Sci. USA* 89:3576-3580; Garrard *et al.* (1991) *Biotechnology (NY)* 9:1373-1377; Hoogenboom *et al.* (1991) *Nucleic Acids Res.* 19:4133-4137; Barbas *et al.* (1991) *Proc. Natl. Acad. Sci. USA* 88:7978-7982; and McCafferty *et al.* (1990) *Nature* 348:552-554.

Since it is well-known in the art that antibody heavy and light chain CDR3 domains play a particularly important role in the binding specificity/affinity of an antibody for an antigen, the recombinant monoclonal antibodies of the present invention prepared as set forth above preferably comprise the heavy and light chain CDR3s of variable regions of the antibodies described herein and well-known in the art. Similarly, the antibodies can further comprise the CDR2s of variable regions of said antibodies. The antibodies can further comprise the CDR1s of variable regions of said antibodies. In other embodiments, the antibodies can comprise any combinations of the CDRs.

The CDR1, 2, and/or 3 regions of the engineered antibodies described above can comprise the exact amino acid sequence(s) as those of variable regions of the present invention described herein. However, the ordinarily skilled artisan will appreciate that some deviation from the exact CDR sequences may be possible while still retaining the ability of the antibody, especially an introbody, to bind a desired target, such as one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and/or a binding partner thereof, either alone or in combination with an immunotherapy, such as PTPN2 and SOCS1, PTPN2/SOCS1 binding partners/substrates, or an immunotherapy effectively (*e.g.*, conservative sequence modifications). Accordingly, in another embodiment, the engineered antibody may be composed of one or more CDRs that are, for example, 50%, 60%, 70%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 99.5% identical to one or more CDRs of the present invention described herein or otherwise publicly available.

For example, the structural features of non-human or human antibodies (*e.g.*, a rat anti-mouse/anti-human antibody) can be used to create structurally related human antibodies, especially introbodies, that retain at least one functional property of the antibodies of the present invention, such as binding to PTPN2 and/or SOCS1, PTPN2/SOCS1 binding partners/substrates, and/or an immune checkpoint. Another functional property includes inhibiting binding of the original known, non-human or human antibodies in a competition ELISA assay.

Antibodies, immunoglobulins, and polypeptides of the invention can be used in an isolated (*e.g.*, purified) form or contained in a vector, such as a membrane or lipid vesicle (*e.g.* a liposome). Moreover, amino acid sequence modification(s) of the antibodies described herein are contemplated. For example, it may be desirable to improve the binding affinity and/or other biological properties of the antibody. It is known that when a

humanized antibody is produced by simply grafting only CDRs in VH and VL of an antibody derived from a non-human animal in FRs of the VH and VL of a human antibody, the antigen binding activity is reduced in comparison with that of the original antibody derived from a non-human animal. It is considered that several amino acid residues of the VH and VL of the non-human antibody, not only in CDRs but also in FRs, are directly or indirectly associated with the antigen binding activity. Hence, substitution of these amino acid residues with different amino acid residues derived from FRs of the VH and VL of the human antibody would reduce binding activity and can be corrected by replacing the amino acids with amino acid residues of the original antibody derived from a non-human animal.

Similarly, modifications and changes may be made in the structure of the antibodies described herein, and in the DNA sequences encoding them, and still obtain a functional molecule that encodes an antibody and polypeptide with desirable characteristics. For example, antibody glycosylation patterns can be modulated to, for example, increase stability. By "altering" is meant deleting one or more carbohydrate moieties found in the antibody, and/or adding one or more glycosylation sites that are not present in the antibody. Glycosylation of antibodies is typically N-linked. "N-linked" refers to the attachment of the carbohydrate moiety to the side chain of an asparagine residue. The tripeptide sequences asparagine-X-serine and asparagines-X-threonine, where X is any amino acid except proline, are the recognition sequences for enzymatic attachment of the carbohydrate moiety to the asparagine side chain. Thus, the presence of either of these tripeptide sequences in a polypeptide creates a potential glycosylation site. Addition of glycosylation sites to the antibody is conveniently accomplished by altering the amino acid sequence such that it contains one or more of the above-described tripeptide sequences (for N-linked glycosylation sites). Another type of covalent modification involves chemically or enzymatically coupling glycosides to the antibody. These procedures are advantageous in that they do not require production of the antibody in a host cell that has glycosylation capabilities for N- or O-linked glycosylation. Depending on the coupling mode used, the sugar(s) may be attached to (a) arginine and histidine, (b) free carboxyl groups, (c) free sulfhydryl groups such as those of cysteine, (d) free hydroxyl groups such as those of serine, threonine, orhydroxyproline, (e) aromatic residues such as those of phenylalanine, tyrosine, or tryptophan, or (f) the amide group of glutamine. For example, such methods are described in WO87/05330.

Similarly, removal of any carbohydrate moieties present on the antibody may be accomplished chemically or enzymatically. Chemical deglycosylation requires exposure of the antibody to the compound trifluoromethanesulfonic acid, or an equivalent compound. This treatment results in the cleavage of most or all sugars except the linking sugar (N-acetylglucosamine or N-acetylgalactosamine), while leaving the antibody intact. Chemical deglycosylation is described by *Sojahr et al.* (1987) and by Edge *et al.* (1981). Enzymatic cleavage of carbohydrate moieties on antibodies can be achieved by the use of a variety of endo- and exo-glycosidases as described by Thotakura *et al.* (1987).

Other modifications can involve the formation of immunoconjugates. For example, in one type of covalent modification, antibodies or proteins are covalently linked to one of a variety of non proteinaceous polymers, *e.g.*, polyethylene glycol, polypropylene glycol, or polyoxyalkylenes, in the manner set forth in U.S. Pat. No. 4,640,835; 4,496,689; 4,301,144; 4,670,417; 4,791,192 or 4,179,337.

Conjugation of antibodies or other proteins of the present invention with heterologous agents can be made using a variety of bifunctional protein coupling agents including but not limited to N-succinimidyl (2-pyridyldithio) propionate (SPDP), succinimidyl (N-maleimidomethyl)cyclohexane-1-carboxylate, iminothiolane (IT), bifunctional derivatives of imidoesters (such as dimethyl adipimidate HCL), active esters (such as disuccinimidyl suberate), aldehydes (such as glutaraldehyde), bis-azido compounds (such as bis (p-azidobenzoyl) hexanediamine), bis-diazonium derivatives (such as bis-(p-diazoniumbenzoyl)-ethylenediamine), diisocyanates (such as toluene 2,6diisocyanate), and bis-active fluorine compounds (such as 1,5-difluoro-2,4-dinitrobenzene). For example, carbon labeled 1-isothiocyanatobenzyl methyldiethylene triaminepentaacetic acid (MX-DTPA) is an exemplary chelating agent for conjugation of radionucleotide to the antibody (WO 94/11026).

In another aspect, the present invention features antibodies conjugated to a therapeutic moiety, such as a cytotoxin, a drug, and/or a radioisotope. When conjugated to a cytotoxin, these antibody conjugates are referred to as "immunotoxins." A cytotoxin or cytotoxic agent includes any agent that is detrimental to (*e.g.*, kills) cells. Examples include taxol, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin, etoposide, tenoposide, vincristine, vinblastine, colchicin, doxorubicin, daunorubicin, dihydroxy anthracin dione, mitoxantrone, mithramycin, actinomycin D, 1-dehydrotestosterone, glucocorticoids, procaine, tetracaine, lidocaine, propranolol, and puromycin and analogs or

homologs thereof. Therapeutic agents include, but are not limited to, antimetabolites (*e.g.*, methotrexate, 6-mercaptopurine, 6-thioguanine, cytarabine, 5-fluorouracil decarbazine), alkylating agents (*e.g.*, mechlorethamine, thioepa chlorambucil, melphalan, carmustine (BSNU) and lomustine (CCNU), cyclothosphamide, busulfan, dibromomannitol, streptozotocin, mitomycin C, and cis-dichlorodiamine platinum (II) (DDP) cisplatin), anthracyclines (*e.g.*, daunorubicin (formerly daunomycin) and doxorubicin), antibiotics (*e.g.*, dactinomycin (formerly actinomycin), bleomycin, mithramycin, and anthramycin (AMC)), and anti-mitotic agents (*e.g.*, vincristine and vinblastine). An antibody of the present invention can be conjugated to a radioisotope, *e.g.*, radioactive iodine, to generate cytotoxic radiopharmaceuticals for treating a related disorder, such as a cancer.

Conjugated antibodies, in addition to therapeutic utility, can be useful for diagnostically or prognostically to monitor polypeptide levels in tissue as part of a clinical testing procedure, *e.g.*, to determine the efficacy of a given treatment regimen. Detection can be facilitated by coupling (*i e.*, physically linking) the antibody to a detectable substance. Examples of detectable substances include various enzymes, prosthetic groups, fluorescent materials, luminescent materials, bioluminescent materials, and radioactive materials. Examples of suitable enzymes include horseradish peroxidase, alkaline phosphatase, β-galactosidase, or acetylcholinesterase; examples of suitable prosthetic group complexes include streptavidin/biotin and avidin/biotin; examples of suitable fluorescent materials include umbelliferone, fluorescein, fluorescein isothiocyanate (FITC), rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or phycoerythrin (PE); an example of a luminescent material includes luminol; examples of bioluminescent materials include luciferase, luciferin, and aequorin, and examples of suitable radioactive material include ^{125}I, ^{131}I, ^{35}S, or ^{3}H. [0134] As used herein, the term "labeled", with regard to the antibody, is intended to encompass direct labeling of the antibody by coupling (*i.e.*, physically linking) a detectable substance, such as a radioactive agent or a fluorophore (*e.g.* fluorescein isothiocyanate (FITC) or phycoerythrin (PE) or Indocyanine (Cy5)) to the antibody, as well as indirect labeling of the antibody by reactivity with a detectable substance.

The antibody conjugates of the present invention can be used to modify a given biological response. The therapeutic moiety is not to be construed as limited to classical chemical therapeutic agents. For example, the drug moiety may be a protein or polypeptide possessing a desired biological activity. Such proteins may include, for example, an

enzymatically active toxin, or active fragment thereof, such as abrin, ricin A, *Pseudomonas* exotoxin, or diphtheria toxin; a protein such as tumor necrosis factor or interferon-.gamma.; or, biological response modifiers such as, for example, lymphokines, interleukin-1 ("IL-1"), interleukin-2 ("IL-2"), interleukin-6 ("IL-6"), granulocyte macrophage colony stimulating factor ("GM-CSF"), granulocyte colony stimulating factor ("G-CSF"), or other cytokines or growth factors.

In one embodiment, an antibody for use in the instant invention is a bispecific or multispecific antibody. A bispecific antibody has binding sites for two different antigens within a single antibody polypeptide. Antigen binding may be simultaneous or sequential. Triomas and hybrid hybridomas are two examples of cell lines that can secrete bispecific antibodies. Examples of bispecific antibodies produced by a hybrid hybridoma or a trioma are disclosed in U.S. Patent 4,474,893. Bispecific antibodies have been constructed by chemical means (Staerz *et al.* (1985) *Nature* 314:628, and Perez *et al.* (1985) *Nature* 316:354) and hybridoma technology (Staerz and Bevan (1986) *Proc. Natl. Acad. Sci. USA*, 83:1453, and Staerz and Bevan (1986) *Immunol. Today* 7:241). Bispecific antibodies are also described in U.S. Patent 5,959,084. Fragments of bispecific antibodies are described in U.S. Patent 5,798,229.

Bispecific agents can also be generated by making heterohybridomas by fusing hybridomas or other cells making different antibodies, followed by identification of clones producing and co-assembling both antibodies. They can also be generated by chemical or genetic conjugation of complete immunoglobulin chains or portions thereof such as Fab and Fv sequences. The antibody component can bind to a polypeptide or a fragment thereof of one or more biomarkers of the invention, including one or more biomarkers listed in Table 1, or a fragment thereof. In one embodiment, the bispecific antibody could specifically bind to both a polypeptide or a fragment thereof and its natural binding partner(s) or a fragment(s) thereof.

Techniques for modulating antibodies, such as humanization, conjugation, recombinant techniques, and the like are well-known in the art.

In another aspect of this invention, peptides or peptide mimetics can be used to antagonize the activity of one or more biomarkers of the invention, including one or more biomarkers listed in Table 1, or a fragment(s) thereof. In one embodiment, variants of one or more biomarkers listed in Table 1 which function as a modulating agent for the respective full length protein, can be identified by screening combinatorial libraries of

mutants, *e.g.*, truncation mutants, for antagonist activity. In one embodiment, a variegated library of variants is generated by combinatorial mutagenesis at the nucleic acid level and is encoded by a variegated gene library. A variegated library of variants can be produced, for instance, by enzymatically ligating a mixture of synthetic oligonucleotides into gene sequences such that a degenerate set of potential polypeptide sequences is expressible as individual polypeptides containing the set of polypeptide sequences therein. There are a variety of methods which can be used to produce libraries of polypeptide variants from a degenerate oligonucleotide sequence. Chemical synthesis of a degenerate gene sequence can be performed in an automatic DNA synthesizer, and the synthetic gene then ligated into an appropriate expression vector. Use of a degenerate set of genes allows for the provision, in one mixture, of all of the sequences encoding the desired set of potential polypeptide sequences. Methods for synthesizing degenerate oligonucleotides are known in the art (see, *e.g.*, Narang, S. A. (1983) *Tetrahedron* 39:3; Itakura *et al.* (1984) *Annu. Rev. Biochem.* 53:323; Itakura *et al.* (1984) *Science* 198:1056; Ike *et al.* (1983) *Nucleic Acid Res.* 11:477.

In addition, libraries of fragments of a polypeptide coding sequence can be used to generate a variegated population of polypeptide fragments for screening and subsequent selection of variants of a given polypeptide. In one embodiment, a library of coding sequence fragments can be generated by treating a double stranded PCR fragment of a polypeptide coding sequence with a nuclease under conditions wherein nicking occurs only about once per polypeptide, denaturing the double stranded DNA, renaturing the DNA to form double stranded DNA which can include sense/antisense pairs from different nicked products, removing single stranded portions from reformed duplexes by treatment with S1 nuclease, and ligating the resulting fragment library into an expression vector. By this method, an expression library can be derived which encodes N-terminal, C-terminal and internal fragments of various sizes of the polypeptide.

Several techniques are known in the art for screening gene products of combinatorial libraries made by point mutations or truncation, and for screening cDNA libraries for gene products having a selected property. Such techniques are adaptable for rapid screening of the gene libraries generated by the combinatorial mutagenesis of polypeptides. The most widely used techniques, which are amenable to high through-put analysis, for screening large gene libraries typically include cloning the gene library into replicable expression vectors, transforming appropriate cells with the resulting library of vectors, and expressing the combinatorial genes under conditions in which detection of a

desired activity facilitates isolation of the vector encoding the gene whose product was detected. Recursive ensemble mutagenesis (REM), a technique which enhances the frequency of functional mutants in the libraries, can be used in combination with the screening assays to identify variants of interest (Arkin and Youvan (1992) *Proc. Natl. Acad. Sci. USA* 89:7811-7815; Delagrave *et al.* (1993) *Protein Eng.* 6(3):327-331). In one embodiment, cell based assays can be exploited to analyze a variegated polypeptide library. For example, a library of expression vectors can be transfected into a cell line which ordinarily synthesizes one or more biomarkers of the invention, including one or more biomarkers listed in Table 1, or a fragment thereof. The transfected cells are then cultured such that the full length polypeptide and a particular mutant polypeptide are produced and the effect of expression of the mutant on the full length polypeptide activity in cell supernatants can be detected, *e.g.*, by any of a number of functional assays. Plasmid DNA can then be recovered from the cells which score for inhibition, or alternatively, potentiation of full length polypeptide activity, and the individual clones further characterized.

Systematic substitution of one or more amino acids of a polypeptide amino acid sequence with a D-amino acid of the same type (*e.g.*, D-lysine in place of L-lysine) can be used to generate more stable peptides. In addition, constrained peptides comprising a polypeptide amino acid sequence of interest or a substantially identical sequence variation can be generated by methods known in the art (Rizo and Gierasch (1992) *Annu. Rev. Biochem.* 61:387, incorporated herein by reference); for example, by adding internal cysteine residues capable of forming intramolecular disulfide bridges which cyclize the peptide.

The amino acid sequences described herein will enable those of skill in the art to produce polypeptides corresponding peptide sequences and sequence variants thereof. Such polypeptides can be produced in prokaryotic or eukaryotic host cells by expression of polynucleotides encoding the peptide sequence, frequently as part of a larger polypeptide. Alternatively, such peptides can be synthesized by chemical methods. Methods for expression of heterologous proteins in recombinant hosts, chemical synthesis of polypeptides, and *in vitro* translation are well-known in the art and are described further in Maniatis *et al. Molecular Cloning: A Laboratory Manual* (1989), 2nd Ed., Cold Spring Harbor, N.Y.; Berger and Kimmel, Methods in Enzymology, Volume 152, Guide to Molecular Cloning Techniques (1987), Academic Press, Inc., San Diego, Calif.; Merrifield,

J. (1969) *J. Am. Chem. Soc.* 91:501; Chaiken I. M. (1981) *CRC Crit. Rev. Biochem.* 11: 255; Kaiser *et al.* (1989) *Science* 243:187; Merrifield, B. (1986) *Science* 232:342; Kent, S. B. H. (1988) *Annu. Rev. Biochem.* 57:957; and Offord, R. E. (1980) *Semisynthetic Proteins*, Wiley Publishing, which are incorporated herein by reference).

Peptides can be produced, typically by direct chemical synthesis. Peptides can be produced as modified peptides, with nonpeptide moieties attached by covalent linkage to the N-terminus and/or C-terminus. In certain preferred embodiments, either the carboxy-terminus or the amino-terminus, or both, are chemically modified. The most common modifications of the terminal amino and carboxyl groups are acetylation and amidation, respectively. Amino-terminal modifications such as acylation (*e.g.*, acetylation) or alkylation (*e.g.*, methylation) and carboxy-terminal-modifications such as amidation, as well as other terminal modifications, including cyclization, can be incorporated into various embodiments of the invention. Certain amino-terminal and/or carboxy-terminal modifications and/or peptide extensions to the core sequence can provide advantageous physical, chemical, biochemical, and pharmacological properties, such as: enhanced stability, increased potency and/or efficacy, resistance to serum proteases, desirable pharmacokinetic properties, and others. Peptides described herein can be used therapeutically to treat disease, *e.g.*, by altering costimulation in a patient.

Peptidomimetics (Fauchere (1986) *Adv. Drug Res.* 15:29; Veber and Freidinger (1985) TINS p.392; and Evans *et al.* (1987) *J. Med. Chem.* 30:1229, which are incorporated herein by reference) are usually developed with the aid of computerized molecular modeling. Peptide mimetics that are structurally similar to therapeutically useful peptides can be used to produce an equivalent therapeutic or prophylactic effect. Generally, peptidomimetics are structurally similar to a paradigm polypeptide (*i.e.*, a polypeptide that has a biological or pharmacological activity), but have one or more peptide linkages optionally replaced by a linkage selected from the group consisting of: -CH2NH-, -CH2S-, -CH2-CH2-, -CH=CH- (cis and trans), -COCH2-, -CH(OH)CH2-, and -CH2SO-, by methods known in the art and further described in the following references: Spatola, A. F. in "*Chemistry and Biochemistry of Amino Acids, Peptides, and Proteins*" Weinstein, B., ed., Marcel Dekker, New York, p. 267 (1983); Spatola, A. F., Vega Data (March 1983), Vol. 1, Issue 3, "Peptide Backbone Modifications" (general review); Morley, J. S. (1980) *Trends Pharm. Sci.* pp. 463-468 (general review); Hudson, D. *et al.* (1979) *Int. J. Pept. Prot. Res.* 14:177-185 (-CH2NH-, CH2CH2-); Spatola, A. F. *et al.*

(1986) *Life Sci.* 38:1243-1249 (-CH2-S); Hann, M. M. (1982) *J. Chem. Soc. Perkin Trans. I.* 307-314 (-CH-CH-, cis and trans); Almquist, R. G. *et al.* (190) *J. Med. Chem.* 23:1392-1398 (-COCH2-); Jennings-White, C. *et al.* (1982) *Tetrahedron Lett.* 23:2533 (-COCH2-); Szelke, M. *et al.* European Appln. EP 45665 (1982) CA: 97:39405 (1982)(-CH(OH)CH2-); Holladay, M. W. *et al.* (1983) *Tetrahedron Lett.* (1983) 24:4401-4404 (-C(OH)CH2-); and Hruby, V. J. (1982) *Life Sci.* (1982) 31:189-199 (-CH2-S-); each of which is incorporated herein by reference. A particularly preferred non-peptide linkage is -CH2NH-. Such peptide mimetics may have significant advantages over polypeptide embodiments, including, for example: more economical production, greater chemical stability, enhanced pharmacological properties (half-life, absorption, potency, efficacy, etc.), altered specificity (*e.g.*, a broad-spectrum of biological activities), reduced antigenicity, and others. Labeling of peptidomimetics usually involves covalent attachment of one or more labels, directly or through a spacer (*e.g.*, an amide group), to non-interfering position(s) on the peptidomimetic that are predicted by quantitative structure-activity data and/or molecular modeling. Such non-interfering positions generally are positions that do not form direct contacts with the macropolypeptides(s) to which the peptidomimetic binds to produce the therapeutic effect. Derivatization (*e.g.*, labeling) of peptidomimetics should not substantially interfere with the desired biological or pharmacological activity of the peptidomimetic.

Also encompassed by the present invention are small molecules which can modulate (either enhance or inhibit) interactions, *e.g.*, between biomarkers described herein or listed in Table 1 and their natural binding partners. The small molecules of the present invention can be obtained using any of the numerous approaches in combinatorial library methods known in the art, including: spatially addressable parallel solid phase or solution phase libraries; synthetic library methods requiring deconvolution; the 'one-bead one-compound' library method; and synthetic library methods using affinity chromatography selection. (Lam, K. S. (1997) *Anticancer Drug Des.* 12:145).

Examples of methods for the synthesis of molecular libraries can be found in the art, for example in: DeWitt *et al.* (1993) *Proc. Natl. Acad. Sci. USA* 90:6909; Erb *et al.* (1994) *Proc. Natl. Acad. Sci. USA* 91:11422; Zuckermann *et al.* (1994) *J. Med. Chem.* 37:2678; Cho *et al.* (1993) *Science* 261:1303; Carrell *et al.* (1994) *Angew. Chem. Int. Ed. Engl.* 33:2059; Carell *et al.* (1994) *Angew. Chem. Int. Ed. Engl.* 33:2061; and in Gallop *et al.* (1994) *J. Med. Chem.* 37:1233.

Libraries of compounds can be presented in solution (*e.g.*, Houghten (1992) *Biotechniques* 13:412-421), or on beads (Lam (1991) *Nature* 354:82-84), chips (Fodor (1993) *Nature* 364:555-556), bacteria (Ladner USP 5,223,409), spores (Ladner USP '409), plasmids (Cull *et al.* (1992) *Proc. Natl. Acad. Sci. USA* 89:1865-1869) or on phage (Scott and Smith (1990) *Science* 249:386-390); (Devlin (1990) *Science* 249:404-406); (Cwirla *et al.* (1990) *Proc. Natl. Acad. Sci. USA* 87:6378-6382); (Felici (1991) *J. Mol. Biol.* 222:301-310); (Ladner *supra.*). Compounds can be screened in cell based or non-cell based assays. Compounds can be screened in pools (*e.g.* multiple compounds in each testing sample) or as individual compounds.

Chimeric or fusion proteins can be prepared for the inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and/or agents for the immunotherapies described herein, such as inhibitors to the biomarkers of the invention, including the biomarkers listed in Table 1, or fragments thereof. As used herein, a "chimeric protein" or "fusion protein" comprises one or more biomarkers of the invention, including one or more biomarkers listed in Table 1, or a fragment thereof, operatively linked to another polypeptide having an amino acid sequence corresponding to a protein which is not substantially homologous to the respective biomarker. In a preferred embodiment, the fusion protein comprises at least one biologically active portion of one or more biomarkers of the invention, including one or more biomarkers listed in Table 1, or fragments thereof. Within the fusion protein, the term "operatively linked" is intended to indicate that the biomarker sequences and the non-biomarker sequences are fused in-frame to each other in such a way as to preserve functions exhibited when expressed independently of the fusion. The "another" sequences can be fused to the N-terminus or C-terminus of the biomarker sequences, respectively.

Such a fusion protein can be produced by recombinant expression of a nucleotide sequence encoding the first peptide and a nucleotide sequence encoding the second peptide. The second peptide may optionally correspond to a moiety that alters the solubility, affinity, stability or valency of the first peptide, for example, an immunoglobulin constant region. In another preferred embodiment, the first peptide consists of a portion of a biologically active molecule (*e.g.* the extracellular portion of the polypeptide or the ligand binding portion). The second peptide can include an immunoglobulin constant region, for example, a human Cγ1 domain or Cγ4 domain (*e.g.*, the hinge, CH2 and CH3 regions of human IgCγ 1, or human IgCγ4, see *e.g.*, Capon *et al.* U.S. Patents 5,116,964; 5,580,756; 5,844,095 and

the like, incorporated herein by reference). Such constant regions may retain regions which mediate effector function (*e.g.* Fc receptor binding) or may be altered to reduce effector function. A resulting fusion protein may have altered solubility, binding affinity, stability and/or valency (*i.e.*, the number of binding sites available per polypeptide) as compared to the independently expressed first peptide, and may increase the efficiency of protein purification. Fusion proteins and peptides produced by recombinant techniques can be secreted and isolated from a mixture of cells and medium containing the protein or peptide. Alternatively, the protein or peptide can be retained cytoplasmically and the cells harvested, lysed and the protein isolated. A cell culture typically includes host cells, media and other byproducts. Suitable media for cell culture are well-known in the art. Protein and peptides can be isolated from cell culture media, host cells, or both using techniques known in the art for purifying proteins and peptides. Techniques for transfecting host cells and purifying proteins and peptides are known in the art.

Preferably, a fusion protein of the invention is produced by standard recombinant DNA techniques. For example, DNA fragments coding for the different polypeptide sequences are ligated together in-frame in accordance with conventional techniques, for example employing blunt-ended or stagger-ended termini for ligation, restriction enzyme digestion to provide for appropriate termini, filling-in of cohesive ends as appropriate, alkaline phosphatase treatment to avoid undesirable joining, and enzymatic ligation. In another embodiment, the fusion gene can be synthesized by conventional techniques including automated DNA synthesizers. Alternatively, PCR amplification of gene fragments can be carried out using anchor primers which give rise to complementary overhangs between two consecutive gene fragments which can subsequently be annealed and reamplified to generate a chimeric gene sequence (see, for example, *Current Protocols in Molecular Biology*, eds. Ausubel *et al.* John Wiley & Sons: 1992).

The fusion proteins of the invention can be used as immunogens to produce antibodies in a subject. Such antibodies may be used to purify the respective natural polypeptides from which the fusion proteins were generated, or in screening assays to identify polypeptides which inhibit the interactions between one or more biomarkers polypeptide or a fragment thereof and its natural binding partner(s) or a fragment(s) thereof.

Also provided herein are compositions comprising one or more nucleic acids comprising or capable of expressing at least 1, 2, 3, 4, 5, 10, 20 or more small nucleic acids or antisense oligonucleotides or derivatives thereof, wherein said small nucleic acids or

antisense oligonucleotides or derivatives thereof in a cell specifically hybridize (*e.g.*, bind) under cellular conditions, with cellular nucleic acids (*e.g.*, small non-coding RNAS such as miRNAs, pre-miRNAs, pri-miRNAs, miRNA*, anti-miRNA, a miRNA binding site, a variant and/or functional variant thereof, cellular mRNAs or a fragments thereof). In one embodiment, expression of the small nucleic acids or antisense oligonucleotides or derivatives thereof in a cell can inhibit expression or biological activity of cellular nucleic acids and/or proteins, *e.g.*, by inhibiting transcription, translation and/or small nucleic acid processing of, for example, one or more biomarkers of the invention, including one or more biomarkers listed in Table 1, or fragment(s) thereof. In one embodiment, the small nucleic acids or antisense oligonucleotides or derivatives thereof are small RNAs (*e.g.*, microRNAs) or complements of small RNAs. In another embodiment, the small nucleic acids or antisense oligonucleotides or derivatives thereof can be single or double stranded and are at least six nucleotides in length and are less than about 1000, 900, 800, 700, 600, 500, 400, 300, 200, 100, 50, 40, 30, 25, 24, 23, 22, 21,20, 19, 18, 17, 16, 15, or 10 nucleotides in length. In another embodiment, a composition may comprise a library of nucleic acids comprising or capable of expressing small nucleic acids or antisense oligonucleotides or derivatives thereof, or pools of said small nucleic acids or antisense oligonucleotides or derivatives thereof. A pool of nucleic acids may comprise about 2-5, 5-10, 10-20, 10-30 or more nucleic acids comprising or capable of expressing small nucleic acids or antisense oligonucleotides or derivatives thereof.

In one embodiment, binding may be by conventional base pair complementarity, or, for example, in the case of binding to DNA duplexes, through specific interactions in the major groove of the double helix. In general, "antisense" refers to the range of techniques generally employed in the art, and includes any process that relies on specific binding to oligonucleotide sequences.

It is well-known in the art that modifications can be made to the sequence of a miRNA or a pre-miRNA without disrupting miRNA activity. As used herein, the term "functional variant" of a miRNA sequence refers to an oligonucleotide sequence that varies from the natural miRNA sequence, but retains one or more functional characteristics of the miRNA (*e.g.* cancer cell proliferation inhibition, induction of cancer cell apoptosis, enhancement of cancer cell susceptibility to chemotherapeutic agents, specific miRNA target inhibition). In some embodiments, a functional variant of a miRNA sequence retains all of the functional characteristics of the miRNA. In certain embodiments, a functional

variant of a miRNA has a nucleobase sequence that is a least about 60%, 65%, 70%, 75%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98% or 99% identical to the miRNA or precursor thereof over a region of about 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100 or more nucleobases, or that the functional variant hybridizes to the complement of the miRNA or precursor thereof under stringent hybridization conditions. Accordingly, in certain embodiments the nucleobase sequence of a functional variant is capable of hybridizing to one or more target sequences of the miRNA.

miRNAs and their corresponding stem-loop sequences described herein may be found in miRBase, an online searchable database of miRNA sequences and annotation, found on the world wide web at microrna.sanger.ac.uk. Entries in the miRBase Sequence database represent a predicted hairpin portion of a miRNA transcript (the stem-loop), with information on the location and sequence of the mature miRNA sequence. The miRNA stem-loop sequences in the database are not strictly precursor miRNAs (pre-miRNAs), and may in some instances include the pre-miRNA and some flanking sequence from the presumed primary transcript. The miRNA nucleobase sequences described herein encompass any version of the miRNA, including the sequences described in Release 10.0 of the miRBase sequence database and sequences described in any earlier Release of the miRBase sequence database. A sequence database release may result in the re-naming of certain miRNAs. A sequence database release may result in a variation of a mature miRNA sequence.

In some embodiments, miRNA sequences of the invention may be associated with a second RNA sequence that may be located on the same RNA molecule or on a separate RNA molecule as the miRNA sequence. In such cases, the miRNA sequence may be referred to as the active strand, while the second RNA sequence, which is at least partially complementary to the miRNA sequence, may be referred to as the complementary strand. The active and complementary strands are hybridized to create a double-stranded RNA that is similar to a naturally occurring miRNA precursor. The activity of a miRNA may be optimized by maximizing uptake of the active strand and minimizing uptake of the complementary strand by the miRNA protein complex that regulates gene translation. This can be done through modification and/or design of the complementary strand.

In some embodiments, the complementary strand is modified so that a chemical group other than a phosphate or hydroxyl at its 5' terminus. The presence of the 5'

modification apparently eliminates uptake of the complementary strand and subsequently favors uptake of the active strand by the miRNA protein complex. The 5' modification can be any of a variety of molecules known in the art, including NH_2, $NHCOCH_3$, and biotin.

In another embodiment, the uptake of the complementary strand by the miRNA pathway is reduced by incorporating nucleotides with sugar modifications in the first 2-6 nucleotides of the complementary strand. It should be noted that such sugar modifications can be combined with the 5' terminal modifications described above to further enhance miRNA activities.

In some embodiments, the complementary strand is designed so that nucleotides in the 3' end of the complementary strand are not complementary to the active strand. This results in double-strand hybrid RNAs that are stable at the 3' end of the active strand but relatively unstable at the 5' end of the active strand. This difference in stability enhances the uptake of the active strand by the miRNA pathway, while reducing uptake of the complementary strand, thereby enhancing miRNA activity.

Small nucleic acid and/or antisense constructs of the methods and compositions presented herein can be delivered, for example, as an expression plasmid which, when transcribed in the cell, produces RNA which is complementary to at least a unique portion of cellular nucleic acids (*e.g.*, small RNAs, mRNA, and/or genomic DNA). Alternatively, the small nucleic acid molecules can produce RNA which encodes mRNA, miRNA, pre-miRNA, pri-miRNA, miRNA*, anti-miRNA, or a miRNA binding site, or a variant thereof. For example, selection of plasmids suitable for expressing the miRNAs, methods for inserting nucleic acid sequences into the plasmid, and methods of delivering the recombinant plasmid to the cells of interest are within the skill in the art. See, for example, Zeng *et al.* (2002) *Mol. Cell* 9:1327-1333; Tuschl (2002), *Nat. Biotechnol.* 20:446-448; Brummelkamp *et al.* (2002) *Science* 296:550-553; Miyagishi *et al.* (2002) *Nat. Biotechnol.* 20:497-500; Paddison *et al.* (2002) *Genes Dev.* 16:948-958; Lee *et al.* (2002) *Nat. Biotechnol.* 20:500-505; and Paul *et al.* (2002) *Nat. Biotechnol.* 20:505-508, the entire disclosures of which are herein incorporated by reference.

Alternatively, small nucleic acids and/or antisense constructs are oligonucleotide probes that are generated *ex vivo* and which, when introduced into the cell, results in hybridization with cellular nucleic acids. Such oligonucleotide probes are preferably modified oligonucleotides that are resistant to endogenous nucleases, *e.g.*, exonucleases and/or endonucleases, and are therefore stable *in vivo*. Exemplary nucleic acid molecules

for use as small nucleic acids and/or antisense oligonucleotides are phosphoramidate, phosphothioate and methylphosphonate analogs of DNA (see also U.S. Patents 5,176,996; 5,264,564; and 5,256,775). Additionally, general approaches to constructing oligomers useful in antisense therapy have been reviewed, for example, by Van der Krol et al. (1988) BioTechniques 6:958-976; and Stein et al. (1988) Cancer Res 48:2659-2668.

Antisense approaches may involve the design of oligonucleotides (either DNA or RNA) that are complementary to cellular nucleic acids (*e.g.*, complementary to biomarkers listed in Table 1). Absolute complementarity is not required. In the case of double-stranded antisense nucleic acids, a single strand of the duplex DNA may thus be tested, or triplex formation may be assayed. The ability to hybridize will depend on both the degree of complementarity and the length of the antisense nucleic acid. Generally, the longer the hybridizing nucleic acid, the more base mismatches with a nucleic acid (*e.g.*, RNA) it may contain and still form a stable duplex (or triplex, as the case may be). One skilled in the art can ascertain a tolerable degree of mismatch by use of standard procedures to determine the melting point of the hybridized complex.

Oligonucleotides that are complementary to the 5' end of the mRNA, *e.g.*, the 5' untranslated sequence up to and including the AUG initiation codon, should work most efficiently at inhibiting translation. However, sequences complementary to the 3' untranslated sequences of mRNAs have recently been shown to be effective at inhibiting translation of mRNAs as well (Wagner (1994) *Nature* 372:333). Therefore, oligonucleotides complementary to either the 5' or 3' untranslated, non-coding regions of genes could be used in an antisense approach to inhibit translation of endogenous mRNAs. Oligonucleotides complementary to the 5' untranslated region of the mRNA may include the complement of the AUG start codon. Antisense oligonucleotides complementary to mRNA coding regions are less efficient inhibitors of translation but could also be used in accordance with the methods and compositions presented herein. Whether designed to hybridize to the 5', 3' or coding region of cellular mRNAs, small nucleic acids and/or antisense nucleic acids should be at least six nucleotides in length, and can be less than about 1000, 900, 800, 700, 600, 500, 400, 300, 200, 100, 50, 40, 30, 25, 24, 23, 22, 21,20, 19, 18, 17, 16, 15, or 10 nucleotides in length.

Regardless of the choice of target sequence, it is preferred that *in vitro* studies are first performed to quantitate the ability of the antisense oligonucleotide to inhibit gene expression. In one embodiment these studies utilize controls that distinguish between

antisense gene inhibition and nonspecific biological effects of oligonucleotides. In another embodiment these studies compare levels of the target nucleic acid or protein with that of an internal control nucleic acid or protein. Additionally, it is envisioned that results obtained using the antisense oligonucleotide are compared with those obtained using a control oligonucleotide. It is preferred that the control oligonucleotide is of approximately the same length as the test oligonucleotide and that the nucleotide sequence of the oligonucleotide differs from the antisense sequence no more than is necessary to prevent specific hybridization to the target sequence.

Small nucleic acids and/or antisense oligonucleotides can be DNA or RNA or chimeric mixtures or derivatives or modified versions thereof, single-stranded or double-stranded. Small nucleic acids and/or antisense oligonucleotides can be modified at the base moiety, sugar moiety, or phosphate backbone, for example, to improve stability of the molecule, hybridization, etc., and may include other appended groups such as peptides (*e.g.*, for targeting host cell receptors), or agents facilitating transport across the cell membrane (see, *e.g.*, Letsinger *et al.* (1989) *Proc. Natl. Acad. Sci. U.S.A.* 86:6553-6556; Lemaitre *et al.* (1987) *Proc. Natl. Acad. Sci. U.S.A.* 84:648-652; PCT Publication No. W088/09810) or the blood-brain barrier (see, *e.g.*, PCT Publication No. W089/10134), hybridization-triggered cleavage agents. (See, *e.g.*, Krol *et al.* (1988) *BioTech.* 6:958-976) or intercalating agents. (See, *e.g.*, Zon (1988) *Pharm. Res.* 5:539-549). To this end, small nucleic acids and/or antisense oligonucleotides may be conjugated to another molecule, *e.g.*, a peptide, hybridization triggered cross-linking agent, transport agent, hybridization-triggered cleavage agent, etc.

Small nucleic acids and/or antisense oligonucleotides may comprise at least one modified base moiety which is selected from the group including but not limited to 5-fluorouracil, 5-bromouracil, 5-chlorouracil, 5-iodouracil, hypoxanthine, xantine, 4-acetylcytosine, 5-(carboxyhydroxytiethyl) uracil, 5-carboxymethylaminomethyl-2-thiouridine, 5-carboxymethylaminomethyluracil, dihydrouracil, beta-D-galactosylqueosine, inosine, N6-isopentenyladenine, 1-methylguanine, 1-methylinosine, 2,2-dimethylguanine, 2-methyladenine, 2-methylguanine, 3-methylcytosine, 5-methylcytosine, N6-adenine, 7-methylguanine, 5-methylaminomethyluracil, 5-methoxyaminomethyl-2-thiouracil, beta-D-mannosylqueosine, 5'-methoxycarboxymethyluracil, 5-methoxyuracil, 2-methylthio-N6-isopentenyladenine, uracil-5-oxyacetic acid (v), wybutoxosine, pseudouracil, queosine, 2-thiocytosine, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-methyluracil, uracil-5-

oxyacetic acid methylester, uracil-5-oxyacetic acid (v), 5-methyl-2-thiouracil, 3-(3-amino-3-N-2-carboxypropyl) uracil, (acp3)w, and 2,6-diaminopurine. Small nucleic acids and/or antisense oligonucleotides may also comprise at least one modified sugar moiety selected from the group including but not limited to arabinose, 2-fluoroarabinose, xylulose, and hexose.

In certain embodiments, a compound comprises an oligonucleotide (*e.g.,* a miRNA or miRNA encoding oligonucleotide) conjugated to one or more moieties which enhance the activity, cellular distribution or cellular uptake of the resulting oligonucleotide. In certain such embodiments, the moiety is a cholesterol moiety (*e.g.*, antagomirs) or a lipid moiety or liposome conjugate. Additional moieties for conjugation include carbohydrates, phospholipids, biotin, phenazine, folate, phenanthridine, anthraquinone, acridine, fluoresceins, rhodamines, coumarins, and dyes. In certain embodiments, a conjugate group is attached directly to the oligonucleotide. In certain embodiments, a conjugate group is attached to the oligonucleotide by a linking moiety selected from amino, hydroxyl, carboxylic acid, thiol, unsaturations (*e.g.*, double or triple bonds), 8-amino-3,6-dioxaoctanoic acid (ADO), succinimidyl 4-(N-maleimidomethyl) cyclohexane-1-carboxylate (SMCC), 6-aminohexanoic acid (AHEX or AHA), substituted C1-C10 alkyl, substituted or unsubstituted C2-C10 alkenyl, and substituted or unsubstituted C2-C10 alkynyl. In certain such embodiments, a substituent group is selected from hydroxyl, amino, alkoxy, carboxy, benzyl, phenyl, nitro, thiol, thioalkoxy, halogen, alkyl, aryl, alkenyl and alkynyl.

In certain such embodiments, the compound comprises the oligonucleotide having one or more stabilizing groups that are attached to one or both termini of the oligonucleotide to enhance properties such as, for example, nuclease stability. Included in stabilizing groups are cap structures. These terminal modifications protect the oligonucleotide from exonuclease degradation, and can help in delivery and/or localization within a cell. The cap can be present at the 5'-terminus (5'-cap), or at the 3'-terminus (3'-cap), or can be present on both termini. Cap structures include, for example, inverted deoxy abasic caps.

Suitable cap structures include a 4',5'-methylene nucleotide, a 1-(beta-D-erythrofuranosyl) nucleotide, a 4'-thio nucleotide, a carbocyclic nucleotide, a 1,5-anhydrohexitol nucleotide, an L-nucleotide, an alpha-nucleotide, a modified base nucleotide, a phosphorodithioate linkage, a threo-pentofuranosyl nucleotide, an acyclic

3',4'-seco nucleotide, an acyclic 3,4-dihydroxybutyl nucleotide, an acyclic 3,5-dihydroxypentyl nucleotide, a 3'-3'-inverted nucleotide moiety, a 3'-3'-inverted abasic moiety, a 3'-2'-inverted nucleotide moiety, a 3'-2'-inverted abasic moiety, a 1,4-butanediol phosphate, a 3'-phosphoramidate, a hexylphosphate, an aminohexyl phosphate, a 3'-phosphate, a 3'-phosphorothioate, a phosphorodithioate, a bridging methylphosphonate moiety, and a non-bridging methylphosphonate moiety 5'-amino-alkyl phosphate, a 1,3-diamino-2-propyl phosphate, 3-aminopropyl phosphate, a 6-aminohexyl phosphate, a 1,2-aminododecyl phosphate, a hydroxypropyl phosphate, a 5'-5'-inverted nucleotide moiety, a 5'-5'-inverted abasic moiety, a 5'-phosphoramidate, a 5'-phosphorothioate, a 5'-amino, a bridging and/or non-bridging 5'-phosphoramidate, a phosphorothioate, and a 5'-mercapto moiety.

Small nucleic acids and/or antisense oligonucleotides can also contain a neutral peptide-like backbone. Such molecules are termed peptide nucleic acid (PNA)-oligomers and are described, *e.g.*, in Perry-O'Keefe et al. (1996) Proc. Natl. Acad. Sci. U.S.A. 93:14670 and in Eglom et al. (1993) Nature 365:566. One advantage of PNA oligomers is their capability to bind to complementary DNA essentially independently from the ionic strength of the medium due to the neutral backbone of the DNA. In yet another embodiment, small nucleic acids and/or antisense oligonucleotides comprises at least one modified phosphate backbone selected from the group consisting of a phosphorothioate, a phosphorodithioate, a phosphoramidothioate, a phosphoramidate, a phosphordiamidate, a methylphosphonate, an alkyl phosphotriester, and a formacetal or analog thereof.

In a further embodiment, small nucleic acids and/or antisense oligonucleotides are α-anomeric oligonucleotides. An α-anomeric oligonucleotide forms specific double-stranded hybrids with complementary RNA in which, contrary to the usual b-units, the strands run parallel to each other (Gautier et al. (1987) Nucl. Acids Res. 15:6625-6641). The oligonucleotide is a 2'-0-methylribonucleotide (Inoue et al. (1987) Nucl. Acids Res. 15:6131-6148), or a chimeric RNA-DNA analogue (Inoue et al. (1987) FEBS Lett. 215:327-330).

Small nucleic acids and/or antisense oligonucleotides of the methods and compositions presented herein may be synthesized by standard methods known in the art, *e.g.*, by use of an automated DNA synthesizer (such as are commercially available from Biosearch, Applied Biosystems, etc.). As examples, phosphorothioate oligonucleotides may be synthesized by the method of Stein et al. (1988) Nucl. Acids Res. 16:3209,

methylphosphonate oligonucleotides can be prepared by use of controlled pore glass polymer supports (Sarin et al. (1988) Proc. Natl. Acad. Sci. U.S.A. 85:7448-7451), etc. For example, an isolated miRNA can be chemically synthesized or recombinantly produced using methods known in the art. In some instances, miRNA are chemically synthesized using appropriately protected ribonucleoside phosphoramidites and a conventional DNA/RNA synthesizer. Commercial suppliers of synthetic RNA molecules or synthesis reagents include, *e.g.*, Proligo (Hamburg, Germany), Dharmacon Research (Lafayette, Colo., USA), Pierce Chemical (part of Perbio Science, Rockford, Ill., USA), Glen Research (Sterling, Va., USA), ChemGenes (Ashland, Mass., USA), Cruachem (Glasgow, UK), and Exiqon (Vedbaek, Denmark).

Small nucleic acids and/or antisense oligonucleotides can be delivered to cells *in vivo*. A number of methods have been developed for delivering small nucleic acids and/or antisense oligonucleotides DNA or RNA to cells; *e.g.*, antisense molecules can be injected directly into the tissue site, or modified antisense molecules, designed to target the desired cells (*e.g.*, antisense linked to peptides or antibodies that specifically bind receptors or antigens expressed on the target cell surface) can be administered systematically.

