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(57) Abstract: The present invention provides methods, compositions, systems, and kits comprising nano-satellite complexes comprising: a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core; 3-25 satellite particles attached to, or absorbed to, said biocompatible coating; a plurality of antigenic peptides conjugated to, or absorbed to, said satellite particles; and at least one additional property: i) a weight-to-weight ratio of all of the satellite particles to the nanoparticle core of 10-40%; a diameter of each of the satellite particles is 2-20 nm; iii) the satellite particles are present at density of 500-20,000 or 15,00-30,000 per square micron; iv) the plurality of antigenic peptides is 100-4000 antigenic peptides; v) 10-300 of the plurality of the antigenic peptides are present on each of the satellite particles; and/or vi) the average distance between each of the satellite particles is 5-20 nm.



NANO-SATELLITE COMPLEXES

The present application claims priority to U.S. Provisional application serial number 62/746,755, filed October 17, 2018, which is herein incorporated by reference in its entirety.

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FIELD OF THE INVENTION

The present invention provides methods, compositions, systems, and kits comprising nano-satellite complexes comprising: a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core; 3-25 satellite particles attached to, or absorbed to, said biocompatible coating; a plurality of antigenic peptides conjugated to, or absorbed to, said satellite particles; and at least one additional property: i) a weight-to-weight ratio of all of the satellite particles to the nanoparticle core of 10-40%; a diameter of each of the satellite particles is 2-20 nm; iii) the satellite particles are present at density of 500-20,000 or 15,00-30,000 per square micron; iv) the plurality of antigenic peptides is 100-4000 antigenic peptides; v) 10-300 of the plurality of the antigenic peptides are present on each of the satellite particles; and/or vi) the average distance between each of the satellite particles is 5-20 nm.

BACKGROUND

Viruses are known to be tremendously efficient delivery vehicles, mediators of cellular uptake and efficacious immunological agents. As such, it has become desirable to utilize viruses and viral properties in wide variety of biotechnology and medicinal applications. However, traditional live attenuated or inactivated viruses remain too dangerous to be employed in this way. To address this concern, virus-like particles have emerged.

Virus-like particles are protein-based nanoparticles that are composed of viral capsid proteins that self-assemble into geometrically rigid nanostructures that directly resemble viral structure and confirmation without the viral genome. Thus, viral-like particles are considered a viable and safe alternative to traditional viruses. Despite this advantage however, numerous obvious disadvantages of virus-like particle technology remain including reliance on protein self-assembly, difficult manufacturing, limited application versatility and significant anti-carrier responses that limits re-dosing potential in-vivo. As a result of these challenges, there has been increasing interest in the development of alternative nanoparticle systems that are viral inspired.

These so-called, viral mimicking nanoparticles are rationally designed and engineered based on an understanding of viral physical and chemical material properties. The viral material properties most commonly utilized to inform the design of viral mimicking nanoparticles include: particle size, particle shape, charge, hydrophobicity, antigen display, antigen organization, antigen density and surface topography. While many advances have been made in the design, engineering and application of viral-mimicking nanoparticles, no one generally applicable nanoparticle system has emerged.

SUMMARY OF THE INVENTION

The present invention provides methods, compositions, systems, and kits comprising nano-satellite complexes comprising: a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core; 3-25 satellite particles attached to, or absorbed to, said biocompatible coating; a plurality of antigenic peptides conjugated to, or absorbed to, said satellite particles; and at least one additional property: i) a weight-to-weight ratio of all of the satellite particles to the nanoparticle core of 10-40%; a diameter of each of the satellite particles is 2-20 nm; iii) the satellite particles are present at density of 500-20,000 or 15,00-30,000 per square micron; iv) the plurality of antigenic peptides is 100-4000 antigenic peptides; v) 10-300 of the plurality of the antigenic peptides are present on each of the satellite particles; and/or vi) the average distance between each of the satellite particles is 5-20 nm. In certain embodiments, the diameter of the nano-satellite complex is about 20-70 nm (e.g., about 25 nm, about 40-50 nm, or about 60 nm).

In certain embodiments, provided herein are compositions comprising: a nano-satellite complex, wherein the nano-satellite complex comprises: a) a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core; b) 3-25 satellite particles (e.g., 3 ... 7 ... 13 ... 17 ... 21 ... or 25) attached to, or absorbed to, the biocompatible coating; c) a plurality of antigenic peptides (e.g., from Table 4 or Table 1, Table 2, or Table 3), or a plurality of haptens, conjugated to, or absorbed to, the satellite particles; and d) wherein the nano-satellite complex comprises at least one (e.g., 1, 2, 3, 4, 5, or 6) of the following properties: i) wherein the weight-to-weight ratio of all of the satellite particles to the nanoparticle core is 10-40% (e.g., 10% ... 20% ... 30% ... or 40%); ii) wherein the diameter of each of the satellite particles is 2-20 nm (e.g., 2 ... 5 ... 8 ... 13 ... 17 ... 20 nm); iii) wherein the satellite particles are present at density of 500-20,000 per square micron (e.g., 500 ... 1000 ... 4000 ... 8000 ... 13,000 ... 17,000 ... or 20,000 per square micron); iv) wherein the plurality of antigenic peptides, or plurality of haptens, is 100-

4000 antigenic peptides (e.g., 100 ... 500 ... 1000 ... 2000 ... 3000 ... or 4000); v) wherein 10-300 (e.g., 10 ... 40 ... 100 ... 175 ... 225 ... or 300) of the plurality of the antigenic peptides, or of the plurality of haptens, are present on each of the satellite particles; and vi) wherein the average distance between each of the satellite particles is 5-20 nm (e.g., 5.0 ...
 5 6.5 ... 7.5 ... 10 ... 13 ... 17 ... or 20 nm).

In certain embodiments, provided herein are compositions, kits, and systems comprising: a nano-satellite complex, wherein said nano-satellite complex comprises: a) a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core (e.g., wherein the nanoparticle core is about 12-18 nm in diameter); b) 10-20 satellite
 10 particles attached to, or absorbed to, said biocompatible coating; c) a plurality of antigenic peptides (e.g., from Table 4 or Table 1, Table 2, or Table 3) conjugated to, or absorbed to, said satellite particles; and d) wherein said nano-satellite complex comprises at least one of the following properties: i) wherein the weight-to-weight ratio of all of said satellite particles to said nanoparticle core is 10-40% (e.g., 10% ... 20% ... 30% ... 40%); ii) wherein the
 15 diameter of each of said satellite particles is 1-5 nm (e.g., about 1, 2, 3, 4, or 5 nm); iii) wherein said satellite particles are present at density of 15,00-30,000 per square micron (e.g., 15,000 ... 18,000 ... 21,000 ... 25,000 ... 28,000 ... or 30,000); iv) wherein said plurality of antigenic peptides is 1500-3000 antigenic peptides (e.g., about 1500 ... 1900 ... 2200 ... 2300 ... 2600 ... 3000); v) wherein 100-400 (e.g., 100 ... 200 ... 250 ... 300 ... 400) of said plurality
 20 of said antigenic peptides are present on each of said satellite particles; and vi) wherein the average distance between each of said satellite particles is 4-7 nm (e.g., 4.0 ... 5.0 ... 5.2 ... 5.9 ... 6.1 ... or 7.0 nm).

In some embodiments, provided herein are kits and systems comprising: a) a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core;
 25 b) 3-25 satellite particles configured to be attached to, or absorbed to, the biocompatible coating; c) a plurality of antigenic peptides, or a plurality of haptens, configured to be conjugated to, or absorbed to, the satellite particles; and d) at least one of the following: i) wherein the weight-to-weight ratio of all of the satellite particles to the nanoparticle core is 10-40%; ii) wherein the diameter of each of the satellite particles is 2-20 nm; and iii) wherein
 30 the plurality of antigenic peptides, or plurality of haptens, is 100-4000 antigenic peptides.

In particular embodiments, provided herein are methods of eliciting an immune response in a subject comprising: administering to a subject the composition as described herein such that antibodies to the antigenic peptides, or haptens, are generated. In certain embodiments, the subject is a human. In other embodiments, the subject is an animal (e.g.,

dog, cat, pig, horse, etc.). In additional embodiments, the methods further comprise taking a sample from the subject, and purifying at some of the antibodies from the sample. In additional embodiments, no adjuvant is administered as part of the composition or otherwise. In some embodiments, the subject is administering a type I interferon agonist agent, either in the composition or separately. In further embodiments, the subject is administering an immune checkpoint inhibitor, either in the composition or separately. In certain embodiments, the antigenic peptides comprise B-Cell epitopes, or T-cell epitopes, or both (see, e.g., Table 4 or Table 1, Table 2, or Table 3). In other embodiments, the nanosatellite complex does not generate detectable non-specific antibody against said nano-satellite complex in the subject. In further embodiments, the nanosatellite complex homes to a lymph node of said subject (e.g., at a level equal to a virus). In further embodiments, the nanosatellite complex homes to a B-cell zone or T-cell zone of a lymph node of said subject. In further embodiments, the nanosatellite complex is taken up by subcapsular sinus macrophages in said subject at a rate equal to a virus.

In certain embodiments, the satellite particles comprise gold. In other embodiments, the core nanoparticle comprises Fe_3O_4 . In some embodiments, the biocompatible coating comprises polysiloxane. In other embodiments, the nanoparticle core comprises Fe_3O_4 , the biocompatible coating comprises polysiloxane, and the at least one satellite particle comprises a plurality of satellite particles composed of gold.

In some embodiments, the 3-25 satellite particles is 10-15 satellite particles. In other embodiments, the at least one property is wherein the weight-to-weight ratio of all of the satellite particles to the nanoparticle core is 10-40% (e.g., about 30%). In additional embodiments, the weight-to-weight ratio of all of the satellite particles to the nanoparticle core is 25-35%. In certain embodiments, the weight-to-weight ratio of all of the satellite particles to the nanoparticle core is 29-31%.

In some embodiments, the at least one property is wherein the diameter of each of the satellite particles is 2-20 nm. In certain embodiments, the diameter of each of the satellite particles is 5-15 nm. In further embodiments, the diameter of each of the satellite particles is 4-6 nm.

In particular embodiments, the at least one property is wherein the satellite particles are present at density of 500-20,000 per square micron. In other embodiments, the satellite particles are present at a density of 13,000 to 17,000 per square micron.

In some embodiments, the at least one property is wherein the plurality of antigenic peptides is 100-4000 antigenic peptides or 100-4000 haptens. In other embodiments, the

plurality of antigenic peptides is 1500-2500 antigenic peptides, or wherein the plurality of haptens is 1500-2500.