In one embodiment, small nucleic acids and/or antisense oligonucleotides may comprise or be generated from double stranded small interfering RNAs (siRNAs), in which sequences fully complementary to cellular nucleic acids (*e.g.* mRNAs) sequences mediate degradation or in which sequences incompletely complementary to cellular nucleic acids (*e.g.*, mRNAs) mediate translational repression when expressed within cells, or piwiRNAs. In another embodiment, double stranded siRNAs can be processed into single stranded antisense RNAs that bind single stranded cellular RNAs (*e.g.*, microRNAs) and inhibit their expression. RNA interference (RNAi) is the process of sequence-specific, post-transcriptional gene silencing in animals and plants, initiated by double-stranded RNA (dsRNA) that is homologous in sequence to the silenced gene. *in vivo*, long dsRNA is cleaved by ribonuclease III to generate 21- and 22-nucleotide siRNAs. It has been shown that 21-nucleotide siRNA duplexes specifically suppress expression of endogenous and heterologous genes in different mammalian cell lines, including human embryonic kidney (293) and HeLa cells (Elbashir et al. (2001) *Nature* 411:494-498). Accordingly, translation of a gene in a cell can be inhibited by contacting the cell with short double stranded RNAs having a length of about 15 to 30 nucleotides or of about 18 to 21 nucleotides or of about 19 to 21 nucleotides. Alternatively, a vector encoding for such siRNAs or short hairpin

RNAs (shRNAs) that are metabolized into siRNAs can be introduced into a target cell (see, *e.g.*, McManus *et al.* (2002) *RNA* 8:842; Xia *et al.* (2002) *Nat. Biotechnol.* 20:1006; and Brummelkamp *et al.* (2002) *Science* 296:550). Vectors that can be used are commercially available, *e.g.*, from OligoEngine under the name pSuper RNAi System™.

Ribozyme molecules designed to catalytically cleave cellular mRNA transcripts can also be used to prevent translation of cellular mRNAs and expression of cellular polypeptides, or both (See, *e.g.*, PCT International Publication WO90/11364, published October 4, 1990; Sarver et al. (1990) Science 247:1222-1225 and U.S. Patent No. 5,093,246). While ribozymes that cleave mRNA at site specific recognition sequences can be used to destroy cellular mRNAs, the use of hammerhead ribozymes is preferred. Hammerhead ribozymes cleave mRNAs at locations dictated by flanking regions that form complementary base pairs with the target mRNA. The sole requirement is that the target mRNA have the following sequence of two bases: 5'-UG-3'. The construction and production of hammerhead ribozymes is well-known in the art and is described more fully in Haseloff and Gerlach (1988) Nature 334:585-591. The ribozyme may be engineered so that the cleavage recognition site is located near the 5' end of cellular mRNAs; *i.e.*, to increase efficiency and minimize the intracellular accumulation of non-functional mRNA transcripts.

The ribozymes of the methods presented herein also include RNA endoribonucleases (hereinafter "Cech-type ribozymes") such as the one which occurs naturally in *Tetrahymena thermophila* (known as the IVS, or L-19 IVS RNA) and which has been extensively described by Thomas Cech and collaborators (Zaug *et al.* (1984) *Science* 224:574-578; Zaug *et al.* (1986) *Science* 231:470-475; Zaug *et al.* (1986) *Nature* 324:429-433; WO 88/04300; and Been *et al.* (1986) *Cell* 47:207-216). The Cech-type ribozymes have an eight base pair active site which hybridizes to a target RNA sequence whereafter cleavage of the target RNA takes place. The methods and compositions presented herein encompasses those Cech-type ribozymes which target eight base-pair active site sequences that are present in cellular genes.

As in the antisense approach, the ribozymes can be composed of modified oligonucleotides (*e.g.*, for improved stability, targeting, etc.). A preferred method of delivery involves using a DNA construct "encoding" the ribozyme under the control of a strong constitutive pol III or pol II promoter, so that transfected cells will produce sufficient quantities of the ribozyme to destroy endogenous cellular messages and inhibit translation.

Because ribozymes unlike antisense molecules, are catalytic, a lower intracellular concentration is required for efficiency.

Nucleic acid molecules to be used in triple helix formation for the inhibition of transcription of cellular genes are preferably single stranded and composed of deoxyribonucleotides. The base composition of these oligonucleotides should promote triple helix formation via Hoogsteen base pairing rules, which generally require sizable stretches of either purines or pyrimidines to be present on one strand of a duplex. Nucleotide sequences may be pyrimidine-based, which will result in TAT and CGC triplets across the three associated strands of the resulting triple helix. The pyrimidine-rich molecules provide base complementarity to a purine-rich region of a single strand of the duplex in a parallel orientation to that strand. In addition, nucleic acid molecules may be chosen that are purine-rich, for example, containing a stretch of G residues. These molecules will form a triple helix with a DNA duplex that is rich in GC pairs, in which the majority of the purine residues are located on a single strand of the targeted duplex, resulting in CGC triplets across the three strands in the triplex.

Alternatively, the potential sequences that can be targeted for triple helix formation may be increased by creating a so called "switchback" nucleic acid molecule. Switchback molecules are synthesized in an alternating 5'-3', 3'-5' manner, such that they base pair with first one strand of a duplex and then the other, eliminating the necessity for a sizable stretch of either purines or pyrimidines to be present on one strand of a duplex.

Small nucleic acids (*e.g.*, miRNAs, pre-miRNAs, pri-miRNAs, miRNA*, anti-miRNA, or a miRNA binding site, or a variant thereof), antisense oligonucleotides, ribozymes, and triple helix molecules of the methods and compositions presented herein may be prepared by any method known in the art for the synthesis of DNA and RNA molecules. These include techniques for chemically synthesizing oligodeoxyribonucleotides and oligoribonucleotides well-known in the art such as for example solid phase phosphoramidite chemical synthesis. Alternatively, RNA molecules may be generated by in vitro and *in vivo* transcription of DNA sequences encoding the antisense RNA molecule. Such DNA sequences may be incorporated into a wide variety of vectors which incorporate suitable RNA polymerase promoters such as the T7 or SP6 polymerase promoters. Alternatively, antisense cDNA constructs that synthesize antisense RNA constitutively or inducibly, depending on the promoter used, can be introduced stably into cell lines.

Moreover, various well-known modifications to nucleic acid molecules may be introduced as a means of increasing intracellular stability and half-life. Possible modifications include but are not limited to the addition of flanking sequences of ribonucleotides or deoxyribonucleotides to the 5' and/or 3' ends of the molecule or the use of phosphorothioate or 2' O-methyl rather than phosphodiesterase linkages within the oligodeoxyribonucleotide backbone. One of skill in the art will readily understand that polypeptides, small nucleic acids, and antisense oligonucleotides can be further linked to another peptide or polypeptide (*e.g.*, a heterologous peptide), *e.g.*, that serves as a means of protein detection. Non-limiting examples of label peptide or polypeptide moieties useful for detection in the invention include, without limitation, suitable enzymes such as horseradish peroxidase, alkaline phosphatase, beta-galactosidase, or acetylcholinesterase; epitope tags, such as FLAG, MYC, HA, or HIS tags; fluorophores such as green fluorescent protein; dyes; radioisotopes; digoxygenin; biotin; antibodies; polymers; as well as others known in the art, for example, in Principles of Fluorescence Spectroscopy, Joseph R. Lakowicz (Editor), Plenum Pub Corp, 2nd edition (July 1999).

The modulatory agents described herein (*e.g.,* antibodies, small molecules, peptides, fusion proteins, or small nucleic acids) can be incorporated into pharmaceutical compositions and administered to a subject *in vivo*. The compositions may contain a single such molecule or agent or any combination of agents described herein. "Single active agents" described herein can be combined with other pharmacologically active compounds ("second active agents") known in the art according to the methods and compositions provided herein.

The production and use of biomarker nucleic acid and/or biomarker polypeptide molecules described herein can be facilitated by using standard recombinant techniques. In some embodiments, such techniques use vectors, preferably expression vectors, containing a nucleic acid encoding a biomarker polypeptide or a portion of such a polypeptide. As used herein, the term "vector" refers to a nucleic acid molecule capable of transporting another nucleic acid to which it has been linked. One type of vector is a "plasmid", which refers to a circular double stranded DNA loop into which additional DNA segments can be ligated. Another type of vector is a viral vector, wherein additional DNA segments can be ligated into the viral genome. Certain vectors are capable of autonomous replication in a host cell into which they are introduced (*e.g.*, bacterial vectors having a bacterial origin of replication and episomal mammalian vectors). Other vectors (*e.g.*, non-episomal

mammalian vectors) are integrated into the genome of a host cell upon introduction into the host cell, and thereby are replicated along with the host genome. Moreover, certain vectors, namely expression vectors, are capable of directing the expression of genes to which they are operably linked. In general, expression vectors of utility in recombinant DNA techniques are often in the form of plasmids (vectors). However, the present invention is intended to include such other forms of expression vectors, such as viral vectors (*e.g.*, replication defective retroviruses, adenoviruses and adeno-associated viruses), which serve equivalent functions.

The recombinant expression vectors of the present invention comprise a nucleic acid of the present invention in a form suitable for expression of the nucleic acid in a host cell. This means that the recombinant expression vectors include one or more regulatory sequences, selected on the basis of the host cells to be used for expression, which is operably linked to the nucleic acid sequence to be expressed. Within a recombinant expression vector, "operably linked" is intended to mean that the nucleotide sequence of interest is linked to the regulatory sequence(s) in a manner which allows for expression of the nucleotide sequence (*e.g.*, in an *in vitro* transcription/translation system or in a host cell when the vector is introduced into the host cell). The term "regulatory sequence" is intended to include promoters, enhancers and other expression control elements (*e.g.*, polyadenylation signals). Such regulatory sequences are described, for example, in Goeddel, *Methods in Enzymology: Gene Expression Technology* vol.185, Academic Press, San Diego, CA (1991). Regulatory sequences include those which direct constitutive expression of a nucleotide sequence in many types of host cell and those which direct expression of the nucleotide sequence only in certain host cells (*e.g.*, tissue-specific regulatory sequences). It will be appreciated by those skilled in the art that the design of the expression vector can depend on such factors as the choice of the host cell to be transformed, the level of expression of protein desired, and the like. The expression vectors of the present invention can be introduced into host cells to thereby produce proteins or peptides, including fusion proteins or peptides, encoded by nucleic acids as described herein.

The recombinant expression vectors for use in the present invention can be designed for expression of a polypeptide corresponding to a marker of the present invention in prokaryotic (*e.g.*, *E. coli*) or eukaryotic cells (*e.g.*, insect cells {using baculovirus expression vectors}, yeast cells or mammalian cells). Suitable host cells are discussed

further in Goeddel, *supra*. Alternatively, the recombinant expression vector can be transcribed and translated *in vitro*, for example using T7 promoter regulatory sequences and T7 polymerase.

Expression of proteins in prokaryotes is most often carried out in *E. coli* with vectors containing constitutive or inducible promoters directing the expression of either fusion or non-fusion proteins. Fusion vectors add a number of amino acids to a protein encoded therein, usually to the amino terminus of the recombinant protein. Such fusion vectors typically serve three purposes: 1) to increase expression of recombinant protein; 2) to increase the solubility of the recombinant protein; and 3) to aid in the purification of the recombinant protein by acting as a ligand in affinity purification. Often, in fusion expression vectors, a proteolytic cleavage site is introduced at the junction of the fusion moiety and the recombinant protein to enable separation of the recombinant protein from the fusion moiety subsequent to purification of the fusion protein. Such enzymes, and their cognate recognition sequences, include Factor Xa, thrombin and enterokinase. Typical fusion expression vectors include pGEX (Pharmacia Biotech Inc; Smith and Johnson, 1988, *Gene* 67:31-40), pMAL (New England Biolabs, Beverly, MA) and pRIT5 (Pharmacia, Piscataway, NJ) which fuse glutathione S-transferase (GST), maltose E binding protein, or protein A, respectively, to the target recombinant protein.

Examples of suitable inducible non-fusion *E. coli* expression vectors include pTrc (Amann *et al.*, 1988, *Gene* 69:301-315) and pET 11d (Studier *et al.*, p. 60-89, In *Gene Expression Technology: Methods in Enzymology* vol.185, Academic Press, San Diego, CA, 1991). Target biomarker nucleic acid expression from the pTrc vector relies on host RNA polymerase transcription from a hybrid trp-lac fusion promoter. Target biomarker nucleic acid expression from the pET 11d vector relies on transcription from a T7 gn10-lac fusion promoter mediated by a co-expressed viral RNA polymerase (T7 gn1). This viral polymerase is supplied by host strains BL21 (DE3) or HMS174(DE3) from a resident prophage harboring a T7 gn1 gene under the transcriptional control of the lacUV 5 promoter.

One strategy to maximize recombinant protein expression in *E. coli* is to express the protein in a host bacterium with an impaired capacity to proteolytically cleave the recombinant protein (Gottesman, p. 119-128, In *Gene Expression Technology: Methods in Enzymology* vol. 185, Academic Press, San Diego, CA, 1990. Another strategy is to alter the nucleic acid sequence of the nucleic acid to be inserted into an expression vector so that

the individual codons for each amino acid are those preferentially utilized in *E. coli* (Wada *et al.,* 1992, *Nucleic Acids Res.* 20:2111-2118). Such alteration of nucleic acid sequences of the present invention can be carried out by standard DNA synthesis techniques.

In another embodiment, the expression vector is a yeast expression vector. Examples of vectors for expression in yeast *S. cerevisiae* include pYepSec1 (Baldari *et al.,* 1987, *EMBO J.* 6:229-234), pMFa (Kurjan and Herskowitz, 1982, *Cell* 30:933-943), pJRY88 (Schultz *et al.,* 1987, *Gene* 54:113-123), pYES2 (Invitrogen Corporation, San Diego, CA), and pPicZ (Invitrogen Corp, San Diego, CA).

Alternatively, the expression vector is a baculovirus expression vector. Baculovirus vectors available for expression of proteins in cultured insect cells (*e.g.*, Sf 9 cells) include the pAc series (Smith *et al.*, 1983, *Mol. Cell Biol.* 3:2156-2165) and the pVL series (Lucklow and Summers, 1989, *Virology* 170:31-39).

In yet another embodiment, a nucleic acid of the present invention is expressed in mammalian cells using a mammalian expression vector. Examples of mammalian expression vectors include pCDM8 (Seed, 1987, *Nature* 329:840) and pMT2PC (Kaufman *et al.,* 1987, *EMBO J.* 6:187-195). When used in mammalian cells, the expression vector's control functions are often provided by viral regulatory elements. For example, commonly used promoters are derived from polyoma, Adenovirus 2, cytomegalovirus and Simian Virus 40. For other suitable expression systems for both prokaryotic and eukaryotic cells see chapters 16 and 17 of Sambrook *et al.*, *supra.*

In another embodiment, the recombinant mammalian expression vector is capable of directing expression of the nucleic acid preferentially in a particular cell type (*e.g.*, tissue-specific regulatory elements are used to express the nucleic acid). Tissue-specific regulatory elements are known in the art. Non-limiting examples of suitable tissue-specific promoters include the albumin promoter (liver-specific; Pinkert *et al.,* 1987, *Genes Dev.* 1:268-277), lymphoid-specific promoters (Calame and Eaton, 1988, *Adv. Immunol.* 43:235-275), in particular promoters of T cell receptors (Winoto and Baltimore, 1989, *EMBO J.* 8:729-733) and immunoglobulins (Banerji *et al.,* 1983, *Cell* 33:729-740; Queen and Baltimore, 1983, *Cell* 33:741-748), neuron-specific promoters (*e.g.*, the neurofilament promoter; Byrne and Ruddle, 1989, *Proc. Natl. Acad. Sci. USA* 86:5473-5477), pancreas-specific promoters (Edlund *et al.,* 1985, *Science* 230:912-916), and mammary gland-specific promoters (*e.g.*, milk whey promoter; U.S. Patent No. 4,873,316 and European Application Publication No. 264,166). Developmentally-regulated promoters are also

encompassed, for example the murine hox promoters (Kessel and Gruss, 1990, *Science* 249:374-379) and the α-fetoprotein promoter (Camper and Tilghman, 1989, *Genes Dev.* 3:537-546).

The present invention further provides a recombinant expression vector comprising a DNA molecule cloned into the expression vector in an antisense orientation. That is, the DNA molecule is operably linked to a regulatory sequence in a manner which allows for expression (by transcription of the DNA molecule) of an RNA molecule which is antisense to the mRNA encoding a polypeptide of the present invention. Regulatory sequences operably linked to a nucleic acid cloned in the antisense orientation can be chosen which direct the continuous expression of the antisense RNA molecule in a variety of cell types, for instance viral promoters and/or enhancers, or regulatory sequences can be chosen which direct constitutive, tissue-specific or cell type specific expression of antisense RNA. The antisense expression vector can be in the form of a recombinant plasmid, phagemid, or attenuated virus in which antisense nucleic acids are produced under the control of a high efficiency regulatory region, the activity of which can be determined by the cell type into which the vector is introduced. For a discussion of the regulation of gene expression using antisense genes (see Weintraub *et al.*, 1986, *Trends in Genetics*, Vol. 1(1)).

Another aspect of the present invention pertains to host cells into which a recombinant expression vector of the present invention has been introduced. The terms "host cell" and "recombinant host cell" are used interchangeably herein. It is understood that such terms refer not only to the particular subject cell but to the progeny or potential progeny of such a cell. Because certain modifications may occur in succeeding generations due to either mutation or environmental influences, such progeny may not, in fact, be identical to the parent cell, but are still included within the scope of the term as used herein.

A host cell can be any prokaryotic (*e.g.*, *E. coli*) or eukaryotic cell (*e.g.*, insect cells, yeast or mammalian cells).

Vector DNA can be introduced into prokaryotic or eukaryotic cells via conventional transformation or transfection techniques. As used herein, the terms "transformation" and "transfection" are intended to refer to a variety of art-recognized techniques for introducing foreign nucleic acid into a host cell, including calcium phosphate or calcium chloride co-precipitation, DEAE-dextran-mediated transfection, lipofection, or electroporation. Suitable methods for transforming or transfecting host cells can be found in Sambrook, *et al.* (*supra*), and other laboratory manuals.

For stable transfection of mammalian cells, it is known that, depending upon the expression vector and transfection technique used, only a small fraction of cells may integrate the foreign DNA into their genome. In order to identify and select these integrants, a gene that encodes a selectable marker (*e.g.*, for resistance to antibiotics) is generally introduced into the host cells along with the gene of interest. Preferred selectable markers include those which confer resistance to drugs, such as G418, hygromycin and methotrexate. Cells stably transfected with the introduced nucleic acid can be identified by drug selection (*e.g.*, cells that have incorporated the selectable marker gene will survive, while the other cells die).

V. Analyzing Biomarker Nucleic Acids and Polypeptides

Biomarker nucleic acids and/or biomarker polypeptides can be analyzed according to the methods described herein and techniques known to the skilled artisan to identify such genetic or expression alterations useful for the present invention including, but not limited to, 1) an alteration in the level of a biomarker transcript or polypeptide, 2) a deletion or addition of one or more nucleotides from a biomarker gene, 4) a substitution of one or more nucleotides of a biomarker gene, 5) aberrant modification of a biomarker gene, such as an expression regulatory region, and the like.

a. Methods for Detection of Copy Number

Methods of evaluating the copy number of a biomarker nucleic acid are well-known to those of skill in the art. The presence or absence of chromosomal gain or loss can be evaluated simply by a determination of copy number of the regions or markers identified herein.

In one embodiment, a biological sample is tested for the presence of copy number changes in genomic loci containing the genomic marker. A copy number of at least 3, 4, 5, 6, 7, 8, 9, or 10 is predictive of poorer outcome of inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, *e.g.* such as PTPN2 and SOCS1) and immunotherapy combination treatments.

Methods of evaluating the copy number of a biomarker locus include, but are not limited to, hybridization-based assays. Hybridization-based assays include, but are not limited to, traditional "direct probe" methods, such as Southern blots, *in situ* hybridization (*e.g.,* FISH and FISH plus SKY) methods, and "comparative probe" methods, such as comparative genomic hybridization (CGH), *e.g.,* cDNA-based or oligonucleotide-based

CGH. The methods can be used in a wide variety of formats including, but not limited to, substrate (*e.g.* membrane or glass) bound methods or array-based approaches.

In one embodiment, evaluating the biomarker gene copy number in a sample involves a Southern Blot. In a Southern Blot, the genomic DNA (typically fragmented and separated on an electrophoretic gel) is hybridized to a probe specific for the target region. Comparison of the intensity of the hybridization signal from the probe for the target region with control probe signal from analysis of normal genomic DNA (*e.g.,* a non-amplified portion of the same or related cell, tissue, organ, *etc.*) provides an estimate of the relative copy number of the target nucleic acid. Alternatively, a Northern blot may be utilized for evaluating the copy number of encoding nucleic acid in a sample. In a Northern blot, mRNA is hybridized to a probe specific for the target region. Comparison of the intensity of the hybridization signal from the probe for the target region with control probe signal from analysis of normal RNA (*e.g.,* a non-amplified portion of the same or related cell, tissue, organ, *etc.*) provides an estimate of the relative copy number of the target nucleic acid. Alternatively, other methods well-known in the art to detect RNA can be used, such that higher or lower expression relative to an appropriate control (*e.g.*, a non-amplified portion of the same or related cell tissue, organ, etc.) provides an estimate of the relative copy number of the target nucleic acid.

An alternative means for determining genomic copy number is *in situ* hybridization (*e.g.,* Angerer (1987) *Meth. Enzymol* 152: 649). Generally, *in situ* hybridization comprises the following steps: (1) fixation of tissue or biological structure to be analyzed; (2) prehybridization treatment of the biological structure to increase accessibility of target DNA, and to reduce nonspecific binding; (3) hybridization of the mixture of nucleic acids to the nucleic acid in the biological structure or tissue; (4) post-hybridization washes to remove nucleic acid fragments not bound in the hybridization and (5) detection of the hybridized nucleic acid fragments. The reagent used in each of these steps and the conditions for use vary depending on the particular application. In a typical *in situ* hybridization assay, cells are fixed to a solid support, typically a glass slide. If a nucleic acid is to be probed, the cells are typically denatured with heat or alkali. The cells are then contacted with a hybridization solution at a moderate temperature to permit annealing of labeled probes specific to the nucleic acid sequence encoding the protein. The targets (*e.g.,* cells) are then typically washed at a predetermined stringency or at an increasing stringency until an appropriate signal to noise ratio is obtained. The probes are typically labeled, *e.g.,*

with radioisotopes or fluorescent reporters. In one embodiment, probes are sufficiently long so as to specifically hybridize with the target nucleic acid(s) under stringent conditions. Probes generally range in length from about 200 bases to about 1000 bases. In some applications it is necessary to block the hybridization capacity of repetitive sequences. Thus, in some embodiments, tRNA, human genomic DNA, or Cot-I DNA is used to block non-specific hybridization.

An alternative means for determining genomic copy number is comparative genomic hybridization. In general, genomic DNA is isolated from normal reference cells, as well as from test cells (*e.g.*, tumor cells) and amplified, if necessary. The two nucleic acids are differentially labeled and then hybridized *in situ* to metaphase chromosomes of a reference cell. The repetitive sequences in both the reference and test DNAs are either removed or their hybridization capacity is reduced by some means, for example by prehybridization with appropriate blocking nucleic acids and/or including such blocking nucleic acid sequences for said repetitive sequences during said hybridization. The bound, labeled DNA sequences are then rendered in a visualizable form, if necessary. Chromosomal regions in the test cells which are at increased or decreased copy number can be identified by detecting regions where the ratio of signal from the two DNAs is altered. For example, those regions that have decreased in copy number in the test cells will show relatively lower signal from the test DNA than the reference compared to other regions of the genome. Regions that have been increased in copy number in the test cells will show relatively higher signal from the test DNA. Where there are chromosomal deletions or multiplications, differences in the ratio of the signals from the two labels will be detected and the ratio will provide a measure of the copy number. In another embodiment of CGH, array CGH (aCGH), the immobilized chromosome element is replaced with a collection of solid support bound target nucleic acids on an array, allowing for a large or complete percentage of the genome to be represented in the collection of solid support bound targets. Target nucleic acids may comprise cDNAs, genomic DNAs, oligonucleotides (*e.g.*, to detect single nucleotide polymorphisms) and the like. Array-based CGH may also be performed with single-color labeling (as opposed to labeling the control and the possible tumor sample with two different dyes and mixing them prior to hybridization, which will yield a ratio due to competitive hybridization of probes on the arrays). In single color CGH, the control is labeled and hybridized to one array and absolute signals are read, and the possible tumor sample is labeled and hybridized to a second array (with identical

content) and absolute signals are read. Copy number difference is calculated based on absolute signals from the two arrays. Methods of preparing immobilized chromosomes or arrays and performing comparative genomic hybridization are well-known in the art (see, *e.g.*, U.S. Pat. Nos: 6,335,167; 6,197,501; 5,830,645; and 5,665,549 and Albertson (1984) *EMBO J.* 3: 1227-1234; Pinkel (1988) *Proc. Natl. Acad. Sci. USA* 85: 9138-9142; EPO Pub. No. 430,402; *Methods in Molecular Biology*, Vol. 33: *In situ* Hybridization Protocols, Choo, ed., Humana Press, Totowa, N.J. (1994), *etc.*). In another embodiment, the hybridization protocol of Pinkel, *et al.* (1998) *Nature Genetics* 20: 207-211, or of Kallioniemi (1992) *Proc. Natl Acad Sci USA* 89:5321-5325 (1992) is used.

In still another embodiment, amplification-based assays can be used to measure copy number. In such amplification-based assays, the nucleic acid sequences act as a template in an amplification reaction (*e.g.,* Polymerase Chain Reaction (PCR). In a quantitative amplification, the amount of amplification product will be proportional to the amount of template in the original sample. Comparison to appropriate controls, *e.g.* healthy tissue, provides a measure of the copy number.

Methods of "quantitative" amplification are well-known to those of skill in the art. For example, quantitative PCR involves simultaneously co-amplifying a known quantity of a control sequence using the same primers. This provides an internal standard that may be used to calibrate the PCR reaction. Detailed protocols for quantitative PCR are provided in Innis, *et al.* (1990) PCR Protocols, *A Guide to Methods and Applications*, Academic Press, Inc. N.Y.). Measurement of DNA copy number at microsatellite loci using quantitative PCR analysis is described in Ginzonger, *et al.* (2000) *Cancer Research* 60:5405-5409. The known nucleic acid sequence for the genes is sufficient to enable one of skill in the art to routinely select primers to amplify any portion of the gene. Fluorogenic quantitative PCR may also be used in the methods of the present invention. In fluorogenic quantitative PCR, quantitation is based on amount of fluorescence signals, *e.g.,* TaqMan and SYBR green.

Other suitable amplification methods include, but are not limited to, ligase chain reaction (LCR) (see Wu and Wallace (1989) *Genomics* 4: 560, Landegren, *et al.* (1988) *Science* 241:1077, and Barringer *et al.* (1990) *Gene* 89: 117), transcription amplification (Kwoh, *et al.* (1989) *Proc. Natl. Acad. Sci. USA* 86: 1173), self-sustained sequence replication (Guatelli, *et al.* (1990) *Proc. Nat. Acad. Sci. USA* 87: 1874), dot PCR, and linker adapter PCR, *etc.*

Loss of heterozygosity (LOH) and major copy proportion (MCP) mapping (Wang, Z.C., *et al.* (2004) *Cancer Res* 64(1):64-71; Seymour, A. B., *et al.* (1994) *Cancer Res* 54, 2761-4; Hahn, S. A., *et al.* (1995) *Cancer Res* 55, 4670-5; Kimura, M., *et al.* (1996) *Genes Chromosomes Cancer* 17, 88-93; Li *et al.*, (2008) *MBC Bioinform.* 9, 204-219) may also be used to identify regions of amplification or deletion.

b. Methods for Detection of Biomarker Nucleic Acid Expression

Biomarker expression may be assessed by any of a wide variety of well-known methods for detecting expression of a transcribed molecule or protein. Non-limiting examples of such methods include immunological methods for detection of secreted, cell-surface, cytoplasmic, or nuclear proteins, protein purification methods, protein function or activity assays, nucleic acid hybridization methods, nucleic acid reverse transcription methods, and nucleic acid amplification methods.

In preferred embodiments, activity of a particular gene is characterized by a measure of gene transcript (*e.g.* mRNA), by a measure of the quantity of translated protein, or by a measure of gene product activity. Marker expression can be monitored in a variety of ways, including by detecting mRNA levels, protein levels, or protein activity, any of which can be measured using standard techniques. Detection can involve quantification of the level of gene expression (*e.g.,* genomic DNA, cDNA, mRNA, protein, or enzyme activity), or, alternatively, can be a qualitative assessment of the level of gene expression, in particular in comparison with a control level. The type of level being detected will be clear from the context.

In another embodiment, detecting or determining expression levels of a biomarker and functionally similar homologs thereof, including a fragment or genetic alteration thereof (*e.g.*, in regulatory or promoter regions thereof) comprises detecting or determining RNA levels for the marker of interest. In one embodiment, one or more cells from the subject to be tested are obtained and RNA is isolated from the cells. In a preferred embodiment, a sample of breast tissue cells is obtained from the subject.

In one embodiment, RNA is obtained from a single cell. For example, a cell can be isolated from a tissue sample by laser capture microdissection (LCM). Using this technique, a cell can be isolated from a tissue section, including a stained tissue section, thereby assuring that the desired cell is isolated (*see, e.g.*, Bonner *et al.* (1997) Science 278: 1481; Emmert-Buck *et al.* (1996) Science 274:998; Fend *et al.* (1999) Am. J. Path. 154: 61

and Murakami *et al.* (2000) Kidney Int. 58:1346). For example, Murakami *et al.*, *supra*, describe isolation of a cell from a previously immunostained tissue section.

It is also be possible to obtain cells from a subject and culture the cells *in vitro*, such as to obtain a larger population of cells from which RNA can be extracted. Methods for establishing cultures of non-transformed cells, *i.e.*, primary cell cultures, are known in the art.

When isolating RNA from tissue samples or cells from individuals, it may be important to prevent any further changes in gene expression after the tissue or cells has been removed from the subject. Changes in expression levels are known to change rapidly following perturbations, *e.g.*, heat shock or activation with lipopolysaccharide (LPS) or other reagents. In addition, the RNA in the tissue and cells may quickly become degraded. Accordingly, in a preferred embodiment, the tissue or cells obtained from a subject is snap frozen as soon as possible.

RNA can be extracted from the tissue sample by a variety of methods, *e.g.*, the guanidium thiocyanate lysis followed by CsCl centrifugation (Chirgwin *et al.*, 1979, Biochemistry 18:5294-5299). RNA from single cells can be obtained as described in methods for preparing cDNA libraries from single cells, such as those described in Dulac, C. (1998) Curr. Top. Dev. Biol. 36, 245 and Jena *et al.* (1996) J. Immunol. Methods 190:199. Care to avoid RNA degradation must be taken, *e.g.*, by inclusion of RNAsin.

The RNA sample can then be enriched in particular species. In one embodiment, poly(A)+ RNA is isolated from the RNA sample. In general, such purification takes advantage of the poly-A tails on mRNA. In particular and as noted above, poly-T oligonucleotides may be immobilized within on a solid support to serve as affinity ligands for mRNA. Kits for this purpose are commercially available, *e.g.*, the MessageMaker kit (Life Technologies, Grand Island, NY).

In a preferred embodiment, the RNA population is enriched in marker sequences. Enrichment can be undertaken, *e.g.*, by primer-specific cDNA synthesis, or multiple rounds of linear amplification based on cDNA synthesis and template-directed *in vitro* transcription (*see, e.g.*, Wang *et al.* (1989) *Proc. Natl. Acad. Sci. U.S.A.* 86: 9717; Dulac *et al.*, *supra*, and Jena *et al.*, *supra*).

The population of RNA, enriched or not in particular species or sequences, can further be amplified. As defined herein, an "amplification process" is designed to strengthen, increase, or augment a molecule within the RNA. For example, where RNA is

mRNA, an amplification process such as RT-PCR can be utilized to amplify the mRNA, such that a signal is detectable or detection is enhanced. Such an amplification process is beneficial particularly when the biological, tissue, or tumor sample is of a small size or volume.

Various amplification and detection methods can be used. For example, it is within the scope of the present invention to reverse transcribe mRNA into cDNA followed by polymerase chain reaction (RT-PCR); or, to use a single enzyme for both steps as described in U.S. Pat. No. 5,322,770, or reverse transcribe mRNA into cDNA followed by symmetric gap ligase chain reaction (RT-AGLCR) as described by R. L. Marshall, *et al.*, PCR Methods and Applications 4: 80-84 (1994). Real time PCR may also be used.

Other known amplification methods which can be utilized herein include but are not limited to the so-called "NASBA" or "3SR" technique described in PNAS USA 87: 1874-1878 (1990) and also described in Nature 350 (No. 6313): 91-92 (1991); Q-beta amplification as described in published European Patent Application (EPA) No. 4544610; strand displacement amplification (as described in G. T. Walker *et al.*, Clin. Chem. 42: 9-13 (1996) and European Patent Application No. 684315; target mediated amplification, as described by PCT Publication WO9322461; PCR; ligase chain reaction (LCR) (*see, e.g.*, Wu and Wallace, Genomics 4, 560 (1989), Landegren *et al.*, Science 241, 1077 (1988)); self-sustained sequence replication (SSR) (*see, e.g.*, Guatelli *et al.*, Proc. Nat. Acad. Sci. USA, 87, 1874 (1990)); and transcription amplification (*see, e.g.*, Kwoh *et al.*, Proc. Natl. Acad. Sci. USA 86, 1173 (1989)).

Many techniques are known in the state of the art for determining absolute and relative levels of gene expression, commonly used techniques suitable for use in the present invention include Northern analysis, RNase protection assays (RPA), microarrays and PCR-based techniques, such as quantitative PCR and differential display PCR. For example, Northern blotting involves running a preparation of RNA on a denaturing agarose gel, and transferring it to a suitable support, such as activated cellulose, nitrocellulose or glass or nylon membranes. Radiolabeled cDNA or RNA is then hybridized to the preparation, washed and analyzed by autoradiography.

In situ hybridization visualization may also be employed, wherein a radioactively labeled antisense RNA probe is hybridized with a thin section of a biopsy sample, washed, cleaved with RNase and exposed to a sensitive emulsion for autoradiography. The samples may be stained with hematoxylin to demonstrate the histological composition of the

sample, and dark field imaging with a suitable light filter shows the developed emulsion. Non-radioactive labels such as digoxigenin may also be used.

Alternatively, mRNA expression can be detected on a DNA array, chip or a microarray. Labeled nucleic acids of a test sample obtained from a subject may be hybridized to a solid surface comprising biomarker DNA. Positive hybridization signal is obtained with the sample containing biomarker transcripts. Methods of preparing DNA arrays and their use are well-known in the art (see, *e.g.*, U.S. Pat. Nos: 6,618,6796; 6,379,897; 6,664,377; 6,451,536; 548,257; U.S. 20030157485 and Schena *et al.* (1995) *Science* 20, 467-470; Gerhold *et al.* (1999) *Trends In Biochem. Sci.* 24, 168-173; and Lennon *et al.* (2000) *Drug Discovery Today* 5, 59-65, which are herein incorporated by reference in their entirety). Serial Analysis of Gene Expression (SAGE) can also be performed (See for example U.S. Patent Application 20030215858).

To monitor mRNA levels, for example, mRNA is extracted from the biological sample to be tested, reverse transcribed, and fluorescently-labeled cDNA probes are generated. The microarrays capable of hybridizing to marker cDNA are then probed with the labeled cDNA probes, the slides scanned and fluorescence intensity measured. This intensity correlates with the hybridization intensity and expression levels.

Types of probes that can be used in the methods described herein include cDNA, riboprobes, synthetic oligonucleotides and genomic probes. The type of probe used will generally be dictated by the particular situation, such as riboprobes for *in situ* hybridization, and cDNA for Northern blotting, for example. In one embodiment, the probe is directed to nucleotide regions unique to the RNA. The probes may be as short as is required to differentially recognize marker mRNA transcripts, and may be as short as, for example, 15 bases; however, probes of at least 17, 18, 19 or 20 or more bases can be used. In one embodiment, the primers and probes hybridize specifically under stringent conditions to a DNA fragment having the nucleotide sequence corresponding to the marker. As herein used, the term "stringent conditions" means hybridization will occur only if there is at least 95% identity in nucleotide sequences. In another embodiment, hybridization under "stringent conditions" occurs when there is at least 97% identity between the sequences.

The form of labeling of the probes may be any that is appropriate, such as the use of radioisotopes, for example, ^{32}P and ^{35}S. Labeling with radioisotopes may be achieved, whether the probe is synthesized chemically or biologically, by the use of suitably labeled bases.

In one embodiment, the biological sample contains polypeptide molecules from the test subject. Alternatively, the biological sample can contain mRNA molecules from the test subject or genomic DNA molecules from the test subject.

In another embodiment, the methods further involve obtaining a control biological sample from a control subject, contacting the control sample with a compound or agent capable of detecting marker polypeptide, mRNA, genomic DNA, or fragments thereof, such that the presence of the marker polypeptide, mRNA, genomic DNA, or fragments thereof, is detected in the biological sample, and comparing the presence of the marker polypeptide, mRNA, genomic DNA, or fragments thereof, in the control sample with the presence of the marker polypeptide, mRNA, genomic DNA, or fragments thereof in the test sample.

c. Methods for Detection of Biomarker Protein Expression

The activity or level of a biomarker protein can be detected and/or quantified by detecting or quantifying the expressed polypeptide. The polypeptide can be detected and quantified by any of a number of means well-known to those of skill in the art. Aberrant levels of polypeptide expression of the polypeptides encoded by a biomarker nucleic acid and functionally similar homologs thereof, including a fragment or genetic alteration thereof (*e.g.*, in regulatory or promoter regions thereof) are associated with the likelihood of response of a cancer to inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatments. Any method known in the art for detecting polypeptides can be used. Such methods include, but are not limited to, immunodiffusion, immunoelectrophoresis, radioimmunoassay (RIA), enzyme-linked immunosorbent assays (ELISAs), immunofluorescent assays, Western blotting, binder-ligand assays, immunohistochemical techniques, agglutination, complement assays, high performance liquid chromatography (HPLC), thin layer chromatography (TLC), hyperdiffusion chromatography, and the like (*e.g.*, Basic and Clinical Immunology, Sites and Terr, eds., Appleton and Lange, Norwalk, Conn. pp 217-262, 1991 which is incorporated by reference). Preferred are binder-ligand immunoassay methods including reacting antibodies with an epitope or epitopes and competitively displacing a labeled polypeptide or derivative thereof.

For example, ELISA and RIA procedures may be conducted such that a desired biomarker protein standard is labeled (with a radioisotope such as ^{125}I or ^{35}S, or an assayable enzyme, such as horseradish peroxidase or alkaline phosphatase), and, together with the unlabeled sample, brought into contact with the corresponding antibody, whereon a

second antibody is used to bind the first, and radioactivity or the immobilized enzyme assayed (competitive assay). Alternatively, the biomarker protein in the sample is allowed to react with the corresponding immobilized antibody, radioisotope- or enzyme-labeled anti-biomarker protein antibody is allowed to react with the system, and radioactivity or the enzyme assayed (ELISA-sandwich assay). Other conventional methods may also be employed as suitable.

The above techniques may be conducted essentially as a "one-step" or "two-step" assay. A "one-step" assay involves contacting antigen with immobilized antibody and, without washing, contacting the mixture with labeled antibody. A "two-step" assay involves washing before contacting, the mixture with labeled antibody. Other conventional methods may also be employed as suitable.

In one embodiment, a method for measuring biomarker protein levels comprises the steps of: contacting a biological specimen with an antibody or variant (*e.g.*, fragment) thereof which selectively binds the biomarker protein, and detecting whether said antibody or variant thereof is bound to said sample and thereby measuring the levels of the biomarker protein.

Enzymatic and radiolabeling of biomarker protein and/or the antibodies may be effected by conventional means. Such means will generally include covalent linking of the enzyme to the antigen or the antibody in question, such as by glutaraldehyde, specifically so as not to adversely affect the activity of the enzyme, by which is meant that the enzyme must still be capable of interacting with its substrate, although it is not necessary for all of the enzyme to be active, provided that enough remains active to permit the assay to be effected. Indeed, some techniques for binding enzyme are non-specific (such as using formaldehyde), and will only yield a proportion of active enzyme.

It is usually desirable to immobilize one component of the assay system on a support, thereby allowing other components of the system to be brought into contact with the component and readily removed without laborious and time-consuming labor. It is possible for a second phase to be immobilized away from the first, but one phase is usually sufficient.

It is possible to immobilize the enzyme itself on a support, but if solid-phase enzyme is required, then this is generally best achieved by binding to antibody and affixing the antibody to a support, models and systems for which are well-known in the art. Simple polyethylene may provide a suitable support.

Enzymes employable for labeling are not particularly limited, but may be selected from the members of the oxidase group, for example. These catalyze production of hydrogen peroxide by reaction with their substrates, and glucose oxidase is often used for its good stability, ease of availability and cheapness, as well as the ready availability of its substrate (glucose). Activity of the oxidase may be assayed by measuring the concentration of hydrogen peroxide formed after reaction of the enzyme-labeled antibody with the substrate under controlled conditions well-known in the art.

Other techniques may be used to detect biomarker protein according to a practitioner's preference based upon the present disclosure. One such technique is Western blotting (Towbin et at., Proc. Nat. Acad. Sci. 76:4350 (1979)), wherein a suitably treated sample is run on an SDS-PAGE gel before being transferred to a solid support, such as a nitrocellulose filter. Anti-biomarker protein antibodies (unlabeled) are then brought into contact with the support and assayed by a secondary immunological reagent, such as labeled protein A or anti-immunoglobulin (suitable labels including ^{125}I, horseradish peroxidase and alkaline phosphatase). Chromatographic detection may also be used.

Immunohistochemistry may be used to detect expression of biomarker protein, *e.g.*, in a biopsy sample. A suitable antibody is brought into contact with, for example, a thin layer of cells, washed, and then contacted with a second, labeled antibody. Labeling may be by fluorescent markers, enzymes, such as peroxidase, avidin, or radiolabeling. The assay is scored visually, using microscopy.

Anti-biomarker protein antibodies, such as intrabodies, may also be used for imaging purposes, for example, to detect the presence of biomarker protein in cells and tissues of a subject. Suitable labels include radioisotopes, iodine (^{125}I, ^{121}I), carbon (^{14}C), sulphur (^{35}S), tritium (^{3}H), indium (^{112}In), and technetium (^{99}mTc), fluorescent labels, such as fluorescein and rhodamine, and biotin.

For *in vivo* imaging purposes, antibodies are not detectable, as such, from outside the body, and so must be labeled, or otherwise modified, to permit detection. Markers for this purpose may be any that do not substantially interfere with the antibody binding, but which allow external detection. Suitable markers may include those that may be detected by X-radiography, NMR or MRI. For X-radiographic techniques, suitable markers include any radioisotope that emits detectable radiation but that is not overtly harmful to the subject, such as barium or cesium, for example. Suitable markers for NMR and MRI generally include those with a detectable characteristic spin, such as deuterium, which may

be incorporated into the antibody by suitable labeling of nutrients for the relevant hybridoma, for example.

The size of the subject, and the imaging system used, will determine the quantity of imaging moiety needed to produce diagnostic images. In the case of a radioisotope moiety, for a human subject, the quantity of radioactivity injected will normally range from about 5 to 20 millicuries of technetium-99. The labeled antibody or antibody fragment will then preferentially accumulate at the location of cells which contain biomarker protein. The labeled antibody or antibody fragment can then be detected using known techniques.

Antibodies that may be used to detect biomarker protein include any antibody, whether natural or synthetic, full length or a fragment thereof, monoclonal or polyclonal, that binds sufficiently strongly and specifically to the biomarker protein to be detected. An antibody may have a K_d of at most about 10^{-6}M, 10^{-7}M, 10^{-8}M, 10^{-9}M, 10^{-10}M, 10^{-11}M, 10^{-12}M. The phrase "specifically binds" refers to binding of, for example, an antibody to an epitope or antigen or antigenic determinant in such a manner that binding can be displaced or competed with a second preparation of identical or similar epitope, antigen or antigenic determinant. An antibody may bind preferentially to the biomarker protein relative to other proteins, such as related proteins.

Antibodies are commercially available or may be prepared according to methods known in the art.

Antibodies and derivatives thereof that may be used encompass polyclonal or monoclonal antibodies, chimeric, human, humanized, primatized (CDR-grafted), veneered or single-chain antibodies as well as functional fragments, *i.e.*, biomarker protein binding fragments, of antibodies. For example, antibody fragments capable of binding to a biomarker protein or portions thereof, including, but not limited to, Fv, Fab, Fab' and F(ab') 2 fragments can be used. Such fragments can be produced by enzymatic cleavage or by recombinant techniques. For example, papain or pepsin cleavage can generate Fab or F(ab') 2 fragments, respectively. Other proteases with the requisite substrate specificity can also be used to generate Fab or F(ab') 2 fragments. Antibodies can also be produced in a variety of truncated forms using antibody genes in which one or more stop codons have been introduced upstream of the natural stop site. For example, a chimeric gene encoding a F(ab') 2 heavy chain portion can be designed to include DNA sequences encoding the CH, domain and hinge region of the heavy chain.

Synthetic and engineered antibodies are described in, *e.g.*, Cabilly *et al.*, U.S. Pat.

No. 4,816,567 Cabilly *et al.*, European Patent No. 0,125,023 B1; Boss *et al.*, U.S. Pat. No. 4,816,397; Boss *et al.*, European Patent No. 0,120,694 B1; Neuberger, M. S. *et al.*, WO 86/01533; Neuberger, M. S. *et al.*, European Patent No. 0,194,276 B1; Winter, U.S. Pat. No. 5,225,539; Winter, European Patent No. 0,239,400 B1; Queen *et al.*, European Patent No. 0451216 B1; and Padlan, E. A. *et al.*, EP 0519596 A1. See also, Newman, R. *et al.*, BioTechnology, 10: 1455-1460 (1992), regarding primatized antibody, and Ladner *et al.*, U.S. Pat. No. 4,946,778 and Bird, R. E. *et al.*, Science, 242: 423-426 (1988)) regarding single-chain antibodies. Antibodies produced from a library, *e.g.*, phage display library, may also be used.

In some embodiments, agents that specifically bind to a biomarker protein other than antibodies are used, such as peptides. Peptides that specifically bind to a biomarker protein can be identified by any means known in the art. For example, specific peptide binders of a biomarker protein can be screened for using peptide phage display libraries.

d. Methods for Detection of Biomarker Structural Alterations

The following illustrative methods can be used to identify the presence of a structural alteration in a biomarker nucleic acid and/or biomarker polypeptide molecule in order to, for example, identify PTPN2, SOCS1, or other biomarkers used in the immunotherapies described herein that are overexpressed, overfunctional, and the like.