In other embodiments, the at least one property is wherein 10-300 of the plurality of the antigenic peptides, or haptens, are present on each of the satellite particles. In further
5 embodiments, 225-275 of the plurality of antigenic peptides, or haptens, are present on each of the satellite particles.

In some embodiments, the at least one property is wherein the average distance between each of the satellite particles is 5-20 nm. In certain embodiments, the average distance between each of the satellite particles is 6-8 nm.

10 In further embodiments, the at least one property is at least two or three of the properties. In some embodiments, the at least one property is at least four or five of the properties. In additional embodiments, the at least one property is all six of the properties.

In certain embodiments, the antigenic peptide comprises: i) a neoantigenic determinant, ii) at least one epitope from a tumor antigen, iii) at least one epitope from a viral
15 oncoprotein, iv) a least one epitope from an infectious virus, v) at least one epitope from a parasite, or vi) at least one epitope from an infectious bacteria. In further embodiments, the compositions, systems, and kits further comprise a physiologically compatible aqueous solution and/or cancer cells and/or antigen presenting cells.

In some embodiments, the plurality of antigenic peptides are not uniformly distributed
20 on the satellite particles. In other embodiments, the the nano-satellite complex is a diameter of 50-100 nm (e.g., 55-65 nm). In further embodiments, the surface of the nano-satellite complex is negatively charged (e.g., -10 to -20 mV). In other embodiments, the core nanoparticle has a diameter of 10-25 nm (e.g., 15-20 nm).

In some embodiments, the composition further comprises a type I interferon agonist
25 agent. In other embodiments, the type I interferon agonist agent is electrostatically attracted to, or absorbed to, i) the antigenic peptides or haptens, ii) the plurality of satellite particles, and/or iii) the core nanoparticle. In additional embodiments, the compositions are adjuvant-free. In additional embodiments, the compositions further comprise an immune checkpoint inhibitor.

30 In further embodiments, the antigenic peptide comprises at least one neoantigenic determinant, including, for example, an oncogenic viral antigenic determinant. In some embodiments, the antigenic peptides comprise at least one epitope from a tumor antigen, including a viral oncoprotein. In certain embodiments, the antigenic peptide comprises a least one epitope from an infectious virus, at least one epitope from a parasite, and/or at least

one epitope from an infectious bacteria. Suitable antigens from viruses, parasites, and bacteria for immunizing subject (e.g., human subjects) are well known in the art (see, e.g., Tables 2 and 3). Additional antigens are in development for vaccines including, for example: Adenovirus vaccine, Coxsackie B virus vaccine, Cytomegalovirus vaccine, Dengue vaccine, Eastern Equine encephalitis virus vaccine, Ebola vaccine, Enterovirus 71 vaccine, Epstein–Barr vaccine, Hepatitis C vaccine, HIV vaccine, HTLV-1 T-lymphotropic leukemia vaccine, Marburg virus disease vaccine; Norovirus vaccine; Respiratory syncytial virus vaccine; Severe acute respiratory syndrome (SARS) vaccine; West Nile virus vaccine; Zika fever; Caries vaccine; Ehrlichiosis vaccine; Leprosy vaccine; Lyme disease vaccine; Staphylococcus aureus vaccine; Streptococcus pyogenes vaccine; Syphilis vaccine; Tularemia vaccine; Yersinia pestis vaccine; Malaria vaccine; Schistosomiasis vaccine; Chagas disease vaccine; Hookworm vaccine; Onchocerciasis river blindness vaccine for humans; Trypanosomiasis vaccine; and Visceral leishmaniasis vaccine.

In certain embodiments, the methods of administering the nano-satellite complexes herein to a subject kills at least some cancer cells and/or modulates antigen-specific immune response in the subject. In further embodiments, the cancer cells are from a type of cancer selected from the group consisting of: head and neck squamous-cell carcinoma (HNSCC), HPV-positive cancer, odontogenic tumors, bladder cancer, breast cancer, cervical cancer, colorectal cancer, leukemia, melanoma, non small lung cell cancer (NSCLC), ovarian cancer, pancreatic cancer, and prostate cancer. In additional embodiments, the cancer cells are part of a tumor in the subject. In further embodiments, the tumor is a hypo-immunogenic “cold” tumor, which is characterized by insufficient elicitation of tumor-specific immunity and resistance to immunogenic cytotoxicity.

In certain embodiments, the nano-satellite complexes can be also used as a photothermal agent and/or an MRI contrast agent.

In certain embodiments, the type I interferon agonist agent comprises activators of a type I interferon signaling adaptor protein, stimulator of interferon genes (STING), which include cyclic dinucleotides selected from c-di-GMP, c-di-AMP, and cGAMP, or its analogs. In other embodiments, the STING agonist agent is selected from the group consisting of: c-di-IMP, c-di-UMP, and 5,6-dimethylxanthenone-4-acetic acid (DMXAA), 2'3'-cGAM(PS)₂ (Rp/Sp), and 2'3'-c-di-AM(PS)₂ (Rp,Rp). In other embodiments, the type I interferon agonist agent comprises a Toll-like Receptor (TLR) family protein agonist, such as TLR9 agonist CpG. In particular embodiments, the kits, compositions, and systems further comprise a physiologically compatible aqueous solution and/or cancer cell lysates.

In certain embodiments, the subject is a human or other mammal. In some embodiments, the methods comprise combining the aforementioned nanosatellite complex with the administration of an immune checkpoint inhibitor agent to the subject. These immune checkpoint inhibitors may include monoclonal antibodies, such as anti-PD-L1, anti-CLTA-4, or anti-PD-1. In further embodiments, the immune check-point inhibitor agent is selected from: YERVOY (ipilimumab), KEYTRUDA (pembrolizumab), OPDIVO (nivolumab), and TECENTRIQ (atezolizumab).

In some embodiments, the core comprises a material selected from: near-infrared photothermal agent material and MRI contrast agent material, and the at least one satellite particle comprises near-infrared photothermal agent material, MRI contrast agent material, and near-infrared optical dye material. In additional embodiments, the nanoparticle core comprises a material that is selected from the group consisting of: Fe_3O_4 , silicon, gold, copper, and carbon. In some embodiments, the at least one satellite particle comprises a material is selected from the group consisting of: gold sulfide (Au_2S), copper sulfide (Cu_2S), carbon nanotubes, and graphene. In certain embodiments, there is no shell surrounding the core, but instead, there are the one or more satellite particles are clearly visible as discrete particles (e.g., as view by a tunneling electron microscope).

In embodiments, the nanoparticle core comprises Fe_3O_4 , and/or biocompatible coating comprises polysiloxane, and/or the at least one satellite particle comprises a plurality of satellite particles composed of gold. In certain embodiments, the core particle has a diameter of 15-20 nm. In other embodiments, the satellite particles have an average diameter of 2-6 nm. In particular embodiments, the core particle is spherical or cubical in shape.

In further embodiments, the core nanoparticle comprises a first type of material is selected from the group consisting of: Fe_3O_4 , silicon, gold, copper, and carbon. In particular embodiments, the first type of material comprises Fe_3O_4 . In additional embodiments, the Fe_3O_4 is highly crystallized and has an X-ray diffraction (XRD) pattern where the brightest diffraction ring is from the 440 plane. In further embodiments, the Fe_3O_4 has a preferred lattice orientation along the 400 and 440 XRD diffraction planes. In other embodiments, the satellite particle comprise a second type of material that is selected from the group consisting of: gold, gold sulfide (Au_2S), copper, copper sulfide (Cu_2S), carbon, carbon nanotubes, and graphene. In certain embodiments, the second type of material comprises gold sulfide (Au_2S). In other embodiments, the near-infrared optical dye material is selected from the group consisting of: IR820, ICG, and 5, aminolevulinic acid (5-ALA). The present invention

is not limited by the shape of the core or the satellite particle. Examples of shapes include, but are not limited to, spherical, cubic, rod shaped, disc shaped, etc.

In some embodiments, each of the satellite particles has a size between 0.5 nm and 25 nm in diameter (e.g., 0.5 ... 1.5 ... 10 ... 15 ... 20 ... 23 ... and 25 nm). In further
 5 embodiments, the satellite particles have a size between 2 nm and 7 nm in diameter (e.g., about 5 nm or about 2-4 nm). In further embodiments, the nanoparticle core has a size between 35 and 100 nm in diameter. In further embodiments, the nano-satellite complex is present in the composition at a concentration of between 1.0 and 5.0 mg/mL (e.g., 1.0 ... 3.3 .. and 5.0 mg/ml). In other embodiments, the biocompatible coating comprises a material
 10 selected from the group consisting of: human serum albumin (HSA), polyethylene glycol, triblock copolymer, PEO-b-PPO-b-PEO (F121), PEO-b-PVP, glucosylated poly(pentafluorostyrene), chitosan, silica, and gum Arabic, gluconic acid, lactobionic acid, polyacrylic acid, apatite, and Casein. In additional embodiments, the biocompatible coating is functionalized with thiol groups or amine groups. In particular, one can use siloxane
 15 molecules like (3-Mercaptopropyl) trimethoxysilane (MPTMS) to produce thiol groups or (3-Aminopropyl)triethoxysilane to produce amine groups on nanoparticle surfaces to functionalize polymer coated nanoparticles.

In some embodiments, the administering the nano-satellite complexes to a subject generates a plurality of core-satellite nanocomposite-impregnated cancer cells in the subject.
 20 In further embodiments, the methods comprise: subjecting the subject to photothermal therapy and/or imaging, wherein the photothermal therapy: A) comprises the use of a treatment device that emits electromagnetic radiation, and B) causes at least a portion of the core-satellite nanocomposite-impregnated cancer cells to be damaged or killed; and wherein the imaging: A) comprises the use of an imaging device configured for MRI/NMR detection
 25 and/or optical detection, and B) causes at least a portion of the core-satellite nanocomposite-impregnated cancer cells to be visualized *ex-vivo*.

DESCRIPTION OF THE FIGURES

The patent or application file contains at least one drawing executed in color. Copies
 30 of this patent or patent application publication with color drawings will be provided by the Office upon request and payment of the necessary fee.

Figure 1, top shows a simplified schematic for generating an exemplary inorganic virus-like nanoparticle (IVLN) blank and IVLN-peptide complex. Figure 1, bottom, shows a

simplified schematic for generating lipid-coated iron-oxide nanoparticle (Lipid-IONP), which are used as controls in Example 1.

Figure 2a shows the IVLN formulation conditions and loading efficiency of satellite particles on iron-oxide nanoparticle cores. Figure 2b shows TEM imaging of the IVLN at different formulation conditions. Figure 2c shows mathematical modeling of distance between satellites at different formulation conditions. Figure 2d shows mathematical modeling of satellite density on nanoparticle surfaces at different formulation conditions. Figure 2e shows peptide loading on IVLN surfaces and loading specificity to satellites. Figure 2f shows the volume-weighted hydrodynamic particle distribution of IVLN at different stages of the formulation.

Figure 3 shows results of Example 1 for antigen-specific antibody production in mice using IVLN-peptides. Figure 3a shows the experimental timeline and immunization schedule. Figure 3b shows the antigen-specific IgG titers at different IVLN formulation conditions and peptide densities 10 days after boost 1. Figure 3c shows the antibody quantification and antigen-specific IgG titers for IVLN versus soluble and nanoparticle-type controls.

Figure 4a shows the delivery efficiency and kinetics of nanoparticles to the lymph node quantified as percent of initial iron dose based on ex-vivo quantification using ICP-MS. Figure 4b shows the semi-quantitative analysis of peptide delivery to lymph nodes at 3 hours based on ex-vivo IVIS imaging. Figure 4c shows the distribution of nanoparticles to lymphocytes and antigen-presenting cells in the lymph node at 3 hours *in-vivo*. Figure 4d shows the cellular uptake of nanoparticles *in-vitro*.

Figure 5 shows the amino acid sequence of ERBB2/HER2 protein (SEQ ID NO:4), with identified T cell epitopes or HLA ligands are highlighted in gray shading, as provided by TANTIGEN, the Tumor T-cell Antigen Database.

Figure 6 shows an exemplary nano-satellite complex, with various exemplary parameters labelled.

Figure 7 shows, in certain embodiments, inorganic viral-like nanosatellites (IVLNs) have three important features that resemble the spiky antigen peplomer of virus: Spiky antigen cluster topography, optimal distance (5 nm) between antigen clusters, and localized high antigen density on the spike. (A) Schematic representation of the step-wise production of peptide functionalized inorganic virus-like nanoparticles (IVLN-HER2) by the (1) self-assembly of AuNPs to polymer-coated IONP surfaces via the gold-siloxane interaction (IVLN) followed by the (2) conjugation of terminal cysteine-modified HER2 peptide to

IVLN via gold-thiol bond. **(B)** Gold nanoparticle (AuNP) loading per iron-oxide nanoparticles core (IONP) measured by ICP-MS. Data represent mean $\pm$ SD, $n \geq 6$; curve is fit using linear regression model, $R^2 = 0.998$, $p < 0.001$. **(C)** STEM HAADF images of IVLN at increasing AuNP/IONP ratios from 0-30%; scale-bar: 0% wt condition (50 nm); scale-bar: 5-30% wt conditions (20 nm). **(C-insert)** STEM image of single IVLN. **(D)** Distances between AuNPs on IVLN surfaces as calculated by mathematical modeling (Fig S2). **(E)** AuNP density (per unit area) on IVLN surfaces as compared to the known antigen density on viral capsids as calculated by mathematical modeling. **(F)** Peptide loading on IVLNs with variable AuNP (0 AuNPs – black; 4 AuNPs – blue; 12 AuNPs – red) as determined by a modified fluorescamine fluorescent detection assay; data represent mean $\pm$ SD, $n = 3$; curve is fit using linear regression model, (0 AuNPs: $R^2 = 0.904$, $p < 0.01$; 4 AuNPs: $R^2 = 0.962$, $p < 0.01$; 12 AuNPs: $R^2 = 0.977$, $p < 0.001$). **(G)** Peptide loading on lipid-coated iron-oxide nanoparticles (IONP-HER2) data represent mean $\pm$ SD, $n = 3$; curve is fit using linear regression model ($R^2 = 0.989$, $p < 0.001$). **(H)** Diagram and volume-weighted particle size of IVLN-HER2 by dynamic light scattering (DLS). **(I)** Diagram and volume weighted particle size of lipid-coated iron-oxide nanoparticle-HER2 (IONP-HER2).

Figure 8 shows data from Example 2 which showed that the tested IVLN-HER2 Enhanced antigen-specific antibody production. **(A)** Animal study immunization and analytical sampling timeline. **(B)** Quantification of non-specific total IgG and antigen-specific antibody titers (IgG, IgG1 and IgG2a) from the serum of BALB/c mice at day 38 and at 5 μ g HER2 peptide + 10 μ g cGAMP as adjuvant. **(C)** Quantification of non-specific total IgG and antigen-specific antibody titers (IgG, IgG1 and IgG2a) from the serum of BALB/c mice at day 38 and at 50 μ g HER2 peptide + 10 μ g cGAMP as adjuvant; data represent mean $\pm$ SE, $n = 5$. Data represent mean $\pm$ SE, $n = 5$. Statistical comparisons are based on one-way ANOVA, followed by post hoc Tukey's pairwise comparisons. The asterisks denote statistical significance at the level of * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. ANOVA, analysis of variance; SE, standard error; n.s., no statistical significance.

Figure 9 shows results from Example 2, including results with an IVLN with the following properties: antigen clusters (14 clusters), distance between antigen clusters (5-6 nm), and localized antigen density (2000 peptides/IVLN, $\sim$ 150 peptides/AuNP) for generation of HER2-specific IgG. **(A)** Immunization scheme in mice. **(B)** Quantification of antigen-specific IgG antibodies by ELISA represented as antibody titer; data represent mean $\pm$ SE, $n = 5$. Statistical comparisons are based on one-way ANOVA, followed by post hoc

Tukey's pairwise comparisons. The asterisks denote statistical significance at the level of * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. ANOVA, analysis of variance; SE, standard error.

Figure 10 shows the IVLN-HER2 tested in Example 2 increased 6-fold higher Ag-specific B cell activation and GC formation vs. IONP-HER2. **(A)** Representative FACS plots for the gating strategy of HER2-specific B-cells using B-cell receptor tetramer staining, identified as the CD19⁺Tetramer⁺ population. **(B)** Quantification of the percentage of HER2-specific B-cells of total viable cells induced 10 days after the primary immunization at 50 µg HER2 peptide dose + 10 µg cGAMP as adjuvant; data represent mean ± SE, $n \geq 3$. **(C)** Representative FACS plots for the gating strategy of GC cells. GC cells were identified as the B220⁺IgD_{low} population that was double-positive for mature GC cell marker CD95 and GL-7. **(D)** Quantification of percentage of GC type cells of the total B220⁺ B-cell population induced 10 days after the primary immunization at 50 µg HER2 peptide dose + 10 µg cGAMP as adjuvant; data represent mean ± SE, $n \geq 3$. Statistical comparisons are based on one-way ANOVA, followed by post hoc Tukey's pairwise comparisons. The asterisks denote statistical significance at the level of * $p < 0.05$, *** $p < 0.001$. ANOVA, analysis of variance; SE, standard error.

Figure 11 shows results of Example 2 which shows a CyTOF analysis of immune cells reveals that IVLN-HER2 promoted Tfh-dependent B cell activation in the lymph node. CyTOF analysis of immune cells in the lymph node 38 days after first immunization (10 days after second boost). **(A, B)** Global analysis using SPADE unsupervised clustering analysis. Nodes contain cells with similar marker expression. Nodes are colored based on whether the relative number of cells within that node is higher (blue) or lower (red) in IVLN-HER2 samples in comparison with IONP-HER2 or HER2. **(D)** The frequencies of germinal center B cells (CD19⁺/GL7⁺ or B220⁺/GL7⁺) in the lymph node in mice immunized with INLN-HER2, INOP-HER2, and HER2 peptide alone. **(D)** The frequencies of CD4⁺ T follicular helper T cells (CD4⁺/CXCR5⁺/PD-1⁺) in the lymph nodes of the mice immunized with INLN-HER2, INOP-HER2, and HER2 peptide. **(E)** The frequencies of plasma cells in the lymph nodes of the mice immunized with INLN-HER2, INOP-HER2, and HER2 peptide. (50 µg HER2 Peptide, 10 µg cGAMP).

Figure 12 shows results from Example 2 that shows IVLN-HER2 improved lymph node delivery and B cell zone distribution in comparison with IONP-HER2. **(A)** Quantification of nanoparticle delivery to lymph nodes (popliteal + inguinal) ipsilateral to the administration site at designated time intervals represented as the percentage of initial iron-oxide delivered using ICP-MS; data represent mean ± SE, $n = 3$. **(B)** Representative ex-vivo

IVIS fluorescence images and semi-quantitative analysis (popliteal (top) + inguinal (bottom)) of peptide delivery to lymph nodes acquired 3 hours after administration of Cy5.5-labeled soluble HER2 peptide, IONP-HER2-Cy5.5 and IVLN-HER2-Cy5.5 (Ex/Em = 675/720 nm, exposure = 0.5 s). The color bar represents mean radiant efficiency (p/s/cm²/sr)/(μW/cm²); data represent mean ± SD, n = 3. (C) Quantification of *in-vivo* nanoparticle distribution to specific immune cell populations in the lymph nodes as identified by flow cytometry (Cy5.5-labeled nanoparticles); Subcapsular sinus macrophages are identified as CD11b⁺CD169^{high}; B-cells are identified as B220⁺; data represent mean ± SD, n = 3. (D) Quantification of *in-vitro* cell uptake of nanoparticles in RAW264.7 macrophages and murine primary B-cells by ICP-MS quantification of total Fe standardized by cell count (pg Fe per cell). Data represent mean ± SD, n = 3. Statistical comparisons are based on one-way ANOVA, followed by post hoc Tukey's pairwise comparisons or by Student's unpaired T-test. The asterisks denote statistical significance at the level of ** $p < 0.01$, *** $p < 0.001$. ANOVA, analysis of variance; SD, standard deviation; SE, standard error.

Figure 13 shows results from Example 2 that show IVLN-HER2 induced HER2-specific antibody has function to inhibit HER2⁺ cancer. (A) Animal study immunization and HER2⁺ breast cancer (D2F2/E2) tumor inoculation timeline. (B) Tumor volume growth curves for D2F2/E2 tumors subcutaneously implanted into the flank of BALB/c mice at 250,000 cells per mouse treated with 50 μg HER2 peptide dose + 10 μg cGAMP. (C) Tumor volume growth curves for D2F2/E2 tumors subcutaneously implanted into the flank of BALB/c mice at 250,000 cells per mouse treated with 5 μg HER2 peptide dose + 10 μg cGAMP. Data represent mean ± SE, n = 5. Statistical comparisons are based on one-way ANOVA, followed by post hoc Tukey's pairwise comparisons. The asterisks denote statistical significance at the level of * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. ANOVA, analysis of variance; SE, standard error.