In certain embodiments, detection of the alteration involves the use of a probe/primer in a polymerase chain reaction (PCR) (see, *e.g.*, U.S. Pat. Nos. 4,683,195 and 4,683,202), such as anchor PCR or RACE PCR, or, alternatively, in a ligation chain reaction (LCR) (see, *e.g.*, Landegran *et al.* (1988) Science 241:1077-1080; and Nakazawa *et al.* (1994) Proc. Natl. Acad. Sci. USA 91:360-364), the latter of which can be particularly useful for detecting point mutations in a biomarker nucleic acid such as a biomarker gene (see Abravaya *et al.* (1995) Nucleic Acids Res. 23:675-682). This method can include the steps of collecting a sample of cells from a subject, isolating nucleic acid (*e.g.*, genomic, mRNA or both) from the cells of the sample, contacting the nucleic acid sample with one or more primers which specifically hybridize to a biomarker gene under conditions such that hybridization and amplification of the biomarker gene (if present) occurs, and detecting the presence or absence of an amplification product, or detecting the size of the amplification product and comparing the length to a control sample. It is anticipated that PCR and/or LCR may be desirable to use as a preliminary amplification step in conjunction with any of the techniques used for detecting mutations described herein.

Alternative amplification methods include: self-sustained sequence replication (Guatelli, J. C. *et al.* (1990) Proc. Natl. Acad. Sci. USA 87:1874-1878), transcriptional amplification system (Kwoh, D. Y. *et al.* (1989) Proc. Natl. Acad. Sci. USA 86:1173-1177), Q-Beta Replicase (Lizardi, P. M. *et al.* (1988) Bio-Technology 6:1197), or any other nucleic acid amplification method, followed by the detection of the amplified molecules using techniques well-known to those of skill in the art. These detection schemes are especially useful for the detection of nucleic acid molecules if such molecules are present in very low numbers.

In an alternative embodiment, mutations in a biomarker nucleic acid from a sample cell can be identified by alterations in restriction enzyme cleavage patterns. For example, sample and control DNA is isolated, amplified (optionally), digested with one or more restriction endonucleases, and fragment length sizes are determined by gel electrophoresis and compared. Differences in fragment length sizes between sample and control DNA indicates mutations in the sample DNA. Moreover, the use of sequence specific ribozymes (see, for example, U.S. Pat. No. 5,498,531) can be used to score for the presence of specific mutations by development or loss of a ribozyme cleavage site.

In other embodiments, genetic mutations in biomarker nucleic acid can be identified by hybridizing a sample and control nucleic acids, *e.g.*, DNA or RNA, to high density arrays containing hundreds or thousands of oligonucleotide probes (Cronin, M. T. *et al.* (1996) Hum. Mutat. 7:244-255; Kozal, M. J. *et al.* (1996) Nat. Med. 2:753-759). For example, biomarker genetic mutations can be identified in two dimensional arrays containing light-generated DNA probes as described in Cronin *et al.* (1996) supra. Briefly, a first hybridization array of probes can be used to scan through long stretches of DNA in a sample and control to identify base changes between the sequences by making linear arrays of sequential, overlapping probes. This step allows the identification of point mutations. This step is followed by a second hybridization array that allows the characterization of specific mutations by using smaller, specialized probe arrays complementary to all variants or mutations detected. Each mutation array is composed of parallel probe sets, one complementary to the wild-type gene and the other complementary to the mutant gene. Such biomarker genetic mutations can be identified in a variety of contexts, including, for example, germline and somatic mutations.

In yet another embodiment, any of a variety of sequencing reactions known in the art can be used to directly sequence a biomarker gene and detect mutations by comparing

the sequence of the sample biomarker with the corresponding wild-type (control) sequence. Examples of sequencing reactions include those based on techniques developed by Maxam and Gilbert (1977) *Proc. Natl. Acad. Sci. USA* 74:560 or Sanger (1977) *Proc. Natl. Acad Sci. USA* 74:5463. It is also contemplated that any of a variety of automated sequencing procedures can be utilized when performing the diagnostic assays (Naeve (1995) *Biotechniques* 19:448-53), including sequencing by mass spectrometry (see, *e.g.*, PCT International Publication No. WO 94/16101; Cohen *et al.* (1996) *Adv. Chromatogr.* 36:127-162; and Griffin *et al.* (1993) *Appl. Biochem. Biotechnol.* 38:147-159).

Other methods for detecting mutations in a biomarker gene include methods in which protection from cleavage agents is used to detect mismatched bases in RNA/RNA or RNA/DNA heteroduplexes (Myers *et al.* (1985) Science 230:1242). In general, the art technique of "mismatch cleavage" starts by providing heteroduplexes formed by hybridizing (labeled) RNA or DNA containing the wild-type biomarker sequence with potentially mutant RNA or DNA obtained from a tissue sample. The double-stranded duplexes are treated with an agent which cleaves single-stranded regions of the duplex such as which will exist due to base pair mismatches between the control and sample strands. For instance, RNA/DNA duplexes can be treated with RNase and DNA/DNA hybrids treated with SI nuclease to enzymatically digest the mismatched regions. In other embodiments, either DNA/DNA or RNA/DNA duplexes can be treated with hydroxylamine or osmium tetroxide and with piperidine in order to digest mismatched regions. After digestion of the mismatched regions, the resulting material is then separated by size on denaturing polyacrylamide gels to determine the site of mutation. See, for example, Cotton *et al.* (1988) Proc. Natl. Acad. Sci. USA 85:4397 and Saleeba *et al.* (1992) Methods Enzymol. 217:286-295. In a preferred embodiment, the control DNA or RNA can be labeled for detection.

In still another embodiment, the mismatch cleavage reaction employs one or more proteins that recognize mismatched base pairs in double-stranded DNA (so called "DNA mismatch repair" enzymes) in defined systems for detecting and mapping point mutations in biomarker cDNAs obtained from samples of cells. For example, the mutY enzyme of *E. coli* cleaves A at G/A mismatches and the thymidine DNA glycosylase from HeLa cells cleaves T at G/T mismatches (Hsu *et al.* (1994) *Carcinogenesis* 15:1657-1662). According to an exemplary embodiment, a probe based on a biomarker sequence, *e.g.*, a wild-type

biomarker treated with a DNA mismatch repair enzyme, and the cleavage products, if any, can be detected from electrophoresis protocols or the like (*e.g.*, U.S. Pat. No. 5,459,039.)

In other embodiments, alterations in electrophoretic mobility can be used to identify mutations in biomarker genes. For example, single strand conformation polymorphism (SSCP) may be used to detect differences in electrophoretic mobility between mutant and wild type nucleic acids (Orita *et al.* (1989) *Proc Natl. Acad. Sci USA* 86:2766; see also Cotton (1993) *Mutat. Res.* 285:125-144 and Hayashi (1992) *Genet. Anal. Tech. Appl.* 9:73-79). Single-stranded DNA fragments of sample and control biomarker nucleic acids will be denatured and allowed to renature. The secondary structure of single-stranded nucleic acids varies according to sequence, the resulting alteration in electrophoretic mobility enables the detection of even a single base change. The DNA fragments may be labeled or detected with labeled probes. The sensitivity of the assay may be enhanced by using RNA (rather than DNA), in which the secondary structure is more sensitive to a change in sequence. In a preferred embodiment, the subject method utilizes heteroduplex analysis to separate double stranded heteroduplex molecules on the basis of changes in electrophoretic mobility (Keen *et al.* (1991) *Trends Genet.* 7:5).

In yet another embodiment the movement of mutant or wild-type fragments in polyacrylamide gels containing a gradient of denaturant is assayed using denaturing gradient gel electrophoresis (DGGE) (Myers *et al.* (1985) *Nature* 313:495). When DGGE is used as the method of analysis, DNA will be modified to ensure that it does not completely denature, for example by adding a GC clamp of approximately 40 bp of high-melting GC-rich DNA by PCR. In a further embodiment, a temperature gradient is used in place of a denaturing gradient to identify differences in the mobility of control and sample DNA (Rosenbaum and Reissner (1987) *Biophys. Chem.* 265:12753).

Examples of other techniques for detecting point mutations include, but are not limited to, selective oligonucleotide hybridization, selective amplification, or selective primer extension. For example, oligonucleotide primers may be prepared in which the known mutation is placed centrally and then hybridized to target DNA under conditions which permit hybridization only if a perfect match is found (Saiki *et al.* (1986) *Nature* 324:163; Saiki *et al.* (1989) *Proc. Natl. Acad. Sci. USA* 86:6230). Such allele specific oligonucleotides are hybridized to PCR amplified target DNA or a number of different mutations when the oligonucleotides are attached to the hybridizing membrane and hybridized with labeled target DNA.

Alternatively, allele specific amplification technology which depends on selective PCR amplification may be used in conjunction with the instant invention. Oligonucleotides used as primers for specific amplification may carry the mutation of interest in the center of the molecule (so that amplification depends on differential hybridization) (Gibbs *et al.* (1989) *Nucleic Acids Res.* 17:2437-2448) or at the extreme 3' end of one primer where, under appropriate conditions, mismatch can prevent, or reduce polymerase extension (Prossner (1993) *Tibtech* 11:238). In addition it may be desirable to introduce a novel restriction site in the region of the mutation to create cleavage-based detection (Gasparini *et al.* (1992) *Mol. Cell Probes* 6:1). It is anticipated that in certain embodiments amplification may also be performed using Taq ligase for amplification (Barany (1991) *Proc. Natl. Acad. Sci USA* 88:189). In such cases, ligation will occur only if there is a perfect match at the 3' end of the 5' sequence making it possible to detect the presence of a known mutation at a specific site by looking for the presence or absence of amplification.

3. Anti-Cancer Therapies

The efficacy of inhibitors ofk one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatment is predicted according to biomarker amount and/or activity associated with a cancer in a subject according to the methods described herein. In one embodiment, such inhibitors and immunotherapy combination treatments (*e.g.*, one or more such inhibitors and immunotherapy combination treatment in combination with one or more additional anti-cancer therapies, such as another immune checkpoint inhibitor) can be administered, particularly if a subject has first been indicated as being a likely responder to such inhibitors and immunotherapy combination treatment. In another embodiment, such inhibitors and immunotherapy combination treatment can be avoided once a subject is indicated as not being a likely responder to such inhibitors and immunotherapy combination treatment and an alternative treatment regimen, such as targeted and/or untargeted anti-cancer therapies can be administered. Combination therapies are also contemplated and can comprise, for example, one or more chemotherapeutic agents and radiation, one or more chemotherapeutic agents and immunotherapy, or one or more chemotherapeutic agents, radiation and chemotherapy, each combination of which can be with anti-immune checkpoint therapy. In addition, any representative embodiment of an agent to modulate a particular target can be adapted to any other target described herein by the ordinarily skilled

artisn (*e.g.*, direct and indirect PD-1 inhibitors described herein can be applied to other immune checkpoint inhibitors and/or biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1), such as monospecific antibodies, bispecific antibodies, non-activiting forms, small molecules, peptides, interfering nucleic acids, and the like).

The term "targeted therapy" refers to administration of agents that selectively interact with a chosen biomolecule to thereby treat cancer. One example includes immunotherapies such as immune checkpoint inhibitors, which are well-known in the art. For example, anti-PD-1 pathway agents, such as therapeutic monoclonal blocking antibodies, which are well-known in the art and described above, can be used to target tumor microenvironments and cells expressing unwanted components of the PD-1 pathway, such as PD-1, PD-L1, and/or PD-L2.

For example, the term "PD-1 pathway" refers to the PD-1 receptor and its ligands, PD-L1 and PD-L2. "PD-1 pathway inhibitors" block or otherwise reduce the interaction between PD-1 and one or both of its ligands such that the immunoinhibitory signaling otherwise generated by the interaction is blocked or otherwise reduced. Anti-immune checkpoint inhibitors can be direct or indirect. Direct anti-immune checkpoint inhibitors block or otherwise reduce the interaction between an immune checkpoint and at least one of its ligands. For example, PD-1 inhibitors can block PD-1 binding with one or both of its ligands. Direct PD-1 combination inhibitors are well-known in the art, especially since the natural binding partners of PD-1 (*e.g.*, PD-L1 and PD-L2), PD-L1 (*e.g.*, PD-1 and B7-1), and PD-L2 (*e.g.*, PD-1 and RGMb) are known.

For example, agents which directly block the interaction between PD-1 and PD-L1, PD-1 and PD-L2, PD-1 and both PD-L1 and PD-L2, such as a bispecific antibody, can prevent inhibitory signaling and upregulate an immune response (*i.e.*, as a PD-1 pathway inhibitor). Alternatively, agents that indirectly block the interaction between PD-1 and one or both of its ligands can prevent inhibitory signaling and upregulate an immune response. For example, B7-1 or a soluble form thereof, by binding to a PD-L1 polypeptide indirectly reduces the effective concentration of PD-L1 polypeptide available to bind to PD-1. Exemplary agents include monospecific or bispecific blocking antibodies against PD-1, PD-L1, and/or PD-L2 that block the interaction between the receptor and ligand(s); a non-activating form of PD-1, PD-L1, and/or PD-L2 (*e.g.*, a dominant negative or soluble polypeptide), small molecules or peptides that block the interaction between PD-1, PD-L1,

and/or PD-L2; fusion proteins (*e.g.* the extracellular portion of PD-1, PD-L1, and/or PD-L2, fused to the Fc portion of an antibody or immunoglobulin) that bind to PD-1, PD-L1, and/or PD-L2 and inhibit the interaction between the receptor and ligand(s); a non-activating form of a natural PD-1, PD-L2, and/or PD-L2 ligand, and a soluble form of a natural PD-1, PD-L2, and/or PD-L2 ligand.

Indirect anti-immune checkpoint inhibitors block or otherwise reduce the immunoinhibitory signaling generated by the interaction between the immune checkpoint and at least one of its ligands. For example, an inhibitor can block the interaction between PD-1 and one or both of its ligands without necessarily directly blocking the interaction between PD-1 and one or both of its ligands. For example, indirect inhibitors include intrabodies that bind the intracellular portion of PD-1 and/or PD-L1 required to signal to block or otherwise reduce the immunoinhibitory signaling. Similarly, nucleic acids that reduce the expression of PD-1, PD-L1, and/or PD-L2 can indirectly inhibit the interaction between PD-1 and one or both of its ligands by removing the availability of components for interaction. Such nucleic acid molecules can block PD-L1, PD-L2, and/or PD-L2 transcription or translation.

Similary, agents which directly block the interaction between one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1)and their binding partners/substrates, and the like, can remove the inhibition to the signaling pathways related to such one or more biomarkers in Table 1 (*e.g.*, PTPN2- and/or SOCS1-regulated signaling) and its downstream immune responses, such as increasing sensitivity to interferon signaling. Alternatively, agents that indirectly block the interaction between one or more biomarkers in Table 1 and their binding partners/substrates can remove the inhibition to such biomarkers-related signaling and its downstream immune responses. For example, a truncated or dominant negative form of such one or more biomarkers in Table 1, such as PTPN2 an/or SOCS1 fragments without phosphatase activity, by binding to a substrate of such biomarkers indirectly reduces the effective concentration of such substrate available to bind to such biomarkers in cell. Exemplary agents include monospecific or bispecific blocking antibodies, especially intrbodies, against such biomarkers and/or their substrate(s) that block the interaction between such one or more biomarkers and their substrate(s); a non-active form of such one or more biomarkers and/or their substrate(s) (*e.g.*, a dominant negative polypeptide), small molecules or peptides that block the interaction between such one or more biomarkers and their

substrate(s) or the catalytic activity of such biomarkers; and a non-activating form of a natural biomarkers in Table 1 and/or its substrate(s).

Immunotherapies that are designed to elicit or amplify an immune response are referred to as "activation immunotherapies." Immunotherapies that are designed to reduce or suppress an immune response are referred to as "suppression immunotherapies." Any agent believed to have an immune system effect on the genetically modified transplanted cancer cells can be assayed to determine whether the agent is an immunotherapy and the effect that a given genetic modification has on the modulation of immune response. In some embodiments, the immunotherapy is cancer cell-specific. In some embodiments, immunotherapy can be "untargeted," which refers to administration of agents that do not selectively interact with immune system cells, yet modulates immune system function. Representative examples of untargeted therapies include, without limitation, chemotherapy, gene therapy, and radiation therapy.

Immunotherapy can involve passive immunity for short-term protection of a host, achieved by the administration of pre-formed antibody directed against a cancer antigen or disease antigen (*e.g.*, administration of a monoclonal antibody, optionally linked to a chemotherapeutic agent or toxin, to a tumor antigen). Immunotherapy can also focus on using the cytotoxic lymphocyte-recognized epitopes of cancer cell lines. Alternatively, antisense polynucleotides, ribozymes, RNA interference molecules, triple helix polynucleotides and the like, can be used to selectively modulate biomolecules that are linked to the initiation, progression, and/or pathology of a tumor or cancer.

In one embodiment, immunotherapy comprises adoptive cell-based immunotherapies. Well-known adoptive cell-based immunotherapeutic modalities, including, without limitation, Irradiated autologous or allogeneic tumor cells, tumor lysates or apoptotic tumor cells, antigen-presenting cell-based immunotherapy, dendritic cell-based immunotherapy, adoptive T cell transfer, adoptive CAR T cell therapy, autologous immune enhancement therapy (AIET), cancer vaccines, and/or antigen presenting cells. Such cell-based immunotherapies can be further modified to express one or more gene products to further modulate immune responses, such as expressing cytokines like GM-CSF, and/or to express tumor-associated antigen (TAA) antigens, such as Mage-1, gp-100, patient-specific neoantigen vaccines, and the like.

In another embodiment, immunotherapy comprises non-cell-based immunotherapies. In one embodiment, compositions comprising antigens with or without

vaccine-enhancing adjuvants are used. Such compositions exist in many well-known forms, such as peptide compositions, oncolytic viruses, recombinant antigen comprising fusion proteins, and the like. In still another embodiment, immunomodulatory interleukins, such as IL-2, IL-6, IL-7, IL-12, IL-17, IL-23, and the like, as well as modulators thereof (*e.g.*, blocking antibodies or more potent or longer lasting forms) are used. In yet another embodiment, immunomodulatory cytokines, such as interferons, G-CSF, imiquimod, TNFalpha, and the like, as well as modulators thereof (*e.g.*, blocking antibodies or more potent or longer lasting forms) are used. In another embodiment, immunomodulatory chemokines, such as CCL3, CCL26, and CXCL7, and the like, as well as modulators thereof (*e.g.*, blocking antibodies or more potent or longer lasting forms) are used. In another embodiment, immunomodulatory molecules targeting immunosuppression, such as STAT3 signaling modulators, NFkappaB signaling modulators, and immune checkpoint modulators, are used. The terms "immune checkpoint" and "anti-immune checkpoint therapy" are described above.

In still another embodiment, immunomodulatory drugs, such as immunocytostatic drugs, glucocorticoids, cytostatics, immunophilins and modulators thereof (*e.g.*, rapamycin, a calcineurin inhibitor, tacrolimus, ciclosporin (cyclosporin), pimecrolimus, abetimus, gusperimus, ridaforolimus, everolimus, temsirolimus, zotarolimus, etc.), hydrocortisone (cortisol), cortisone acetate, prednisone, prednisolone, methylprednisolone, dexamethasone, betamethasone, triamcinolone, beclometasone, fludrocortisone acetate, deoxycorticosterone acetate (doca) aldosterone, a non-glucocorticoid steroid, a pyrimidine synthesis inhibitor, leflunomide, teriflunomide, a folic acid analog, methotrexate, anti-thymocyte globulin, anti-lymphocyte globulin, thalidomide, lenalidomide, pentoxifylline, bupropion, curcumin, catechin, an opioid, an IMPDH inhibitor, mycophenolic acid, myriocin, fingolimod, an NF-xB inhibitor, raloxifene, drotrecogin alfa, denosumab, an NF-xB signaling cascade inhibitor, disulfiram, olmesartan, dithiocarbamate, a proteasome inhibitor, bortezomib, MG132, Prol, NPI-0052, curcumin, genistein, resveratrol, parthenolide, thalidomide, lenalidomide, flavopiridol, non-steroidal anti-inflammatory drugs (NSAIDs), arsenic trioxide, dehydroxymethylepoxyquinomycin (DHMEQ), I3C(indole-3-carbinol)/DIM(di-indolmethane) (13C/DIM), Bay 11-7082, luteolin, cell permeable peptide SN-50, IKBa.-super repressor overexpression, NFKB decoy oligodeoxynucleotide (ODN), or a derivative or analog of any thereo, are used. In yet another embodiment, immunomodulatory antibodies or protein are used. For example, antibodies that bind to CD40, Toll-like

receptor (TLR), OX40, GITR, CD27, or to 4-1BB, T-cell bispecific antibodies, an anti-IL-2 receptor antibody, an anti-CD3 antibody, OKT3 (muromonab), otelixizumab, teplizumab, visilizumab, an anti-CD4 antibody, clenoliximab, keliximab, zanolimumab, an anti-CD11 a antibody, efalizumab, an anti-CD18 antibody, erlizumab, rovelizumab, an anti-CD20 antibody, afutuzumab, ocrelizumab, ofatumumab, pascolizumab, rituximab, an anti-CD23 antibody, lumiliximab, an anti-CD40 antibody, teneliximab, toralizumab, an anti-CD40L antibody, ruplizumab, an anti-CD62L antibody, aselizumab, an anti-CD80 antibody, galiximab, an anti-CD147 antibody, gavilimomab, a B-Lymphocyte stimulator (BLyS) inhibiting antibody, belimumab, an CTLA4-Ig fusion protein, abatacept, belatacept, an anti-CTLA4 antibody, ipilimumab, tremelimumab, an anti-eotaxin 1 antibody, bertilimumab, an anti-a4-integrin antibody, natalizumab, an anti-IL-6R antibody, tocilizumab, an anti-LFA-1 antibody, odulimomab, an anti-CD25 antibody, basiliximab, daclizumab, inolimomab, an anti-CD5 antibody, zolimomab, an anti-CD2 antibody, siplizumab, nerelimomab, faralimomab, atlizumab, atorolimumab, cedelizumab, dorlimomab aritox, dorlixizumab, fontolizumab, gantenerumab, gomiliximab, lebrilizumab, maslimomab, morolimumab, pexelizumab, reslizumab, rovelizumab, talizumab, telimomab aritox, vapaliximab, vepalimomab, aflibercept, alefacept, rilonacept, an IL-1 receptor antagonist, anakinra, an anti-IL-5 antibody, mepolizumab, an IgE inhibitor, omalizumab, talizumab, an IL12 inhibitor, an IL23 inhibitor, ustekinumab, and the like.

Nutritional supplements that enhance immune responses, such as vitamin A, vitamin E, vitamin C, and the like, are well-known in the art (see, for example, U.S. Pat. Nos. 4,981,844 and 5,230,902 and PCT Publ. No. WO 2004/004483) can be used in the methods described herein.

Similarly, agents and therapies other than immunotherapy or in combination thereof can be used with in combination with inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1)/immunotherapies to stimulate an immune response to thereby treat a condition that would benefit therefrom. For example, chemotherapy, radiation, epigenetic modifiers (*e.g.*, histone deacetylase (HDAC) modifiers, methylation modifiers, phosphorylation modifiers, and the like), targeted therapy, and the like are well-known in the art.

The term "untargeted therapy" refers to administration of agents that do not selectively interact with a chosen biomolecule yet treat cancer. Representative examples of

untargeted therapies include, without limitation, chemotherapy, gene therapy, and radiation therapy.

In one embodiment, chemotherapy is used. Chemotherapy includes the administration of a chemotherapeutic agent. Such a chemotherapeutic agent may be, but is not limited to, those selected from among the following groups of compounds: platinum compounds, cytotoxic antibiotics, antimetabolites, anti-mitotic agents, alkylating agents, arsenic compounds, DNA topoisomerase inhibitors, taxanes, nucleoside analogues, plant alkaloids, and toxins; and synthetic derivatives thereof. Exemplary compounds include, but are not limited to, alkylating agents: cisplatin, treosulfan, and trofosfamide; plant alkaloids: vinblastine, paclitaxel, docetaxol; DNA topoisomerase inhibitors: teniposide, crisnatol, and mitomycin; anti-folates: methotrexate, mycophenolic acid, and hydroxyurea; pyrimidine analogs: 5-fluorouracil, doxifluridine, and cytosine arabinoside; purine analogs: mercaptopurine and thioguanine; DNA antimetabolites: 2'-deoxy-5-fluorouridine, aphidicolin glycinate, and pyrazoloimidazole; and antimitotic agents: halichondrin, colchicine, and rhizoxin. Compositions comprising one or more chemotherapeutic agents (*e.g.*, FLAG, CHOP) may also be used. FLAG comprises fludarabine, cytosine arabinoside (Ara-C) and G-CSF. CHOP comprises cyclophosphamide, vincristine, doxorubicin, and prednisone. In another embodiments, PARP (*e.g.*, PARP-1 and/or PARP-2) inhibitors are used and such inhibitors are well-known in the art (*e.g.*, Olaparib, ABT-888, BSI-201, BGP-15 (N-Gene Research Laboratories, Inc.); INO-1001 (Inotek Pharmaceuticals Inc.); PJ34 (Soriano *et al.*, 2001; Pacher *et al.*, 2002b); 3-aminobenzamide (Trevigen); 4-amino-1,8-naphthalimide; (Trevigen); 6(5H)-phenanthridinone (Trevigen); benzamide (U.S. Pat. Re. 36,397); and NU1025 (Bowman *et al.*). The mechanism of action is generally related to the ability of PARP inhibitors to bind PARP and decrease its activity. PARP catalyzes the conversion of .beta.-nicotinamide adenine dinucleotide (NAD+) into nicotinamide and poly-ADP-ribose (PAR). Both poly (ADP-ribose) and PARP have been linked to regulation of transcription, cell proliferation, genomic stability, and carcinogenesis (Bouchard V. J. et.al. Experimental Hematology, Volume 31, Number 6, June 2003, pp. 446-454(9); Herceg Z.; Wang Z.-Q. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis, Volume 477, Number 1, 2 Jun. 2001, pp. 97-110(14)). Poly(ADP-ribose) polymerase 1 (PARP1) is a key molecule in the repair of DNA single-strand breaks (SSBs) (de Murcia J. *et al.* 1997. Proc Natl Acad Sci USA 94:7303-7307; Schreiber V, Dantzer F, Ame J C, de Murcia G (2006) Nat Rev Mol Cell Biol 7:517-528;

Wang Z Q, *et al.* (1997) Genes Dev 11:2347-2358). Knockout of SSB repair by inhibition of PARP1 function induces DNA double-strand breaks (DSBs) that can trigger synthetic lethality in cancer cells with defective homology-directed DSB repair (Bryant H E, *et al.* (2005) Nature 434:913-917; Farmer H, *et al.* (2005) Nature 434:917-921). The foregoing examples of chemotherapeutic agents are illustrative, and are not intended to be limiting.

In another embodiment, radiation therapy is used. The radiation used in radiation therapy can be ionizing radiation. Radiation therapy can also be gamma rays, X-rays, or proton beams. Examples of radiation therapy include, but are not limited to, external-beam radiation therapy, interstitial implantation of radioisotopes (I-125, palladium, iridium), radioisotopes such as strontium-89, thoracic radiation therapy, intraperitoneal P-32 radiation therapy, and/or total abdominal and pelvic radiation therapy. For a general overview of radiation therapy, see Hellman, Chapter 16: Principles of Cancer Management: Radiation Therapy, 6th edition, 2001, DeVita *et al.*, eds., J. B. Lippencott Company, Philadelphia. The radiation therapy can be administered as external beam radiation or teletherapy wherein the radiation is directed from a remote source. The radiation treatment can also be administered as internal therapy or brachytherapy wherein a radioactive source is placed inside the body close to cancer cells or a tumor mass. Also encompassed is the use of photodynamic therapy comprising the administration of photosensitizers, such as hematoporphyrin and its derivatives, Vertoporfin (BPD-MA), phthalocyanine, photosensitizer Pc4, demethoxy-hypocrellin A; and 2BA-2-DMHA.

In another embodiment, surgical intervention can occur to physically remove cancerous cells and/or tissues.

In still another embodiment, hormone therapy is used. Hormonal therapeutic treatments can comprise, for example, hormonal agonists, hormonal antagonists (*e.g.*, flutamide, bicalutamide, tamoxifen, raloxifene, leuprolide acetate (LUPRON), LH-RH antagonists), inhibitors of hormone biosynthesis and processing, and steroids (*e.g.*, dexamethasone, retinoids, deltoids, betamethasone, cortisol, cortisone, prednisone, dehydrotestosterone, glucocorticoids, mineralocorticoids, estrogen, testosterone, progestins), vitamin A derivatives (*e.g.*, all-trans retinoic acid (ATRA)); vitamin D3 analogs; antigestagens (*e.g.*, mifepristone, onapristone), or antiandrogens (*e.g.*, cyproterone acetate).

In yet another embodiment, hyperthermia, a procedure in which body tissue is exposed to high temperatures (up to 106°F.) is used. Heat may help shrink tumors by

damaging cells or depriving them of substances they need to live. Hyperthermia therapy can be local, regional, and whole-body hyperthermia, using external and internal heating devices. Hyperthermia is almost always used with other forms of therapy (*e.g.*, radiation therapy, chemotherapy, and biological therapy) to try to increase their effectiveness. Local hyperthermia refers to heat that is applied to a very small area, such as a tumor. The area may be heated externally with high-frequency waves aimed at a tumor from a device outside the body. To achieve internal heating, one of several types of sterile probes may be used, including thin, heated wires or hollow tubes filled with warm water; implanted microwave antennae; and radiofrequency electrodes. In regional hyperthermia, an organ or a limb is heated. Magnets and devices that produce high energy are placed over the region to be heated. In another approach, called perfusion, some of the patient's blood is removed, heated, and then pumped (perfused) into the region that is to be heated internally. Whole-body heating is used to treat metastatic cancer that has spread throughout the body. It can be accomplished using warm-water blankets, hot wax, inductive coils (like those in electric blankets), or thermal chambers (similar to large incubators). Hyperthermia does not cause any marked increase in radiation side effects or complications. Heat applied directly to the skin, however, can cause discomfort or even significant local pain in about half the patients treated. It can also cause blisters, which generally heal rapidly.

In still another embodiment, photodynamic therapy (also called PDT, photoradiation therapy, phototherapy, or photochemotherapy) is used for the treatment of some types of cancer. It is based on the discovery that certain chemicals known as photosensitizing agents can kill one-celled organisms when the organisms are exposed to a particular type of light. PDT destroys cancer cells through the use of a fixed-frequency laser light in combination with a photosensitizing agent. In PDT, the photosensitizing agent is injected into the bloodstream and absorbed by cells all over the body. The agent remains in cancer cells for a longer time than it does in normal cells. When the treated cancer cells are exposed to laser light, the photosensitizing agent absorbs the light and produces an active form of oxygen that destroys the treated cancer cells. Light exposure must be timed carefully so that it occurs when most of the photosensitizing agent has left healthy cells but is still present in the cancer cells. The laser light used in PDT can be directed through a fiber-optic (a very thin glass strand). The fiber-optic is placed close to the cancer to deliver the proper amount of light. The fiber-optic can be directed through a bronchoscope into the lungs for the treatment of lung cancer or through an endoscope into the esophagus for the

treatment of esophageal cancer. An advantage of PDT is that it causes minimal damage to healthy tissue. However, because the laser light currently in use cannot pass through more than about 3 centimeters of tissue (a little more than one and an eighth inch), PDT is mainly used to treat tumors on or just under the skin or on the lining of internal organs.

Photodynamic therapy makes the skin and eyes sensitive to light for 6 weeks or more after treatment. Patients are advised to avoid direct sunlight and bright indoor light for at least 6 weeks. If patients must go outdoors, they need to wear protective clothing, including sunglasses. Other temporary side effects of PDT are related to the treatment of specific areas and can include coughing, trouble swallowing, abdominal pain, and painful breathing or shortness of breath. In December 1995, the U.S. Food and Drug Administration (FDA) approved a photosensitizing agent called porfimer sodium, or Photofrin®, to relieve symptoms of esophageal cancer that is causing an obstruction and for esophageal cancer that cannot be satisfactorily treated with lasers alone. In January 1998, the FDA approved porfimer sodium for the treatment of early non-small cell lung cancer in patients for whom the usual treatments for lung cancer are not appropriate. The National Cancer Institute and other institutions are supporting clinical trials (research studies) to evaluate the use of photodynamic therapy for several types of cancer, including cancers of the bladder, brain, larynx, and oral cavity.

In yet another embodiment, laser therapy is used to harness high-intensity light to destroy cancer cells. This technique is often used to relieve symptoms of cancer such as bleeding or obstruction, especially when the cancer cannot be cured by other treatments. It may also be used to treat cancer by shrinking or destroying tumors. The term "laser" stands for light amplification by stimulated emission of radiation. Ordinary light, such as that from a light bulb, has many wavelengths and spreads in all directions. Laser light, on the other hand, has a specific wavelength and is focused in a narrow beam. This type of high-intensity light contains a lot of energy. Lasers are very powerful and may be used to cut through steel or to shape diamonds. Lasers also can be used for very precise surgical work, such as repairing a damaged retina in the eye or cutting through tissue (in place of a scalpel). Although there are several different kinds of lasers, only three kinds have gained wide use in medicine: Carbon dioxide (CO_2) laser--This type of laser can remove thin layers from the skin's surface without penetrating the deeper layers. This technique is particularly useful in treating tumors that have not spread deep into the skin and certain precancerous conditions. As an alternative to traditional scalpel surgery, the CO_2 laser is

also able to cut the skin. The laser is used in this way to remove skin cancers. Neodymium:yttrium-aluminum-garnet (Nd:YAG) laser-- Light from this laser can penetrate deeper into tissue than light from the other types of lasers, and it can cause blood to clot quickly. It can be carried through optical fibers to less accessible parts of the body. This type of laser is sometimes used to treat throat cancers. Argon laser--This laser can pass through only superficial layers of tissue and is therefore useful in dermatology and in eye surgery. It also is used with light-sensitive dyes to treat tumors in a procedure known as photodynamic therapy (PDT). Lasers have several advantages over standard surgical tools, including: Lasers are more precise than scalpels. Tissue near an incision is protected, since there is little contact with surrounding skin or other tissue. The heat produced by lasers sterilizes the surgery site, thus reducing the risk of infection. Less operating time may be needed because the precision of the laser allows for a smaller incision. Healing time is often shortened; since laser heat seals blood vessels, there is less bleeding, swelling, or scarring. Laser surgery may be less complicated. For example, with fiber optics, laser light can be directed to parts of the body without making a large incision. More procedures may be done on an outpatient basis. Lasers can be used in two ways to treat cancer: by shrinking or destroying a tumor with heat, or by activating a chemical--known as a photosensitizing agent--that destroys cancer cells. In PDT, a photosensitizing agent is retained in cancer cells and can be stimulated by light to cause a reaction that kills cancer cells. CO_2 and Nd:YAG lasers are used to shrink or destroy tumors. They may be used with endoscopes, tubes that allow physicians to see into certain areas of the body, such as the bladder. The light from some lasers can be transmitted through a flexible endoscope fitted with fiber optics. This allows physicians to see and work in parts of the body that could not otherwise be reached except by surgery and therefore allows very precise aiming of the laser beam. Lasers also may be used with low-power microscopes, giving the doctor a clear view of the site being treated. Used with other instruments, laser systems can produce a cutting area as small as 200 microns in diameter--less than the width of a very fine thread. Lasers are used to treat many types of cancer. Laser surgery is a standard treatment for certain stages of glottis (vocal cord), cervical, skin, lung, vaginal, vulvar, and penile cancers. In addition to its use to destroy the cancer, laser surgery is also used to help relieve symptoms caused by cancer (palliative care). For example, lasers may be used to shrink or destroy a tumor that is blocking a patient's trachea (windpipe), making it easier to breathe. It is also sometimes used for palliation in colorectal and anal cancer. Laser-

induced interstitial thermotherapy (LITT) is one of the most recent developments in laser therapy. LITT uses the same idea as a cancer treatment called hyperthermia; that heat may help shrink tumors by damaging cells or depriving them of substances they need to live. In this treatment, lasers are directed to interstitial areas (areas between organs) in the body. The laser light then raises the temperature of the tumor, which damages or destroys cancer cells.

The duration and/or dose of treatment with therapies may vary according to the particular therapeutic agent or combination thereof. An appropriate treatment time for a particular cancer therapeutic agent will be appreciated by the skilled artisan. The present invention contemplates the continued assessment of optimal treatment schedules for each cancer therapeutic agent, where the phenotype of the cancer of the subject as determined by the methods of the present invention is a factor in determining optimal treatment doses and schedules.

Any means for the introduction of a polynucleotide into mammals, human or non-human, or cells thereof may be adapted to the practice of this invention for the delivery of the various constructs of the present invention into the intended recipient. In one embodiment of the present invention, the DNA constructs are delivered to cells by transfection, *i.e.*, by delivery of "naked" DNA or in a complex with a colloidal dispersion system. A colloidal system includes macromolecule complexes, nanocapsules, microspheres, beads, and lipid-based systems including oil-in-water emulsions, micelles, mixed micelles, and liposomes. The preferred colloidal system of this invention is a lipid-complexed or liposome-formulated DNA. In the former approach, prior to formulation of DNA, *e.g.*, with lipid, a plasmid containing a transgene bearing the desired DNA constructs may first be experimentally optimized for expression (*e.g.*, inclusion of an intron in the 5' untranslated region and elimination of unnecessary sequences (Felgner, *et al.*, Ann NY Acad Sci 126-139, 1995). Formulation of DNA, *e.g.* with various lipid or liposome materials, may then be effected using known methods and materials and delivered to the recipient mammal. See, *e.g.*, Canonico et al, Am J Respir Cell Mol Biol 10:24-29, 1994; Tsan et al, Am J Physiol 268; Alton *et al.*, Nat Genet. 5:135-142, 1993 and U.S. patent No. 5,679,647 by Carson *et al.*

The targeting of liposomes can be classified based on anatomical and mechanistic factors. Anatomical classification is based on the level of selectivity, for example, organ-specific, cell-specific, and organelle-specific. Mechanistic targeting can be distinguished

based upon whether it is passive or active. Passive targeting utilizes the natural tendency of liposomes to distribute to cells of the reticulo-endothelial system (RES) in organs, which contain sinusoidal capillaries. Active targeting, on the other hand, involves alteration of the liposome by coupling the liposome to a specific ligand such as a monoclonal antibody, sugar, glycolipid, or protein, or by changing the composition or size of the liposome in order to achieve targeting to organs and cell types other than the naturally occurring sites of localization.

The surface of the targeted delivery system may be modified in a variety of ways. In the case of a liposomal targeted delivery system, lipid groups can be incorporated into the lipid bilayer of the liposome in order to maintain the targeting ligand in stable association with the liposomal bilayer. Various linking groups can be used for joining the lipid chains to the targeting ligand. Naked DNA or DNA associated with a delivery vehicle, *e.g.*, liposomes, can be administered to several sites in a subject (see below).

Nucleic acids can be delivered in any desired vector. These include viral or non-viral vectors, including adenovirus vectors, adeno-associated virus vectors, retrovirus vectors, lentivirus vectors, and plasmid vectors. Exemplary types of viruses include HSV (herpes simplex virus), AAV (adeno associated virus), HIV (human immunodeficiency virus), BIV (bovine immunodeficiency virus), and MLV (murine leukemia virus). Nucleic acids can be administered in any desired format that provides sufficiently efficient delivery levels, including in virus particles, in liposomes, in nanoparticles, and complexed to polymers.

The nucleic acids encoding a protein or nucleic acid of interest may be in a plasmid or viral vector, or other vector as is known in the art. Such vectors are well-known and any can be selected for a particular application. In one embodiment of the present invention, the gene delivery vehicle comprises a promoter and a demethylase coding sequence. Preferred promoters are tissue-specific promoters and promoters which are activated by cellular proliferation, such as the thymidine kinase and thymidylate synthase promoters. Other preferred promoters include promoters which are activatable by infection with a virus, such as the α- and β-interferon promoters, and promoters which are activatable by a hormone, such as estrogen. Other promoters which can be used include the Moloney virus LTR, the CMV promoter, and the mouse albumin promoter. A promoter may be constitutive or inducible.

In another embodiment, naked polynucleotide molecules are used as gene delivery vehicles, as described in WO 90/11092 and U.S. Patent 5,580,859. Such gene delivery vehicles can be either growth factor DNA or RNA and, in certain embodiments, are linked to killed adenovirus. Curiel *et al.*, Hum. Gene. Ther. 3:147-154, 1992. Other vehicles which can optionally be used include DNA-ligand (Wu *et al.*, J. Biol. Chem. 264:16985-16987, 1989), lipid-DNA combinations (Felgner *et al.*, Proc. Natl. Acad. Sci. USA 84:7413 7417, 1989), liposomes (Wang *et al.*, Proc. Natl. Acad. Sci. 84:7851-7855, 1987) and microprojectiles (Williams *et al.*, Proc. Natl. Acad. Sci. 88:2726-2730, 1991).

A gene delivery vehicle can optionally comprise viral sequences such as a viral origin of replication or packaging signal. These viral sequences can be selected from viruses such as astrovirus, coronavirus, orthomyxovirus, papovavirus, paramyxovirus, parvovirus, picornavirus, poxvirus, retrovirus, togavirus or adenovirus. In a preferred embodiment, the growth factor gene delivery vehicle is a recombinant retroviral vector. Recombinant retroviruses and various uses thereof have been described in numerous references including, for example, Mann *et al.*, Cell 33:153, 1983, Cane and Mulligan, Proc. Nat'l. Acad. Sci. USA 81:6349, 1984, Miller *et al.*, Human Gene Therapy 1:5-14, 1990, U.S. Patent Nos. 4,405,712, 4,861,719, and 4,980,289, and PCT Application Nos. WO 89/02,468, WO 89/05,349, and WO 90/02,806. Numerous retroviral gene delivery vehicles can be utilized in the present invention, including for example those described in EP 0,415,731; WO 90/07936; WO 94/03622; WO 93/25698; WO 93/25234; U.S. Patent No. 5,219,740; WO 9311230; WO 9310218; Vile and Hart, Cancer Res. 53:3860-3864, 1993; Vile and Hart, Cancer Res. 53:962-967, 1993; Ram *et al.*, Cancer Res. 53:83-88, 1993; Takamiya *et al.*, J. Neurosci. Res. 33:493-503, 1992; Baba *et al.*, J. Neurosurg. 79:729-735, 1993 (U.S. Patent No. 4,777,127, GB 2,200,651, EP 0,345,242 and WO91/02805).

Other viral vector systems that can be used to deliver a polynucleotide of the present invention have been derived from herpes virus, *e.g.*, Herpes Simplex Virus (U.S. Patent No. 5,631,236 by Woo *et al.*, issued May 20, 1997 and WO 00/08191 by Neurovex), vaccinia virus (Ridgeway (1988) Ridgeway, "Mammalian expression vectors," In: Rodriguez R L, Denhardt D T, ed. Vectors: A survey of molecular cloning vectors and their uses. Stoneham: Butterworth,; Baichwal and Sugden (1986) "Vectors for gene transfer derived from animal DNA viruses: Transient and stable expression of transferred genes," In: Kucherlapati R, ed. Gene transfer. New York: Plenum Press; Coupar *et al.* (1988) Gene,

68:1-10), and several RNA viruses. Preferred viruses include an alphavirus, a poxivirus, an arena virus, a vaccinia virus, a polio virus, and the like. They offer several attractive features for various mammalian cells (Friedmann (1989) Science, 244:1275-1281; Ridgeway, 1988, supra; Baichwal and Sugden, 1986, supra; Coupar *et al.*, 1988; Horwich *et al.*(1990) J.Virol., 64:642-650).

In other embodiments, target DNA in the genome can be manipulated using well-known methods in the art. For example, the target DNA in the genome can be manipulated by deletion, insertion, and/or mutation are retroviral insertion, artificial chromosome techniques, gene insertion, random insertion with tissue specific promoters, gene targeting, transposable elements and/or any other method for introducing foreign DNA or producing modified DNA/modified nuclear DNA. Other modification techniques include deleting DNA sequences from a genome and/or altering nuclear DNA sequences. Nuclear DNA sequences, for example, may be altered by site-directed mutagenesis.

In other embodiments, recombinant biomarker polypeptides, and fragments thereof, can be administered to subjects. In some embodiments, fusion proteins can be constructed and administered which have enhanced biological properties. In addition, the biomarker polypeptides, and fragment thereof, can be modified according to well-known pharmacological methods in the art (*e.g.*, pegylation, glycosylation, oligomerization, *etc.*) in order to further enhance desirable biological activities, such as increased bioavailability and decreased proteolytic degradation.

4. Clincal Efficacy

Clinical efficacy can be measured by any method known in the art. For example, the response to a therapy, such as inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatment, relates to any response of the cancer, *e.g.,* a tumor, to the therapy, preferably to a change in tumor mass and/or volume after initiation of neoadjuvant or adjuvant chemotherapy. Tumor response may be assessed in a neoadjuvant or adjuvant situation where the size of a tumor after systemic intervention can be compared to the initial size and dimensions as measured by CT, PET, mammogram, ultrasound or palpation and the cellularity of a tumor can be estimated histologically and compared to the cellularity of a tumor biopsy taken before initiation of treatment. Response may also be assessed by caliper measurement or pathological examination of the tumor after biopsy or surgical

resection. Response may be recorded in a quantitative fashion like percentage change in tumor volume or cellularity or using a semi-quantitative scoring system such as residual cancer burden (Symmans *et al.*, *J. Clin. Oncol.* (2007) 25:4414-4422) or Miller-Payne score (Ogston *et al.*, (2003) *Breast* (Edinburgh, Scotland) 12:320-327) in a qualitative fashion like "pathological complete response" (pCR), "clinical complete remission" (cCR), "clinical partial remission" (cPR), "clinical stable disease" (cSD), "clinical progressive disease" (cPD) or other qualitative criteria. Assessment of tumor response may be performed early after the onset of neoadjuvant or adjuvant therapy, *e.g.*, after a few hours, days, weeks or preferably after a few months. A typical endpoint for response assessment is upon termination of neoadjuvant chemotherapy or upon surgical removal of residual tumor cells and/or the tumor bed.

In some embodiments, clinical efficacy of the therapeutic treatments described herein may be determined by measuring the clinical benefit rate (CBR). The clinical benefit rate is measured by determining the sum of the percentage of patients who are in complete remission (CR), the number of patients who are in partial remission (PR) and the number of patients having stable disease (SD) at a time point at least 6 months out from the end of therapy. The shorthand for this formula is CBR=CR+PR+SD over 6 months. In some embodiments, the CBR for a particular anti-immune checkpoint therapeutic regimen is at least 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, or more.