DETAILED DESCRIPTION

The present invention provides methods, compositions, systems, and kits comprising nano-satellite complexes comprising: a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core; 3-25 (or 2-35) satellite particles attached to, or absorbed to, said biocompatible coating; a plurality of antigenic peptides (or haptens with carrier) conjugated to, or absorbed to, said satellite particles; and at least one additional property: i) a weight-to-weight ratio of all of the satellite particles to the nanoparticle core of 10-40%; a diameter of each of the satellite particles is 2-20 nm; iii) the

satellite particles are present at density of 500-20,000 or 15,00-30,000 per square micron; iv) the plurality of antigenic peptides is 100-4000 antigenic peptides; v) 10-300 of the plurality of the antigenic peptides are present on each of the satellite particles; and/or vi) the average distance between each of the satellite particles is 5-20 nm. In certain embodiments, the nanosatellite complexes have a viral-like topology with virus-like antigen patch distances and a 3D patch topology.

Viruses are nature's most efficient delivery vehicles and efficacious immunological agents. As such, for decades now, viral material properties have been inspirational to nanoparticle design and engineering. These so-called viral mimicking nanoparticles have the potential to be widely exploited for applications including drug delivery, molecular imaging, cancer immunotherapy and genetic transfections. However, to date, this potential has been limited by a selective material property approach to viral mimicry. Here, we demonstrate that a holistic approach to viral mimicking nanoparticle design is vital for functional efficacy. Specifically, in some embodiments, described herein are nano-satellite complexes that, in comparison to traditional nanoparticle systems, has unique surface roughness, epitope organization and epitope density. Work conducted during developments of embodiments, herein, it was found that, in the context of B-cell immunity and lymph node delivery, these nanoparticles features resulted in 18.5-fold improvement in antigen-specific IgG antibody production in a mouse model (see Example 1). Mechanistically, it was shown that this significant improvement in antibody production is the result of a 3-fold improvement in lymph node delivery and 2 to 3-fold higher retention with relevant immune cell populations, which facilitates an increase in B-cell activation and germinal center formation, respectively.

In certain embodiments, the nano-satellite complexes herein employ a hybrid Fe@Au core/satellite nanoparticle with a poly(siloxane) containing diblock copolymer coated iron-oxide nanoparticle core (e.g., IONP, 15-20 nm) that anchors a controlled quantity of gold nanoparticles (e.g., AuNP, 2-3 nm) to the surface. Through these gold nanoparticles, terminally cysteine modified peptides are conjugated at defined quantities and densities utilizing the Au-S bond.

While the present disclosure is not limited to any particular mechanism, it is believed that, compared to traditional viral mimicking nanoparticle systems, the nano-satellite nanoparticle complexes herein incorporates more biologically relevant surface topography, as well as antigen display at spatially defined and locally high density that is akin to the geometric rigidity of viruses. The nano-satellite nanoparticles herein can be harnessed for a myriad of biological applications, including use in the context of B-cell immunity. In this

context, these unique material properties would manifest as enhanced antigen-presenting cell uptake and B-cell immunity due to improved B-cell receptor crosslinking.

In work conducted during development of embodiments, herein, the results generated (in Example 1) indicate that nano-satellite complexes can be successfully prepared as
5 approximately 60 nm particles hydrodynamically with 10-15 AuNPs per IONP core, which correlates to a less than 7.5 nm distance between AuNPs that is ideal for B-cell receptor crosslinking. Additionally, the nano-satellite complexes herein can be prepared with about 2,000 peptides per particle with specific localization to AuNPs.

The present disclosure is not limited by the type of antigen that is used with in the
10 nano-satellite complexes. In certain embodiments, a B-cell antigen and/or T-cell antigen is employed. In certain embodiments, at least a portion of a human tumor-associated antigen is employed. Examples of human tumor-associated antigens (TAAs) include differentiation antigens (such as melanocyte differentiation antigens), mutational antigens (such as p53), overexpressed cellular antigens (such as HER2), viral antigens (such as human
15 papillomavirus proteins), and cancer/testis (CT) antigens that are expressed in germ cells of the testis and ovary but are silent in normal somatic cells (such as MAGE and NY-ESO-1). In other embodiments, antigens from bacteria or viruses are employed.

In certain embodiments, the antigen is provided from the TANTIGEN web site that provide a comprehensive database of tumor T cell antigens (See, Olson et al., Cancer
20 Immunol Immunother. 2017 Mar 9, which is herein incorporated by reference in its entirety). Table 1 below provides a list of antigens, at least a portion of which may be employed with the nano-satellite complexes provided herein. The TANTIGEN web site may be used to select portions of a particular antigen (see, "http://" followed by "projects.met-
hilab.org/tadb/index.php"). For example, with regard to the ERBB2/HER2 antigen, the
25 TANTIGEN web site shows the amino acid sequence for this antigen, providing highlighted short antigenic regions of this antigen that are immunogenic (as shown in Figure 5, for the TANTIGEN accession number "Ag000001"). One may employ one or more of the highlighted regions of this antigen in the complexes described herein. The same procedure may be employed with any of the antigens listed in Tables 1 and 4 using the TANTIGEN
30 web site or similar resource. In further embodiments, ongoing cancer deep sequencing provides new tools for additional neoantigen discovery which may be employed with the present disclosure. The nano-satellite complex and/or the serum albumin carrier-antigen-
adjuvant complex are not limited by the specific sequences of the antigenic peptides. Both

systems provide methods, compositions, and kits to specifically modulate the additional neoantigen-targeted immune response.

TABLE 1

Antigen Name	Common Name	Antigen Name	Common Name
ERBB2	HER2	COTL1	Coactosin-like 1
BIRC5	Survivin	CALR3	CRT2
CEACAM5	CEA	PA2G4	ErbB3-binding protein 1
WDR46	BING4	EZH2	Polycomb group protein enhancer of zeste homolog 2 (EZH2)
BAGE	BAGE1	FMNL1	Formin-related protein in leukocytes 1 (FMNL1)
CSAG2	TRAG-3	HPSE	Heparanase
DCT	TRP-2	APC	
MAGED4		UBE2A	
GAGE1	GAGE-1	BCAP31	
GAGE2	GAGE-2	TOP2A	
TGAGE3	GAGE-3	TOP2B	
GAGE4	GAGE-4	ITGB8	
GAGE5	GAGE-5	RPA1	
GAGE6	GAGE-6	ABI2	
GAGE7	GAGE-7	CCN1	
GAGE8	GAGE-8	CDC2	
IL13RA2	Interleukin 13 receptor alpha 2	SEPT2	
MAGEA1	MAGE-A1	STAT1	
MAGEA2	MAGE-A2	LRP1	
MAGEA3	MAGE-A3	ADAM17	
MAGEA4	MAGE-A4	JUP	
MAGEA6	MAGE-A6	DDR1	
MAGEA9	MAGE-A9	ITPR2	
MAGEA10	MAGE-A10	HMOX1	heme oxygenase-1 (HO-1)
MAGEA12	MAGE-A12	TPM4	Troponin-4
MAGEB1	MAGE-B1	BAAT	
MAGEB2	MAGE-B2	DNAJC8	
MAGEC2	MAGE-C2	TAPBP	
TP53		LGALS3BP	Mac-2-binding protein
TYR	Tyrosinase	PAGE4	PAGE-4
TYRP1	TRP-1	PAK2	P21-activated serin kinase 2 (PAK2)
SAGE1	SAGE	CDKN1A	cyclin-dependent kinase inhibitor 1A (CDKN1A)
SYCP1	HOM-TES-14/SCP1	PTH1 H	Parathyroid hormone-related
SSX2	SSX2 or HOM-MEL-40		
SSX4			
KRAS	K-ras		

PRAME	
NRAS	N-ras
ACTN4	Alpha-actinin-4
CTNNB1	
CASP8	Caspase-8
CDC27	
CDK4	
EEF2	
FN1	Fibronectin
HSPA1B	Hsp70
LPGAT1	KIAA0205
ME1	Malic enzyme
HHAT	MART-2
TRAPPC1	MUM-2
MUM3	MUM-3
MYO1B	Unconventional myosin class I gene
PAPOLG	neo-PAP
OS9	OS-9
PTPRK	Receptor-like protein tyrosine phosphatase kappa
TPI1	Triosephosphate isomerase or TPI1
ADFP	Perilipin-2
AFP	Alpha-fetoprotein
AIM2	
ANXA2	Annexin II
ART4	Endoplasmic reticulum-resident protein
CLCA2	
CPSF1	CPSF
PPIB	Cyclophilin B
EPHA2	EphA2
EPHA3	EphA3
FGF5	Fibroblast growth factor 5 or FGF5
CA9	Carbonic anhydrase IX
TERT	hTERT
MGAT5	GNT-V or N-acetylglucosaminyltransferase V
CEL	intestinal carboxylesterase
F4.2	
CAN	CAN protein
ETV6	TEL1 or ETV6
BIRC7	Livin/ML-IAP

	protein (PTHrP)
SOX2	
SOX11	
TRPM8	Prostate-specific protein transient receptor potential-p8 (trp-p8)
TYMS	Thymidylate synthase (TYMS)
ATIC	5'-aminoimidazole-4-carboxamide-1-beta-d-ribose nucleotide transferase/inosinase (AICRT/I)
PGK1	phosphoglycerate kinase 1 (PGK1)
SOX4	SOX-4
TOR3A	ATP-dependent interferon-responsive (ADIR)
TRGC2	T-cell receptor gamma alternate reading frame protein (TARP)
BTBD2	BTB domain containing 2 (BTBD2)
SLBP	hairpin-binding protein
EGFR	Epidermal growth factor receptor (EGFR)
IER3	immediate early response gene X-1 (IEX-1)
TTK	TTK protein kinase (TTK)
LY6K	lymphocyte antigen 6 complex locus K (LY6K)
IGF2BP3	insulin-like growth factor (IGF)-II mRNA binding protein 3 (IMP-3)
GPC3	glypican-3 (GPC3)
SLC35A4	
HSMD	HMSD-v-encoded mHA
H3F3A	
ALDH1A1	aldehyde dehydrogenase 1 family member A1 (ALDH1A1)
MF12	Melanotransferrin
MMP14	
SDCBP	
PARP12	
MET	c-Met protein
CCNB1	cyclin B1
PAX3-FKHR	
PAX3	
FOXO1	FKHR