Additional criteria for evaluating the response to immunotherapies, such as anti-immune checkpoint therapies, are related to "survival," which includes all of the following: survival until mortality, also known as overall survival (wherein said mortality may be either irrespective of cause or tumor related); "recurrence-free survival" (wherein the term recurrence shall include both localized and distant recurrence); metastasis free survival; disease free survival (wherein the term disease shall include cancer and diseases associated therewith). The length of said survival may be calculated by reference to a defined start point (*e.g.*, time of diagnosis or start of treatment) and end point (*e.g.*, death, recurrence or metastasis). In addition, criteria for efficacy of treatment can be expanded to include response to chemotherapy, probability of survival, probability of metastasis within a given time period, and probability of tumor recurrence.

For example, in order to determine appropriate threshold values, a particular anti-cancer therapeutic regimen can be administered to a population of subjects and the outcome

can be correlated to biomarker measurements that were determined prior to administration of any immunotherapy, such as anti-immune checkpoint therapy. The outcome measurement may be pathologic response to therapy given in the neoadjuvant setting. Alternatively, outcome measures, such as overall survival and disease-free survival can be monitored over a period of time for subjects following immunotherapies for whom biomarker measurement values are known. In certain embodiments, the same doses of immunotherapy agents, if any, are administered to each subject. In related embodiments, the doses administered are standard doses known in the art for those agents used in immunotherapies. The period of time for which subjects are monitored can vary. For example, subjects may be monitored for at least 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 25, 30, 35, 40, 45, 50, 55, or 60 months. Biomarker measurement threshold values that correlate to outcome of an immunotherapy can be determined using methods such as those described in the Examples section.

5. Further Uses and Methods of the Present Invention

The compositions described herein can be used in a variety of diagnostic, prognostic, and therapeutic applications. In any method described herein, such as a diagnostic method, prognostic method, therapeutic method, or combination thereof, all steps of the method can be performed by a single actor or, alternatively, by more than one actor. For example, diagnosis can be performed directly by the actor providing therapeutic treatment. Alternatively, a person providing a therapeutic agent can request that a diagnostic assay be performed. The diagnostician and/or the therapeutic interventionist can interpret the diagnostic assay results to determine a therapeutic strategy. Similarly, such alternative processes can apply to other assays, such as prognostic assays.

a. Screening Methods

One aspect of the present invention relates to screening assays, including non-cell based assays and xenograft animal model assays. In one embodiment, the assays provide a method for identifying whether a cancer is likely to respond to inhibitor of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatments, such as in a human by using a xenograft animal model assay, and/or whether an agent can inhibit the growth of or kill a cancer cell that is unlikely to respond to such inhibitors and immunotherapy combination treatments.

In one embodiment, the present invention relates to assays for screening test agents which bind to, or modulate the biological activity of, at least one biomarker described herein (*e.g.*, in the tables, figures, examples, or otherwise in the specification). In one embodiment, a method for identifying such an agent entails determining the ability of the agent to modulate, *e.g.* inhibit, the at least one biomarker described herein.

In one embodiment, an assay is a cell-free or cell-based assay, comprising contacting at least one biomarker described herein, with a test agent, and determining the ability of the test agent to modulate (*e.g.*, inhibit) the enzymatic activity of the biomarker, such as by measuring direct binding of substrates or by measuring indirect parameters as described below.

For example, in a direct binding assay, biomarker protein (or their respective target polypeptides or molecules) can be coupled with a radioisotope or enzymatic label such that binding can be determined by detecting the labeled protein or molecule in a complex. For example, the targets can be labeled with ^{125}I, ^{35}S, ^{14}C, or ^{3}H, either directly or indirectly, and the radioisotope detected by direct counting of radioemmission or by scintillation counting. Alternatively, the targets can be enzymatically labeled with, for example, horseradish peroxidase, alkaline phosphatase, or luciferase, and the enzymatic label detected by determination of conversion of an appropriate substrate to product. Determining the interaction between biomarker and substrate can also be accomplished using standard binding or enzymatic analysis assays. In one or more embodiments of the above described assay methods, it may be desirable to immobilize polypeptides or molecules to facilitate separation of complexed from uncomplexed forms of one or both of the proteins or molecules, as well as to accommodate automation of the assay.

Binding of a test agent to a target can be accomplished in any vessel suitable for containing the reactants. Non-limiting examples of such vessels include microtiter plates, test tubes, and micro-centrifuge tubes. Immobilized forms of the antibodies described herein can also include antibodies bound to a solid phase like a porous, microporous (with an average pore diameter less than about one micron) or macroporous (with an average pore diameter of more than about 10 microns) material, such as a membrane, cellulose, nitrocellulose, or glass fibers; a bead, such as that made of agarose or polyacrylamide or latex; or a surface of a dish, plate, or well, such as one made of polystyrene.

In an alternative embodiment, determining the ability of the agent to modulate the interaction between the biomarker and a substrate or a biomarker and its natural binding

partner can be accomplished by determining the ability of the test agent to modulate the activity of a polypeptide or other product that functions downstream or upstream of its position within the signaling pathway (*e.g.*, feedback loops). Such feedback loops are well-known in the art (see, for example, Chen and Guillemin (2009) *Int. J. Tryptophan Res.* 2:1-19).

The present invention further pertains to novel agents identified by the above-described screening assays. Accordingly, it is within the scope of this invention to further use an agent identified as described herein, such as in an appropriate animal model. For example, an agent identified as described herein can be used in an animal model to determine the efficacy, toxicity, or side effects of treatment with such an agent. Alternatively, an antibody identified as described herein can be used in an animal model to determine the mechanism of action of such an agent.

b. Predictive Medicine

The present invention also pertains to the field of predictive medicine in which diagnostic assays, prognostic assays, and monitoring clinical trials are used for prognostic (predictive) purposes to thereby treat an individual prophylactically. Accordingly, one aspect of the present invention relates to diagnostic assays for determining the amount and/or activity level of a biomarker described herein in the context of a biological sample (*e.g.*, blood, serum, cells, or tissue) to thereby determine whether an individual afflicted with a cancer is likely to respond to inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatments, such as in a cancer. Such assays can be used for prognostic or predictive purpose alone, or can be coupled with a therapeutic intervention to thereby prophylactically treat an individual prior to the onset or after recurrence of a disorder characterized by or associated with biomarker polypeptide, nucleic acid expression or activity. The skilled artisan will appreciate that any method can use one or more (*e.g.*, combinations) of biomarkers described herein, such as those in the tables, figures, examples, and otherwise described in the specification.

Another aspect of the present invention pertains to monitoring the influence of agents (*e.g.*, drugs, compounds, and small nucleic acid-based molecules) on the expression or activity of a biomarker described herein. These and other agents are described in further detail in the following sections.

The skilled artisan will also appreciated that, in certain embodiments, the methods of the present invention implement a computer program and computer system. For example, a computer program can be used to perform the algorithms described herein. A computer system can also store and manipulate data generated by the methods of the present invention which comprises a plurality of biomarker signal changes/profiles which can be used by a computer system in implementing the methods of this invention. In certain embodiments, a computer system receives biomarker expression data; (ii) stores the data; and (iii) compares the data in any number of ways described herein (*e.g.*, analysis relative to appropriate controls) to determine the state of informative biomarkers from cancerous or pre-cancerous tissue. In other embodiments, a computer system (i) compares the determined expression biomarker level to a threshold value; and (ii) outputs an indication of whether said biomarker level is significantly modulated (*e.g.*, above or below) the threshold value, or a phenotype based on said indication.

In certain embodiments, such computer systems are also considered part of the present invention. Numerous types of computer systems can be used to implement the analytic methods of this invention according to knowledge possessed by a skilled artisan in the bioinformatics and/or computer arts. Several software components can be loaded into memory during operation of such a computer system. The software components can comprise both software components that are standard in the art and components that are special to the present invention (*e.g.*, dCHIP software described in Lin *et al.* (2004) *Bioinformatics* 20, 1233-1240; radial basis machine learning algorithms (RBM) known in the art).

The methods of the present invention can also be programmed or modeled in mathematical software packages that allow symbolic entry of equations and high-level specification of processing, including specific algorithms to be used, thereby freeing a user of the need to procedurally program individual equations and algorithms. Such packages include, *e.g.*, Matlab from Mathworks (Natick, Mass.), Mathematica from Wolfram Research (Champaign, Ill.) or S-Plus from MathSoft (Seattle, Wash.).

In certain embodiments, the computer comprises a database for storage of biomarker data. Such stored profiles can be accessed and used to perform comparisons of interest at a later point in time. For example, biomarker expression profiles of a sample derived from the non-cancerous tissue of a subject and/or profiles generated from population-based distributions of informative loci of interest in relevant populations of the

same species can be stored and later compared to that of a sample derived from the cancerous tissue of the subject or tissue suspected of being cancerous of the subject.

In addition to the exemplary program structures and computer systems described herein, other, alternative program structures and computer systems will be readily apparent to the skilled artisan. Such alternative systems, which do not depart from the above described computer system and programs structures either in spirit or in scope, are therefore intended to be comprehended within the accompanying claims.

c. Diagnostic Assays

The present invention provides, in part, methods, systems, and code for accurately classifying whether a biological sample is associated with a cancer that is likely to respond to inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatments. In some embodiments, the present invention is useful for classifying a sample (*e.g.*, from a subject) as associated with or at risk for responding to or not responding to such inhibitor and immunotherapy combination treatments using a statistical algorithm and/or empirical data (*e.g.*, the amount or activity of a biomarker described herein, such as in the tables, figures, examples, and otherwise described in the specification).

An exemplary method for detecting the amount or activity of a biomarker described herein, and thus useful for classifying whether a sample is likely or unlikely to respond to inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatments involves obtaining a biological sample from a test subject and contacting the biological sample with an agent, such as a protein-binding agent like an antibody or antigen-binding fragment thereof, or a nucleic acid-binding agent like an oligonucleotide, capable of detecting the amount or activity of the biomarker in the biological sample. In some embodiments, at least one antibody or antigen-binding fragment thereof is used, wherein two, three, four, five, six, seven, eight, nine, ten, or more such antibodies or antibody fragments can be used in combination (*e.g.*, in sandwich ELISAs) or in serial. In certain instances, the statistical algorithm is a single learning statistical classifier system. For example, a single learning statistical classifier system can be used to classify a sample as a based upon a prediction or probability value and the presence or level of the biomarker. The use of a single learning statistical classifier system typically classifies the sample as, for example, a likely immunotherapy responder or progressor sample with a sensitivity,

specificity, positive predictive value, negative predictive value, and/or overall accuracy of at least about 75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99%.

Other suitable statistical algorithms are well-known to those of skill in the art. For example, learning statistical classifier systems include a machine learning algorithmic technique capable of adapting to complex data sets (*e.g.*, panel of markers of interest) and making decisions based upon such data sets. In some embodiments, a single learning statistical classifier system such as a classification tree (*e.g.*, random forest) is used. In other embodiments, a combination of 2, 3, 4, 5, 6, 7, 8, 9, 10, or more learning statistical classifier systems are used, preferably in tandem. Examples of learning statistical classifier systems include, but are not limited to, those using inductive learning (*e.g.*, decision/classification trees such as random forests, classification and regression trees (C&RT), boosted trees, etc.), Probably Approximately Correct (PAC) learning, connectionist learning (*e.g.*, neural networks (NN), artificial neural networks (ANN), neuro fuzzy networks (NFN), network structures, perceptrons such as multi-layer perceptrons, multi-layer feed-forward networks, applications of neural networks, Bayesian learning in belief networks, etc.), reinforcement learning (*e.g.*, passive learning in a known environment such as naive learning, adaptive dynamic learning, and temporal difference learning, passive learning in an unknown environment, active learning in an unknown environment, learning action-value functions, applications of reinforcement learning, etc.), and genetic algorithms and evolutionary programming. Other learning statistical classifier systems include support vector machines (*e.g.*, Kernel methods), multivariate adaptive regression splines (MARS), Levenberg-Marquardt algorithms, Gauss-Newton algorithms, mixtures of Gaussians, gradient descent algorithms, and learning vector quantization (LVQ). In certain embodiments, the method of the present invention further comprises sending the sample classification results to a clinician, *e.g.*, an oncologist.

In another embodiment, the diagnosis of a subject is followed by administering to the individual a therapeutically effective amount of a defined treatment based upon the diagnosis.

In one embodiment, the methods further involve obtaining a control biological sample (*e.g.*, biological sample from a subject who does not have a cancer or whose cancer is susceptible to inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination

treatments), a biological sample from the subject during remission, or a biological sample from the subject during treatment for developing a cancer progressing despite such inhibitors and immunotherapy combination treatments.

d. Prognostic Assays

The diagnostic methods described herein can furthermore be utilized to identify subjects having or at risk of developing a cancer that is likely or unlikely to be responsive to inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy combination treatments. The assays described herein, such as the preceding diagnostic assays or the following assays, can be utilized to identify a subject having or at risk of developing a disorder associated with a misregulation of the amount or activity of at least one biomarker described herein, such as in cancer. Alternatively, the prognostic assays can be utilized to identify a subject having or at risk for developing a disorder associated with a misregulation of the at least one biomarker described herein, such as in cancer. Furthermore, the prognostic assays described herein can be used to determine whether a subject can be administered an agent (*e.g.*, an agonist, antagonist, peptidomimetic, polypeptide, peptide, nucleic acid, small molecule, or other drug candidate) to treat a disease or disorder associated with the aberrant biomarker expression or activity.

e. Treatment Methods

The therapeutic compositions described herein, such as the combination of inhibitors of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1) and immunotherapy, can be used in a variety of *in vitro* and *in vivo* therapeutic applications using the formulations and/or combinations described herein. In one embodiment, the therapeutic agents can be used to treat cancers determined to be responsive thereto. For example, single or multiple agents that inhibit or block both such inhibitors and a immunotherapy can be used to treat cancers in subjects identified as likely responders thereto.

Modulatory methods of the present invention involve contacting a cell, such as an immune cell with an agent that inhibits or blocks the expression and/or activity of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, *e.g.* such as PTPN2 and SOCS1) and an immunotherapy, such as an immune checkpoint inhibitor (*e.g.*, PD-1). Exemplary agents useful in such methods are described above. Such agents can be administered *in vitro* or *ex vivo* (*e.g.*, by contacting the cell with the agent) or, alternatively,

in vivo (*e.g.*, by administering the agent to a subject). As such, the present invention provides methods useful for treating an individual afflicted with a condition that would benefit from an increased immune response, such as an infection or a cancer like colorectal cancer.

Agents that upregulate immune responses can be in the form of enhancing an existing immune response or eliciting an initial immune response. Thus, enhancing an immune response using the subject compositions and methods is useful for treating cancer, but can also be useful for treating an infectious disease (*e.g.*, bacteria, viruses, or parasites), a parasitic infection, and an immunosuppressive disease.

Exemplary infectious disorders include viral skin diseases, such as Herpes or shingles, in which case such an agent can be delivered topically to the skin. In addition, systemic viral diseases, such as influenza, the common cold, and encephalitis might be alleviated by systemic administration of such agents. In one preferred embodiment, agents that upregulate the immune response described herein are useful for modulating the arginase/iNOS balance during *Trypanosoma cruzi* infection in order to facilitate a protective immune response against the parasite.

Immune responses can also be enhanced in an infected patient through an *ex vivo* approach, for instance, by removing immune cells from the patient, contacting immune cells *in vitro* with an agent described herein and reintroducing the *in vitro* stimulated immune cells into the patient.

In certain instances, it may be desirable to further administer other agents that upregulate immune responses, for example, forms of other B7 family members that transduce signals via costimulatory receptors, in order to further augment the immune response. Such additional agents and therapies are described further below.

Agents that upregulate an immune response can be used prophylactically in vaccines against various polypeptides (*e.g.*, polypeptides derived from pathogens). Immunity against a pathogen (*e.g.*, a virus) can be induced by vaccinating with a viral protein along with an agent that upregulates an immune response, in an appropriate adjuvant.

In another embodiment, upregulation or enhancement of an immune response function, as described herein, is useful in the induction of tumor immunity.

In another embodiment, the immune response can be stimulated by the methods described herein, such that preexisting tolerance, clonal deletion, and/or exhaustion (*e.g.*, T

cell exhaustion) is overcome. For example, immune responses against antigens to which a subject cannot mount a significant immune response, *e.g.*, to an autologous antigen, such as a tumor specific antigens can be induced by administering appropriate agents described herein that upregulate the immune response. In one embodiment, an autologous antigen, such as a tumor-specific antigen, can be coadministered. In another embodiment, the subject agents can be used as adjuvants to boost responses to foreign antigens in the process of active immunization.

In one embodiment, immune cells are obtained from a subject and cultured *ex vivo* in the presence of an agent as described herein, to expand the population of immune cells and/or to enhance immune cell activation. In a further embodiment the immune cells are then administered to a subject. Immune cells can be stimulated *in vitro* by, for example, providing to the immune cells a primary activation signal and a costimulatory signal, as is known in the art. Various agents can also be used to costimulate proliferation of immune cells. In one embodiment immune cells are cultured *ex vivo* according to the method described in PCT Application No. WO 94/29436. The costimulatory polypeptide can be soluble, attached to a cell membrane, or attached to a solid surface, such as a bead.

6. Administration of Agents

The immune modulating agents of the invention are administered to subjects in a biologically compatible form suitable for pharmaceutical administration *in vivo,* to enhance immune cell mediated immune responses. By "biologically compatible form suitable for administration *in vivo*" is meant a form to be administered in which any toxic effects are outweighed by the therapeutic effects. The term "subject" is intended to include living organisms in which an immune response can be elicited, *e.g.*, mammals. Examples of subjects include humans, dogs, cats, mice, rats, and transgenic species thereof. Administration of an agent as described herein can be in any pharmacological form including a therapeutically active amount of an agent alone or in combination with a pharmaceutically acceptable carrier.

Administration of a therapeutically active amount of the therapeutic composition of the present invention is defined as an amount effective, at dosages and for periods of time necessary, to achieve the desired result. For example, a therapeutically active amount of an agent may vary according to factors such as the disease state, age, sex, and weight of the individual, and the ability of peptide to elicit a desired response in the individual. Dosage

regimens can be adjusted to provide the optimum therapeutic response. For example, several divided doses can be administered daily or the dose can be proportionally reduced as indicated by the exigencies of the therapeutic situation.

Inhibiting or blocking expression and/or activity of one or more biomarkers in Table 1 (*e.g.*, one or more kinase signaling inhibitors, such as PTPN2 and SOCS1), alone or in combination with an immunotherapy, can be accomplished by combination therapy with the modulatory agents described herein. Combination therapy describes a therapy in which one or more biomarkers in Table 1 are inhibited or blocked with an immunotherapy simultaneously. This may be achieved by administration of the modulatory agent described herein swith the immunotherapy imultaneously (*e.g.*, in a combination dosage form or by simultaneous administration of single agents) or by administration of single inhibitory agent for one or more biomarkers in Table 1 and the immunotherapy, according to a schedule that results in effective amounts of each modulatory agent present in the patient at the same time.

The therapeutic agents described herein can be administered in a convenient manner such as by injection (subcutaneous, intravenous, etc.), oral administration, inhalation, transdermal application, or rectal administration. Depending on the route of administration, the active compound can be coated in a material to protect the compound from the action of enzymes, acids and other natural conditions which may inactivate the compound. For example, for administration of agents, by other than parenteral administration, it may be desirable to coat the agent with, or co-administer the agent with, a material to prevent its inactivation.

An agent can be administered to an individual in an appropriate carrier, diluent or adjuvant, co-administered with enzyme inhibitors or in an appropriate carrier such as liposomes. Pharmaceutically acceptable diluents include saline and aqueous buffer solutions. Adjuvant is used in its broadest sense and includes any immune stimulating compound such as interferon. Adjuvants contemplated herein include resorcinols, non-ionic surfactants such as polyoxyethylene oleyl ether and n-hexadecyl polyethylene ether. Enzyme inhibitors include pancreatic trypsin inhibitor, diisopropylfluorophosphate (DEEP) and trasylol. Liposomes include water-in-oil-in-water emulsions as well as conventional liposomes (Sterna *et al.* (1984) *J. Neuroimmunol.* 7:27).

As described in detail below, the pharmaceutical compositions of the present invention may be specially formulated for administration in solid or liquid form, including

those adapted for the following: (1) oral administration, for example, drenches (aqueous or non-aqueous solutions or suspensions), tablets, boluses, powders, granules, pastes; (2) parenteral administration, for example, by subcutaneous, intramuscular or intravenous injection as, for example, a sterile solution or suspension; (3) topical application, for example, as a cream, ointment or spray applied to the skin; (4) intravaginally or intrarectally, for example, as a pessary, cream or foam; or (5) aerosol, for example, as an aqueous aerosol, liposomal preparation or solid particles containing the compound.

The phrase "therapeutically-effective amount" as used herein means that amount of an agent that modulates (*e.g.*, inhibits) biomarker expression and/or activity, or expression and/or activity of the complex, or composition comprising an agent that modulates (*e.g.*, inhibits) biomarker expression and/or activity, or expression and/or activity of the complex, which is effective for producing some desired therapeutic effect, *e.g.*, cancer treatment, at a reasonable benefit/risk ratio.

The phrase "pharmaceutically acceptable" is employed herein to refer to those agents, materials, compositions, and/or dosage forms which are, within the scope of sound medical judgment, suitable for use in contact with the tissues of human beings and animals without excessive toxicity, irritation, allergic response, or other problem or complication, commensurate with a reasonable benefit/risk ratio.

The phrase "pharmaceutically-acceptable carrier" as used herein means a pharmaceutically-acceptable material, composition or vehicle, such as a liquid or solid filler, diluent, excipient, solvent or encapsulating material, involved in carrying or transporting the subject chemical from one organ, or portion of the body, to another organ, or portion of the body. Each carrier must be "acceptable" in the sense of being compatible with the other ingredients of the formulation and not injurious to the subject. Some examples of materials which can serve as pharmaceutically-acceptable carriers include: (1) sugars, such as lactose, glucose and sucrose; (2) starches, such as corn starch and potato starch; (3) cellulose, and its derivatives, such as sodium carboxymethyl cellulose, ethyl cellulose and cellulose acetate; (4) powdered tragacanth; (5) malt; (6) gelatin; (7) talc; (8) excipients, such as cocoa butter and suppository waxes; (9) oils, such as peanut oil, cottonseed oil, safflower oil, sesame oil, olive oil, corn oil and soybean oil; (10) glycols, such as propylene glycol; (11) polyols, such as glycerin, sorbitol, mannitol and polyethylene glycol; (12) esters, such as ethyl oleate and ethyl laurate; (13) agar; (14) buffering agents, such as magnesium hydroxide and aluminum hydroxide; (15) alginic acid;

(16) pyrogen-free water; (17) isotonic saline; (18) Ringer's solution; (19) ethyl alcohol; (20) phosphate buffer solutions; and (21) other non-toxic compatible substances employed in pharmaceutical formulations.

The term "pharmaceutically-acceptable salts" refers to the relatively non-toxic, inorganic and organic acid addition salts of the agents that modulates (*e.g.*, inhibits) biomarker expression and/or activity, or expression and/or activity of the complex encompassed by the present invention. These salts can be prepared *in situ* during the final isolation and purification of the therapeutic agents, or by separately reacting a purified therapeutic agent in its free base form with a suitable organic or inorganic acid, and isolating the salt thus formed. Representative salts include the hydrobromide, hydrochloride, sulfate, bisulfate, phosphate, nitrate, acetate, valerate, oleate, palmitate, stearate, laurate, benzoate, lactate, phosphate, tosylate, citrate, maleate, fumarate, succinate, tartrate, napthylate, mesylate, glucoheptonate, lactobionate, and laurylsulphonate salts and the like (See, for example, Berge *et al.* (1977) "Pharmaceutical Salts", *J. Pharm. Sci.* 66:1-19).

In other cases, the agents useful in the methods of the present invention may contain one or more acidic functional groups and, thus, are capable of forming pharmaceutically-acceptable salts with pharmaceutically-acceptable bases. The term "pharmaceutically-acceptable salts" in these instances refers to the relatively non-toxic, inorganic and organic base addition salts of agents that modulates (*e.g.*, inhibits) biomarker expression and/or activity, or expression and/or activity of the complex. These salts can likewise be prepared in situ during the final isolation and purification of the therapeutic agents, or by separately reacting the purified therapeutic agent in its free acid form with a suitable base, such as the hydroxide, carbonate or bicarbonate of a pharmaceutically-acceptable metal cation, with ammonia, or with a pharmaceutically-acceptable organic primary, secondary or tertiary amine. Representative alkali or alkaline earth salts include the lithium, sodium, potassium, calcium, magnesium, and aluminum salts and the like. Representative organic amines useful for the formation of base addition salts include ethylamine, diethylamine, ethylenediamine, ethanolamine, diethanolamine, piperazine and the like (see, for example, Berge *et al.*, *supra*).

Wetting agents, emulsifiers and lubricants, such as sodium lauryl sulfate and magnesium stearate, as well as coloring agents, release agents, coating agents, sweetening,

flavoring and perfuming agents, preservatives and antioxidants can also be present in the compositions.

Examples of pharmaceutically-acceptable antioxidants include: (1) water soluble antioxidants, such as ascorbic acid, cysteine hydrochloride, sodium bisulfate, sodium metabisulfite, sodium sulfite and the like; (2) oil-soluble antioxidants, such as ascorbyl palmitate, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), lecithin, propyl gallate, alpha-tocopherol, and the like; and (3) metal chelating agents, such as citric acid, ethylenediamine tetraacetic acid (EDTA), sorbitol, tartaric acid, phosphoric acid, and the like.

Formulations useful in the methods of the present invention include those suitable for oral, nasal, topical (including buccal and sublingual), rectal, vaginal, aerosol and/or parenteral administration. The formulations may conveniently be presented in unit dosage form and may be prepared by any methods well-known in the art of pharmacy. The amount of active ingredient which can be combined with a carrier material to produce a single dosage form will vary depending upon the host being treated, the particular mode of administration. The amount of active ingredient, which can be combined with a carrier material to produce a single dosage form will generally be that amount of the compound which produces a therapeutic effect. Generally, out of one hundred per cent, this amount will range from about 1 per cent to about ninety-nine percent of active ingredient, preferably from about 5 per cent to about 70 per cent, most preferably from about 10 per cent to about 30 per cent.

Methods of preparing these formulations or compositions include the step of bringing into association an agent that modulates (*e.g.*, inhibits) biomarker expression and/or activity, with the carrier and, optionally, one or more accessory ingredients. In general, the formulations are prepared by uniformly and intimately bringing into association a therapeutic agent with liquid carriers, or finely divided solid carriers, or both, and then, if necessary, shaping the product.

Formulations suitable for oral administration may be in the form of capsules, cachets, pills, tablets, lozenges (using a flavored basis, usually sucrose and acacia or tragacanth), powders, granules, or as a solution or a suspension in an aqueous or non-aqueous liquid, or as an oil-in-water or water-in-oil liquid emulsion, or as an elixir or syrup, or as pastilles (using an inert base, such as gelatin and glycerin, or sucrose and acacia) and/or as mouth washes and the like, each containing a predetermined amount of a

therapeutic agent as an active ingredient. A compound may also be administered as a bolus, electuary or paste.

In solid dosage forms for oral administration (capsules, tablets, pills, dragees, powders, granules and the like), the active ingredient is mixed with one or more pharmaceutically-acceptable carriers, such as sodium citrate or dicalcium phosphate, and/or any of the following: (1) fillers or extenders, such as starches, lactose, sucrose, glucose, mannitol, and/or silicic acid; (2) binders, such as, for example, carboxymethylcellulose, alginates, gelatin, polyvinyl pyrrolidone, sucrose and/or acacia; (3) humectants, such as glycerol; (4) disintegrating agents, such as agar-agar, calcium carbonate, potato or tapioca starch, alginic acid, certain silicates, and sodium carbonate; (5) solution retarding agents, such as paraffin; (6) absorption accelerators, such as quaternary ammonium compounds; (7) wetting agents, such as, for example, acetyl alcohol and glycerol monostearate; (8) absorbents, such as kaolin and bentonite clay; (9) lubricants, such a talc, calcium stearate, magnesium stearate, solid polyethylene glycols, sodium lauryl sulfate, and mixtures thereof; and (10) coloring agents. In the case of capsules, tablets and pills, the pharmaceutical compositions may also comprise buffering agents. Solid compositions of a similar type may also be employed as fillers in soft and hard-filled gelatin capsules using such excipients as lactose or milk sugars, as well as high molecular weight polyethylene glycols and the like.

A tablet may be made by compression or molding, optionally with one or more accessory ingredients. Compressed tablets may be prepared using binder (for example, gelatin or hydroxypropylmethyl cellulose), lubricant, inert diluent, preservative, disintegrant (for example, sodium starch glycolate or cross-linked sodium carboxymethyl cellulose), surface-active or dispersing agent. Molded tablets may be made by molding in a suitable machine a mixture of the powdered peptide or peptidomimetic moistened with an inert liquid diluent.

Tablets, and other solid dosage forms, such as dragees, capsules, pills and granules, may optionally be scored or prepared with coatings and shells, such as enteric coatings and other coatings well-known in the pharmaceutical-formulating art. They may also be formulated so as to provide slow or controlled release of the active ingredient therein using, for example, hydroxypropylmethyl cellulose in varying proportions to provide the desired release profile, other polymer matrices, liposomes and/or microspheres. They may be sterilized by, for example, filtration through a bacteria-retaining filter, or by incorporating

sterilizing agents in the form of sterile solid compositions, which can be dissolved in sterile water, or some other sterile injectable medium immediately before use. These compositions may also optionally contain opacifying agents and may be of a composition that they release the active ingredient(s) only, or preferentially, in a certain portion of the gastrointestinal tract, optionally, in a delayed manner. Examples of embedding compositions, which can be used include polymeric substances and waxes. The active ingredient can also be in micro-encapsulated form, if appropriate, with one or more of the above-described excipients.

Liquid dosage forms for oral administration include pharmaceutically acceptable emulsions, microemulsions, solutions, suspensions, syrups and elixirs. In addition to the active ingredient, the liquid dosage forms may contain inert diluents commonly used in the art, such as, for example, water or other solvents, solubilizing agents and emulsifiers, such as ethyl alcohol, isopropyl alcohol, ethyl carbonate, ethyl acetate, benzyl alcohol, benzyl benzoate, propylene glycol, 1,3-butylene glycol, oils (in particular, cottonseed, groundnut, corn, germ, olive, castor and sesame oils), glycerol, tetrahydrofuryl alcohol, polyethylene glycols and fatty acid esters of sorbitan, and mixtures thereof.

Besides inert diluents, the oral compositions can also include adjuvants such as wetting agents, emulsifying and suspending agents, sweetening, flavoring, coloring, perfuming and preservative agents.

Suspensions, in addition to the active agent may contain suspending agents as, for example, ethoxylated isostearyl alcohols, polyoxyethylene sorbitol and sorbitan esters, microcrystalline cellulose, aluminum metahydroxide, bentonite, agar-agar and tragacanth, and mixtures thereof.

Formulations for rectal or vaginal administration may be presented as a suppository, which may be prepared by mixing one or more therapeutic agents with one or more suitable nonirritating excipients or carriers comprising, for example, cocoa butter, polyethylene glycol, a suppository wax or a salicylate, and which is solid at room temperature, but liquid at body temperature and, therefore, will melt in the rectum or vaginal cavity and release the active agent.

Formulations which are suitable for vaginal administration also include pessaries, tampons, creams, gels, pastes, foams or spray formulations containing such carriers as are known in the art to be appropriate.

Dosage forms for the topical or transdermal administration of an agent that modulates (*e.g.*, inhibits) biomarker expression and/or activity include powders, sprays, ointments, pastes, creams, lotions, gels, solutions, patches and inhalants. The active component may be mixed under sterile conditions with a pharmaceutically-acceptable carrier, and with any preservatives, buffers, or propellants which may be required.

The ointments, pastes, creams and gels may contain, in addition to a therapeutic agent, excipients, such as animal and vegetable fats, oils, waxes, paraffins, starch, tragacanth, cellulose derivatives, polyethylene glycols, silicones, bentonites, silicic acid, talc and zinc oxide, or mixtures thereof.

Powders and sprays can contain, in addition to an agent that modulates (*e.g.*, inhibits) biomarker expression and/or activity, excipients such as lactose, talc, silicic acid, aluminum hydroxide, calcium silicates and polyamide powder, or mixtures of these substances. Sprays can additionally contain customary propellants, such as chlorofluorohydrocarbons and volatile unsubstituted hydrocarbons, such as butane and propane.

The agent that modulates (*e.g.*, inhibits) biomarker expression and/or activity, can be alternatively administered by aerosol. This is accomplished by preparing an aqueous aerosol, liposomal preparation or solid particles containing the compound. A nonaqueous (*e.g.*, fluorocarbon propellant) suspension could be used. Sonic nebulizers are preferred because they minimize exposing the agent to shear, which can result in degradation of the compound.

Ordinarily, an aqueous aerosol is made by formulating an aqueous solution or suspension of the agent together with conventional pharmaceutically acceptable carriers and stabilizers. The carriers and stabilizers vary with the requirements of the particular compound, but typically include nonionic surfactants (Tweens, Pluronics, or polyethylene glycol), innocuous proteins like serum albumin, sorbitan esters, oleic acid, lecithin, amino acids such as glycine, buffers, salts, sugars or sugar alcohols. Aerosols generally are prepared from isotonic solutions.

Transdermal patches have the added advantage of providing controlled delivery of a therapeutic agent to the body. Such dosage forms can be made by dissolving or dispersing the agent in the proper medium. Absorption enhancers can also be used to increase the flux of the peptidomimetic across the skin. The rate of such flux can be controlled by either

providing a rate controlling membrane or dispersing the peptidomimetic in a polymer matrix or gel.

Ophthalmic formulations, eye ointments, powders, solutions and the like, are also contemplated as being within the scope of this invention.

Pharmaceutical compositions of this invention suitable for parenteral administration comprise one or more therapeutic agents in combination with one or more pharmaceutically-acceptable sterile isotonic aqueous or nonaqueous solutions, dispersions, suspensions or emulsions, or sterile powders which may be reconstituted into sterile injectable solutions or dispersions just prior to use, which may contain antioxidants, buffers, bacteriostats, solutes which render the formulation isotonic with the blood of the intended recipient or suspending or thickening agents.

Examples of suitable aqueous and nonaqueous carriers which may be employed in the pharmaceutical compositions of the present invention include water, ethanol, polyols (such as glycerol, propylene glycol, polyethylene glycol, and the like), and suitable mixtures thereof, vegetable oils, such as olive oil, and injectable organic esters, such as ethyl oleate. Proper fluidity can be maintained, for example, by the use of coating materials, such as lecithin, by the maintenance of the required particle size in the case of dispersions, and by the use of surfactants.

These compositions may also contain adjuvants such as preservatives, wetting agents, emulsifying agents and dispersing agents. Prevention of the action of microorganisms may be ensured by the inclusion of various antibacterial and antifungal agents, for example, paraben, chlorobutanol, phenol sorbic acid, and the like. It may also be desirable to include isotonic agents, such as sugars, sodium chloride, and the like into the compositions. In addition, prolonged absorption of the injectable pharmaceutical form may be brought about by the inclusion of agents which delay absorption such as aluminum monostearate and gelatin.

In some cases, in order to prolong the effect of a drug, it is desirable to slow the absorption of the drug from subcutaneous or intramuscular injection. This may be accomplished by the use of a liquid suspension of crystalline or amorphous material having poor water solubility. The rate of absorption of the drug then depends upon its rate of dissolution, which, in turn, may depend upon crystal size and crystalline form. Alternatively, delayed absorption of a parenterally-administered drug form is accomplished by dissolving or suspending the drug in an oil vehicle.

Injectable depot forms are made by forming microencapsule matrices of an agent that modulates (*e.g.*, inhibits) biomarker expression and/or activity, in biodegradable polymers such as polylactide-polyglycolide. Depending on the ratio of drug to polymer, and the nature of the particular polymer employed, the rate of drug release can be controlled. Examples of other biodegradable polymers include poly(orthoesters) and poly(anhydrides). Depot injectable formulations are also prepared by entrapping the drug in liposomes or microemulsions, which are compatible with body tissue.

When the therapeutic agents of the present invention are administered as pharmaceuticals, to humans and animals, they can be given per se or as a pharmaceutical composition containing, for example, 0.1 to 99.5% (more preferably, 0.5 to 90%) of active ingredient in combination with a pharmaceutically acceptable carrier.

Actual dosage levels of the active ingredients in the pharmaceutical compositions of this invention may be determined by the methods of the present invention so as to obtain an amount of the active ingredient, which is effective to achieve the desired therapeutic response for a particular subject, composition, and mode of administration, without being toxic to the subject.

The nucleic acid molecules of the present invention can be inserted into vectors and used as gene therapy vectors. Gene therapy vectors can be delivered to a subject by, for example, intravenous injection, local administration (see U.S. Pat. No. 5,328,470) or by stereotactic injection (see *e.g.*, Chen *et al.* (1994) *Proc. Natl. Acad. Sci. USA* 91:3054-3057). The pharmaceutical preparation of the gene therapy vector can include the gene therapy vector in an acceptable diluent, or can comprise a slow release matrix in which the gene delivery vehicle is imbedded. Alternatively, where the complete gene delivery vector can be produced intact from recombinant cells, *e.g.*, retroviral vectors, the pharmaceutical preparation can include one or more cells which produce the gene delivery system.

In one embodiment, an agent of the invention is an antibody. As defined herein, a therapeutically effective amount of antibody (*i.e.*, an effective dosage) ranges from about 0.001 to 30 mg/kg body weight, preferably about 0.01 to 25 mg/kg body weight, more preferably about 0.1 to 20 mg/kg body weight, and even more preferably about 1 to 10 mg/kg, 2 to 9 mg/kg, 3 to 8 mg/kg, 4 to 7 mg/kg, or 5 to 6 mg/kg body weight. The skilled artisan will appreciate that certain factors may influence the dosage required to effectively treat a subject, including but not limited to the severity of the disease or disorder, previous treatments, the general health and/or age of the subject, and other diseases present.

Moreover, treatment of a subject with a therapeutically effective amount of an antibody can include a single treatment or, preferably, can include a series of treatments. In a preferred example, a subject is treated with antibody in the range of between about 0.1 to 20 mg/kg body weight, one time per week for between about 1 to 10 weeks, preferably between 2 to 8 weeks, more preferably between about 3 to 7 weeks, and even more preferably for about 4, 5, or 6 weeks. It will also be appreciated that the effective dosage of antibody used for treatment may increase or decrease over the course of a particular treatment. Changes in dosage may result from the results of diagnostic assays.

7. Kits

The present invention also encompasses kits for detecting and/or modulating biomarkers described herein. A kit of the present invention may also include instructional materials disclosing or describing the use of the kit or an antibody of the disclosed invention in a method of the disclosed invention as provided herein. A kit may also include additional components to facilitate the particular application for which the kit is designed. For example, a kit may additionally contain means of detecting the label (*e.g.*, enzyme substrates for enzymatic labels, filter sets to detect fluorescent labels, appropriate secondary labels such as a sheep anti-mouse-HRP, *etc.*) and reagents necessary for controls (*e.g.*, control biological samples or standards). A kit may additionally include buffers and other reagents recognized for use in a method of the disclosed invention. Non-limiting examples include agents to reduce non-specific binding, such as a carrier protein or a detergent.

EXAMPLES

Example 1: Materials and methods for Examples 2-8

a. *In vivo* CRISPR screening in B16 tumor cells

A Cas9-expressing version of the B16 melanoma cell line was created and confirmed that it could edit DNA efficiently with CRISPR using sgRNAs targeting the PD-L1 gene. For screening the B16-Cas9 cell line, a library of 9,992 optimized sgRNAs was created to target 2,398 genes, selected from the GO term categories: kinase, phosphatase, cell surface, plasma membrane, antigen processing and presentation, immune system process, and chromatin remodeling. The transcript abundance of the genes in these categories were then filtered to include only those that were expressed > RPKM ($\log_2$) = 0.9. These genes were then ranked for expression in the B16 cell line using RNAseq to

select for the top 2,398 expressed genes. The library was divided into 4 sub-pools, each containing one sgRNA per gene and 100 non-targeting control sgRNAs. The 4 sub-pools were screened individually and sgRNAs were delivered to B16-Cas9 cells via lentiviral infection at an infection rate of 30%. Transduced B16 cells were purified using a hCD19 reporter by positive magnetic selection (Miltenyi Biotech, Cambridge, MA) and then expanded *in vitro* before being implanted into animals. For each sub-pool, B16 cells were implanted into 10 TCR$\alpha^{-/-}$ mice, 10 WT mice treated with GVAX, and 10 WT mice treated with GVAX and PD-1 blockade (see below for treatment protocols). B16 cells transduced with libraries were also grown *in vitro* at approximately 2000 x library coverage for the same time period as the animal experiment. Mice were sacrificed 12-14 days after tumor implantation tumor genomic DNA was prepared from whole tumor tissue using the Qiagen DNA Blood Midi kit (Qiagen, Hilden, Germany). PCR was used to amplify the sgRNA region and sequencing to determine sgRNA abundance was performed on an Illumina HiSeq system (Illumina, San Diego, CA). Significantly enriched or depleted sgRNAs from any comparison of conditions were identified using the STARS algorithm (Doench *et al.* (2014) *Nat. Biotechnol.* 32:1262-1267).

b. Cell lines

B16F10 melanoma and B16-GM-CSF cells were gifts from Dr. Glenn Dranoff. *Braf/Pten* melanoma cells were a gift from Dr. David Fisher. MC38 colon carcinoma cells were a gift from Dr. Arlene Sharpe. A375 melanoma, A549 lung carcinoma, and HT-29 colon carcinoma were purchased from ATCC. MelJuSo melanoma cells were a gift from the Cancer Cell Line Encyclopedia (Broad Institute). B16, MC38, A549, and HT-29 cells were all grown in DMEM (Gibco) with 10% fetal bovine serum (Gemini biosciences) and antibiotics. A375 and MelJuSo cells were grown in RPMI 1640 (Gibco) with 10% fetal bovine serum and antibiotics. All cell lines were subject to periodic testing for mycoplasma using the LookOut® Mycoplasma PCR detection kit (Sigma).

c. Animal treatment and tumor challenges

The designs of the animal studies and procedures were approved by the Dana Farber Cancer Institute IACUC committee. Dana Farber's specific-pathogen free facility was used for the storage and care of all mice. Seven-week old wild-type female C57BL/6J mice were obtained from Jackson laboratories (Bar Harbor, ME). A colony of B6.129S2-Tcra^{tm1Mom}/J (Tcra) T cell-deficient mice were bred on site. Mice were aged-matched to be 7-12 weeks old at the time of tumor inoculation. For screening, 2.0 x 10^6 library-

transduced B16-Cas9 cells resuspended in Hanks Balanced Salt Solution (Gibco, Thermo Fisher Scientific, Waltham, MA) were mixed 1:1 by volume with Matrigel® (Corning, Corning, NY) and subcutaneously injected into the right flank on day 0. Mice were vaccinated with 1.0 x 10^6 GM-CSF-secreting B16 (GVAX) cells that had been irradiated with 3500 Gy on days 1 and 4 to elicit an anti-tumor immune response. Subsequently, mice were treated with 100 μg of rat monoclonal anti-PD1 antibody (clone: 29F.1A12) on days 9 and 12 via intraperitoneal injection. For validation assays, 1.0 x 10^6 tumor cells were subcutaneously injected into the right flank without matrigel. Tumors were measured every 3 days beginning on day 6 after challenge until time of death. Measurements were taken manually by collecting the longest dimension (length) and the longest perpendicular dimension (width). Tumor volume was estimated with the formula: (L x W^2)/2. CO_2 inhalation was used to euthanize mice on the day of sacrifice.

d. Creation of CRISPR edited tumor cell lines

Transient transfection of Cas9-sgRNA plasmid (pX459, Addgene, Cambridge, MA) was used to edit B16 and *Braf/Pten* melanoma cell lines. pX459 was digested with the enzyme BpiI (Thermo Fisher Scientific) as per the manufacturer's instructions and sgRNA oligos were cloned in using standard molecular cloning. For B16 cells, 5 x 10^5 cells were plated in a well of a 6-well plate and were transfected the following day using 2 μg of pX459 plasmid DNA and Turbofect™ (3:1 ratio, Thermo Fisher Scientific). Twenty-four hours after transfection, transfectants were selected in puromycin (6 μg/mL, Thermo Fisher Scientific). For *Braf/Pten* melanoma cells, 5 x 10^5 cells were plated in a well of a 6-well plate and were transfected the following day using 4 μg of pX459 plasmid DNA and Turbofect™ (3:1 ratio). After selection, cells were grown for 14 days *in vitro* before being implanted into mice.

e. *In vivo* competition assays

B16 cells were engineered to express GFP or TdTomato by lentiviral transduction to differentiate populations. Cas9-target sgRNA-transfected cells and Cas9-control sgRNA-transfected cells were mixed and then grown for at least two passages *in vitro* before implantation into mice. Mixes were analyzed by flow cytometry on the day of tumor inoculation. Mice were euthanized 15-21 days after tumor inoculation for tumor harvest. Tumors were macerated on ice and incubated in collagenase P (2 mg/mL, Sigma, St. Louis, MO) and DNase I (50 μg/mL, Sigma) supplemented DMEM for 10 minutes at 37°C. After incubation, tumor cells were passed through 70 μm filters to remove undigested tumor.