CSF1	Macrophage colony stimulating factor
OGT	
MUC1	Mucin or MUC1
MUC2	
MUM1	MUM-1
CTAG1	NY-ESO-1 or LAGE-2
CTAG2	NY-ESO-ORF2 or LAGE-1
CAMEL	
MRPL28	Melanoma antigen p15
FOLH1	Prostate-specific membrane antigen
RAGE	
SFMBT1	Renal ubiquitous protein 1
KAAG1	RU2AS
SART1	SART-1
TSPYL1	SART-2
SART3	
SOX10	
TRG	
WT1	
TACSTD1	Ep-CAM
SILV	Pmel 17 or gp100
SCGB2A2	Mammaglobin A
MC1R	
MLANA	MART-1 or Melan-A
GPR143	OA1
OCA2	P polypeptide
KLK3	PSA or Prostate-specific antigen
SUPT7L	ART-1
ARTC1	
BRAF	
CASP5	Caspase-5
CDKN2A	
UBXD5	COA-1
EFTUD2	Elongation factor Tu GTP binding domain containing or SNRP116
GPNMB	
NFYC	
PRDX5	Peroxiredoxin 5
ZUBR1	E3 ubiquitin-protein ligase UBR4
SIRT2	

XBP1	XBP1
SYND1	CD138
ETV5	
HSPA1A	
HMHA1	
TRIM68	
ACSM2A	ACSM2A
ATR	ATR
USB1	USB1
RTCB	RTCB
C6ORF89	C6ORF89
CDC25A	CDC25A
CDK12	CDK12
CRYBA1	CRYBA1
CSNK1A1	CSNK1A1
DSCAML1	DSCAML1
F2R	F2R
FNDC3B	FNDC3B
GAS7	GAS7
HAUS3	HAUS3
HERC1	HERC1
HMG2	HMG2
SZT2	SZT2
LRRC41	LRRC41
MATN2	Matrilin-2
NIN	Ninein
PLEKHM2	PLEKHM2
POLR2A	POLR2A
PPP1R3B	PPP1R3B
RALGAPB	RALGAPB
SF3B1	SF3B1
SLC46A1	SLC46A1
STRAP	STRAP
SYT15	SYT15
TBC1D9B	TBC1D9B
THNSL2	THNSL2
THOC6	THOC6
WHSC1L1	WHSC1L1
XPO1	XPO1
BCL11A	BCL11A
SPEN	SPEN
VPS13D	VPS13D
SOGA1	SOGA1

SNRPD1	
HERV-K-MEL	
CXorf61	Kita-kyushu lung cancer antigen 1;
CCDC110	KM-HN-1
VENTXP1	NA88-A
SPA17	Sperm protein 17
KLK4	
ANKRD30A	NY-BR-1
RAB38	NY-MEL-1 or RAB38
CCND1	Cyclin D1
CYP1B1	P450 1B1 or CYP1B1
MDM2	
MMP2	Matrix metalloproteinase-2
ZNF395	Papillomavirus binding factor (PBF)
RNF43	
SCRN1	Secernin 1
STEAP1	STEAP
707-AP	
TGFBR2	TGF-beta receptor type IIB
PXDNL	MG50
AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein
PRTN3	Proteinase 3
PSCA	Prostate stem cell antigen
RHAMM	RHAMM/CD168
ACPP	Prostatic acid phosphatase
ACRBP	OY-TES-1
LCK	Lck
RCVRN	Recoverin
RPS2	Ribosomal protein S2
RPL10A	Ribosomal protein L10a
SLC45A3	Protein
BCL2L1	Bcl-xL
DKK1	Dickkopf-1 (DKK1)
ENAH	Human Mena protein
CSPG4	Melanoma-associated chondroitin sulfate proteoglycan (MCSP)
RGS5	
BCR	Breakpoint cluster region
BCR-ABL	
ABL-BCR	

MAP1A	MAP1A
ZNF219	ZNF219
SYNPO	SYNPO
NFATC2	NFATC2
NCBP3	NCBP3
HIVEP2	HIVEP2
NCOA1	NCOA1
LPP	LPP
ARID1B	ARID1B
SYNM	SYNM
SVIL	SVIL
SRRM2	SRRM2
RREB1	RREB1
EP300	EP300
RCSD1	RCSD1
CEP95	CEP95
IP6K1	IP6K1
RSRP1	RSRP1
MYL9	MYL9
TBC1D10C	TBC1D10C
MACF1	MACF1
MAP7D1	MAP7D1
MORC2	MORC2
RBM14	RBM14
GRM5	GRM5
NIFK	NIFK
TLK1	TLK1
IRS2	IRS2
PPP1CA	PPP1CA
GPSM3	GPSM3
SIK1	SIK1
HMG1	HMG1
MAP3K11	MAP3K11
GFI1	GFI1
KANSL3	KANSL3
KLF2	KLF2
CCDC88B	CCDC88B
TNS3	TNS3
N4BP2	N4BP2
TPX2	TPX2
KMT2A	KMT2A
SRSF7	SRSF7
GRK2	GRK2

DEK	DEK oncogene
DEK-CAN	
ETV6-AML1	
LDLR-FUT	
NPM1-ALK1	
PML-RARA	
SYT-SSX1	
SYT-SSX2	
FLT3	FLT1
ABL1	Proto-oncogene tyrosine-protein kinase ABL1
AML1	AML
LDLR	Low density lipid receptor (LDLR)
FUT1	GDP-L-fucose
NPM1	NPM
ALK	
PML1	promyelocytic leukemia or PML
RARA	RAR alpha
SYT	
SSX1	
MSLN	Mesothelin
UBE2V1	Ubiquitin-conjugating enzyme variant Kua
HNRPL	
WHSC2	
EIF4EBP1	
WNK2	
OAS3	
BCL-2	Bcl-2
MCL1	Mcl-1
CTSH	Cathepsin H
ABCC3	Multidrug resistance-associated protein 3 (MRP3)
BST2	HM1.24
MFGE8	Milk fat globule membrane protein BA46 (lactadherin)
TPBG	5T4 oncofetal antigen
FMOD	Fibromodulin (FMOD)
XAGE1	XAGE antigen
RPSA	Oncofetal Ag immature laminin receptor (OFA-iLR)

GIGYF2	GIGYF2
SCAP	SCAP
MIIP	MIIP
ZC3H14	ZC3H14
ZNF106	ZNF106
SKI	SKI
SETD2	SETD2
ATXN2L	ATXN2L
SRSF8	SRSF8
LUZP1	LUZP1
KLF10	KLF10
RERE	RERE
MEF2D	MEF2D
PCBP2	PCBP2
LSP1	LSP1
MEFV	MEFV
ARHGAP30	ARHGAP30
CHAF1A	CHAF1A
FAM53C	FAM53C
ARHGAP17	ARHGAP17
HSPB1	HSPB1
NCOR2	NCOR2
ATXN2	ATXN2
RBM15	RBM15
RBM17	RBM17
SON	SON
TSC22D4	TSC22D4
MYC	MYC
ANKRD17	ANKRD17

In certain embodiments, the antigen employed in the complexes described herein is from a human oncogenic or tumor virus. Viruses that are associated with human malignancies include: HTLV-1 (adult T-cell leukemia (ATL), HPV (cervical cancer, skin cancer in patients with epidermodysplasia verruciformis (EV), head and neck cancers, and other anogenital cancers); HHV-8 (Kaposi's sarcoma (KS), primary effusion lymphoma, and Castleman's disease), EBV (Burkitt's Lymphoma (BL), nasopharyngeal carcinoma (NPC), MCPyV (Merkel Cell Carcinoma), post-transplant lymphomas, and Hodgkin's disease), HBV, and HCV (hepatocellular carcinoma (HCC)). Additionally, viruses with possible roles in human malignancies include: simian vacuolating virus 40 (SV40) (brain cancer, bone cancer, and mesothelioma), BK virus (BKV) (prostate cancer), JC virus (JCV) (brain cancer), human endogenous retroviruses (HERVs) (germ cell tumors, breast cancer, ovarian cancer, and melanoma), human mammary tumor virus (HMTV) (breast cancer), and (vi) Torque teno virus (TTV) (gastrointestinal cancer, lung cancer, breast cancer, and myeloma).

In certain embodiments, antigens from viruses or bacteria are employed with the nano-satellite complexes described herein. Such antigens are well known in the art. Examples of viruses (Table 2) and bacteria (Table 3) that are the source of such well-known antigens are provided below.

Table 2 - Viral diseases

Virus antigen source	Diseases or conditions
Hepatitis A virus	Hepatitis A
Hepatitis B virus	Hepatitis B
Hepatitis E virus	Hepatitis E
Human papillomavirus	Cervical cancer, Genital warts, anogenital cancers
Influenza virus	Influenza

Virus antigen source	Diseases or conditions
Japanese encephalitis virus	Japanese encephalitis
Measles virus	Measles
Mumps virus	Mumps
Polio virus	Poliomyelitis
Rabies virus	Rabies
Rotavirus	Rotaviral gastroenteritis
Rubella virus	Rubella
Tick-borne encephalitis virus	Tick-borne encephalitis
Varicella zoster virus	Chickenpox, Shingles
Variola virus	Smallpox
Yellow fever virus	Yellow fever

Table 3 - Bacterial diseases

Bacterium antigen source	Diseases or conditions
Bacillus anthracis	Anthrax
Bordetella pertussis	Whooping cough

Bacterium antigen source	Diseases or conditions
<i>Clostridium tetani</i>	Tetanus
<i>Corynebacterium diphtheriae</i>	Diphtheria
<i>Coxiella burnetii</i>	Q fever
<i>Haemophilus influenzae</i> type B (Hib)	Epiglottitis, meningitis, pneumonia
<i>Mycobacterium tuberculosis</i>	Tuberculosis
<i>Neisseria meningitidis</i>	Meningococcal meningitis
<i>Salmonella typhi</i>	Typhoid fever
<i>Streptococcus pneumoniae</i>	Pneumococcal pneumonia
<i>Vibrio cholerae</i>	Cholera

EXAMPLES

5

EXAMPLE 1

Virus-Like Nanoparticles for Antigen-Specific Antibody Production

This Examples describes the production and use of virus-like nanoparticles to produce antibodies.

- 10 **Materials:** All reagents were used as obtained from commercial sources without further purification. Iron oxide (III) ($\text{FeO}(\text{OH})$, hydrated, catalyst grade, 30–50 mesh), oleic acid (technical grade, 90%), 1-octadecene (technical grade, 90%), anhydrous tetrahydrofuran (THF, 99.8%), sodium sulfide, chloroauric acid, ammonium iron (II) sulfate hexahydrate ($\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$, ACS reagent, 99%), nitric acid (ACS reagent, 70%), and

hydrochloric acid (ACS reagent, 37%) were purchased from Sigma-Aldrich. Mouse uncoated IgG and IgM Total ELISA Ready-SET-Go! Kits, 1-Step Ultra TMB-ELISA substrate solution, HRP-conjugated goat anti-mouse IgG1 secondary antibody, HRP-conjugated goat anti-mouse IgG2a secondary antibody, Nunc Immobilizer Amino 96-well ELISA plates, BupH carbonate bicarbonate buffer packs (coating buffer), Pierce protein free PBS tween blocking buffer, 20x PBS-tween wash buffer, Geneticin (G418) selective antibiotic, Invitrogen eBioscience fixable viability dye eFluor 780, and Molecular Probes streptavidin Alexa Fluor 647 conjugate were obtained from Thermo Fisher Scientific. HRP conjugated goat anti-mouse IgG secondary antibody, Zombie UV fixable viability kit, FITC anti-mouse CD19, PE/Dazzle 594 anti-mouse CD38, Brilliant Violet 421 anti-mouse CD138, PE/Dazzle 594 anti-mouse IgD, Alexa Fluor 647 anti-mouse/house GL7 antigen, Brilliant Violet 421 and PE/Dazzle 594 anti-mouse/human CD45R/B220, FITC anti-mouse CD95, Brilliant Violet 421 anti-mouse/human CD11b, FITC anti-mouse CD169, PE/Dazzle 594 anti-mouse CD11c were purchased from BioLegend. HER2 peptides (CDDDPESFDGDPASNTAPLQPEQLQ (SEQ ID NO:1), Biotin-PESFDGDPASNTAPLQPEQLQ (SEQ ID NO:2), CDDDPESFDGDPASNTAPLQPEQLQGGGK (SEQ ID NO:3)) were custom synthesized. 30 nm iron-oxide nanoparticles cores stabilized by oleic acid in chloroform were purchased from Ocean Nanotech. DSPE-PEG(2000) and DSPE-PEG(2000)maleimide were obtained from Avanti Polar Lipids. 2'3'-cGAMP was acquired from InvivoGen. Fluorescamine was purchased from MP Biomedicals. Sulfo-Cy5.5 NHS ester was acquired from Lumiprobe. Microvette 500 Z-Gel serum collection vials with clotting factor were obtained from Sarstedt. Matrigel Basement Membrane Matrix was purchased from Corning. Gold and iron ICP standards were purchased from Fluka Analytical.

Mice. All animal experiments were conducted according to the protocols approved by the University of Michigan Committee on Use and Care of Animals (UCUCA). BALB/c mice ages 5-7 weeks were purchased from Charles River Labs.

Cells. All cells were maintained at 37C, 5% CO₂/95% air atmosphere and approximately 85% relative humidity. D2F2/E2 cells were cultured in complete DMEM high glucose supplemented with 10% NCTC 109 media, 1% L-glutamine, 1% MEMs non-essential amino acids, 0.5% sodium pyruvate, 2.5% sodium bicarbonate, 1% pen/strep, 5% cosmic calf serum, 5% fetal bovine serum, 500 µg/mL Geneticin and 50 µM 2-mercaptoethanol.

RAW264.7 macrophages were cultured in complete RPMI-1640 media supplemented with 10% fetal bovine serum, 1% L-glutamine, 1% MEMs non-essential amino acids, 1% sodium pyruvate and 1% pen/strep. DC2.4 dendritic cells were cultured in RPMI-1640 media supplemented with 10% fetal bovine serum, 1% L-glutamine, 1% MEMs non-essential amino acids, 1% HEPES buffered solution, 1% pen/strep and 50 μ M 2-mercaptoethanol.

Formulation and Characterization of Inorganic Virus-Like Nanoparticles (IVLN). The IVLN was formulate as follows.

- 10 **Synthesis of IONPs Coated with Polysiloxane-Containing Diblock Copolymer.** Spherical IONPs (15 nm in diameter) were synthesized in organic solvent by thermal decomposition. Cubic IONPs (25 nm in edge length) were also synthesized. Diblock copolymer (PEO-*b*-P γ MPS) was synthesized by the reversible addition of fragmentation chain transfer (RAFT) polymerization. The preparation of the polymer-coated MNPs with either single or clustered
- 15 core was performed. The IONP iron concentration was determined using o-phenanthroline (ACS reagent, 99%) after digestion with hydrochloric acid (ACS reagent, 37%). General methods of such synthesis are found in Chen et al., ACS Appl. Mater. Interfaces 2015, 7, 12814–12823, herein incorporated by reference.
- 20 **Synthesis of AuNPs.** AuNPs were synthesized by using sodium sulfide (Na₂S) as the reducing reagent. Gold in the form of chloroauric acid (HAuCl₄) was prepared to a concentration of 100 mM as a stock solution and was diluted to 2.0 mM before use. Na₂S (50mM) was prepared and aged in the dark for 40–48 h prior to use and was diluted to 1.0 mM before use. The volume ratio of Na₂S to HAuCl₄ was varied from 2.5/1.0 to 3.0/1.0.
- 25 UV/Vis spectra were recorded to monitor the reaction. Without specification, the reaction with a volume ratio of 3.0/1.0 was chosen to use in the following steps. General methods of such synthesis are found in Chen et al., ACS Appl. Mater. Interfaces 2015, 7, 12814–12823, herein incorporated by reference.
- 30 **Synthesis of Inorganic Virus-Like Nanoparticles (IVLN).** IVLNs were made by incubating AuNPs with polymer-coated IONPs at 4 °C. In a typical experiment, two milligram Fe of IONPs (0.5 mL) was mixed with AuNP solution 6 mL of for spherical IONPs and 4 mL for cubic IONPs, respectively, if without specification. The formed IVLNs were purified by magnet to remove unbound AuNPs after overnight incubation.

The final Au:Fe ratio of the formulated IVLN was quantified by inductively coupled plasma mass spectrometry using a Perkin-Elmer Nexion 2000 based on established protocols. IVLN formulations were imaged by transmission electron microscopy (TEM) using the JEOL 3011 High Resolution Electron Microscope. The true particle size of AuNPs, IONPs and IVLNs was quantified using ImageJ software. The volume-weighted hydrodynamic particle size, polydispersity index and zeta-potential of all formulations in milliQ water at 25°C was evaluated with the Malvern Zetasizer Nano-ZS using dynamic light scattering and phase analysis light scattering, respectively.

10 **Lipid-Coated Iron-Oxide Nanoparticle Formulations (Lipid-IONP).** Lipid-coated iron-oxide nanoparticles were prepared based on previously reported methods for thin-film hydration with minor modifications. 10 mg of DSPE-PEG(2000)-maleimide was added to 1 mg of 30-nm iron-oxide nanoparticle cores stabilized by oleic acid in chloroform as gently mixed. The resulting solution was subjected to solvent rotary evaporation to remove all
15 chloroform and form a thin film. Simultaneously, this film and 100 mM PBS, pH 7.4 were heated to 75°C in an oven. Upon reaching temperature, hot PBS was rapidly added to the film and mixed immediately and vigorously to facilitate thin film hydration. The resulting nanoparticle solution was stored at 4°C to promote lipid self-assembly. Free phospholipid were removed by magnetic separation overnight at 4°C using the a magnetic separator
20 device.

Lipid-IONP-HER2 and IVLN-HER2 Formulations. HER2 peptides were conjugated to both Lipid-IONP and IVLN through thiol-mediated chemistries. Specifically, Lipid-IONP-HER2 was formulated via maleimide chemistry and IVLN-HER2 was formulated via the
25 gold-thiol linkage. HER2 peptide was added to Lipid-IONP at 1.5x weight ratio excess in milliQ and incubated overnight at 4°C. HER2 peptide was added to IVLN-HER2 at 5x weight ratio excess in milliQ and incubated overnight at 4°C. Both materials were purified either by magnetic separation overnight at 4°C using a magnetic separator device, or by centrifugal separation at 10,000 x g for 30 minutes at 4°C.

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Immunizations and Serum Collection. At day 0, mice were immunized with the equivalent of 50 µg of HER2 peptide plus 10 µg of cGAMP regardless of formulation type. Subsequently, at day 14, mice were boosted twice at two-week intervals with 50% of the original dosage for both antigen and adjuvant (day 14 and 28). To evaluate serum antibody

titers, blood was collected by submandibular puncture 10 days after each immunization (day 10, 24 and 38). Serum was separated from whole blood by centrifugal separation at 10,000 x g for 5 minutes at 25°C using the Microvette 500 Ser-Gel collection vessels with clotting activator.

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Enzyme-Linked Immunosorbent Assay (ELISA). Absolution quantification of total IgG and total IgM antibody analysis was performed using the mouse uncoated total IgG and total IgM ELISA kits based on protocols provided by ThermoFisher. Antigen-specific IgG, IgG1 and IgG2a antibody titers were quantified based on previously established protocols for indirect ELISA with minor modifications. Specifically, HER2 peptides (200 µL, 100 ug/mL in 100 mM carbonate buffer, pH 9.4) were chemically conjugated to ELISA plates through the terminal amine group utilizing Nunc Immobilizer Amino immunoassay plates by overnight incubation with exposure to light at room temperature. Following overnight incubation, ELISA plates were washed three times with 100 mM PBS, pH 7.4 with 2% Tween-20. Subsequently, ELISA plates were blocked overnight at 4°C with 300 µL of ELISA blocker (Pierce Protein-Free PBS Blocking Buffer). Following blocking, the ELISA plates were washed 3x. Serum samples containing primary antibodies were serially diluted (10¹-10⁸ fold) using 100 mM PBS, pH 7.4 containing 10% ELISA blocker reagent and added to each well at 200 µL total for 2 hour incubation at room temperature. Following sample addition, the ELISA plates were washed 3x. 500-fold diluted anti-IgG-HRP, anti-IgG1-HRP, or anti-IgG2a-HRP was added at 100 µL to each well and incubated for 1 hour at room temperature. After 1 hour, the ELISA plates were washed 5x. Next, 100 µL of 1-Step Ultra TMB Substrate Solution was added to each well and allowed to incubate and develop color for 15-20 minutes at room temperature with gentle agitation. After 15-20 minutes, color development was stopped by the addition of 100 µL of 100 mM sulfuric acid. Colorimetric development was quantified by absorbance spectroscopy at 450 nm using a BioTek Cytation 5. Antibody titers were determined by any absorbance signal at a given dilution factor that was greater than the PBS control absorbance signal plus 3x standard deviations.