Tumor cells were washed with ice-cold MACS media and stained with Near-IR LIVE/DEAD® (1:1000, BD Biosciences, Franklin Lakes, NJ) for 10 minutes on ice. Tumor cells were then washed and resuspended in ice-cold PBS with 2% FBS. An Accuri™ C6 flow cytometry system (BD Biosiences) was used to analyze final GFP/TdTomato tumor cell ratios.

f. *In vitro* cytokine stimulations

Differentially labeled B16 cells were plated in 12-well plates in DMEM + 10% FBS containing the indicated combinations of cytokines: TNFα (10 ng/mL, PeproTech, Rocky Hill, NJ), IFNγ (100 ng/mL, Cell Signaling Technology, Danvers, MA), and IFNβ (1000 U/mL, Pbl Assay Science, Piscataway Township, NJ). Cells were passaged every 3 or 4 days. On day 14, tumor cells were analyzed by flow cytometry for changes in the ratio of $GFP^+/TdTomato^+$ cells.

g. *In vitro* T cell killing assays

Differentially labeled, ovalbumin-expressing B16 cells were plated onto 12 well plates in DMEM + 10% FBS containing IFNβ at 50 U/mL. The following day, media was removed and RPMI + 10% FBS was added containing preactivated OT-1 T cells at the indicated ratio. Tumor cells were passaged and fresh OT-1 T cells were added every 2 days until day 6. On day 6, tumor cells were analyzed by flow cytometry for changes in the ratio of $GFP^+/TdTomato^+$ cells.

h. Analysis tumor-infiltrating lymphocytes by flow cytometry

Mice were injected subcutaneously (s.c.) with 1.0×10^6 CRISPR/Cas9-modified B16 cells and treated with GVAX + anti-PD-1 mAb as described above. Tumors were harvested on day 12-13, weighed, mechanically diced, incubated with collagenase P (2 mg/mL, Sigma Aldrich) and DNAse I (50 μg/mL, Sigma Aldrich) for 10 minutes, and pipetted into a single-cell suspension. After filtering through a 70 μm filter, cells were blocked with anti-mouse CD16/32 antibody (BioLegend, San Diego, CA) and stained with indicated antibodies for 30 minutes on ice. Dead cells were excluded using Aqua Live/Dead® (1:1000, ThermoFisher Scientific) added concurrently with surface antibodies. After washing, cells were fixed with Foxp3/transcription factor staining buffer set (eBiosciences, San Diego, CA) as per manufacturer's instructions, blocked with mouse and rat serum, then stained with intracellular antibodies. AccuCount Fluorescent particles (Spherotech, Lake Forest, IL) were added for cell quantification prior to analysis on an LSR Fortessa™ cell analyzer (BD Biosciences) using single-color compensation controls and

fluorescence-minus-one thresholds to set gate margins. Comparisons between groups were performed using Student's t test.

i. Flow cytometry analysis of B16 tumor cells

B16 cells were trypsinized and washed in PBS + 2% FBS, stained with antibodies for cell surface proteins as per the manufacturer's instructions and then analyzed on an Accuri™ C6 flow cytometry system (BD Biosciences).

j. Restimulation of T cells on B16 tumor cells

OT-I T cells were isolated from the spleens of OT-I T cell receptor transgenic mice using the $CD8a^+$ T cell isolation mouse kit (Miltenyi), as per manufacturer's instructions. Purified OT-I T cells were then stimulated in 24 well plates with plate-bound anti-mouse CD3ε antibody (2 μg/ml, BD Biosciences), soluble anti-mouse CD28 antibody (2 μg/ml, BD Biosciences) and recombinant human IL-2 (100 U/ml, DFCI supply center). Fourty-eight hours later, activated OT-I T cells were transferred into fresh media containing recombinant human IL-2 and allowed to expand for 5-7 days. For restimulation, 1×10^5 ovalbumin-expressing *Ptpn2* null or control-guide transfected B16 tumor cells were first plated in 24 well plates and stimulated with recombinant mouse IFNγ overnight to induce ovalbumin surface expression. 1×10^6 pre-activated OT-I T cells were then added to the wells on the next day and co-cultured with the B16 tumor cells for 2-3 hrs. Subsequently, 1x brefeldin (eBiosciences) was added to the cultures for 4 hours to inhibit intracellular protein transport. Afterward, OT-I T cells were harvested from each well, stained with surface markers and then fixed with Foxp3/transcription factor staining buffer set (eBiosciences) as per the manufacturer's instructions. Intracellular cytokine staining was then performed prior to analysis on an LSR Fortessa™ cell analyzer (BD Biosciences).

k. RNAseq analysis of tumor cells

Ptpn2 null or control sgRNA-transfected B16 cells were stimulated with IFNγ (100 ng/mL, Cell Signaling Technology), TNFα (10 ng/mL, Peprotech) or both for 48 hours. RNA was extracted from cell pellets using the Qiagen RNeasy Mini kit according to manufacturer's instructions. First-strand Illumina-barcoded libraries were generated using the NEB RNA Ultra™ Directional kit according to manufacturer's instructions, including a 12-cycle PCR enrichment. Libraries were sequenced on an Illumina NextSeq™ 500 instrument using paired-end 37 base pair (bp) reads. Data were trimmed for quality using the Trimmomatic pipeline with the following parameters: LEADING:15 TRAILING:15 SLIDINGWINDOW:4:15 MINLEN:16. Data were aligned to mouse reference genome

mm10 using the Bowtie 2 aligning sequencing tool (available at the World Wide Web website of Johns Hopkins University). HTSeq was used to map aligned reads to genes and to generate a gene count matrix and it is available at the World Wide Web address of www-huber.embl.de/users/anders/HTSeq/doc/overview.html. Normalized counts and differential expression analysis was performed using the DESeq2 R package. The gene set enrichment analysis was performed as described previously in Subramanian *et al.* (2005) *Proc Natl Acad Sci USA* 102:15545-15550. Principle Components Analysis (PCA) was performed on the normalized gene counts including all genes that passed a minimal expression filter. Signature scores for the individual samples were generated using FastProject (available at the World Wide Web address of bmcbioinformatics.biomedcentral.com/articles/10.1186/s12859-016-1176-5) and the Hallmark gene signature collection (Liberzon *et al.* (2015) *Cell Sys.* 1:417-425). Pearson correlation coefficients were calculated between the Hallmark gene signatures and PC1 and PC2. Selected signatures were plotted on a normalized PCA projection of the dataset.

l. Western blotting

Whole cell lysates were prepared in lysis buffer (60 mM Tris HCl, 2% SDS, 10% glycerol, complete EDTA-free protease-inhibitor (Roche, Basel, Switzerland), and 500 U/mL benzonase nuclease (Novagen, Merck, Darmstadt, Germany)). Samples were boiled at 100°C and clarified by centrifugation. Protein concentration was measured with a BCA protein assay kit (Pierce, Dallas, Texas). Fifty to one hundred and fifty micrograms of protein was loaded on 4-12% Bolt® Bis-Tris Plus gels (Life Technologies, Carlsbad, CA) in MES buffer (Life Technologies). Protein was transferred to 0.45 μm nitrocellulose membranes (Bio-Rad, Hercules, CA). Membranes were blocked in Tris-buffered saline plus 0.1% Tween 20 (TBS-T) containing 5% non-fat dry milk for 1 hour at room temperature followed by overnight incubation with primary antibody at 4°C. Membranes were washed with TBS-T and incubated with HRP-conjugated secondary antibodies for 1 hour at room temperature. HRP was activated with Supersignal® West Dura Extended Duration Substrate (Pierce) and visualized with a chemiluminscent detection system using Fuji ImageQuant™ LAS4000 (GE Healthcare Life Sciences, Pittsburgh, PA). Blots were then analyzed using ImageJ and Adobe® Photoshop® software.

m. Immunohistochemistry

Whole B16 tumors were fixed for 24 hours in 10% neutral buffered formalin and then permeabilized in 70% ethanol overnight. Fixed tissue was then embedded into

paraffin, sectioned, and then mounted onto slides for staining with mouse CD8α (eBiosciences Cat. #14-0808-82). Slides were imaged on a Leica Scanscope XT and analyzed using Aperio software (Leica Biosystems, Buffalo Grove, IL).

n. Antibodies

For Western blotting, primary antibodies against STAT1 (Cell Signaling, Cat. #9172), JAK1 (Cell Signaling, Cat. #3332 and #3344 [clone 6G4]), phospho-STAT1 (Tyr701) (clone D4A7, Cell Signaling), β-ACTIN (Abcam, Cambridge, UK, Cat. #8227), TC-TPT (PTPN2) (Abcam, Cat. #180764), and FLAG (clone M2, Sigma Aldrich) were used. Peroxidase-conjugated secondaries against Rabbit-IgG (Cat. #111-035-046) and Mouse-IgG (Cat. #115-035-174) were purchased from Jackson Laboratories (Bar Harbor, ME).

For flow cytometry, the following anti-mouse (m) fluorochrome-conjugated antibodies were used: H2K(b)/H2D(b) (clone 28-8-6, BioLegend), CD47 (clone miap301, BioLegend), SIINFEKL-H2K(b) (clone 25-D1.16, BioLegend), Granzyme B (clone GB11, BioLegend), TNF (clone MP6-XT22, BioLegend), IFNγ (clone XMG1.2, BioLegend), CD8α (clone 53-6.7, BioLegend), CD4 (clone RM4-5 or GK15, BioLegend), TCR-β (clone H57-597, BioLegend), PD-1 (clone RPMI-30, BioLegend), Tim-3 (clone TMR3-2.3, BioLegend), CD45 (clone 104 or 30-F11, BioLegend), Ly6C (clone HK1.4, BioLegend), I-A/I-E (clone M5/114.15.2, BioLegend), F4/80 (clone BM8, BioLegend), CD11c (clone N418, BioLegend), CD24 (clone M1/69, BioLegend), CD11b (clone M1/70, BioLegend), CD103 (clone 2E7, BioLegend), CD3ε (clone 145-2C11, BioLegend), TCRγ/δ (clone GL3, BioLegend), NK1.1 (clone PK136, BioLegend), CD44 (clone IM7, BioLegend), Ki-67 (clone B56, BD Biosciences), CD274 (clone MIH5, BD Biosciences), IFNGR1 (clone 2E2, Life Technologies), IFNAR2 (R&D Systems; Cat. #FAB1083A), and Foxp3 (clone JFK-16s, eBioscience).

o. CRISPR sgRNA sequences

CRISPR sgRNA sequences used are shown in Table 2 below:

Table 2

Gene Name/sg#	**sgRNA Sequence**	
Cd274 sgRNA 1	GCCTGCTGTCACTTGCTACG	(SEQ ID NO: 36)
Cd274 sgRNA 2	AATCAACCAGAGAATTTCCG	(SEQ ID NO: 37)
Cd274 sgRNA 3	GGTCCAGCTCCCGTTCTACA	(SEQ ID NO: 38)
Cd274 sgRNA 4	GTATGGCAGCAACGTCACGA	(SEQ ID NO: 39)

Cd47 sgRNA 1	TATAGAGCTGAAAAACCGCA	(SEQ ID NO: 40)
Cd47 sgRNA 2	CCACATTACGGACGATGCAA	(SEQ ID NO: 41)
Cd47 sgRNA 3	TCTTACGAGGAGGAGAAAGG	(SEQ ID NO: 42)
Cd47 sgRNA 4	GCAAGTGTAGTTTCCCACCA	(SEQ ID NO: 43)
Stat1 sgRNA 1	GATCATCTACAACTGTCTGA	(SEQ ID NO: 44)
Stat1 sgRNA 2	GTACGATGACAGTTTCCCCA	(SEQ ID NO: 45)
Jak1 sgRNA 1	CAGCGGAGAGTATACAGCCG	(SEQ ID NO: 46)
Jak1 sgRNA 2	GTACTCACTGCACTCCTGGG	(SEQ ID NO: 47)
Ifngr1 sgRNA 1	CGACTTCAGGGTGAAATACG	(SEQ ID NO: 48)
Ifngr1 sgRNA 2	GGTATTCCCAGCATACGACA	(SEQ ID NO: 49)
Ptpn2 sgRNA 1	CCATGACTATCCTCATAGAG	(SEQ ID NO: 50)
Ptpn2 sgRNA 2	TCATTCACAGAACAGAGTGA	(SEQ ID NO: 51)
Ptpn2 sgRNA 3	ATGTGCACAGTACTGGCCAA	(SEQ ID NO: 52)
Ifnar2 sgRNA 1	GTACCAGAGGGTGTAGTTAG	(SEQ ID NO: 53)
Ifnar2 sgRNA 2	ACACAAGCTGAGGAGACCGA	(SEQ ID NO: 54)
control sgRNA 1	GCGAGGTATTCGGCTCCGCG	(SEQ ID NO: 55)
control sgRNA 2	GCTTTCACGGAGGTTCGACG	(SEQ ID NO: 56)
control sgRNA 3	ATGTTGCAGTTCGGCTCGAT	(SEQ ID NO: 57)
control sgRNA 4	ACGTGTAAGGCGAACGCCTT	(SEQ ID NO: 58)
control sgRNA 5	ATTGTTCGACCGTCTACGGG	(SEQ ID NO: 59)
human *Ptpn2* sgRNA 1	TTCGAACTCCCGCTCGATGG	(SEQ ID NO: 60)
human *Ptpn2* sgRNA 2	CCATGACTATCCTCATAGAG	(SEQ ID NO: 61)

Examples 2-7 disclose the development of a pooled loss-of-function *in vivo* genetic screening approach that uses CRISPR-Cas9 genome editing to discover genes that increase sensitivity or cause resistance to immunotherapy in a mouse transplantable tumor model. About 2,400 genes expressed by tumor cells were screened in the B16 murine melanoma model to identify those that increase or decrease sensitivity to immunotherapy with tumor vaccination and PD-1 checkpoint blockade. The screen identified known immune evasion molecules PD-L1 and CD47, as tumor cells bearing sgRNAs for these targets were significantly depleted in animals treated with immunotherapy. In contrast, loss of function of any of the genes that sense or signal in response to interferon-γ (IFNγ) rendered cells resistant to immunotherapy with PD-1 checkpoint blockade and vaccination, recapitulating resistance mutations identified in melanoma patients (Zaretsky *et al.* (2016) *N. Engl. J.*

Med. 375:819-829; Gao *et al.* (2016) *Cell* 167:397-404.e9). In addition, deletion of *Ptpn2*, which encodes a protein tyrosine phosphatase, significantly increased sensitivity of tumor cells to immunotherapy by increasing IFNγ-mediated effects on antigen presentation and cell growth. These findings reveal that therapeutic strategies, such as *Ptpn2* inhibition, that sensitize tumor cells to the effects of IFNγ are capable of increasing the efficacy of cancer immunotherapy. Moreover, this screening approach can discover new immunotherapy targets in diverse, unanticipated biologic pathways and prioritize their combination with existing immunotherapies.

Example 2: A pooled loss-of-function *in vivo* genetic screen recovers known immune evasion molecules expressed by tumors

In order to systematically identify new cancer immunotherapy targets and resistance mechanisms, a pooled genetic screening approach was developed to identify genes that increase or decrease the fitness of tumor cells growing *in vivo* in animals treated with immunotherapy (Figure 1A). First, a B16 melanoma cell line was engineered to express Cas9 (Figure 2A), confirmed of efficient DNA editing using sgRNAs targeting PD-L1 (Figure 1D, bottom). Next, a library of lentiviral vectors was created to encode 9,992 sgRNAs targeting 2,398 genes from relevant functional classes that were expressed at detectable levels in the tumor cell line (Figure 2B). After transduction and *in vitro* passage to allow gene editing to take place, the tumor cells were transplanted into animals that were then treated with either a GM-CSF-secreting, irradiated tumor cell vaccine (GVAX) or GVAX plus PD-1 blockade using a monoclonal antibody for PD-1, in order to apply immune selective pressure on the tumor cells (Figure 1B) (see Dranoff (2003) *Oncogene* 22:3188-3192; Dranoff *et al.* (1993) *Proc. Natl. Acad. Sci. U.S.A.* 90:3539-3543; and Duraiswamy *et al.* (2013) *Cancer Res.* 73:3591-3603; Curran & Allison (2009) *Cancer Res* 69:7747-7755; Curran *et al.* (2010) *Proc. Natl. Acad. Sci. U.S.A.* 107:4275-4280). In parallel, the library-transduced tumor cells were transplanted into TCRα$^{-/-}$ mice, which lack CD4^{+} and CD8^{+} T cells and were therefore unable to apply adaptive immune selective pressure on the tumors. This allowed the distinguishing of effects of immune selective pressure on library representation from nonspecific effects on tumor cell viability. After 12-14 days, tumors were harvested (Figure 1B), with all sgRNAs recovered from each animal having good inter-animal reproducibility (Figures 2C-2E).

The library representation in tumors from immunotherapy-treated wild-type (WT) animals were compared with that found in tumors growing in TCRα$^{-/-}$ mice, in which deletion of genes that result in resistance to immunotherapy would be expected to increase tumor sgRNA representation in WT animals, while deletion of genes that result in increased sensitivity of tumors to immunotherapy would decrease sgRNA representation. Analysis of sgRNAs enriched by immune selective pressure revealed those targeting genes involved in cytokine-mediating signaling and immune-system processes (Figure 1C). sgRNAs depleted by immunotherapy included those targeting genes involved in antigen processing, necroptosis, and regulation of immune responses (Figure 1C). These results indicate that the genetic screening approach used here identified genes expressed by tumors cells that play a role in interaction with the immune system.

Inspection of the list of genes targeted by sgRNAs depleted from tumors treated with immunotherapy revealed the known immune evasion molecule PD-L1, indicating that loss of PD-L1 increased the sensitivity of tumor cells to immune attack. sgRNAs targeting PD-L1 were not depleted from tumors in TCRα$^{-/-}$ mice relative to cells growing *in vitro*, presumably due to the absence of T cell-mediated selective pressure (Figure 1D), but were significantly depleted in WT mice treated with GVAX relative to TCRα$^{-/-}$ mice (FDR = 0.004). However, the depletion of PD-L1-targeting sgRNAs seen in GVAX-treated tumors was not observed in tumors treated with GVAX and anti-PD-1, indicating that loss of PD-L1 does not confer a selective disadvantage to tumors when PD-L1:PD-1 interactions are blocked (Figure 1D).

It was also found that sgRNAs targeting CD47, which enables immune evasion by impairing engulfment of tumors cells by phagocytes (as in Liu *et al.* (2015) *Nat. Med.* 21:1209-1215; Weiskopf *et al.* (2016) *J. Clin. Invest.* 126:2610-2620; and Tseng *et al.* (2013) *Proc. Natl. Acad. Sci. U.S.A.* 110: 11103-11108), were markedly depleted in tumors treated with either GVAX or with GVAX plus PD-1 blockade (FDR = 0.005, 0.002 respectively) (Figure 1E). To confirm that CD47 null tumors were more susceptible to GVAX and PD-1 blockade, CD47 null B16 melanoma cells were generated using transient transfection of a Cas9-sgRNA plasmid (as in Ran *et al.* (2013) *Nat. Protoc.* 8:2281-2308) (Figure 2F). It was found that loss of CD47 significantly improved control of tumor growth mediated by GVAX plus anti-PD-1 immunotherapy (Figure 1F, $p< 0.01$).

Using the pooled loss-of-function *in vivo* genetic screen for identifying immune evasion molecules expressed by tumors described above, genes that increase or decrease the

fitness of MC38 colon cancer cells growing *in vivo* in animal treated with immunotherapy. Just as with the melanoma cells described above, *Ptpn2* was identified among the top hits of approximately 442 genes which, when acquiring a loss-of-function mutation, improved the sensitivity to immunotherapy.

Gene Symbol	# of perturbations	Ranks of perturbations	Most enriched perturbation	STARS Score	Average Score	p-value	FDR	q-value
Ptpn2	4	122;302;3855;4385	2	2.277631575	1.799909246	0.060021818	0.561906378	0.545510713

Thus, *in vivo* genetic screening recovered genes known to confer tumor evasion properties on cancer cells.

Example 3: Loss of IFNγ sensing or signaling causes resistance to immunotherapy

Genes that, when deleted, become significantly enriched in immunotherapy treated tumors were analyzed, as these might represent resistance mechanisms. sgRNAs enriched under immune selective pressure included those targeting genes involved in cytokine signaling (Figure 1C). It was observed that sgRNAs targeting five genes required for sensing and signaling through the IFNγ pathway (*Stat1*, *Jak1*, *Ifngr2*, *Ifngr1*, and *Jak2*) were significantly enriched in immunotherapy-treated mice (Figure 3A; FDR<0.09). This finding was confirmed in an *in vivo* competitive assay that compared the relative growth of mixtures of isogenic *Stat1* null or control B16 cells in animals treated with immunotherapy (Figure 3B). The ratio of *Stat1* null cells to control cells in TCR$\alpha^{-/-}$ mice was unchanged relative to cells grown *in vitro* (Figure 3C), indicating that loss of *Stat1* does not change tumor cell growth or survival *in vivo* in the absence of T cells. However, in WT mice treated with GVAX plus anti-PD-1 immunotherapy, the relative proportion of *Stat1* null cells increased significantly (Figure 3D; $p<0.01$, Student's t test), indicating that *Stat1* null cells have a marked growth advantage over WT tumor cells when under immune attack. Similar results were obtained for *Jak1* null and *Ifngr1* null cells (Figure 3D). Consistent with this finding, tumors deficient for *Stat1* or *Ifngr1* (Figures 4A and 4C) grew significantly faster than WT tumors when treated with immunotherapy (Figure 3E; $p<0.05$, Student's t test). Similar trends were observed for *Jak1* null tumors (Figure 3E).

To test if this observation was seen in other melanoma models, IFNγ sensing genes were deleted from the *Braf*^{V600E}/*Pten*$^{-/-}$ (*Braf/Pten*) murine melanoma line (Figures 4B-4D). A variant of the *Braf/Pten* model that had been subjected to sub-lethal irradiation was used

to increase tumor responsiveness to immunotherapy (Lo *et al.*, submitted). Mice injected with tumor cells deficient in *Stat1*, *Jak1*, or *Ifngr1* had significantly larger tumors and shorter survival compared to WT tumors when treated with PD-1 blockade (Figure 3F; $p<0.05$, Student's t test; $p<0.0001$, Log-rank test). Thus the efficacy of immunotherapy in both melanoma models depends in part on the sensing of IFNγ by tumor cells.

Several mechanisms were tested to determine why IFNγ-pathway mutant tumors were resistant to immunotherapy. First, the effect of gene deletion of *Stat1*, *Jak1* or *Ifngr1* on cell growth in response to TNF, IFNγ and IFNβ was tested using an *in vitro* competition assay. IFNγ-pathway deficient B16 tumor cells had a significant growth advantage over WT tumor cells when exposed to IFNγ or IFNβ (Figure 3G, $p<0.001$, Student's t test), and this advantage was even greater with combinations of IFNγ and TNF or IFNγ and IFNβ (Figure 3G, $p<0.001$, Student's t test). Unlike *Stat1* and *Jak1* null tumors, it was found that *Ifngr1* null tumor cells were still sensitive to growth inhibition by IFNβ (Figure 3G).

Tumor cells that are insensitive to IFNγ could also resist immunotherapy by failing to present antigen. Indeed, it was observed that tumor cells deficient in *Stat1*, *Jak1* or *Ifngr1* failed to upregulate MHC-I presentation molecules after stimulation with IFNγ (Figure 3H), which might lead to less efficient T cell recognition. To test whether or not T cell recognition of IFNγ-insensitive tumors is impaired, WT and *Stat1* null tumor cells that had been engineered to express the model antigen ovalbumin (OVA) as a full-length protein were co-cultured with antigen-specific OT-I $CD8^+$ T cells in an *in vitro* killing assay. After six days of co-culture with T cells, a significantly larger fraction of *Stat1* null B16 cells were surviving relative to WT B16 cells (Figure 3I; $p<0.001$, Student's t test), indicating decreased sensitivity of *Stat1* null tumor cells to the effects of cytotoxic T cells. Similar results were obtained for *Jak1* and *Ifngr1* null cells. Thus, the screening platform recovered both known immune evasion molecules and resistance mechanisms to immunotherapy.

Example 4: Discovery of novel gene targets to increase the efficacy of immunotherapy

Deletion of novel candidate immunotherapy targets was found to increase sensitivity of tumor cells to immunotherapy. Analysis of the functional classes of genes targeted by sgRNAs depleted by immunotherapy included antigen processing, necroptosis, and regulation of immune responses (Figure 1C and Table 1 for a summary of results). Thus,

genes involved in the interaction of tumor cells with the immune system were enriched in screen hits, and encompassed multiple biological processes.

Among the 50 most depleted genes in immunotherapy treated mice (all with an FDR < 0.08), several prominent biological pathways were identified. In particular, sgRNAs targeting genes involved in inhibition of kinase signaling were determined to be markedly depleted in mice treated with GVAX and PD-1 blockade (Figure 5A) relative to growth in TCR$\alpha^{-/-}$ mice.

Representative genes from the inhibition of kinase signaling pathway were selected to validate based on their highest cumulative score as ranked by the STARS algorithm (Doench *et al.* (2014) *Nat. Biotechnol.* 32:1262-1267). These genes included *Ptpn2*, a phosphatase involved in multiple signaling processes. *In vivo* competition assays showed that tumor cells deleted for Ptpn2 was strongly selected against in WT animals treated with immunotherapy but grew at equivalent rates to control tumor cells *in vitro* and in TCR $\alpha^{-/-}$ mice (Figure 5C and 5D; $p<0.01$, Student's t test). This indicates that Ptpn2 is synthetically lethal with an anti-tumor immune response, rendering tumor cells more sensitive to immunotherapy but not altering their cell growth or survival in the absence of T cells.

Example 5: Loss of Ptpn2 increases sensitivity of tumors to immunotherapy

In order to identify novel targets for immunotherapy, genes that, when deleted, increased sensitivity of tumor cells to immunotherapy were analyzed. It was found that sgRNAs targeting the pleiotropic protein tyrosine phosphatase, *Ptpn2*, were markedly depleted in mice treated with GVAX and PD-1 blockade (Figure 5A, FDR<0.00016). *In vivo* competition assays showed that tumor cells deleted for *Ptpn2* with any of three different sgRNAs (Figure 5B) were strongly selected against in WT animals treated with immunotherapy but grew at equivalent rates to control tumor cells *in vitro* and in TCR$\alpha^{-/-}$ mice (Figures 5C and 5E; $p<0.01$, Student's t test). Two additional sgRNAs against *Ptpn2* were used in *in vivo* competition assays to confirm that loss of *Ptpn2* sensitizes tumors to immunotherapy (Figures 5B and 5E; $p<0.01$, Student's t test; all sgRNAs shown). This indicates that loss of *Ptpn2* renders tumor cells more sensitive to immunotherapy but does not affect cell growth or survival in the absence of immune cells.

Consistent with this observation, *Ptpn2* null B16 tumors had a significantly better response to immunotherapy measured by tumor size (Figure 5H; $p<0.01$, Student's t test) and overall survival (Figure 5I; $p<0.001$, Log-rank test). No growth disadvantage was

observed in the absence of T cell-mediated immunity or immunotherapy (Figures 6A-6D), again indicating that loss of *Ptpn2* did not cause a general impairment of cell growth and survival *in vivo*. Loss of *Ptpn2* increased sensitivity to T cell immunity in two additional tumor models: *Braf/Pten* melanoma (Figures 4F and 5J; $p<0.01$, Student's t test) and MC38 colon carcinoma (Figure 6G; $p<0.05$; Student's t test) in which *Ptpn2* deficiency led to a decrease in tumor volume and an increase in survival (Figure 6H; $p<0.05$, Log-rank test) in immunocompetent animals but not in TCR$\alpha^{-/-}$ mice (Figures 6E-6F and 6I-6J). Thus, loss of *Ptpn2* sensitizes tumor cells to the effect of immunotherapy.

Enforced expression of *Ptpn2* in *Ptpn2* null tumor cells (*i.e. Ptpn2* rescue) abrogated the sensitivity to immunotherapy *in vivo* (Figures 5F-5G), making it unlikely that the effect was due to off-target effects of genome editing with *Ptpn2*-targeting sgRNAs. Moreover, overexpression of *Ptpn2* in control B16 tumor cells (*i.e. Ptpn2* overexpression) led to an outgrowth of tumor cells in immunotherapy treated mice (Figures 5F-5G; $p<0.001$, Student's t test), indicating that increased *Ptpn2* expression renders tumor cells resistant to the effect of immunotherapy.

Example 6: Loss of Ptpn2 increases antigen presentation and T cell recognition of tumors

To identify the mechanism by which loss of *Ptpn2* enhanced the efficacy of immunotherapy, the composition of immune cell subsets in the tumor microenvironment of control and *Ptpn2* null tumors was compared using flow cytometry. No difference was observed in the number of total CD45$^+$ cells, NK cells, CD4$^+$ T cells, FoxP3$^+$ regulatory T cells, or cells in the myeloid compartment in *Ptpn2* null tumors relative to WT tumors (Figures 7A, 8A-8D and 9A-9B). However, *Ptpn2* null tumors contained a significantly greater number of CD8$^+$ T cells and $\gamma\delta^+$ T cells per milligram of tumor (Figure 7A; $p<0.05$, Student's t test). Confirmation by immunohistochemistry staining for CD8α in *Ptpn2* null or control B16 tumors treated with GVAX and PD-1 blockade was performed and a 3-fold increase in the number of CD8α+ cells, which diffusely infiltrates *Ptpn2* deficient tumors, was found (Figure 7B; $p<0.01$, Student's t test). In particular, further flow cytometry analysis of infiltrating CD8+ T cells revealed that *Ptpn2* null tumors contained a striking increase in the fraction of CD8$^+$ T cells expressing Granzyme B (Figure 7C, c; $p<0.01$, Student's T test). Thus, *Ptpn2* loss increased the number of activated, cytotoxic CD8$^+$ T cell in tumors.

The increased number of cytotoxic $CD8^+$ T cells in *Ptpn2* null tumors could be due to better recognition of tumor cells due to increased antigen presentation. To test this, full-length OVA was expressed in *Ptpn2* null or WT B16 cells. Staining with a monoclonal antibody specific for the SIINFEKL epitope from OVA in the context of H2K(b) was significantly higher in *Ptpn2* null cells treated with IFNγ, indicating that loss of *Ptpn2* caused increased levels of antigen-loaded MHC-I on the surface of tumor cells (Figure 7D; $p<0.001$, Student's t test). Additionally, *Ptpn2* deficient cells increased total MHC-I after treatment with IFNγ to a greater degree than did control cells (Figure 10A).

To test whether loss of *Ptpn2* made tumor cells more recognizable to T cells, OVA-expressing *Ptpn2* null or control cells were cultured with OT-I $CD8^+$ T cells that recognize the SIINFEKL epitope. T cells cultured with *Ptpn2* null OVA-B16 cells were significantly more activated as measured by intracellular IFNγ and TNF staining (Figure 7E; $p<0.001$, Student's t test). To test if *Ptpn2* null tumor cells were more sensitive to the presence of T cells, mixed populations of OVA-expressing *Ptpn2* null or WT B16 cells were co-cultured with antigen-specific $CD8^+$ T cells for six days. *Ptpn2* deficient tumor cells were preferentially depleted from the co-culture and the extent of depletion increased with a greater ratio of T cells to tumor cells (Figure 7F; $p<0.05$, Student's t test). Thus, loss of *Ptpn2* in tumor cells increased antigen presentation and sensitivity to cytotoxic $CD8^+$ T cells.

Example 7: Loss of Ptpn2 increases IFNγ sensing by tumor cells

Ptpn2 regulates multiple signaling pathways and has a role in negatively regulating IFNγ signaling by dephosphorylating JAK1 and STAT1 (Kleppe *et al.* (2011) *Blood* 117:7090-7098; Kleppe *et al.* (2010) *Nat. Genet.* 42:530-535; Wiede *et al.* (2014) *J. Autoimmun.* 53:105–14; Pike & Tremblay (2016) *Cytokine* 82: 52-57; Wiede *et al.* (2011) *J. Clin. Invest.* 121:4758-4774; Doody *et al.* (2009) *Immunol. Rev.* 228:325-341). Several approaches were used to determine whether *Ptpn2* loss sensitized tumors to immunotherapy by increasing IFNγ signaling. First, STAT1 activity was assayed [measured by accumulation of phosphorylated STAT1 (pSTAT1)] in *Ptpn2* null cells in response to IFNγ stimulation. *Ptpn2* null B16 cells had increased pSTAT1 after treatment with IFNγ while overexpression of *Ptpn2* repressed this phosphorylation (Figure 11A).

Transcriptional analysis of the *Ptpn2* null and WT B16 tumor cells exposed to IFNγ, TNF, or both indicated that loss of *Ptpn2* caused a marked change in expression profile in

response to cytokine exposure, but did not change gene expression in unstimulated conditions (Figures 11B-11C). Co-stimulation with IFNγ and TNF together had a synergistic effect on *Ptpn2* null cells, as IFNγ stimulation appeared to sensitize B16 cells to TNF (Figure 10B). Unsupervised clustering of samples showed cytokine-exposed *Ptpn2* null tumor cells clustered separately from WT tumor cells (Figure 11B). The gene signatures most strongly correlated with this difference in gene expression included those related to IFNγ, IFNα, and TNF signaling. Loss of function of *PTPN2* in four human tumor cell lines increased IFNγ response gene expression following stimulation with IFNγ (Figure 11D; FDR<0.001) in a manner similar to loss of function of *Ptpn2* in mouse tumor cells. Among the genes upregulated in *Ptpn2* null cells (relative to control cells) following cytokine exposure were several T cell chemokines, such as *Cxcl9*, *Cxcl10*, *Cxcl11* and *Ccl5* (Figure 11C), which could act to enhance infiltration of T cells into tumors. Members of the antigen processing and presentation pathway, such as *Tap1*, *Tapbp*, and *B2m* were also upregulated in *Ptpn2* null cells (Figure 11C), consistent with our previous observation of enhanced antigen presentation in *Ptpn2* deficient cells.

It was also found that cell cycle regulators, such as *Cdkn1a* (Abbas & Dutta (2009) *Nat. Rev. Cancer* 9:400-414), and several genes involved in apoptosis, such as *Casp4*, *Casp8*, *Ifit2*, *Ripk1*, and *Bak1*, were significantly upregulated in *Ptpn2* null tumor cells treated with cytokines relative to WT tumor cells. Consistent with this finding, exposure to IFNγ alone or in combination with IFNβ or TNF significantly reduced the growth of *Ptpn2* null tumor cells *in vitro* relative to WT tumor cells (Figure 11E; $p<0.001$, Student's t test), and in *PTPN2* null human A375 melanoma cells and HT-29 colon carcinoma cells *in vitro* (Figure 11F; $p<0.01$, Student's t test). These results demonstrate that IFNγ alone is sufficient to cause a growth disadvantage in both mouse and human tumor cells that lack *Ptpn2*.

Example 8: Increased sensitivity of *Ptpn2* null tumors to immunotherapy depends on IFNγ sensing

To determine whether the mechanism of increased immunotherapy sensitivity of *Ptpn2* null tumor cells depends on IFNγ sensing and signaling, B16 tumor cell lines that lacked both *Ptpn2* and either *Stat1*, *Jak1,* or *Ifngr1* were made (Figure 11G). The growth of these double-null cells, relative to tumor cells lacking only *Stat1*, *Jak1,* or *Ifngr1* in animals treated with GVAX plus anti-PD-1 immunotherapy, was then tested. Loss of *Ptpn2* was

associated with a significant growth disadvantage in the presence of immunotherapy as expected (Figures 11H and 11I). However, loss of function of any of the genes necessary for the sensing of IFNγ abolished the growth disadvantage of *Ptpn2* null cells (Figures 11H and 11I; $p<0.01$, Student's t test). Loss of *Ifnar2*, a gene that senses IFNβ, did not abrogate the sensitivity of *Ptpn2* null tumors to GVAX plus anti-PD-1 immunotherapy (Figure 11I). This genetic epistasis experiment indicates that in the absence of IFNγ signaling, *Ptpn2* deficiency does not affect tumor cell response to immunotherapy.

The importance of IFNγ sensing to *Ptpn2*-mediated cancer cell response to immunotherapy was further confirmed using non-genetic methods. For example, sensitivity to IFNγ was increased in B16 cells treated with IFNγ, as well as a small molecule inhibitor of PTP1B (available on the World Wide Web at fishersci.com/shop/products/ptp1b-inhibitor/5397415mg; CAS 765317-72-4), which also inhibits Ptpn2 (Figure 12). Thus, the mechanism by which *Ptpn2* deficiency sensitizes tumor cells to immunotherapy is entirely dependent on the sensing of IFNγ.

Immunotherapy with checkpoint blockade is rapidly becoming a cornerstone of cancer therapy (Reck *et al.* (2016) *N. Engl. J. Med.* 375:1823-1833; Hodi *et al.* (2010) N *N. Engl. J. Med.* 363:711-723; Postow *et al.* (2015) *N. Engl. J. Med.* 372:2006-2017; Wolchok *et al.* (2013) *N. Engl. J. Med.* 369:122-133; Ferris *et al.* (2016) *N. Engl. J. Med.* 375:1856-1867; Brahmer *et al.* (2012) *N. Engl. J. Med.* 366:2455-2465; Nghiem *et al.* (2016) *N. Engl. J. Med.* 374:2542-2552; Topalian *et al.* (2012) *N. Engl. J. Med.* 366:2443-2454); and Motzer *et al.* (2015) *N. Engl. J. Med.* 373:1803-1813). However, incomplete clinical response and the development of resistance limit its efficacy (Tumeh *et al.* (2014) *Nature* 515:568-571; Kelderman *et al.* (2014) *Mol. Oncol.* 8:1132-1139; Zaretsky *et al.* (2016) *N. Engl. J. Med.* 375:819-829), indicating that new targets are needed to improve clinical response. It has been demonstrated herein that pooled loss-of-function genetic screens *in vivo* can identify genes that modulate the efficacy of immunotherapy and therefore represent potential new therapeutic targets. The screening approach identified genes that, when deleted, make cells more sensitive to immunotherapy.

These genetic dependencies included known targets that are currently the focus of intense therapeutic development: PD-L1, which inhibits T cells via PD-1 (Freeman *et al.* (2000) *J. Exp.Med.* 192:1027-1034; and Dong *et al.* (2002) *Nat. Med.* 8:793-800) and CD47, which inhibits tumor cell phagocytosis via SIRPα (Liu *et al.* (2015) *Nat. Med.* 21:1209-1215; Weiskopf *et al.* (2016) *J. Clin. Invest.* 126:2610-2620; Tseng *et al.* (2013)

Proc. Natl. Acad. Sci. U.S.A. 110: 11103-11108). As the number of emerging immunotherapies, such as blockade of CD47, increases, it is becoming more challenging to select those that should be prioritized for combination therapy with PD-1 checkpoint blockade. Genetic screens can identify genes that cause synthetic lethality with specific immunotherapies, providing a rational means to identify effective combinations.

In addition to known targets, it was also discovered that deletion of new genes (*e.g.*, *Ptpn2* and *Socs1*) involved in diverse biological processes markedly increased the response of tumors to immunotherapy. *Ptpn2* encodes a protein tyrosine phosphatase that regulates a range of intracellular processes including IFNγ signaling, which it can inhibit by dephosphorylating STAT1 and JAK1 (Kleppe *et al.* (2011) *Blood* 117:7090-7098; Kleppe *et al.* (2010) *Nat. Genet.* 42:530-535; Wiede *et al.* (2014) *J. Autoimmun.* 53:105-114; Pike & Tremblay (2016) *Cytokine* 82: 52-57; Wiede *et al.* (2011) *J. Clin. Invest.* 121:4758-4774; Doody *et al.* (2009) *Immunol. Rev.* 228:325-341; Todd *et al.* (2007) *Nat. Genet.* 39:857-864; and The Wellcome Trust Case Control Consortium (2007) *Nature* 447:661-678). It was found that loss of *Ptpn2* in tumor cells increased IFNγ signaling and antigen presentation to T cells, and amplified growth arrest in response to cytokines. Genetic epistasis was used to demonstrate that the increased sensitivity of *Ptpn2* null tumors to immunotherapy was not only *associated* with increased IFNγ signaling, but *required* it, because simultaneous deletion of *Stat1*, *Jak1* and IFNGR (but not loss of IFNAR) abrogated the increased sensitivity of *Ptpn2* null tumors to immunotherapy. This study indicates that inhibition of *Ptpn2* could augment the efficacy of cancer immunotherapy. Deletion of *Ptpn2* has also been reported to increase the function of immune effector cells, providing an additional rationale to develop pharmacologic inhibitors of *Ptpn2* (Wiede *et al.* (2014) *J. Autoimmun.* 53:105-114 and Wiede *et al.* (2011) *J. Clin. Invest.* 121:4758-4774). More generally, these findings indicate that sensitizing tumor cells to the effects of inflammatory cytokines might represent a new therapeutic strategy to amplify the efficacy of existing immunotherapies.

The screens identified not only genes that increased sensitivity of tumors to immunotherapy but also those that caused resistance. Loss of function of any gene that sensed or signaled downstream of IFNγ conferred a fitness advantage to tumor cells exposed to immune attack. It was noted that this recapitulates the recent findings that loss-of-function mutations in *JAK1* and *JAK2* emerged in tumors from patients who developed resistance to PD-1 checkpoint blockade (Zaretsky *et al.* (2016) *N. Engl. J. Med.* 375:819-

829 and Gao *et al.* (2016) *Cell* 167:397-404.e9). Together, these findings indicate that the efficacy of immunotherapy with checkpoint blockade relies in large part on the direct effect of IFNγ on tumor cells. Genome editing of mouse transplantable models may provide a useful way to discover and model immunotherapy resistance mechanisms.

One of the central challenges in cancer biology is to identify the genes that underlie the hallmarks of cancer. To date, functional genomic approaches using genome editing have largely focused on identifying genes required by tumor cells for the cancer hallmarks of growth, metastasis and drug resistance (Ebert *et al.* (2008) *Nature* 451:335-339; Hart *et al.* (2015) *Cell* 163:1515-1526; Yu *et al.* (2016) *Nat. Biotechnol.* 34:419-423; Chen *et al.* (2015) *Cell* 160:1246-1260). This study extends this approach to the interrogation of the interaction of the tumor cell with the immune system, which can be broadly applied to multiple tumor models and immunotherapy modalities to systematically define genes that govern interactions between cancer cells and the immune system.

Incorporation by Reference

All publications, patents, and patent applications mentioned herein are hereby incorporated by reference in their entirety as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated by reference. In case of conflict, the present application, including any definitions herein, will control.

Also incorporated by reference in their entirety are any polynucleotide and polypeptide sequences which reference an accession number correlating to an entry in a public database, such as those maintained by The Institute for Genomic Research (TIGR) on the world wide web at tigr.org and/or the National Center for Biotechnology Information (NCBI) on the World Wide Web at ncbi.nlm.nih.gov.

Equivalents

Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. Such equivalents are intended to be encompassed by the following claims.

What is claimed is:

1. A method of treating a subject afflicted with a cancer comprising administering to the subject a therapeutically effective amount of an agent that modifies the copy number, the expression level, and/or the activity of one or more biomarkers listed in Table 1 or a fragment thereof, in combination with an immunotherapy, optionally wheren in the agent inhibits the copy number, the expression level, and/or the activity of one or more biomarkers listed in Table 1 or a fragment thereof.

2. The method of claim 1, wherein the agent decreases the copy number, the expression level, and/or the activity of tyrosine-protein phosphatase non-receptor type 2 (Ptpn2) and/or suppressor of cytokine signaling 1 (SOCS1).

3. The method of claim 1 or 2, wherein the agent selectively decreases the phosphatase activity and/or the substrate binding activity of Ptpn2.

4. The method of any one of claims 1-3, wherein the agent is a small molecule inhibitor, CRISPR single-guide RNA (sgRNA), RNA interfering agent, antisense oligonucleotide, peptide or peptidomimetic inhibitor, aptamer, or intrabody.

5. The method of claim 4, wherein the RNA interfering agent is a small interfering RNA (siRNA), CRISPR RNA (crRNA), a small hairpin RNA (shRNA), a microRNA (miRNA), or a piwi-interacting RNA (piRNA).

6. The method of claim 5, wherein the RNA interfering agent is a CRISPR single-guide RNA (sgRNA).

7. The method of claim 6, wherein the sgRNA comprises a nucleic acid sequence selected from the group consisting of nucleic acid sequence listed in Table 2.

8. The method of claim 4, wherein the agent comprises an intrabody, or an antigen binding fragment thereof, which specifically binds to the one or more biomarkers and/or a substrate of the one or more biomarkers.

9. The method of claim 8, wherein the intrabody, or antigen binding fragment thereof, is murine, chimeric, humanized, composite, or human.

10. The method of claim 8 or 9, wherein the intrabody, or antigen binding fragment thereof, is detectably labeled, comprises an effector domain, comprises an Fc domain, and/or is selected from the group consisting of Fv, Fav, F(ab')2, Fab', dsFv, scFv, sc(Fv)2, and diabodies fragments.

11. The method of any one of claims 8-10, wherein the intrabody, or antigen binding fragment thereof, is conjugated to a cytotoxic agent.

12. The method of claim 11, wherein the cytotoxic agent is selected from the group consisting of a chemotherapeutic agent, a biologic agent, a toxin, and a radioactive isotope.

13. The method of any one of claims 1-12, wherein the agent increases the sensitivity of the cancer cells to an immunotherapy.

14. The method of any one of claims 1-13, wherein the immunotherapy and/or a cancer therapy is administered before, after, or concurrently with the agent.

15. The method of claim 13 or 14, wherein the immunotherapy comprises an anti-cancer vaccine and/or virus.

16. The method of any one of claims 13-15, wherein the immunotherapy is cell-based.

17. The method of any one of claims 13-16, wherein the immunotherapy inhibits an immune checkpoint.

18. The method of claim 17, wherein the immune checkpoint is selected from the group consisting of CTLA-4, PD-1, VISTA, B7-H2, B7-H3, PD-L1, B7-H4, B7-H6, ICOS, HVEM, PD-L2, CD160, gp49B, PIR-B, KIR family receptors, TIM-1, TIM-3, TIM-4, LAG-3, GITR, 4-IBB, OX-40, BTLA, SIRP, CD47, CD48, 2B4 (CD244), B7.1, B7.2, ILT-2, ILT-4, TIGIT, HHLA2, butyrophilins, IDO, CD39, CD73 and A2aR.

19. The method of claim 18, wherein the immune checkpoint is selected from the group consisting of PD-1, PD-L1, and PD-L2, optionally wherein the immune checkpoint is PD-1.

20. The method of any one of claims 1-19, wherein the one or more biomarker comprises a nucleic acid sequence having at least 95% identity to a nucleic acid sequence

listed in Table 1 and/or encodes an amino acid sequence having at least 95% identity to an amino acid sequence listed in Table 1.

21. The method of any one of claims 1-20, wherein the one or more biomarker is human, mouse, chimeric, or a fusion.

22. The method of any one of claims 1-21, wherein the agent reduces the number of proliferating cells in the cancer and/or reduces the volume or size of a tumor comprising the cancer cells.

23. The method of any one of claims 1-22, wherein the agent increases the sensitivity of the cancer to the immunotherapy, optionally wherein the immunotherapy is T-cell-mediated.

24. The method of any one of claims 1-23, wherein the agent increases the amount of CD8+ T cells in a tumor comprising the cancer cells.

25. The method of any one of claims 1-24, wherein the agent increases the level of MHC-I on the surface of the cancer cells.