Quantification of Nanoparticle Delivery to Lymph Nodes *in-vivo*. Mice were injected subcutaneously in the left hock with either Lipid-IONP or IVLN-peptide at 200 µg total Fe per mouse. At the designated time intervals, mice were sacrificed, and lymph nodes of interest were dissected for *ex-vivo* analysis. The extent of nanoparticle delivery to the lymph nodes was quantified using ICP-MS based on previously reported protocols.

Quantification of Peptide Delivery to Lymph Nodes *in-vivo*. To facilitate quantification of peptide delivery to lymph nodes, lysine terminally modified HER2 peptides were chemically conjugated to sulfo-Cy5.5 NHS Ester. This conjugation was carried out at a 5-fold molar excess of sulfo-Cy5.5 NHS Ester to HER2 peptide. IONP-HER2-Cy5.5 and IVLN-HER2-Cy5.5 were subjected to Cy5.5 functionalization after initial peptide conjugation was completed in order to enable facile purification of excess fluorescent dye by magnetic separation. Subsequent to Cy5.5 functionalization, mice were injected as previously stated. After 3 hours, mice were sacrificed and lymph nodes of interest were dissected for *ex-vivo* analysis by IVIS imaging. IVIS imaging was utilized for semi-quantification of peptide delivery in terms of radiant efficiency.

In-vitro Cell Uptake. IVLN-HER2 and IONP-HER2 cellular uptakes was evaluated in RAW264.7 macrophages, DC2.4 dendritic cells and primary B-cells isolated from murine spleens using an EasySep Mouse B-cell isolation kit. Nanoparticle samples were incubated at 50 µg/mL Fe with cells for 18 hours in blank RPMI media at 37C, 5% CO₂/95% air atmosphere and approximately 85% relative humidity. After 18 hours, cells were lifted by cell scraping and washed thrice with phosphate-buffered saline (PBS). Following the wash steps, resulting cell pellets were re-suspend in 1 mL of PBS, cell counted and then digested in 1 mL aqua regia (1:3 molar ratio nitric acid: hydrochloric acid) for analysis by ICP-MS.

In-vivo Cell Uptake. IVLN-HER-Cy5.5 and IONP-HER2-Cy5.5 were injected subcutaneously in the left hock with either Lipid-IONP or IVLN at 200 µg total Fe per mouse. At 3 hours and 24 hours, mice were sacrificed and lymph nodes of interest were dissected for *ex-vivo* analysis by flow cytometry. Lymph nodes were dissociated by mechanical methods to prepare single cell suspensions. Single cell suspensions of lymph node cells were stained for analysis by flow cytometry using the MoFlo Astrios flow cytometer. The first panel was for viable cells, B-cells (B220⁺), subcapsular sinus macrophages (CD169⁺CD11b⁺), dendritic cells (CD11c⁺) and nanoparticle positive cells (Cy5.5). Flow cytometry data was analyzed by FCS express.

Antigen-Specific B-cell and Germinal Center Flow Cytometry. Mice were immunized as previously introduced. At day 24 and day 38, mice were sacrificed and spleens and lymph nodes were dissected for *ex-vivo* analysis by flow cytometry. Antigen-specific B-cell analysis

was accomplished using tetramer staining. HER2/neu peptide tetramers were prepared by mixture of biotin-labeled HER2 peptide with Alexa Fluor 647 labeled streptavidin at a 4:1 molar ratio at room temperature for 1 hour without further purification. Antigen-specific B-cell population were identified as either memory B-cells (B220⁺CD38⁺Tetramer⁺) or plasma cells (B220⁺CD138⁺Tetramer⁺) using flow cytometry. Germinal center B-cell populations were identified using the following markers CD19, IgD, GL7 and CD95.

Tumor Studies. Sixty days after the primary immunization, mice were inoculated with 500,000 D2F2/E2 cells subcutaneously in the right flank. D2F2/E2 cells were prepared at 5e6 cells/mL in 100 μ L and mixed at equal volume with Matrigel matrix. Tumor size was quantified by caliper measurements every 7 days. Tumor volumes were calculated using the following equation:

$$\text{Tumor Volume} = \frac{\pi \times \text{length} \times \text{width}^2}{2}$$

End points were determined by using the End-Stage Illness Scoring System; mice receiving an End-Stage Illness Score greater than 6 were euthanized by CO₂ asphyxiation.

Statistics. Data are expressed as mean $\pm$ standard deviation (SD), unless otherwise specified. Comparisons between two groups were made using the unpaired Student's *t*-test. Means of multiple groups were compared with the one-way analysis of variance (ANOVA), followed by post hoc Tukey's pairwise comparisons. All probability values are two-sided, and values of *p* < 0.05 were considered statistically significant. Statistical analyses were carried out using the GraphPad Prism 7 software package.

RESULTS

Inorganic Virus-Like Nanoparticle (IVLN) Formulation and Viral Properties

The IVLN is formulated by the self-assembly of two separately prepared nanoparticle systems, an iron-oxide nanoparticle core and gold nanoparticle satellites, through the association of hydrolyzed siloxane groups and gold (Figure 1). The iron-oxide nanoparticle (IONP) core was synthesized by thermal decomposition to produce a ~15-nm spherical core

stabilized by oleic acid in chloroform. To achieve aqueous stabilization, the IONP core was coated with a polysiloxane/PEG diblock copolymer (IONP-polymer). Separately, ultra-small gold nanoparticles (AuNP) with ~3 nm size were prepared using a modified self-assembly method by reduction of chloroauric acid in aged sodium sulfide. Following synthesis, AuNPs are added to the polymer-coated IONP cores in solution at defined weight ratios.

To quantify the extent of AuNP loading per IONP core following self-assembly, inductively coupled plasma mass spectrometry (ICP-MS) was used. With ICP-MS, it was determined that the average loading efficiency on a per weight basis was $73 \pm 7\%$ with a linear dependence ($R^2 = 0.997$) (Figure 2A). Notably, above an initial loading ratio of 50% weight Au,

destabilization of nanoparticles in solution was observed, and was therefore not the focus of further research. To provide visual confirmation of AuNP and IONP-polymer self-assembly to form the IVLN, transmission electron microscopy (TEM) was performed (Figure 2B).

TEM imaging confirmed that by controlling the initial loading ratio of AuNP to IONP-polymer cores on a per weight basis it is possible to yield IVLNs with variable gold nanoparticle surface density and viral-like character (Figure 2B-insert). IONP-polymer core and AuNP diameters were quantified to be 15.9 ± 1.3 nm and 2.3 ± 0.4 nm, respectively. TEM imaging was further utilized to estimate the AuNP loading per IONP-polymer core. Specifically, 10%, 20% and 30% weight Au conditions yielded IVLNs with 4 ± 2 , 9 ± 3 and 13 ± 5 AuNPs per IONP-polymer core, respectively.

Following ICP-MS quantification and TEM visualization of IVLN formulations, elementary mathematical modeling was performed in order to determine the structural relevance of IVLN as compared to virus-like particles. Given the crystalline nature of AuNPs and IONPs, it is feasible to determine the number of particles of a determined particle size for a given weight of either Au or Fe, respectively. Based on the ICP-MS measurements performed in Figure 2A and the particle size confirmation by TEM in Figure 2B, it is therefore possible to estimate the average distance between AuNPs on the IONP surface, as well as the average number of AuNPs per unit area on IONP surfaces. From this analysis, it was determined that depending on the initial weight loading ratio of Au to Fe, IVLNs can be formulated with a minimum average distance of 6.75 nm between AuNPs – a preferred distance for B-cell receptor crosslinking (Figure 2C). In addition to AuNP spatial distribution, at this same initial loading ratio, the number of AuNPs per unit area was determined to be approximately 12,500-17,000 AuNPs per square micron – a value that compares favorably with the antigen density reported for viral-like particles (e.g. Hepatitis B Virus) (Figure 2D).

To further evaluate the viral-like potential of the IVLN, we next evaluated the capacity for and mechanism of peptide loading in this system. The peptide of interest in these studies is a human HER2/neu-specific peptide that, based on previously published works, contains a B-cell epitope with an overlapping CD4 helper T-cell epitope. In addition to these functional epitopes, a cysteine containing terminal flank was added to facilitate facile loading to the IVLN via the Au-S linkage (CDDD-PESFDGDPASNTAPLQPEQLQ, SEQ ID NO:1). The capacity for peptide conjugation to the IVLN was quantified utilizing a modified fluorescamine peptide assay. Peptide loading was evaluated under three separate IVLN formulation conditions: 0%, 10% and 30% Au to Fe final weight loading ratio (wt/wt Au/Fe). In terms of AuNPs per IONP-polymer core, these values approximately translate to 0 AuNPs, 4 AuNPs and 10 AuNPs per IONP-polymer core, respectively. Peptide conjugation was performed in water at 4°C overnight with subsequent purification by centrifugal separations. Fluorescent peptide quantification analysis revealed that, at maximum peptide loading conditions, the 0%, 10% and 30% wt/wt formulations were loaded with 232 ± 73 , 888 ± 42 and 1954 ± 157 peptides per IVLN, respectively (Figure 2E). When these same values were standardized by total AuNPs it was determined that maximum peptide loading per AuNP was 227 ± 5 . Additionally, this analysis revealed a positive correlation between peptide loading and AuNP number ($R = 0.95$). Taken together, these results suggest although there is low-level non-specific physical association to the core (~12% under maximum loading conditions), peptide loading is AuNP dependent. Thus, peptide conjugation to IVLN surface is AuNP localized, which indicates that the IVLN-peptide is characterized by heterogeneous and patchy peptide distribution. This patterned antigen display is viral-like in nature and can not be reproduced by traditional nanoparticle systems that employ homogeneous antigen distribution on their surfaces.