26. The method of any one of claims 1-25, wherein the anti-cancer function of the agent is dependent on IFNγ signaling.

27. The method of any one of claims 1-26, further comprising administering to the subject at least one additional cancer therapy or regimen, optionally wherein the at least one additional cancer therapy or regimen is administered before, after, or concurrently with the agent and/or the immunotherapy.

28. The method of any one of claims 1-27, wherein the agent is administered in a pharmaceutically acceptable formulation.

29. A method of killing cancer cells comprising contacting the cancer cells with an agent that inhibits the copy number, the expression level, and/or the activity of one or more biomarkers listed in Table 1 or a fragment thereof, in combination with an immunotherapy.

30. The method of claim 29, wherein the agent decreases the copy number, the expression level, and/or the activity of Ptpn2.

31. The method of claim 29 or 30, wherein the agent selectively decreases the phosphatase activity and/or the substrate binding activity of Ptpn2.

32. The method of any one of claims 29-31, wherein the agent is a small molecule inhibitor, CRISPR single-guide RNA (sgRNA), RNA interfering agent, antisense oligonucleotide, peptide or peptidomimetic inhibitor, aptamer, or intrabody.

33. The method of claim 32, wherein the RNA interfering agent is a small interfering RNA (siRNA), CRISPR RNA (crRNA), a small hairpin RNA (shRNA), a microRNA (miRNA), or a piwi-interacting RNA (piRNA).

34. The method of claim 33, wherein the RNA interfering agent is a CRISPR single-guide RNA (sgRNA).

35. The method of claim 34, wherein the sgRNA comprises a nucleic acid sequence selected from the group consisting of nucleic acid sequence listed in Table 2.

36. The method of claim 32, wherein the agent comprises an intrabody, or an antigen binding fragment thereof, which specifically binds to the one or more biomarkers and/or a substrate of the one or more biomarkers.

37. The method of claim 36, wherein the intrabody, or antigen binding fragment thereof,
is murine, chimeric, humanized, composite, or human.

38. The method of claim 36 or 37, wherein the intrabody, or antigen binding fragment thereof, is detectably labeled, comprises an effector domain, comprises an Fc domain, and/or is selected from the group consisting of Fv, Fav, F(ab')2, Fab', dsFv, scFv, sc(Fv)2, and diabodies fragments.

39. The method of any one of claims 36-38, wherein the intrabody, or antigen binding fragment thereof, is conjugated to a cytotoxic agent.

40. The method of claim 39, wherein the cytotoxic agent is selected from the group consisting of a chemotherapeutic agent, a biologic agent, a toxin, and a radioactive isotope.

41. The method of any one of claims 29-40, wherein the agent increases the sensitivity of the cancer cells to an immunotherapy.

42. The method of any one of claims 29-41, wherein the cancer cells are contacted with an immunotherapy and/or a cancer therapy before, after, or concurrently with the agent.

43. The method of claim 41 or 42, wherein the immunotherapy comprises an anti-cancer vaccine and/or virus.

44. The method of any one of claims 41-43, wherein the immunotherapy is cell-based.

45. The method of any one of claims 41-44, wherein the immunotherapy inhibits an immune checkpoint.

46. The method of claim 45, wherein the immune checkpoint is selected from the group consisting of CTLA-4, PD-1, VISTA, B7-H2, B7-H3, PD-L1, B7-H4, B7-H6, ICOS, HVEM, PD-L2, CD160, gp49B, PIR-B, KIR family receptors, TIM-1, TIM-3, TIM-4, LAG-3, GITR, 4-IBB, OX-40, BTLA, SIRP, CD47, CD48, 2B4 (CD244), B7.1, B7.2, ILT-2, ILT-4, TIGIT, HHLA2, butyrophilins, IDO, CD39, CD73 and A2aR.

47. The method of claim 46, wherein the immune checkpoint is selected from the group consisting of PD-1, PD-L1, and PD-L2, optionally wherein the immune checkpoint is PD-1.

48. The method of any one of claims 29-47, wherein the biomarker comprises a nucleic acid sequence having at least 95% identity to a nucleic acid sequence listed in Table 1 and/or encodes an amino acid sequence having at least 95% identity to an amino acid sequence listed in Table 1.

49. The method of any one of claims 29-48, wherein the one or more biomarker is human, mouse, chimeric, or a fusion.

50. The method of any one of claims 29-49, wherein the agent reduces the number of proliferating cells in the cancer and/or reduces the volume or size of a tumor comprising the cancer cells.

51. The method of any one of claims 29-50, wherein the agent increases the sensitivity of the cancer to the immunotherapy, optionally wherein the immunotherapy is T-cell-mediated.

52. The method of any one of claims 29-51, wherein the agent increases the amount of CD8+ T cells in a tumor comprising the cancer cells.

53. The method of any one of claims 29-52, wherein the agent increases the level of MHC-I on the surface of the cancer cells.

54. The method of any one of claims 29-53, wherein the anti-cancer function of the agent is dependent on IFNγ signaling.

55. The method of any one of claims 29-54, further comprising administering to the subject at least one additional cancer therapy or regimen, optionally wherein the at least one additional cancer therapy or regimen is administered before, after, or concurrently with the agent and/or the immunotherapy.

56. The method of any one of claims 29-55, wherein the agent is administered in a pharmaceutically acceptable formulation.

57. A method of determining whether a subject afflicted with a cancer or at risk for developing a cancer would benefit from inhibiting the copy number, amount, and/or activity of at least one biomarker listed in Table 1, the method comprising:

a) obtaining a biological sample from the subject;

b) determining the copy number, amount, and/or activity of at least one biomarker listed in Table 1;

c) determining the copy number, amount, and/or activity of the at least one biomarker in a control; and

d) comparing the copy number, amount, and/or activity of the at least one biomarker detected in steps b) and c);

wherein the presence of, or a significant increase in, the copy number, amount, and/or activity of, the at least one biomarker listed in Table 1 in the subject sample relative to the control copy number, amount, and/or activity of the at least one biomarker indicates that the subject afflicted with the cancer or at risk for developing the cancer would benefit

from inhibiting the copy number, amount, and/or activity of the at least one biomarker listed in Table 1.

58. The method of claim 57, further comprising recommending, prescribing, or administering an agent that inhibits the at least one biomarker listed in Table 1 if the cancer is determined to benefit from the agent, optionally further administering at least one additional cancer therapy that is administered before, after, or concurrently with the agent.

59. The method of claim 57, further comprising recommending, prescribing, or administering cancer therapy other than an agent that inhibits the at least one biomarker listed in Table 1 if the cancer is determined to not benefit from the agent.

60. The method of claim 58 or 59, wherein the cancer therapy is selected from the group consisting of immunotherapy, targeted therapy, chemotherapy, radiation therapy, hormonal therapy, an anti-cancer vaccine, an anti-cancer virus, and a checkpoint inhibitor.

61. The method of any one of claims 57-60, wherein the control sample is determined from a cancerous or non-cancerous sample from either the patient or a member of the same species to which the patient belongs.

62. The method of any one of claims 57-61, wherein the control sample comprises cells.

63. A method for predicting the clinical outcome of a subject afflicted with a cancer expressing one or more biomarkers listed in Table 1 or a fragment thereof to treatment with an immunotherapy, the method comprising:

a) determining the copy number, amount, and/or activity of at least one biomarker listed in Table 1 in a subject sample;

b) determining the copy number, amount, and/or activity of the at least one biomarker in a control having a good clinical outcome; and

c) comparing the copy number, amount, and/or activity of the at least one biomarker in the subject sample and in the control;

wherein the presence of, or a significant increase in, the copy number, amount, and/or activity of, the at least one biomarker listed in Table 1 in the subject sample as compared to the copy number, amount and/or activity in the control, is an indication that the subject has a poor clinical outcome.

64. A method for monitoring the progression of a cancer in a subject, wherein the subject is administered a therapeutically effective amount of an agent that inhibits the copy number, amount, and/or activity of at least one biomarker listed in Table 1 and an immunotherapy, the method comprising:

a) detecting in a subject sample at a first point in time the copy number, amount, and/or activity of at least one biomarker listed in Table 1;

b) repeating step a) at a subsequent point in time; and

c) comparing the amount or activity of at least one biomarker listed in Table 1 detected in steps a) and b) to monitor the progression of the cancer in the subject.

65. A method of assessing the efficacy of an agent that inhibits the copy number, amount, and/or activity of at least one biomarker listed in Table 1 and an immunotherapy for treating a cancer in a subject, comprising:

a) detecting in a subject sample at a first point in time the copy number, amount, and/or or activity of at least one biomarker listed in Table 1;

b) repeating step a) during at least one subsequent point in time after administration of the agent and the immunotherapy; and

c) comparing the copy number, amount, and/or activity detected in steps a) and b), wherein the absence of, or a significant decrease in, the copy number, amount, and/or activity of, the at least one biomarker listed in Table 1, in the subsequent sample as compared to the copy number, amount, and/or activity in the sample at the first point in time, indicates that the agent and immunotherapy treats the cancer in the subject.

66. The method of claim 64 or 65, wherein between the first point in time and the subsequent point in time, the subject has undergone treatment, completed treatment, and/or is in remission for the cancer.

67. The method of claim 66, wherein the cancer treatment is selected from the group consisting of immunotherapy, targeted therapy, chemotherapy, radiation therapy, hormonal therapy, an anti-cancer vaccine, an anti-cancer virus, and a checkpoint inhibitor.

68. The method of any one of claims 64-67, wherein the first and/or at least one subsequent sample is selected from the group consisting of *ex vivo* and *in vivo* samples.

69. The method of any one of claims 64-68, wherein the first and/or at least one subsequent sample is a portion of a single sample or pooled samples obtained from the subject.

70. The method of any one of claims 51-69, wherein the sample comprises cells, serum, peritumoral tissue, and/or intratumoral tissue obtained from the subject.

71. The method of any one of claims 51-70, wherein the one or more biomarkers listed in Table 1 comprises Ptpn2.

72. The method of any one of claims 1-71, wherein the cancer is responsive to IFNγ.

73. The method of any one of claims 1-72, wherein the cancer cells are in a parainflamed tumor.

74. The method of any one of claims 1-73, wherein the cancer cells produce interferon.

75. The method of any one of claims 1-74, wherein the cancer is selected from the group consisting of melanoma, colorectal cancer, gliomas, neuroblastoma, prostate cancer, breast cancer, pancreatic ductal carcinoma, epithelial ovarian cancer, B-CLL, leukemia, B cell lymphoma, and renal cell carcinoma.

76. The method of any one of claims 1-75, wherein the cancer is in a subject and the subject is an animal model of the cancer.

77. The method of claim 76, wherein the animal model is a mouse model.

78. The method of any one of claims 1-75, wherein the cancer is in a subject and the subject is a mammal.

79. The method of claim 43, wherein the mammal is a mouse or a human.

80. The method of claim 44, wherein the mammal is a human.

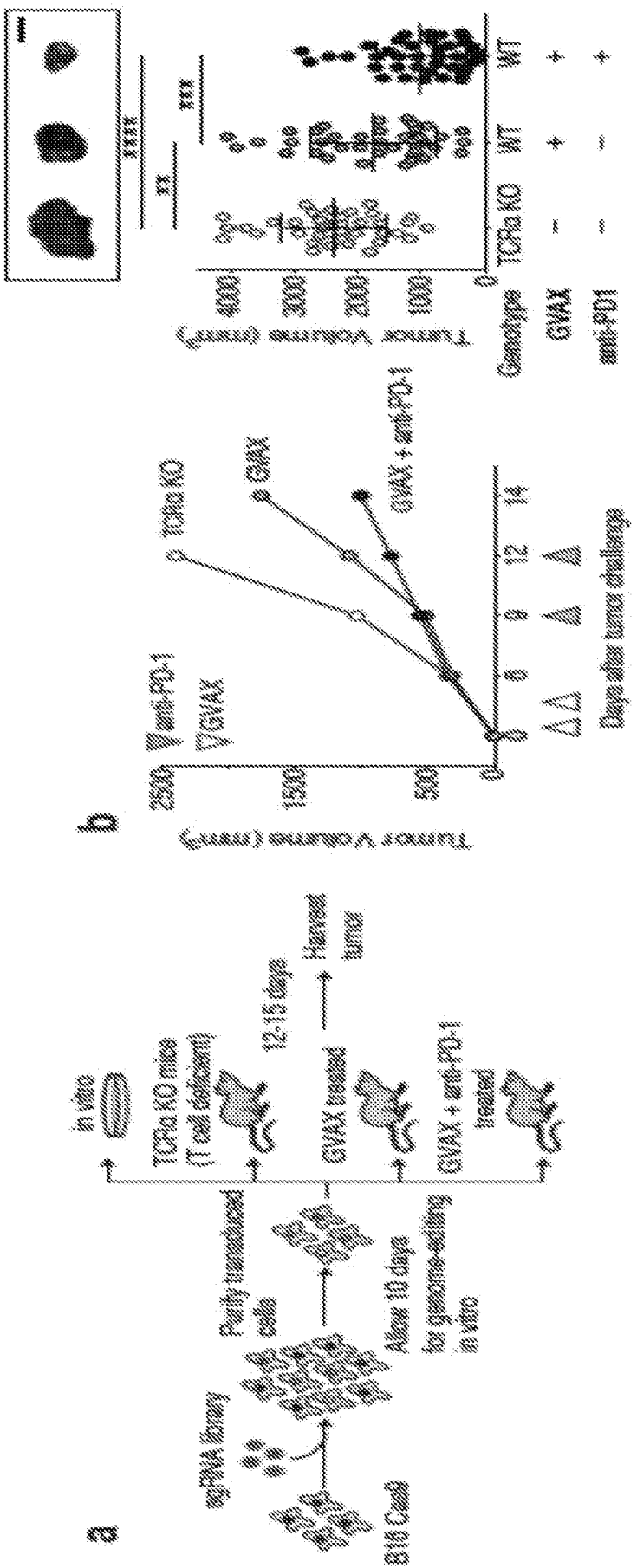
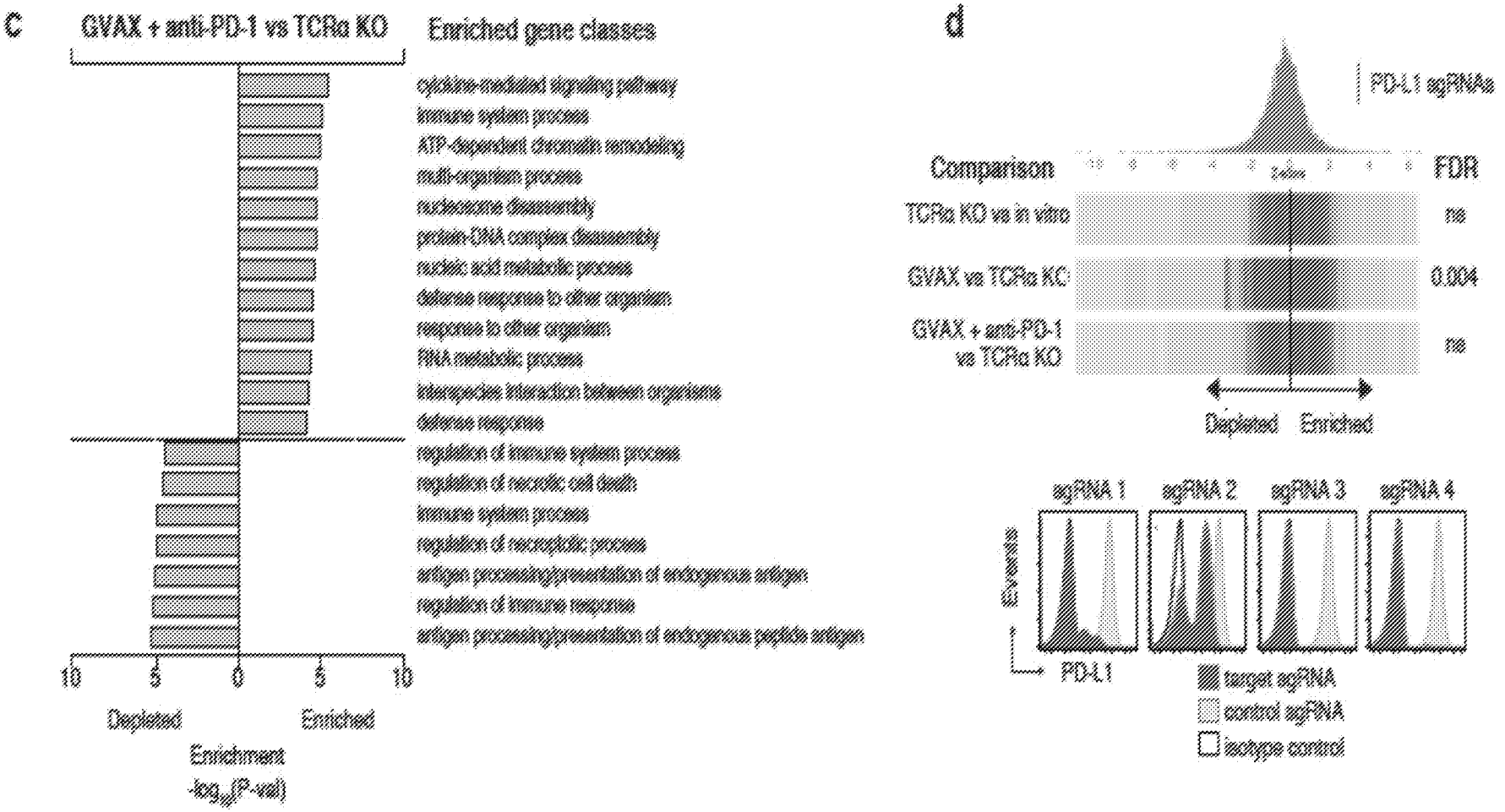

a
B16 Cells
sgRNA library
Purify transduced cells
Allow 10 days for genome-editing in vitro
in vitro
TCRa KO mice (T cell deficient)
GVAX treated
GVAX + anti-PD-1 treated
12-15 days
Harvest tumor
b
Tumor Volume (mm3)
2500
1500
500
0
anti-PD-1
GVAX
TCRa KO
GVAX
GVAX + anti-PD-1
0
6
12
14
Days after tumor challenge
Tumor Volume (mm3)
4000
3000
2000
1000
0
Genotype
TCRa KO
WT
WT
GVAX
-
+
+
anti-PD1
-
-
+

Figure 1

Figure 1 (cont.)



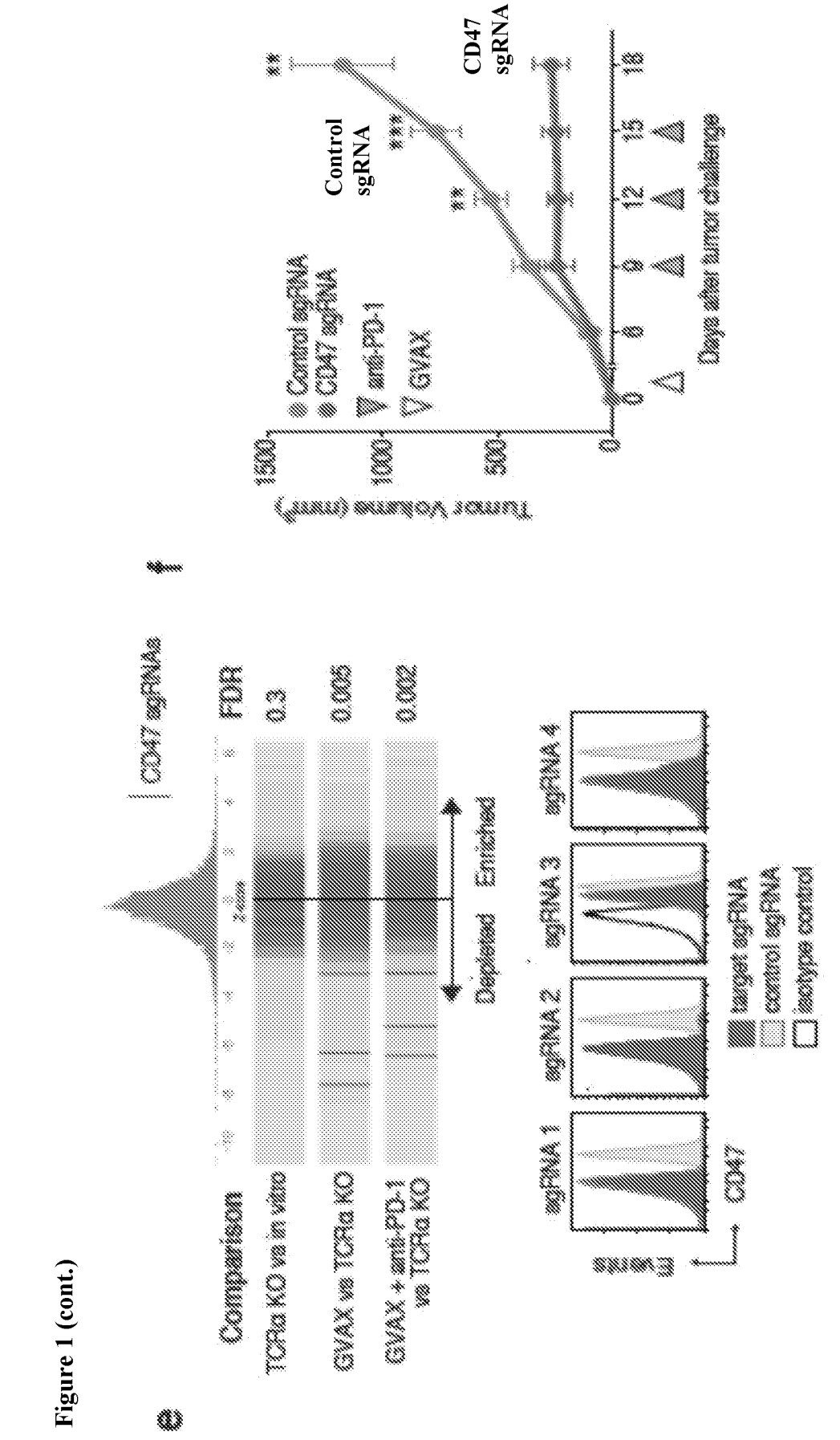


Figure 1 (cont.)

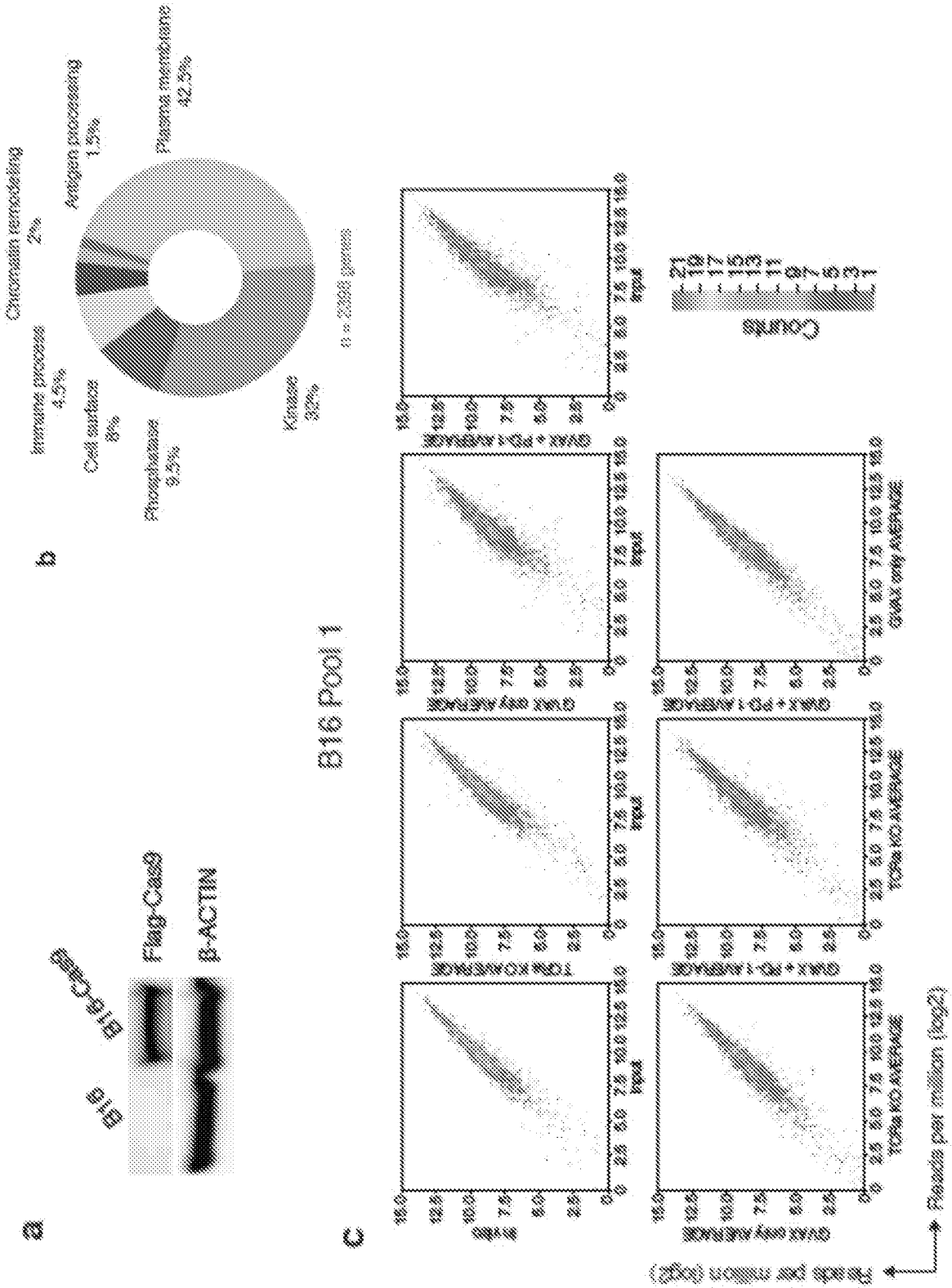

a
B16
B16-Cas9
Flag-Cas9
β-ACTIN
b
Chromatin remodeling 2%
Immune process 4.5%
Cell surface 8%
Phosphatase 9.5%
Kinase 32%
Antigen processing 1.5%
Plasma membrane 42.5%
n = 2356 genes
c
B16 Pool 1
Counts
Reads per million (log2)
Input
TCRa KO AVERAGE
GMAX only AVERAGE

Figure 2

Figure 2 (cont.)

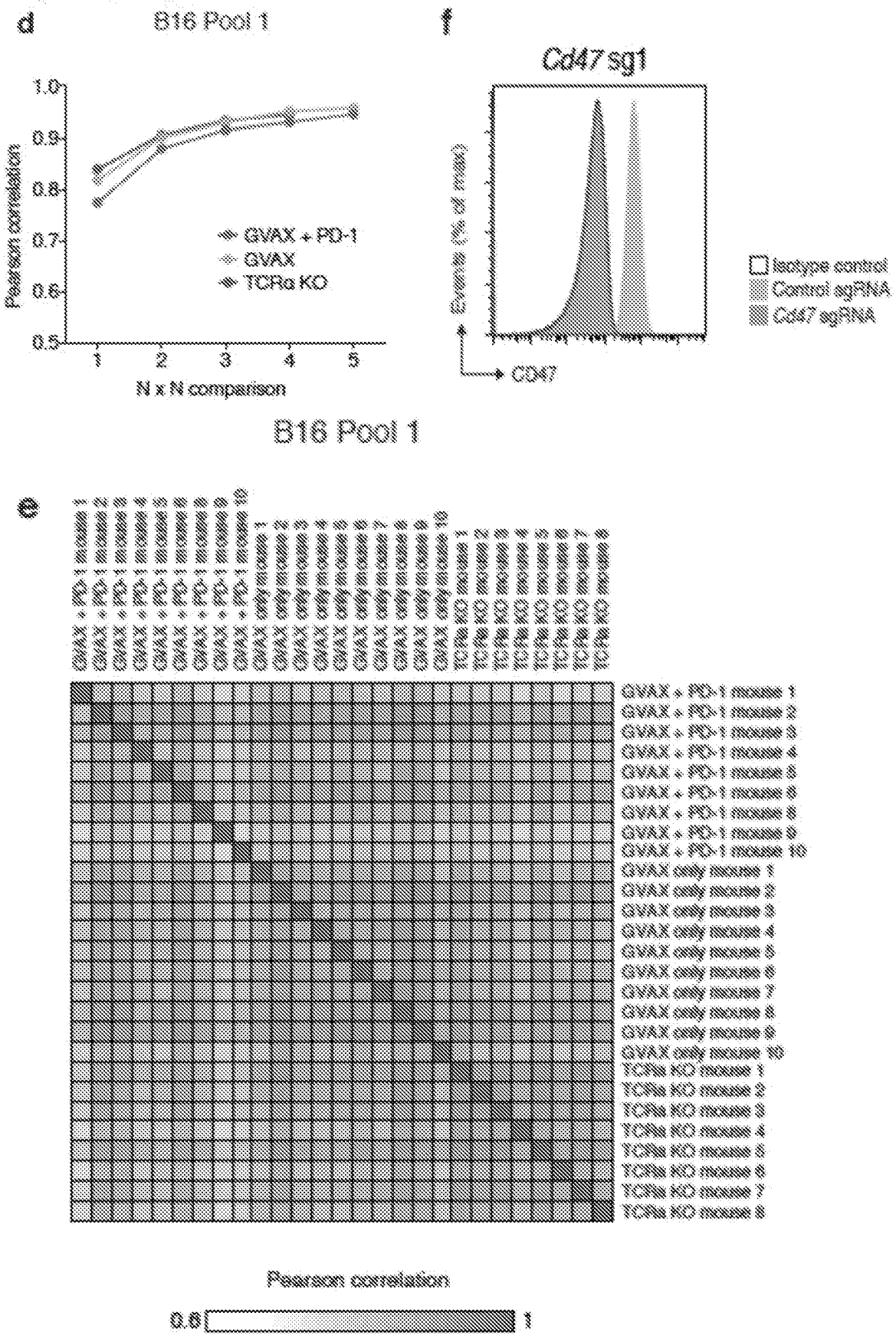
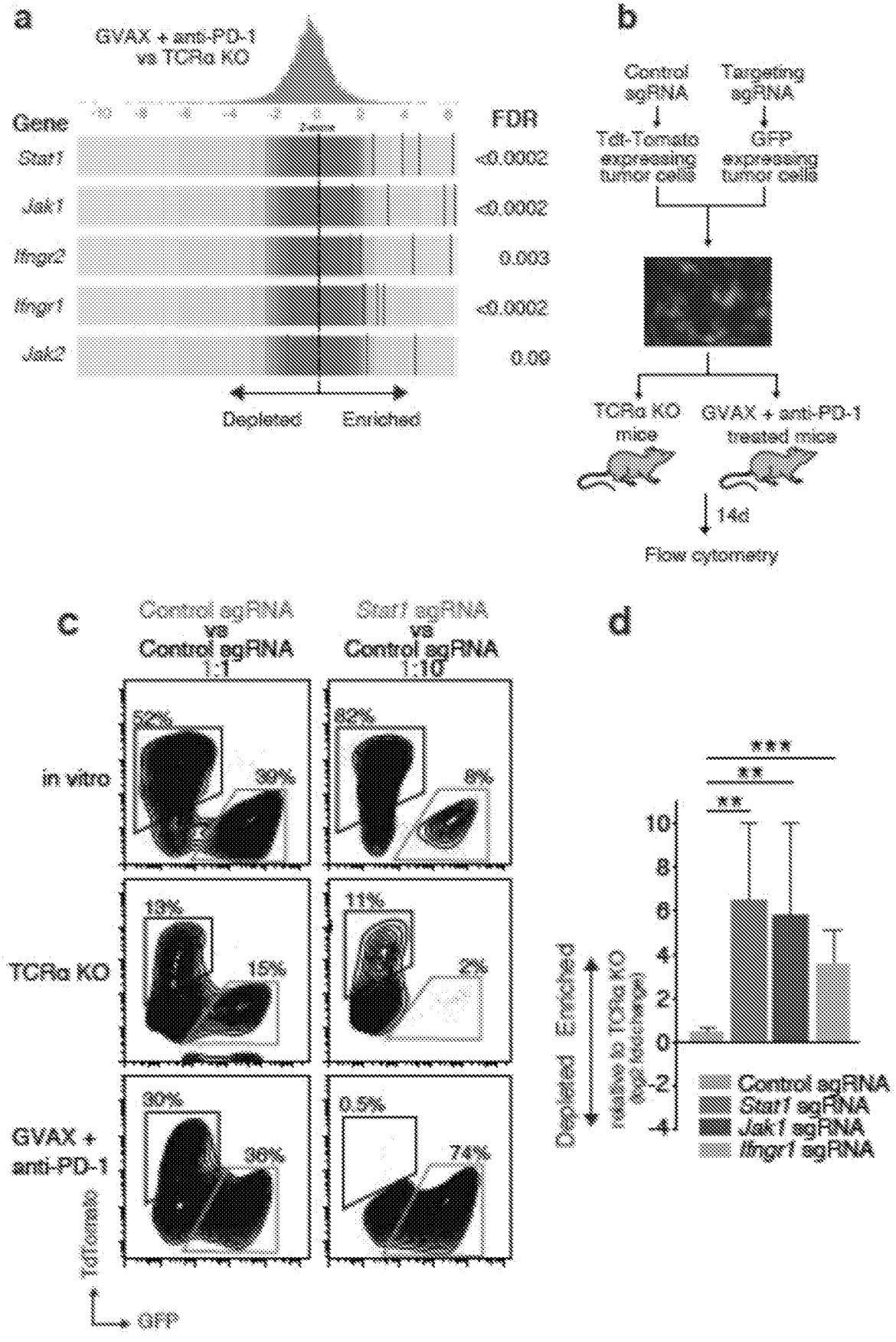
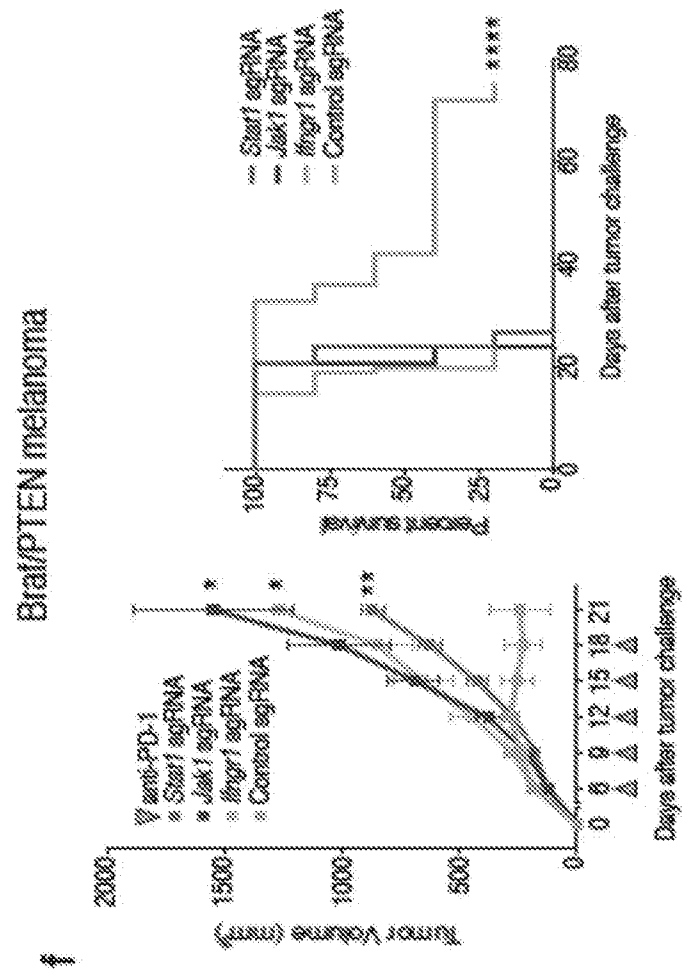


Figure 3


a
GVAX + anti-PD-1 vs TCRα KO
Gene
FDR
Stat1
Jak1
Ifngr2
Ifngr1
Jak2
<0.0002
<0.0002
0.003
<0.0002
0.09
Depleted
Enriched
b
Control sgRNA
Targeting sgRNA
Tet-Tomato expressing tumor cells
GFP expressing tumor cells
TCRα KO mice
GVAX + anti-PD-1 treated mice
14d
Flow cytometry
c
Control sgRNA vs Control sgRNA 1:1
Stat1 sgRNA vs Control sgRNA 1:10
in vitro
TCRα KO
GVAX + anti-PD-1
52%
39%
62%
8%
19%
15%
11%
2%
90%
36%
0.5%
74%
Tet-Tomato
GFP
d
***
**
**
Depleted Enriched
(relative to TCRα KO high tumors)
10
8
6
4
2
0
-2
-4
Control sgRNA
Stat1 sgRNA
Jak1 sgRNA
Ifngr1 sgRNA



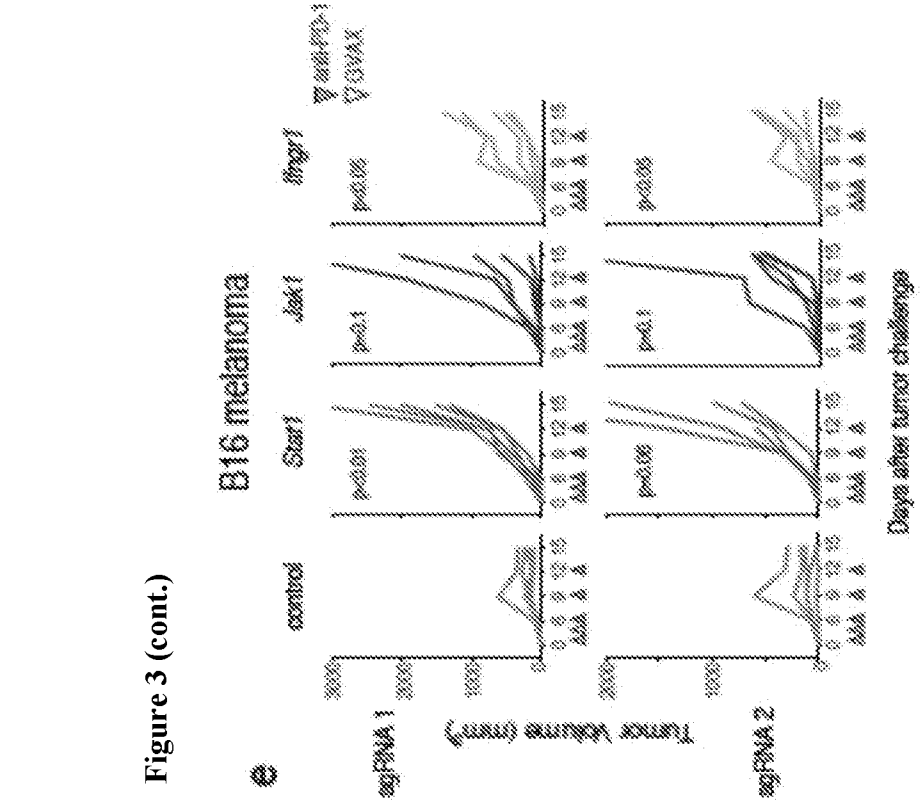


Figure 3 (cont.)

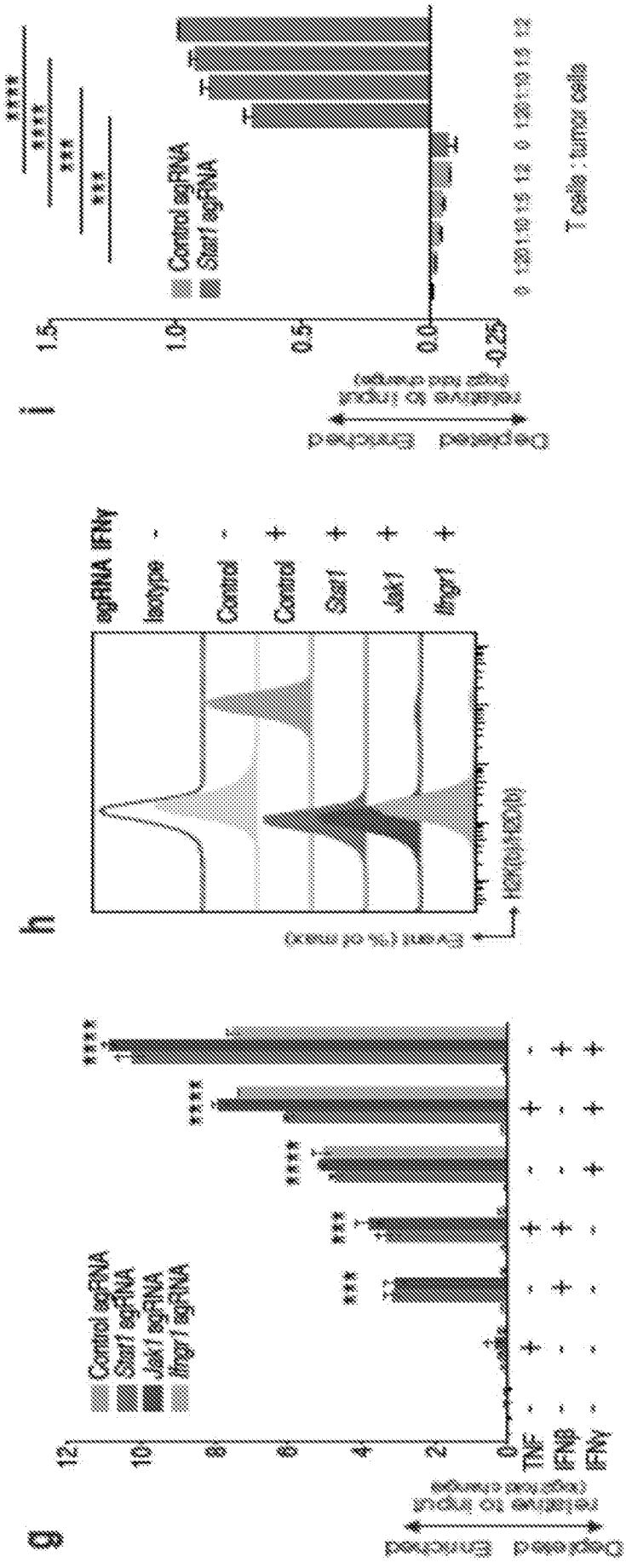


Figure 3 (cont.)

Figure 4

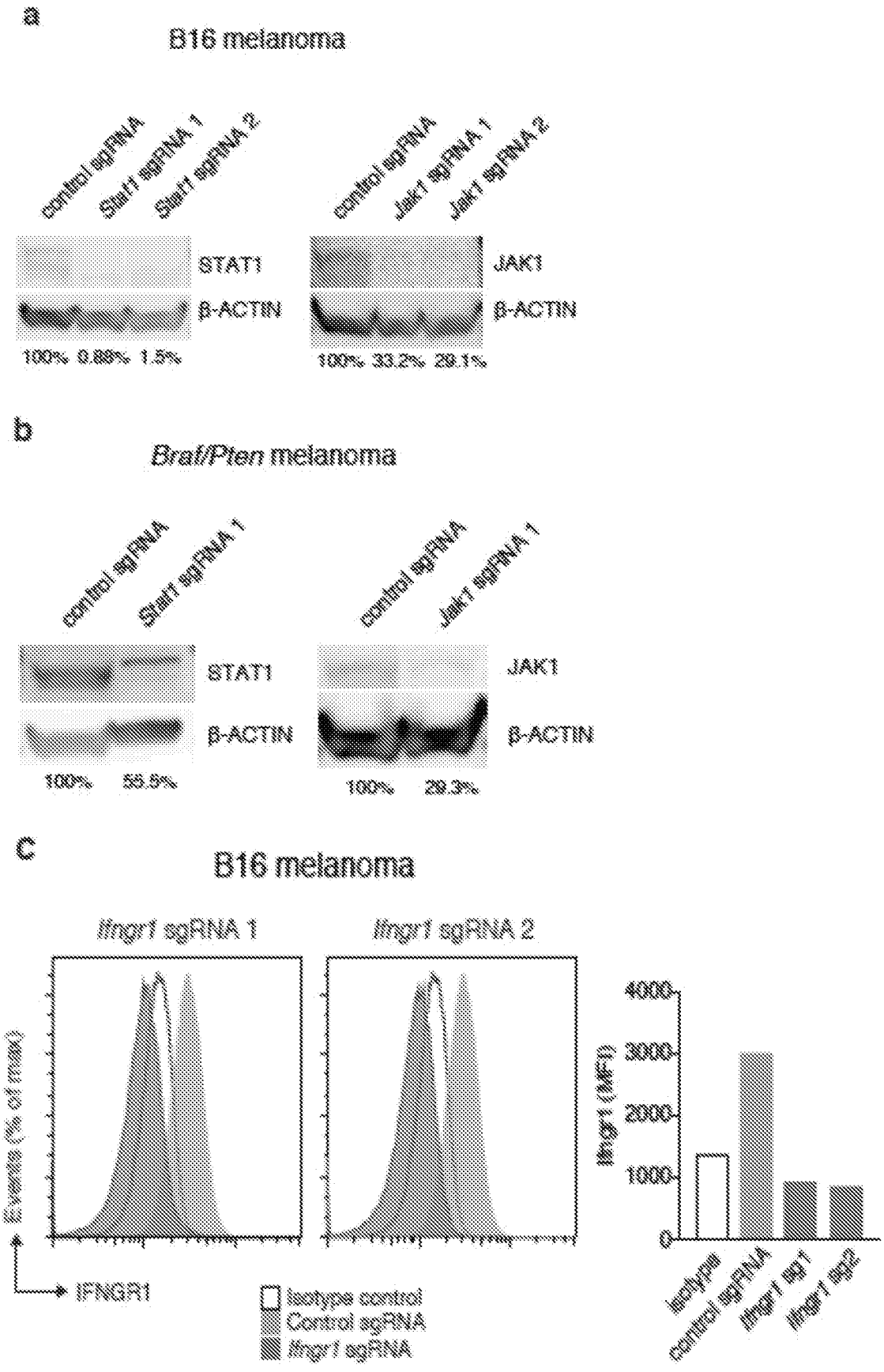

a
B16 melanoma
control sgRNA
Stat1 sgRNA 1
Stat1 sgRNA 2
control sgRNA
Jak1 sgRNA 1
Jak1 sgRNA 2
STAT1
β-ACTIN
JAK1
β-ACTIN
100% 9.88% 1.5%
100% 33.2% 29.1%
b
Braf/Pten melanoma
control sgRNA
Stat1 sgRNA 1
control sgRNA
Jak1 sgRNA 1
STAT1
β-ACTIN
JAK1
β-ACTIN
100% 55.5%
100% 29.3%
c
B16 melanoma
Ifngr1 sgRNA 1
Ifngr1 sgRNA 2
Events (% of max)
IFNGR1
Isotype control
Control sgRNA
Ifngr1 sgRNA
Ifngr1 (MFI)
4000
3000
2000
1000
0
Isotype
control sgRNA
Ifngr1 sg1
Ifngr1 sg2

Figure 4 (cont.)

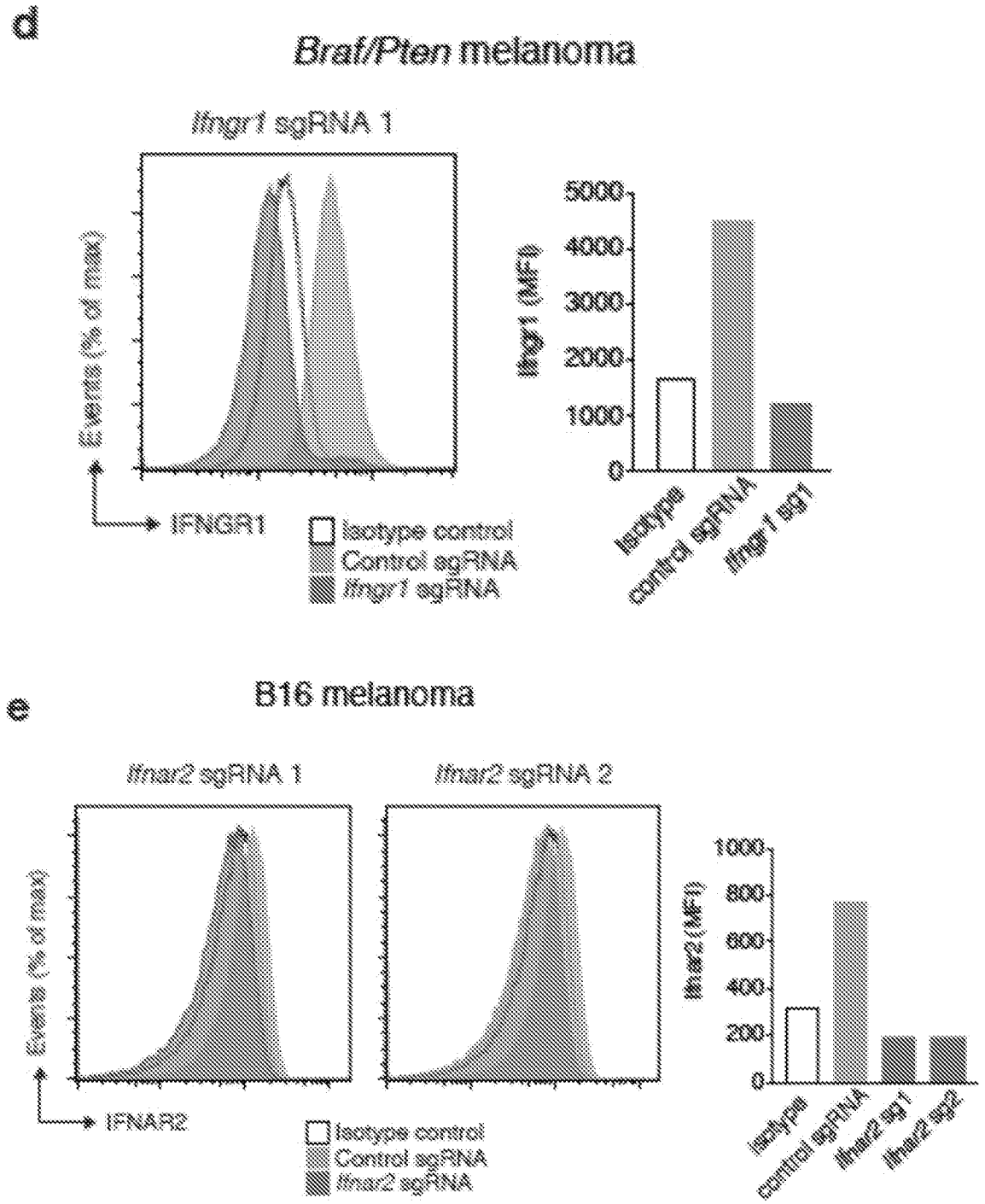


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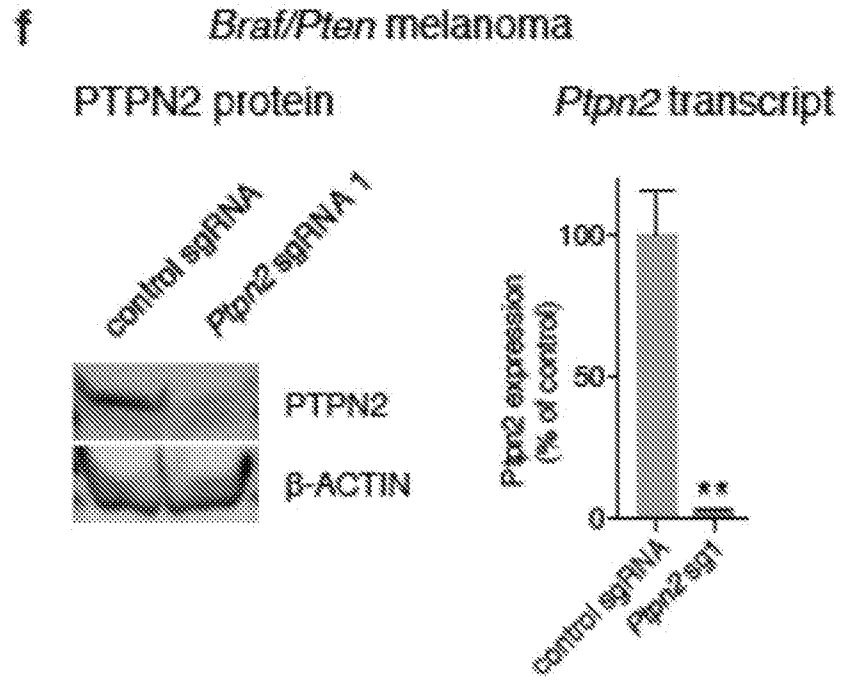


Figure 5

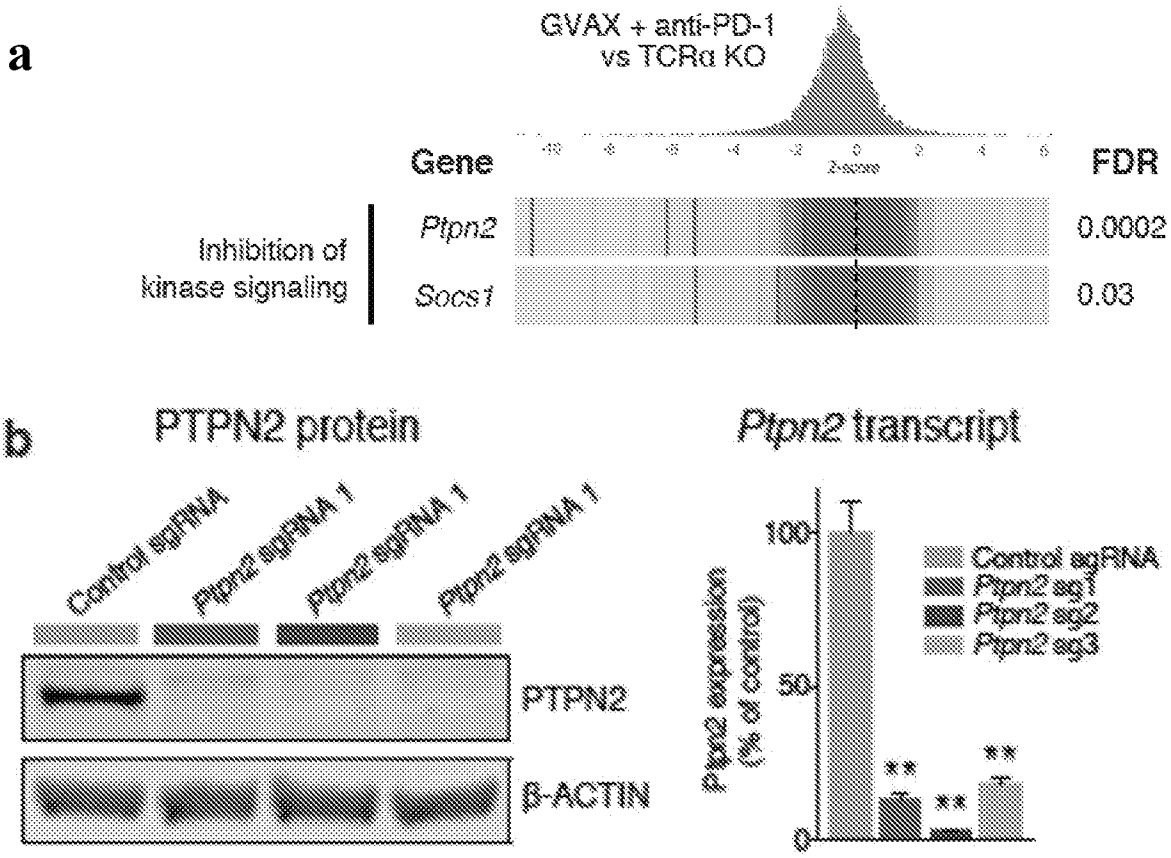


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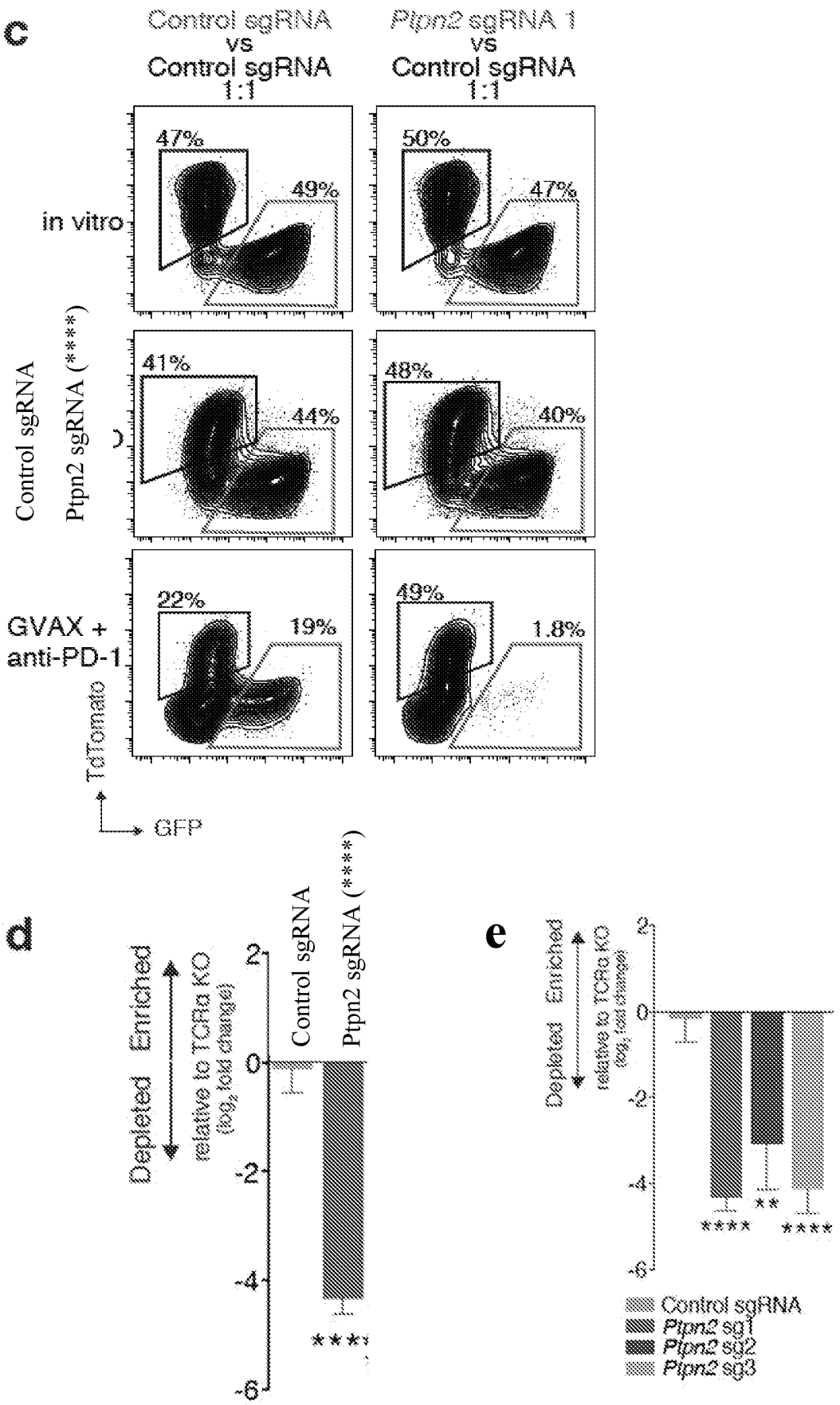
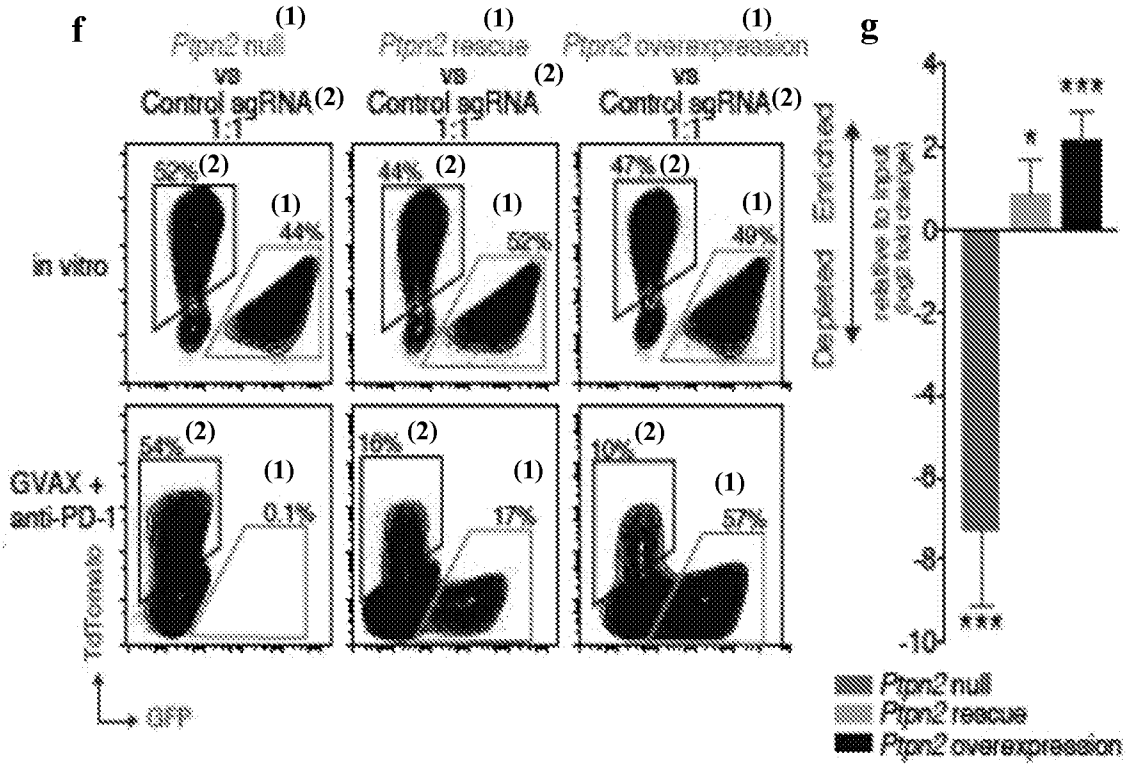


Figure 5 (cont.)



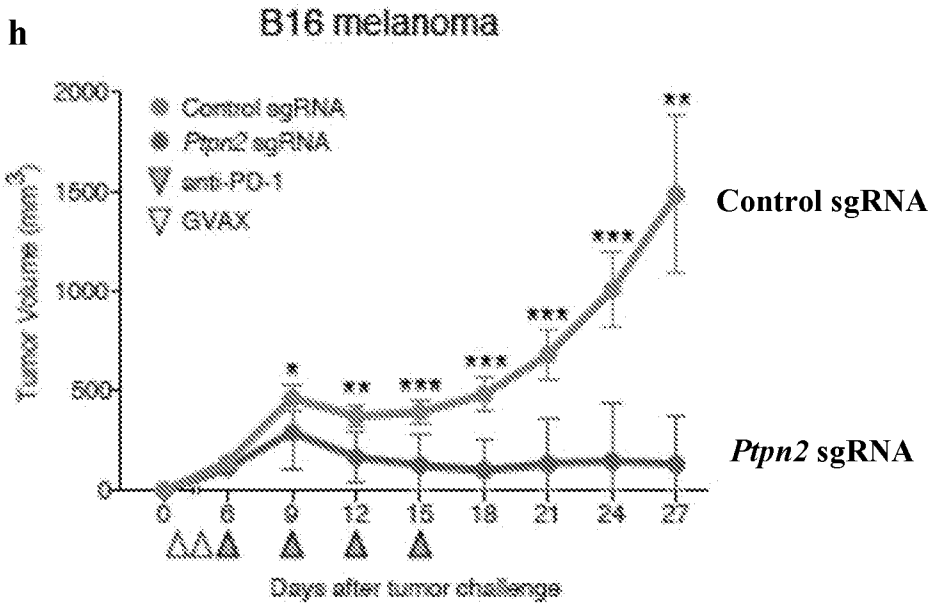


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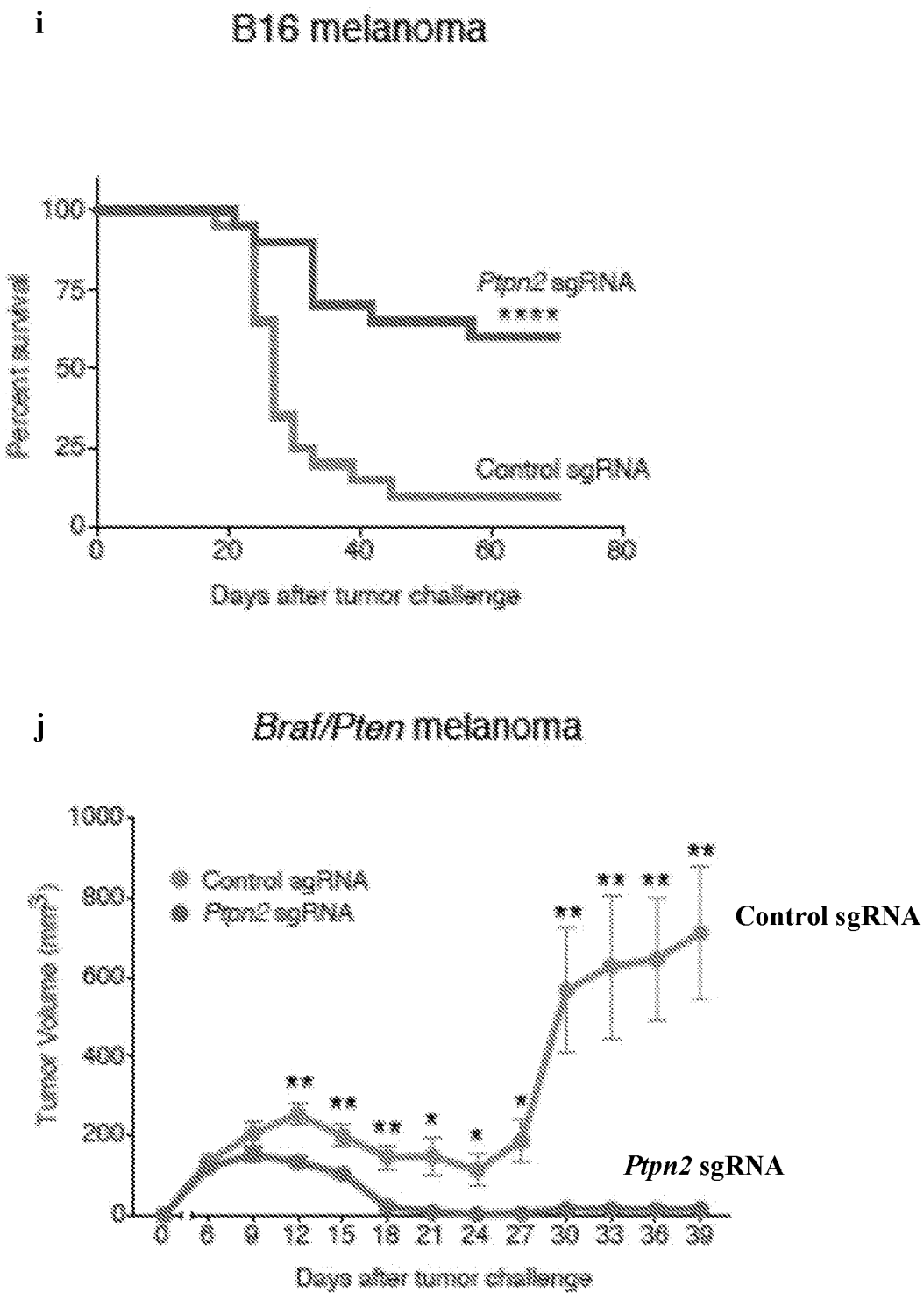


Figure 6

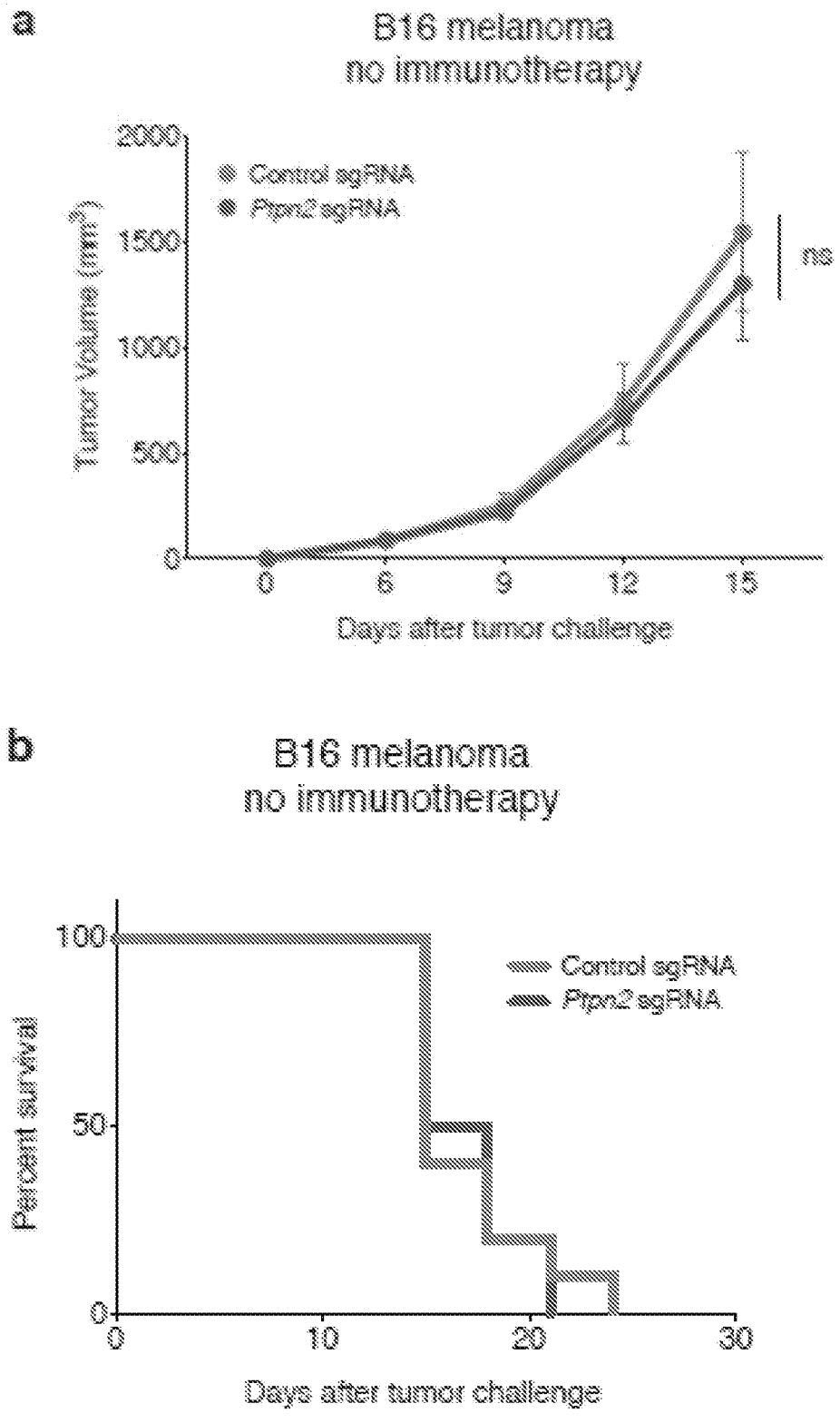
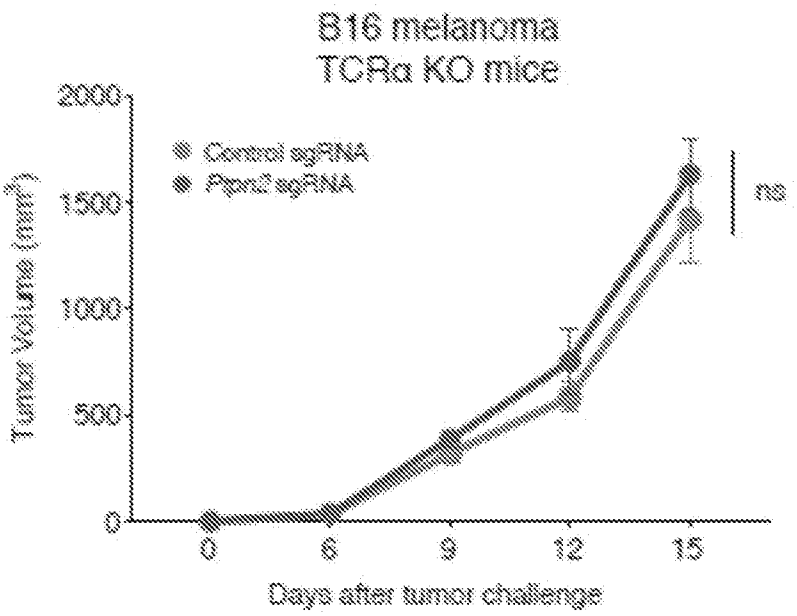

a
B16 melanoma
no immunotherapy
Control sgRNA
Ptpn2 sgRNA
Tumor Volume (mm3)
2000
1500
1000
500
0
ns
0
6
9
12
15
Days after tumor challenge
b
B16 melanoma
no immunotherapy
Control sgRNA
Ptpn2 sgRNA
Percent survival
100
50
0
0
10
20
30
Days after tumor challenge

Figure 6 (cont.)

c



d

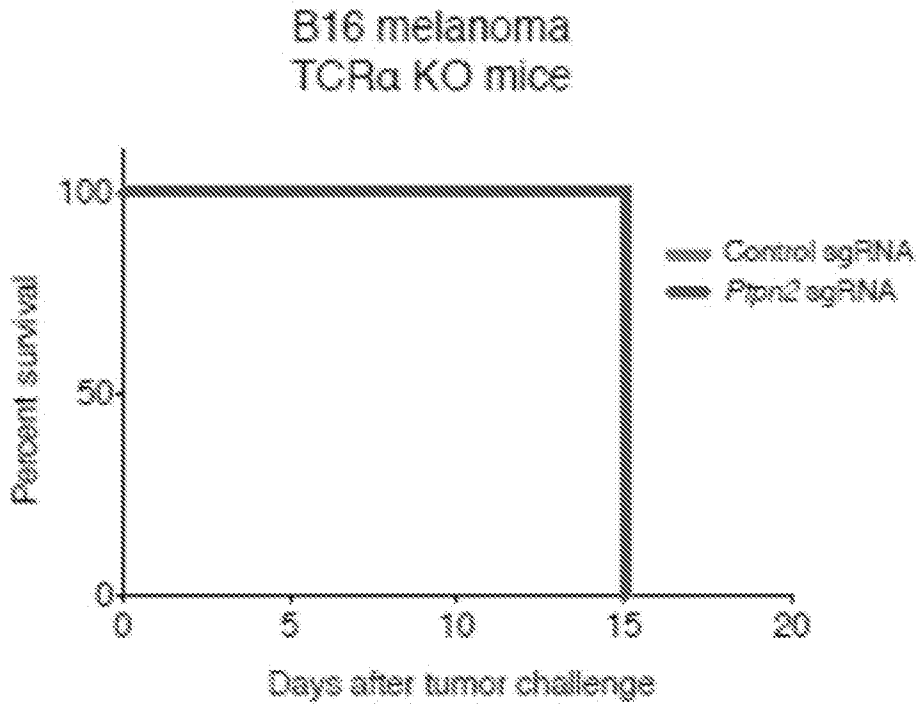


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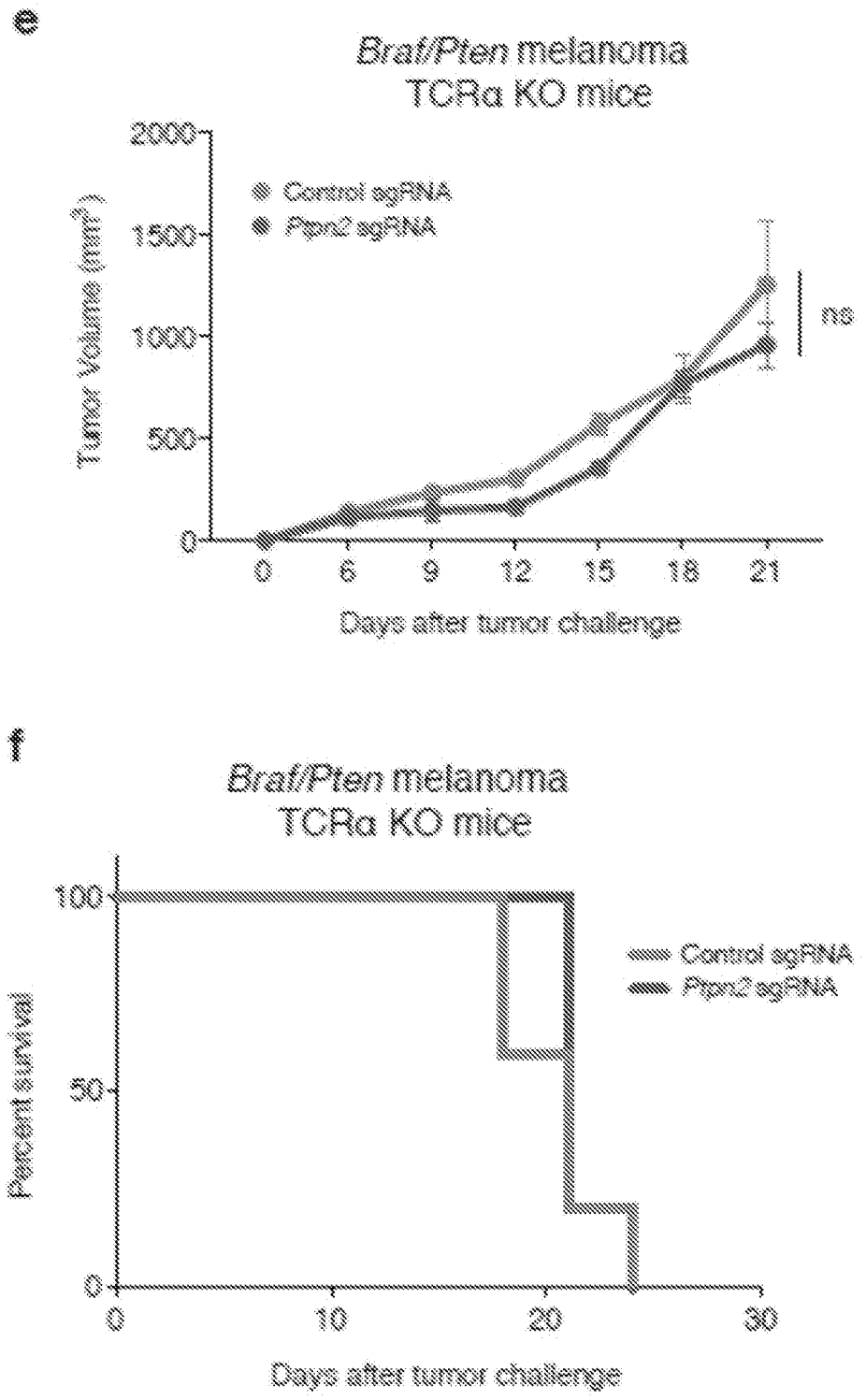
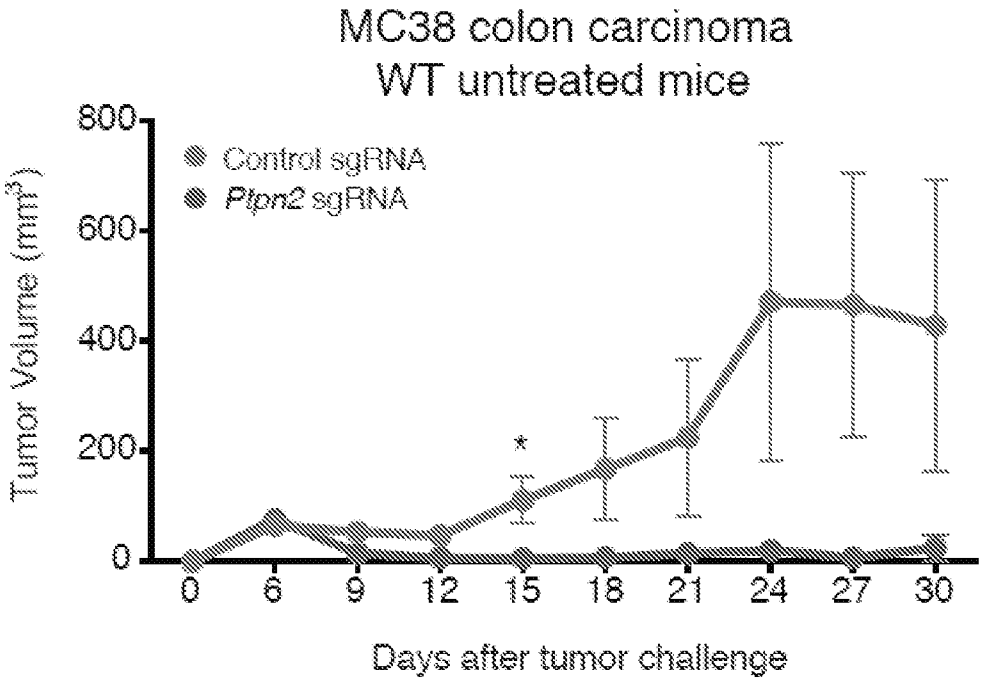


Figure 6 (cont.)

g



h

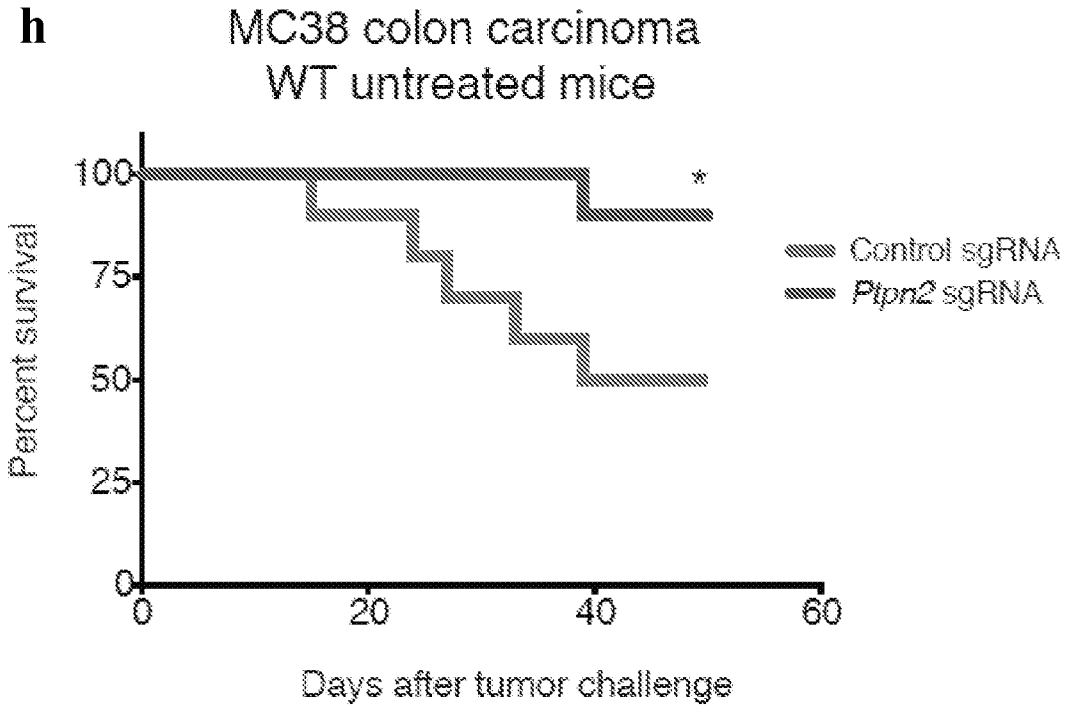
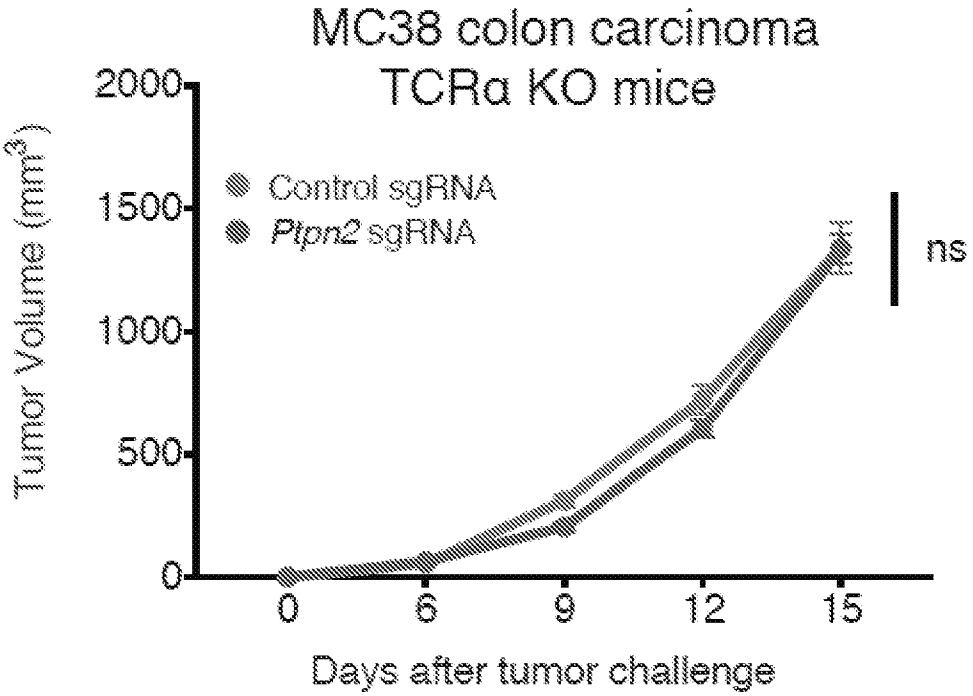


Figure 6 (cont.)

i



j

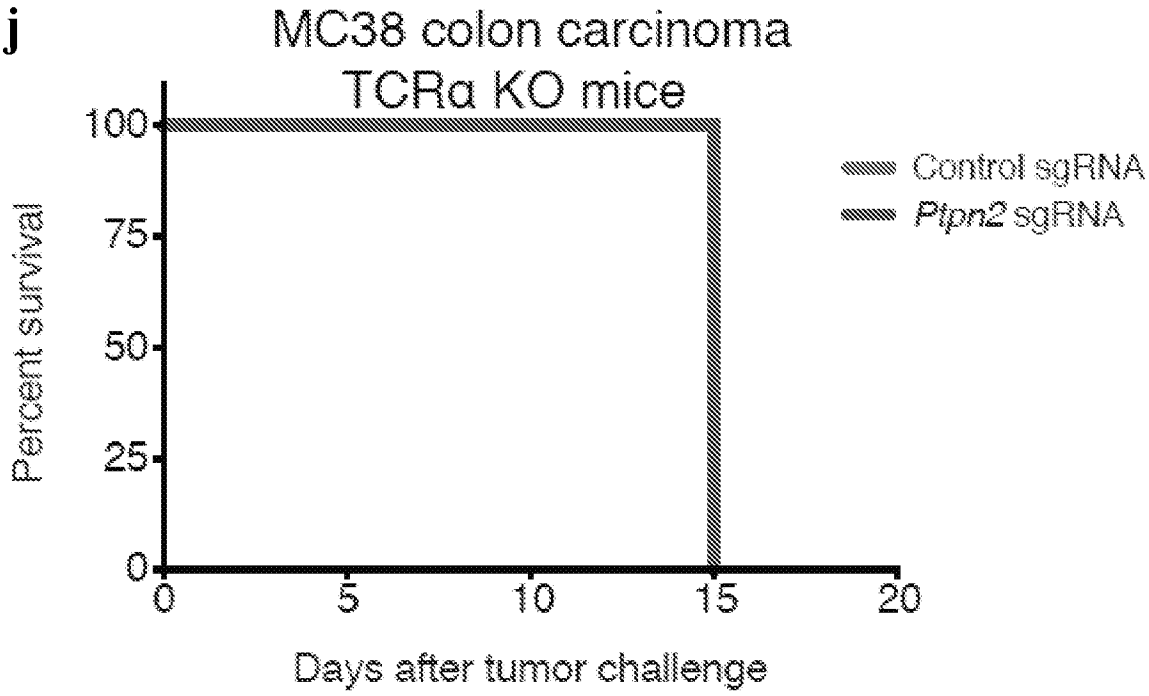


Figure 7

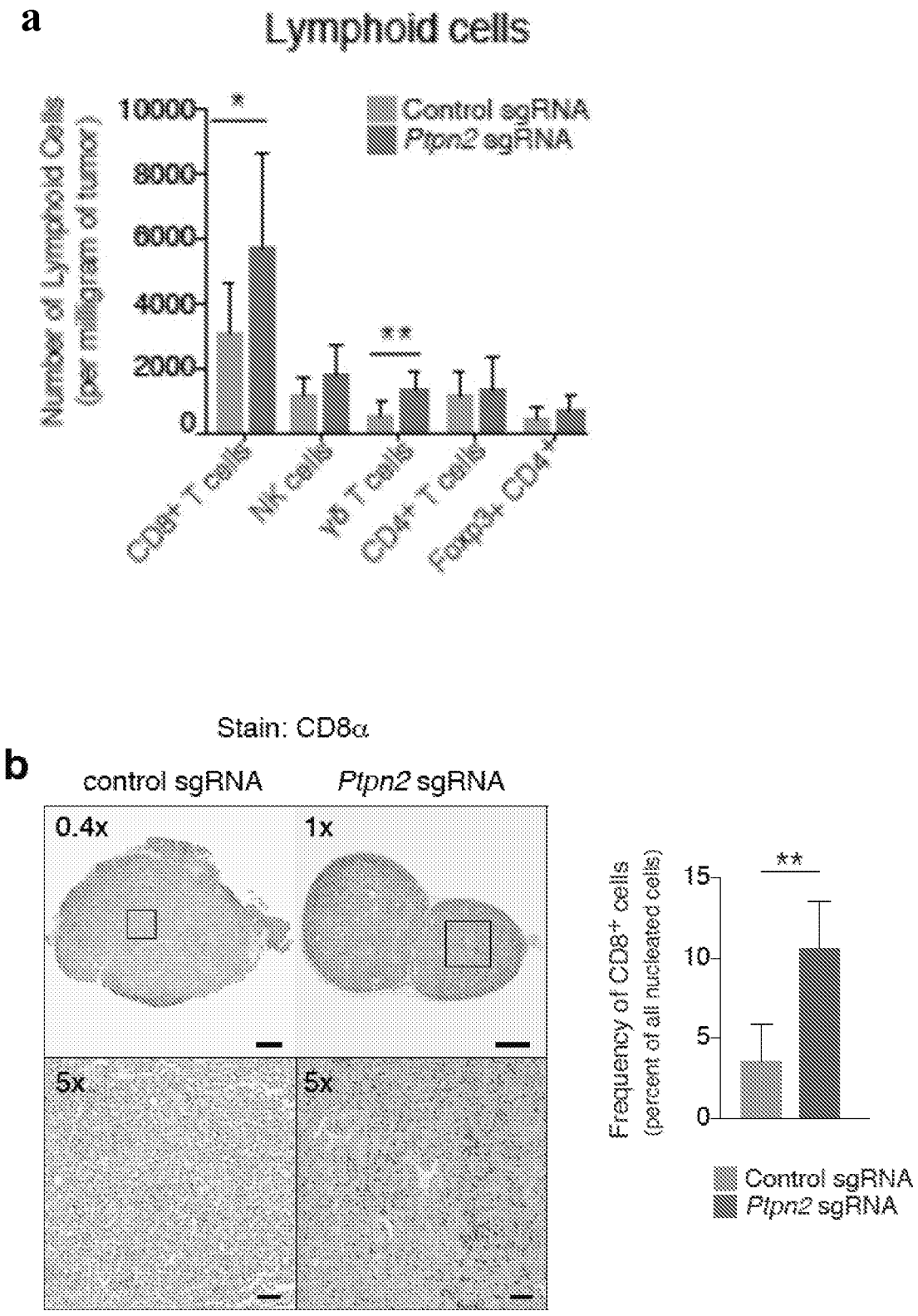

a
Lymphoid cells
Number of Lymphoid Cells (per milligram of tumor)
10000
8000
6000
4000
2000
0
*
**
Control sgRNA
Ptpn2 sgRNA
CD8+ T cells
NK cells
γδ T cells
CD4+ T cells
Foxp3+ CD4+
b
Stain: CD8α
control sgRNA
Ptpn2 sgRNA
0.4x
1x
5x
5x
Frequency of CD8+ cells (percent of all nucleated cells)
15
10
5
0
**
Control sgRNA
Ptpn2 sgRNA

Figure 7 (cont.)

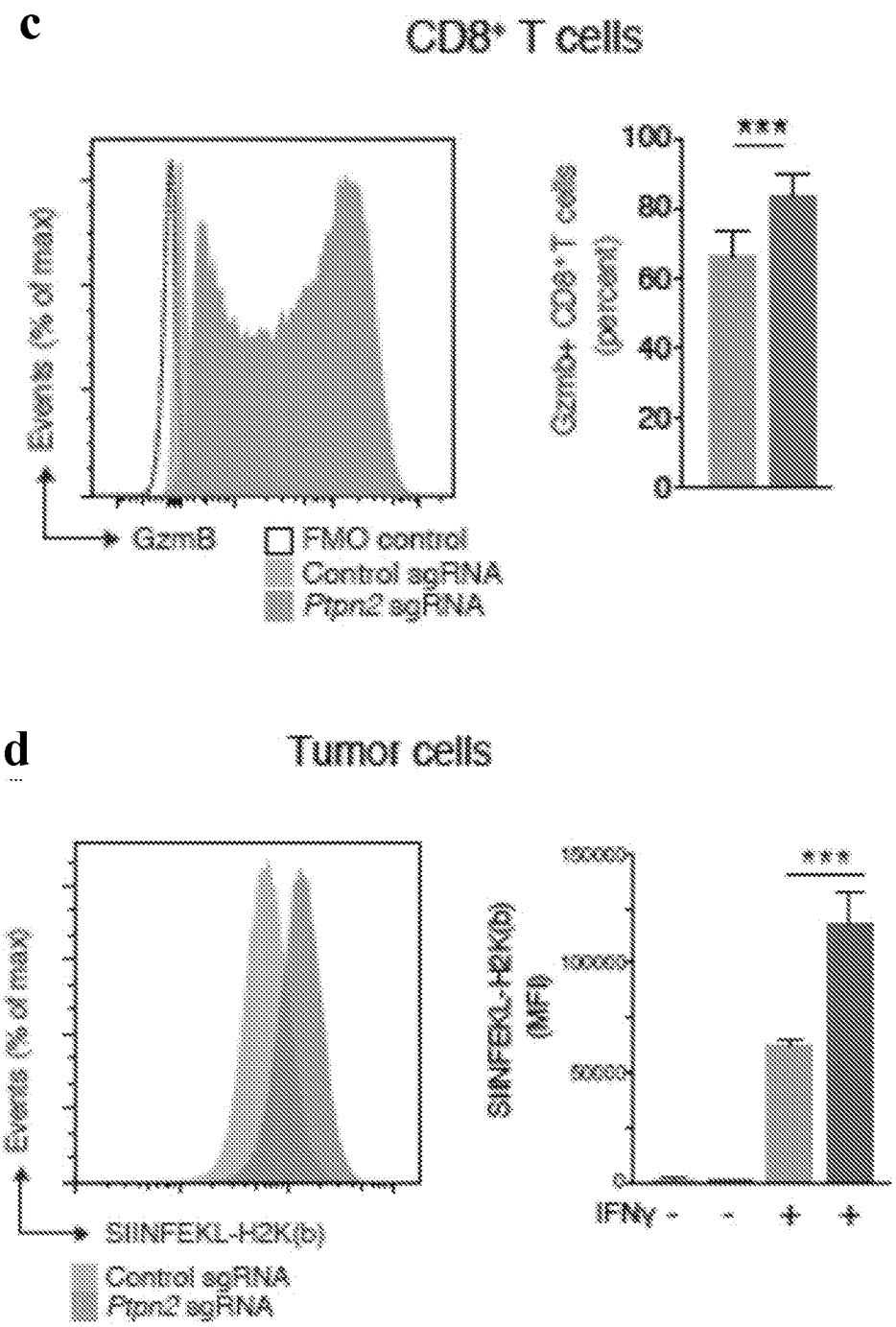
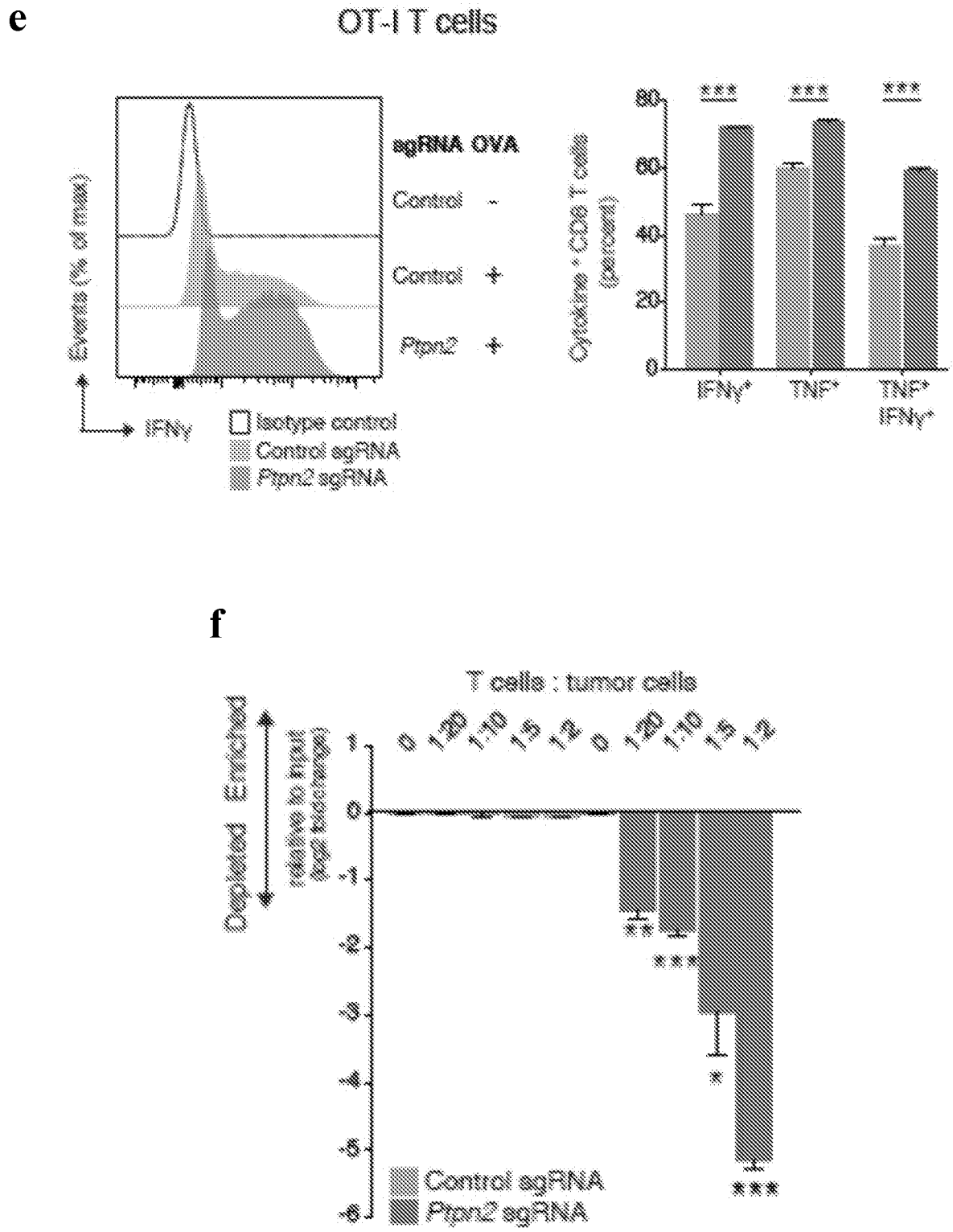


Figure 7 (cont.)



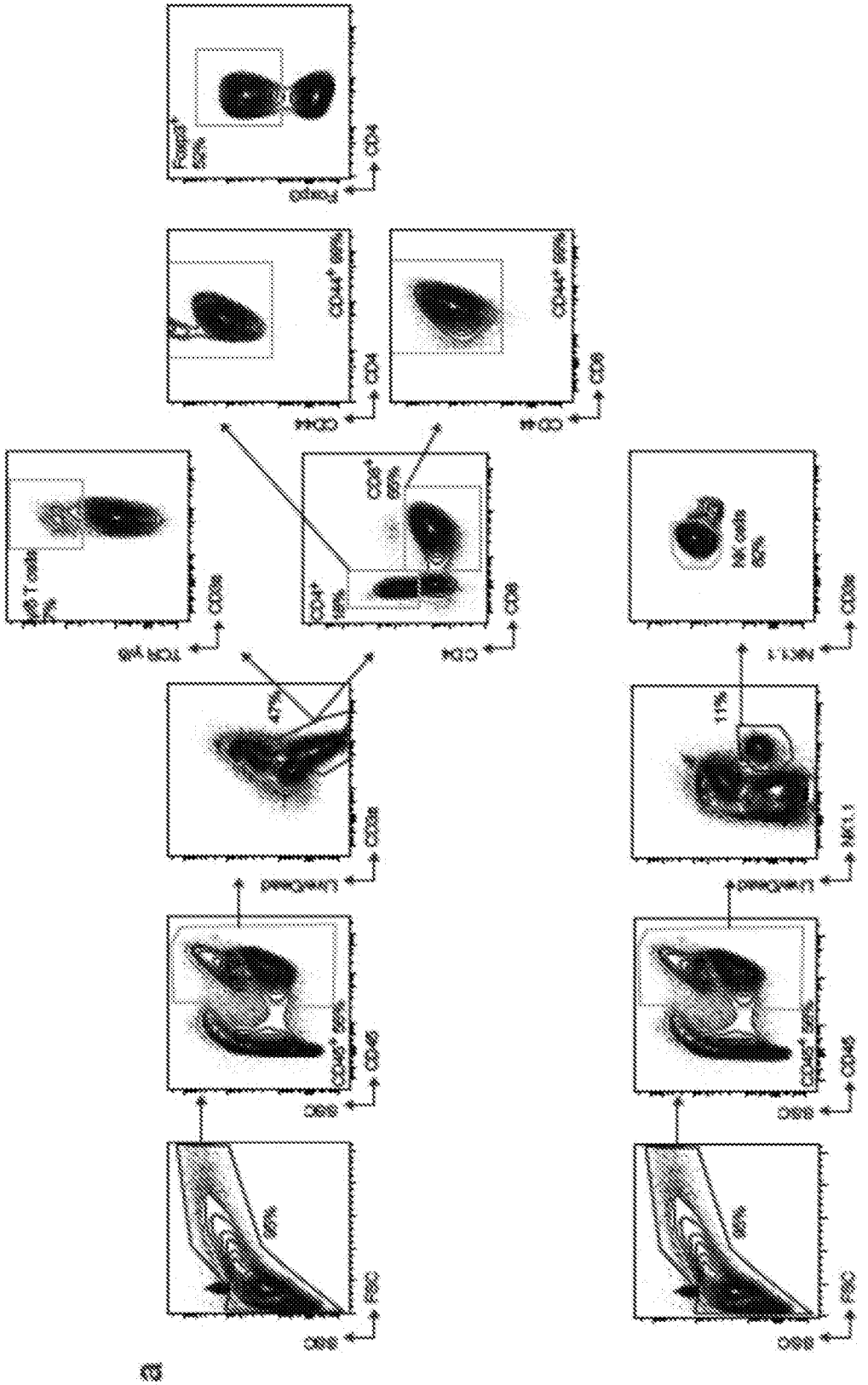
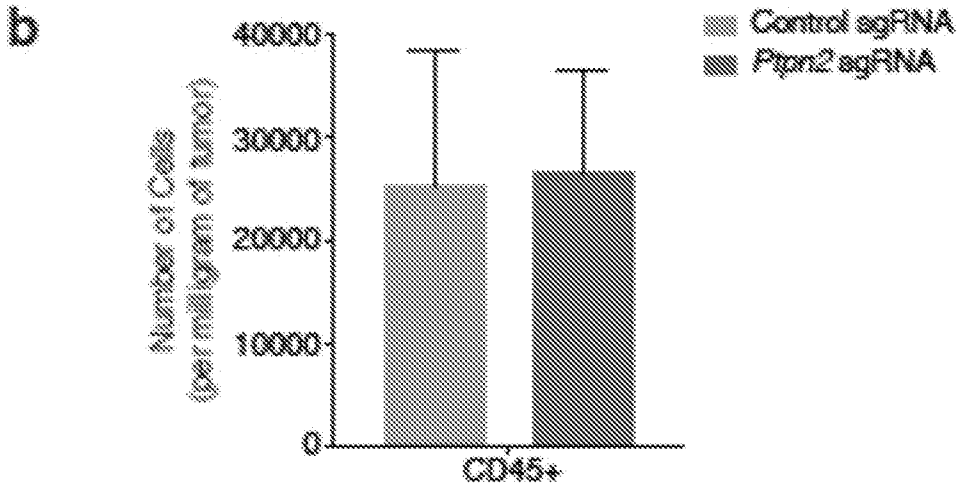


Figure 8

Figure 8 (cont.)



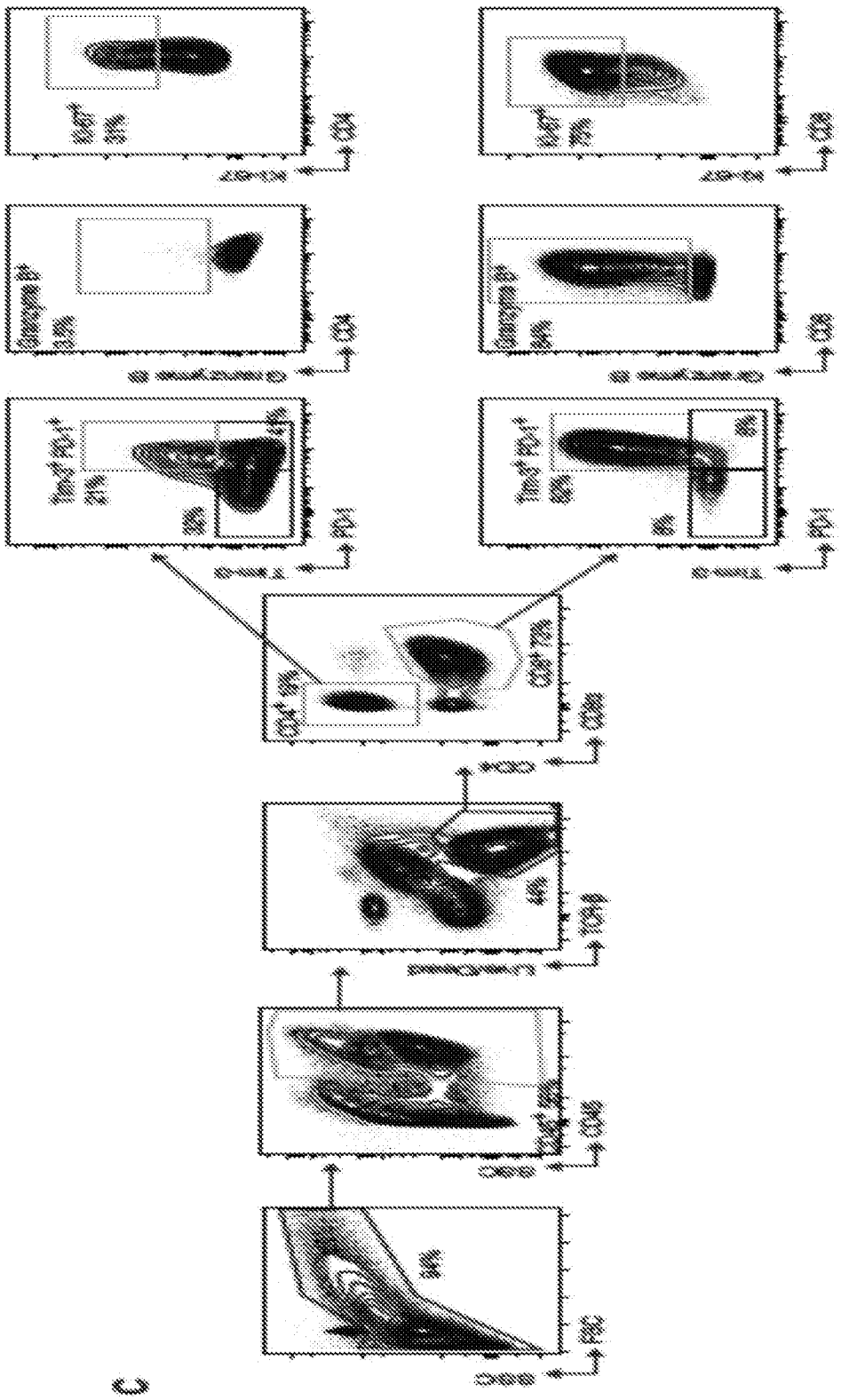


Figure 8 (cont.)

Figure 8 (cont.)

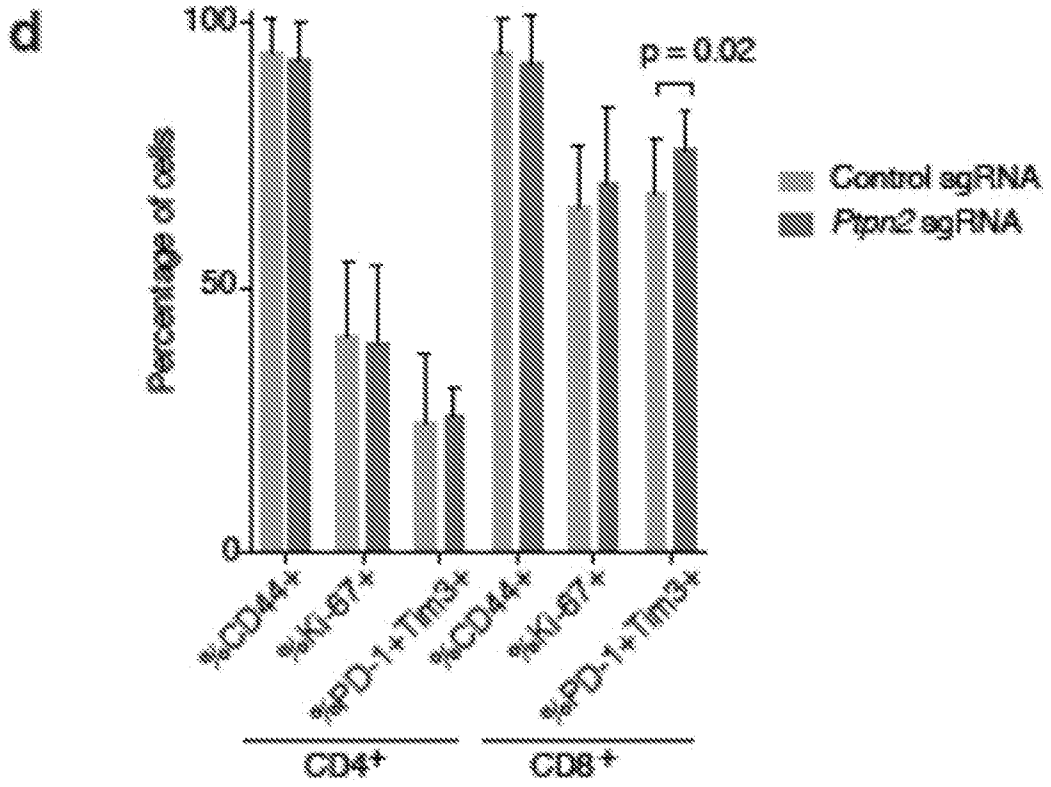


Figure 9

a

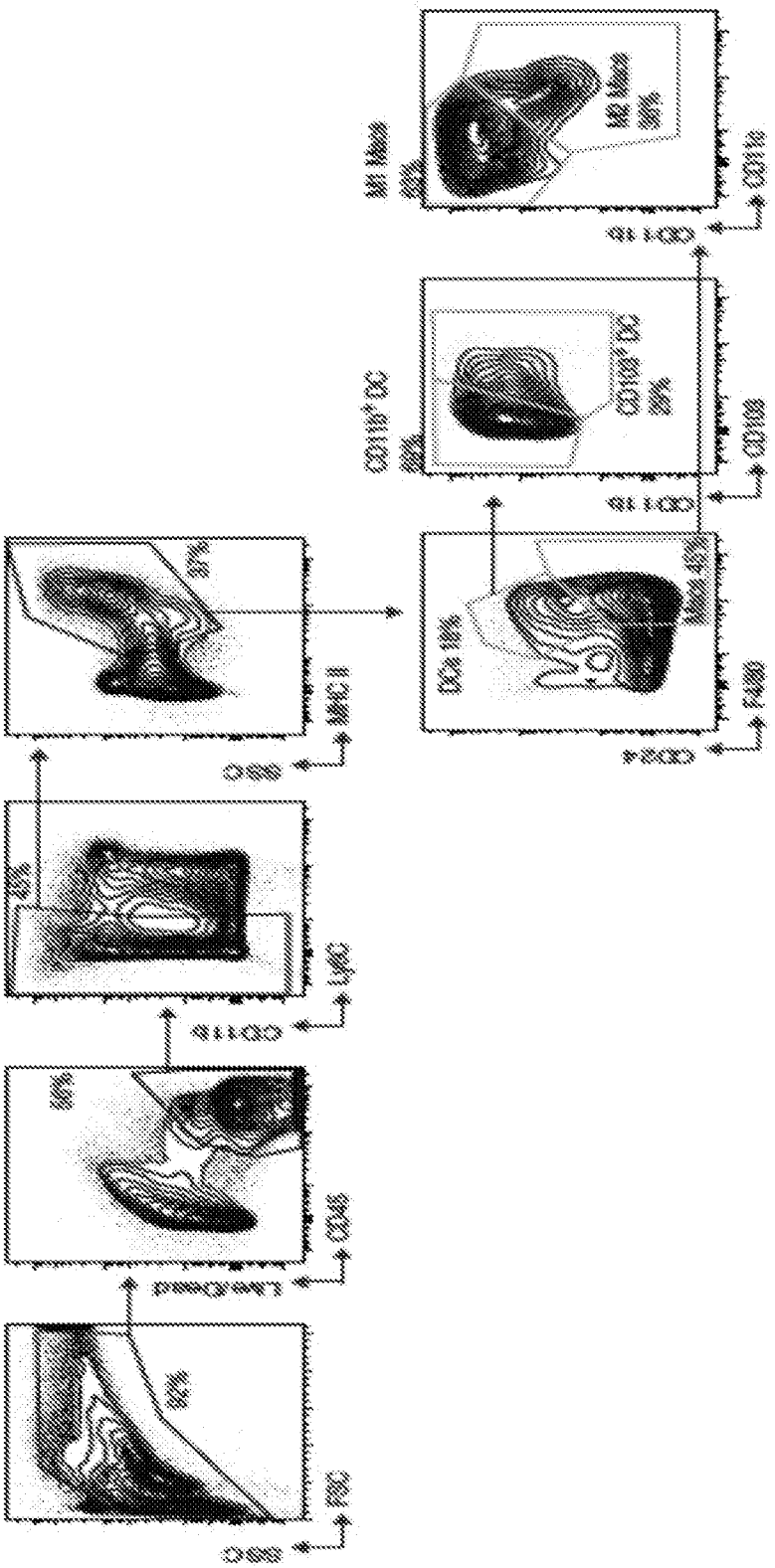

SSC
FSC
Live/Dead
CD45
CD11b
Ly6C
MHC II
CD64
F4/80
CD11c
CD103
CD11b
M1 Macs
M2 Macs

Figure 9 (cont.)

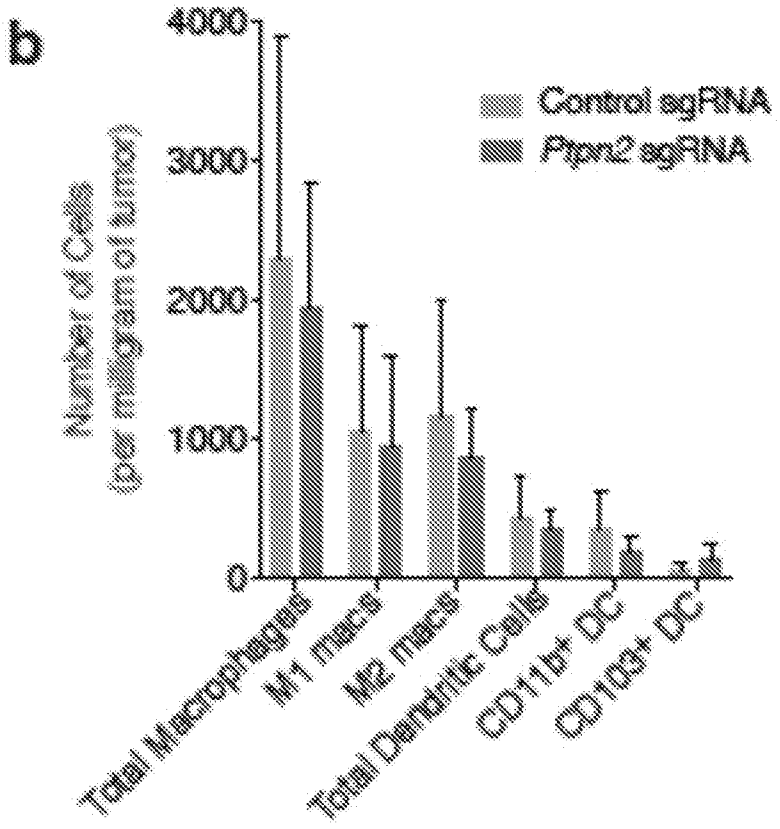
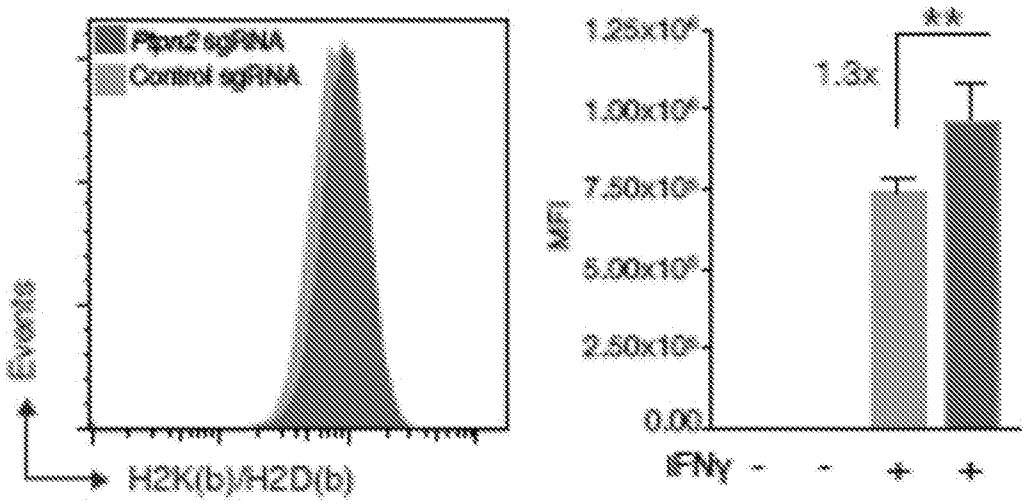


Figure 10

a


Ptpn2 sgRNA
Control sgRNA
Events
H2K(b)/H2D(b)
MFI
1.3x
**
IFNγ - - + +

b

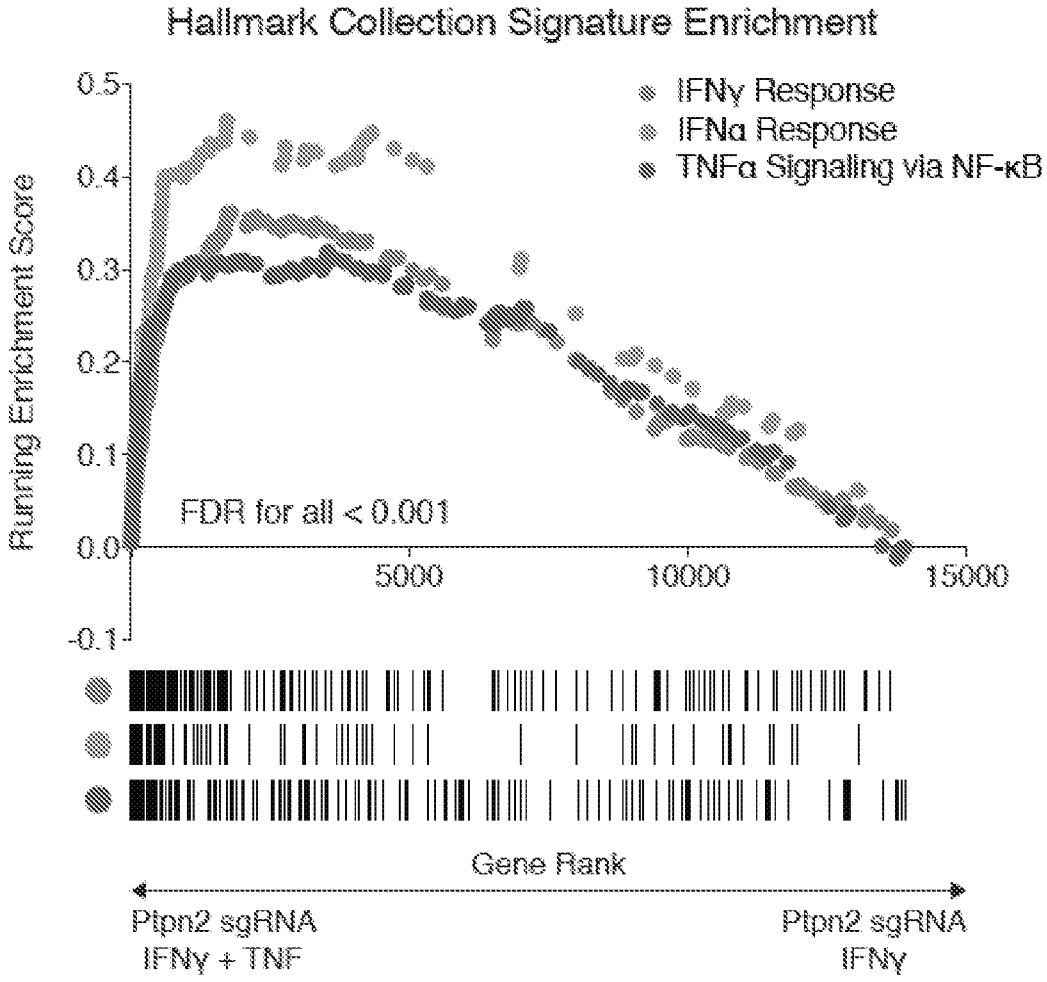
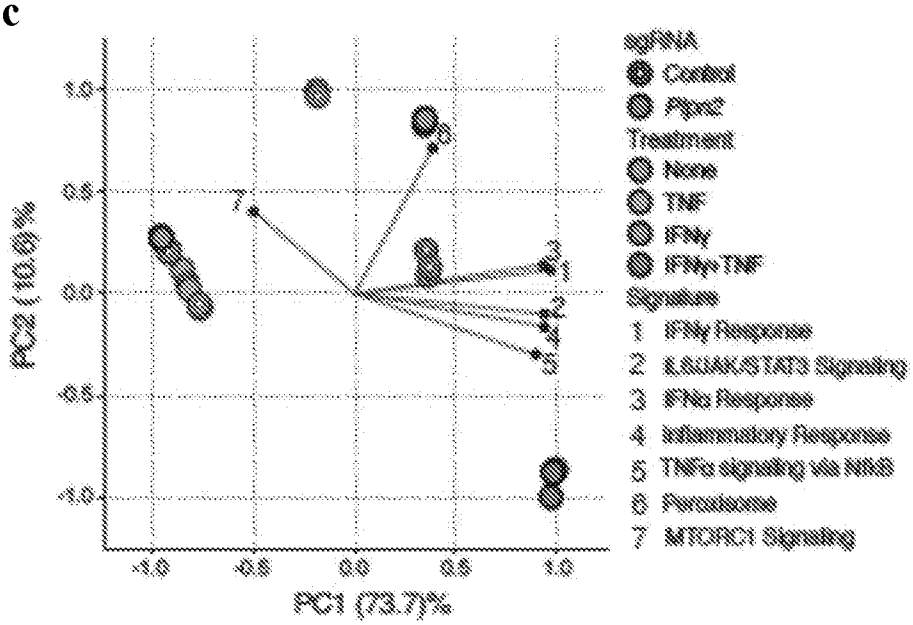

Hallmark Collection Signature Enrichment
IFNγ Response
IFNα Response
TNFα Signaling via NF-κB
Running Enrichment Score
FDR for all < 0.001
Gene Rank
Ptpn2 sgRNA
IFNγ + TNF
Ptpn2 sgRNA
IFNγ

Figure 11


a
Control
Ptpn2 null
Rescue
Overexpression
IFNγ
20 mins
p-STAT1
β-ACTIN
PTPN2
β-ACTIN
b
B16 melanoma
Control sgRNA
Ptpn2 sgRNA
Cxcl11
Zbp1
Nlrc5
Irf7
Ccl5
Ddx60
Casp4
Cxcl1
Tap1
Socs10
Irf1
Cd27
Tapbp
Ddx58
Stat2
B2m
Ifih1
Ifit2
Socs3
Stat1
Myd88
Stat3
Eif2ak2
Ripk1
Ifnar2
Cdkn1a
Jak2
Casp8
TNF - + - + - + - +
IFNγ - - + + - - + +
Gene expression
row min
row max

Figure 11 (cont.)

c



d

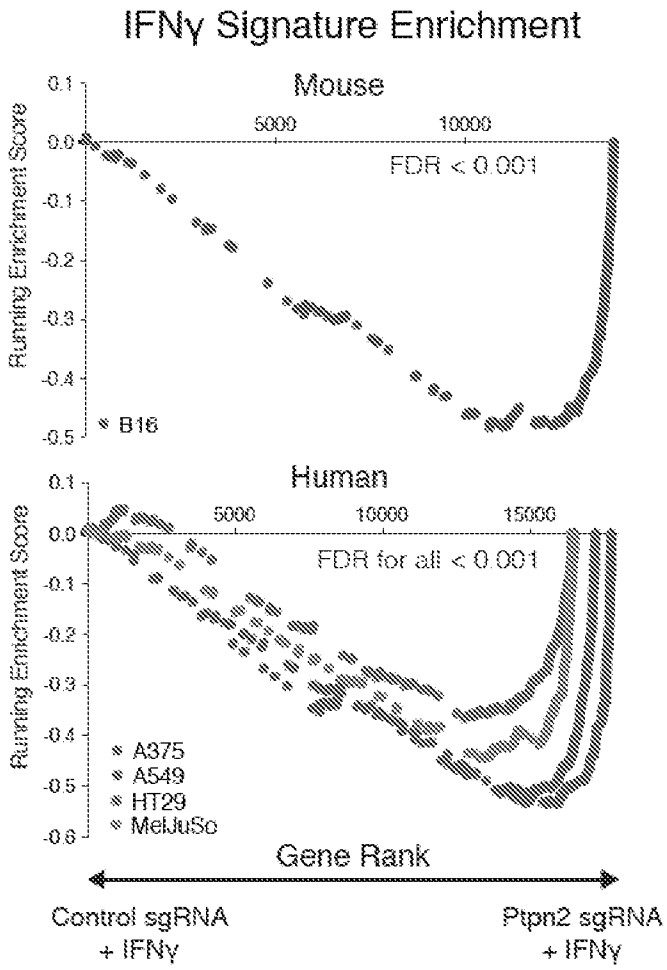
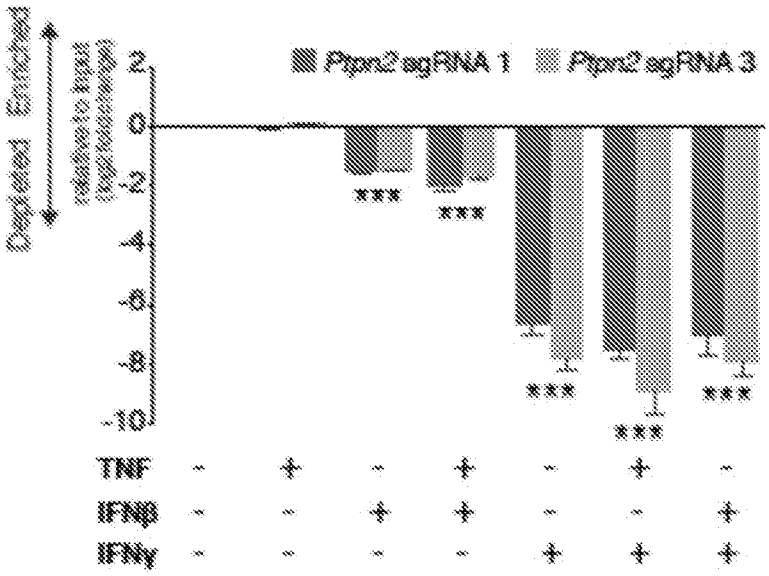
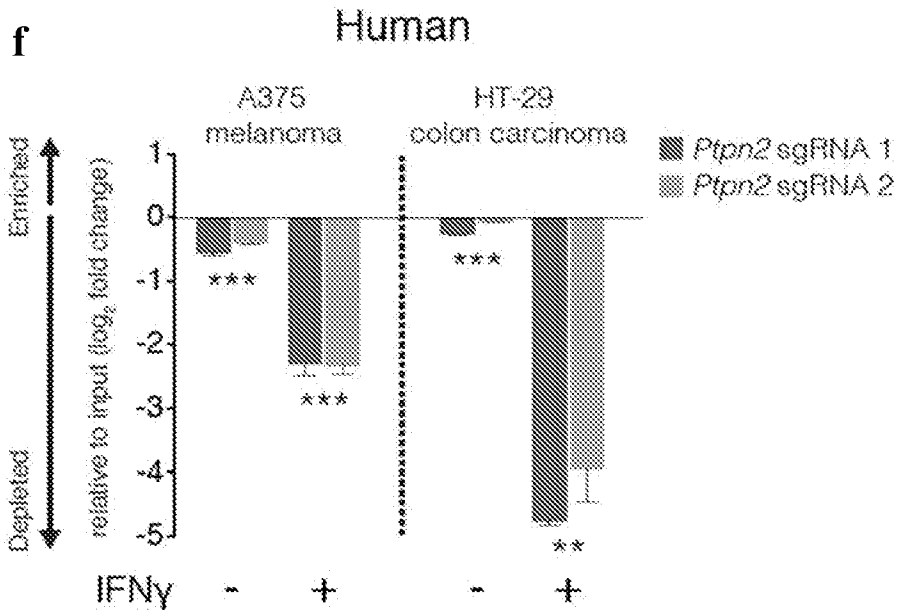


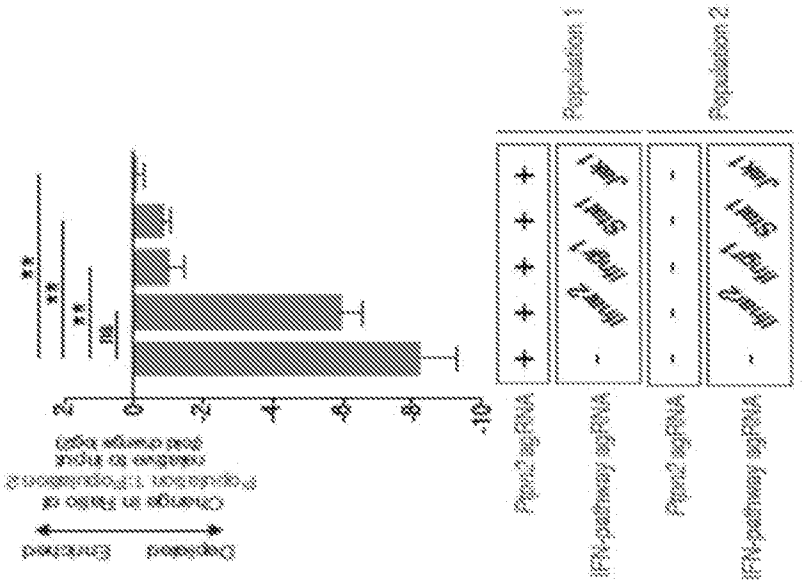
Figure 11 (cont.)

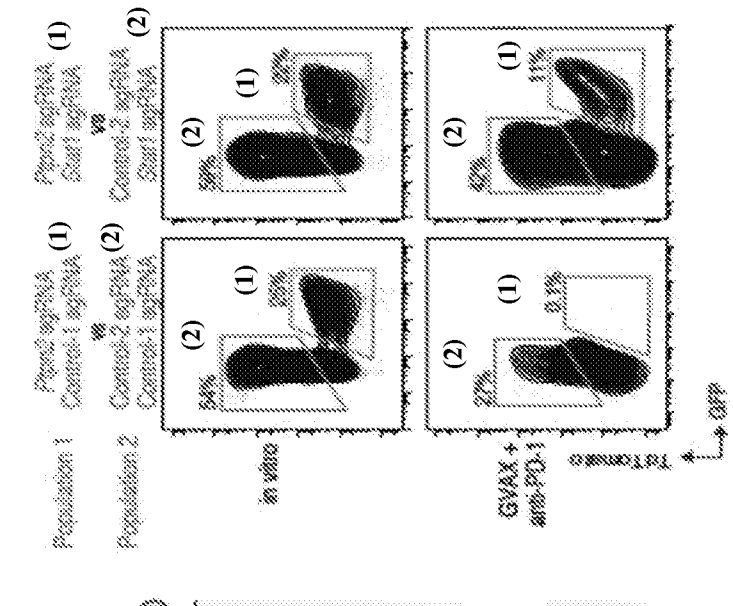
e



f







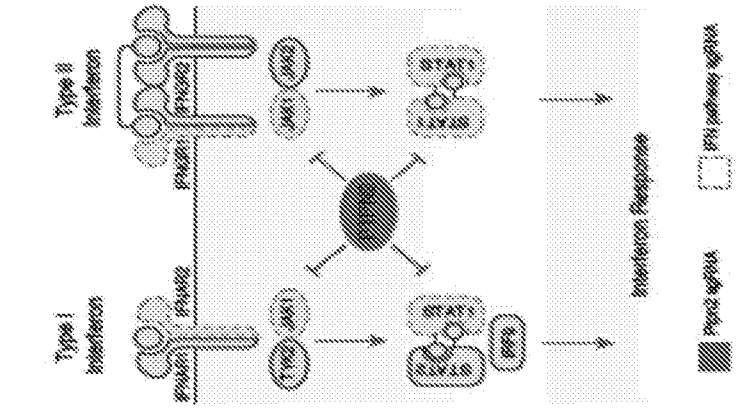
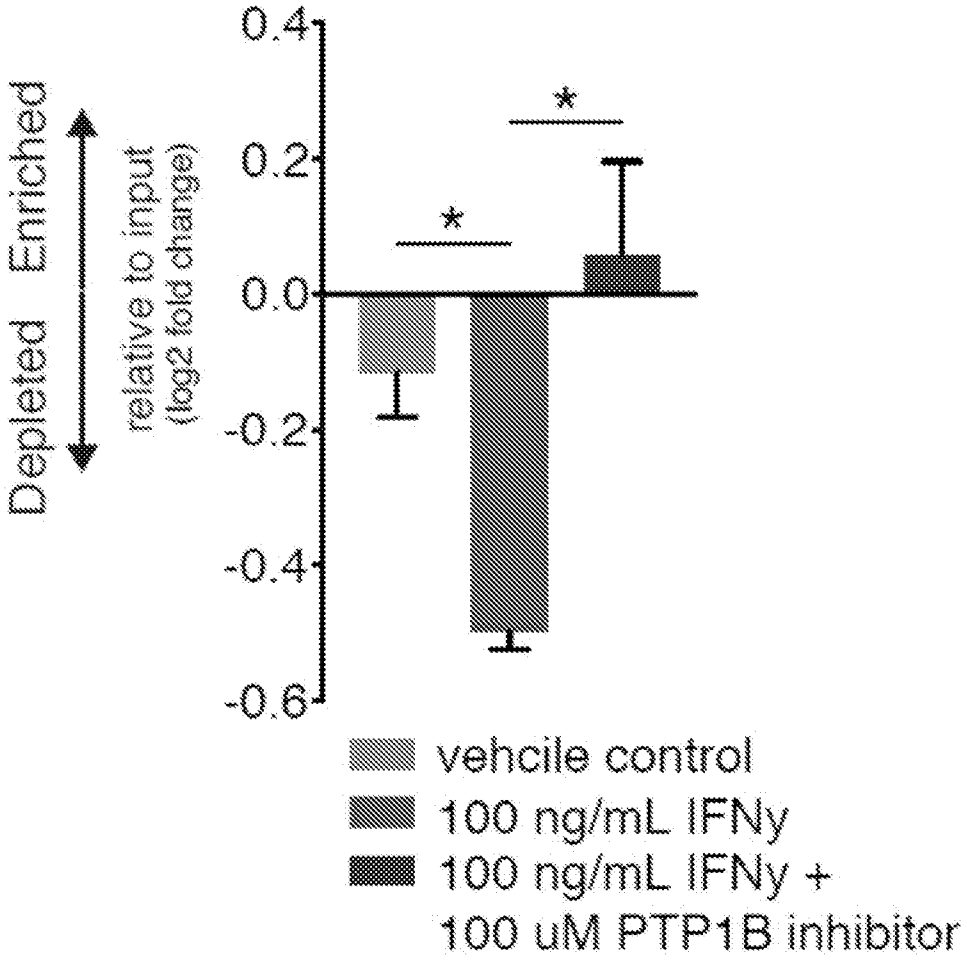


Figure 11 (cont.)

Figure 12


Depleted Enriched
relative to input
(log2 fold change)
0.4
0.2
0.0
-0.2
-0.4
-0.6
*
*
vehicle control
100 ng/mL IFNy
100 ng/mL IFNy +
100 uM PTP1B inhibitor

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 18/17379

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61K 38/18, A61K 48/00, A61P 35/00 (2018.01)
CPC - A61K 38/465, C12Y 301/03048, G01N 33/6893

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ------ Y	US 2005/0074878 A1 (COWSERT et al.) 07 April 2005 (07.04.2005) claims 1, 16-19; para [0025]; [0056]; [0123]; [0179]; [0195]-[0196]; [0202]; [0212].	1, 2, 65, (66,67)/65 ------ 3, 64, (66,67)/64
X ------ Y	WO 2015/188228 A1 (MONASH UNIVERSITY) 17 December 2015 (17.12.2015) claim 21; p. 6; p. 15-17; p. 27; p. 51.	29-31 ------ 3
X ------ Y	US 6,534,056 B1 (TROMBLAY et al.) 18 March 2003 (18.03.2003) col 2, ln 30-60; col 3, ln 44-66; col 8, ln 6-10; col 10, ln 1-20; col 22, ln 20-32.	57-60 ------ 63, 64, (66,67)/64
Y	US 2013/0202577 A1 (TIGANIS et al.) 08 August 2013 (08.08.2013) para [0033]-[0035]; [0043].	63

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2018	01 MAY 2018
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 18/17379

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-28, 32-56, 61, 62, 68-80
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.