After the evaluation of peptide loading, we next assessed the IVLN-peptide's material properties to determine if the material was suitable for *in-vivo* applications and appropriately aligned with viral-like properties (Figure 2F). Before incubation with AuNPs, the IONP-polymer core of the IVLN was shown to have a 51 ± 2 nm volume-weighted hydrodynamic particle size by dynamic light scattering (DLS) with a 0.15 ± 0.03 polydispersity index (PDI). In addition, the zeta-potential of this material in milliQ water at pH 7 was determined to be -7 ± 4 mV. Following formulation at a final weight loading ratio of 30% wt/wt Au/Fe, the IVLN-Blank was shown to have a 55 ± 2 nm particle size, 0.20 ± 0.05 PDI and a -16 ± 4 mV zeta-potential before peptide loading. After peptide loading, the IVLN-Peptide was shown to have a 60 ± 4 nm particle size, 0.20 ± 0.05 PDI and a -17 ± 1 mV zeta-potential. Taken

together, the IVLN-peptide was determined to have optimal material properties for *in-vivo* applications. Moreover, these properties were deemed acceptably within the design criteria for viral mimicking nanoparticles, which includes particle size between 20-300 nm and negative overall surface charge.

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Inorganic Virus-Like Nanoparticle (IVLN) for Antigen-Specific Antibody Production in Mice

Viral mimicking nanoparticles have been utilized in a wide-range of *in-vitro* and *in-vivo* applications, but the one application that viral-like material properties are very good for is B-cell activation for antigen-specific antibody production. Accordingly, based on the establish viral-like material properties of IVLN-peptides. In this study, BALB/c mice (6-8 weeks old) were immunized with 50 µg of HER2 peptide plus 10 µg of cGAMP as adjuvant at day 0 and boosted once 14 days later. Mice were bled, and serum was collected for analysis 10-days following every administration (Figure 3A).

Based on an understanding of the requirement of B-cell receptor crosslinking for B-cell activation and germinal center formation, we first asked what the role of AuNP quantity and spatial distribution on IVLN surfaces at saturated peptide loading was. To answer this question, we evaluated the titer of antigen-specific IgG antibodies produced in mice after a booster immunization with IVLN at 10%, 20% and 30% wt/wt Au/Fe final weight loading ratios by indirect ELISA. From this analysis, it was determined that by day 24 the production of antigen-specific IgG, in terms of median antibody titers, was 7,500, 12,500 and 32,500 for 10%, 20% and 30% wt/wt formulations, respectively (Figure 3B). This initial result suggested that increasing AuNP quantity on IVLN surfaces improved antibody production. Presumably, this improvement was the result of reduced AuNP spacing (10% wt = ~11.25 nm; 20% wt = ~ 8.05 nm; 30% wt = 6.25 nm) to facilitate more efficient B-cell receptor crosslinking.

Subsequent to the evaluation of AuNP surface density, we questioned what the role of peptide conjugation density on IVLNs was for a given Au/Fe weight loading ratio. Peptide density has been positively connected to increased B-cell activation with potential for dose sparing by numerous previous reports. Notably, peptide density negatively correlated to reduction of antibody specificity. For the 30% wt ratio, low density peptide on IVLN surfaces yielded a median antigen-specific IgG antibody titer of 6,500, while high density peptide on IVLN surface yielded a median titer of 32,500 (Figure 3B). This trend was also observed at the 20% wt ratio condition, which produced median titers of 1,300 and 12,500 for low density

and high density, respectively. However, this trend did not translate to the 10% wt ratio condition. Presumably, this is due to a greater than 10 nm spacing between AuNPs on IVLN surfaces. Based on the above analysis, it was determined that higher peptide density and higher number of AuNPs per IVLN surface were generally preferred for antigen-specific antibody production due to the increasingly viral-like nature of the material. Significantly, peptide density was demonstrated to improve antibody titers without a loss of antigen-specificity. Based on these results, the 30% wt ratio plus high-density peptide condition was employed in all assays moving forward and referred to simply as IVLN or IVLN-HER2.

To effectively evaluate the significance of viral-like character for the application of antigen-specific antibody production, we next asked how the IVLN would perform as directly compared to a traditional nanoparticle system. For this comparison, we utilized a lipid-coated iron-oxide nanoparticle (Lipid-IONP) as a control (see Figure 1). This nanoparticle has a 30-nm iron-oxide nanoparticle core and a functionalized DSPE-PEG(2000)-maleimide shell that facilitates facile peptide conjugation. Significantly, Lipid-IONPs have similar material properties in terms of hydrodynamic particle size (69 ± 1 nm), PDI (0.20 ± 0.01 nm), and maximum peptide number per particle (2323 ± 394 peptides per IVLN). However, as a traditional nanoparticle system, Lipid-IONPs have smooth PEGylated surfaces with homogeneous peptide distribution. Taken together, we believe that the side-by-side comparison of IVLNs and Lipid-IONPs would offer valuable insights into the role of viral mimicry for *in-vivo* functionality.

As before, BALB/c mice were immunized with 50 μ g of HER2 peptide plus 10 μ g of cGAMP as adjuvant at day 0 and boosted at day 14. At day 24, 10 days post-boost 1, serum was analyzed for total IgM, total IgG, antigen-specific IgG and the antigen-specific IgG isotypes, IgG1 and IgG2a (Figure 3C). At this time point, no statistically significant difference in total IgM antibody production were observed ($p = 0.09$), however a significant increase in total IgG was observed for both Lipid-IONP-HER2 and IVLN-HER2 as compared to PBS alone and soluble HER2 peptide treated mice. More specifically, an approximately 7-fold and 3-fold increase in total IgG was observed for both the Lipid-IONP-HER2 and IVLN-HER2 samples as compared to PBS alone ($p < 0.001$; $p < 0.001$) and soluble HER2 ($p < 0.01$; $p < 0.01$), respectively. No statistically significant difference between Lipid-IONP-HER2 and IVLN-HER2 was observed for total IgG ($p = 0.98$). However, when antigen-specific IgG was evaluated a dramatic difference between IVLN-HER2 and Lipid-IONP-HER2 was observed. Namely, IVLN-HER2 was determined to have an 18.5-fold higher antigen-specific IgG titer (39,500 vs. 2,140; $p < 0.001$) a 15-fold higher antigen-specific IgG1 titer (9,600 vs. 640;

p<0.001) and a 4.5-fold higher antigen-specific IgG2a titer (5,760 vs. 1,280; p<0.05) as compared to Lipid-IONP-HER2. Moreover, IVLN-HER2 yielded an 9-fold higher antigen-specific IgG titer (39,500 vs. 4,300; p<0.001), a 48-fold higher antigen-specific IgG1 titer (9,600 vs. 200; p<0.001) and a 72-fold higher antigen-specific IgG2a titer (5,760 vs. 80; p<0.01) as directly compared to soluble HER2 peptide.

Lymph Node Delivery and Nanoparticle Distribution

Upon establishing the significant enhancement of antigen-specific antibodies for the IVLN-HER2 as compared traditional nanoparticle and soluble controls, we next set out to answer why. To begin the mechanistic evaluation of the role of viral mimicking properties for antibody production, we first evaluated the ability of these materials to be delivered and retained with the lymph nodes. As sites with dense populations of antigen-presenting cells and lymphocytes, the lymph nodes are ideal target sites for immune activation. Specifically, the lymph nodes are primary sites for B-cell activation and the formation of germinal centers that are ultimately responsible for initiating antigen-specific IgG antibody production. In the context of viral mimicry, the lymph nodes are known to be critically important in the effort to combat and control viral dissemination throughout the body. This functionality is the result of unique physiological features that have been developed for viral recognition and viral-specific immune activation. For example, subcapsular sinus macrophages are a highly specialized phenotype of macrophage that is responsible for viral uptake and direct presentation to B-cells to promote directed viral clearance via antigen-specific antibody production. Thus, studying lymph node delivery and immune cell interactions within the lymph node is essential in the evaluation of the mechanism of viral mimicking nanoparticle functionality.

Delivery to the lymph nodes was quantified for both nanoparticle delivery and peptide delivery following administration by subcutaneous hock immunization, which was determined to be the most efficient delivery pathway. Nanoparticle delivery kinetics to the lymph nodes (popliteal and inguinal) was determined using ICP-MS quantification of Fe and Au in excised lymph nodes based on previously established protocols. From this analysis, it was determined that while the t_{max} of both IVLN-HER2 and Lipid-IONP-HER2 was 3 hours post-administration, the percent of initial nanoparticle dose delivered was $5.1 \pm 1.6\%$ and $1.9 \pm 0.8\%$ (p<0.05) for IVLN-HER2 and Lipid-IONP-HER2, respectively (Figure 4A). Over 72 hours, IVLN-HER2 was shown to have a 2.8-fold increase (p<0.05) in overall exposure compared to Lipid-IONP-HER2 based on AUC. In addition to the nearly 3-fold increase in

delivery observed, the retention of nanoparticles within the lymph node was an estimated 65% for IVLN-HER2 as compared to 48% for Lipid-IONP-HER2. Beyond the direct quantification of nanoparticle delivery by raw elemental analysis, peptide delivery to the lymph node at 3 hours was validated through semi-quantitative analysis of fluorescent intensity using IVIS imaging of excised popliteal and inguinal lymph nodes (Figure 4B). IVIS imaging revealed that IVLN-HER2 led to a 4.3-fold improvement in peptide delivery as compared to both the Lipid-IONP-HER2 and soluble HER2 peptide ($p < 0.001$; $p < 0.001$), which have no statistically significant difference in delivery ($p > 0.99$).

Subsequent to the quantification of lymph node delivery, we next asked where IVLN and IONP distributed within the lymph node at a cellular level. To answer this question, fluorescently labeled nanoparticles were delivered to lymph nodes and flow cytometry was applied in order to identify the percentage of nanoparticle-positive cells out of total cells of different phenotypes. More specifically, lymph node antigen-presenting cells (subcapsular sinus macrophages and dendritic cells) and lymphocytes (B-cells and T-cells) were identified and assessed for nanoparticle uptake. This analysis revealed that after 3-hours and relative to the Lipid-IONP-HER2, IVLN-HER2 improved subcapsular sinus macrophage uptake by 1.7-fold ($86.7 \pm 2.4\%$ vs. $52.2 \pm 2.8\%$, $p < 0.001$), dendritic cell uptake by 1.8-fold ($75.2 \pm 1.9\%$ vs. $41.1 \pm 5.8\%$, $p < 0.001$), and B-cell uptake by 3.4-fold ($63.9 \pm 1.1\%$ vs. $19.7 \pm 2.2\%$, $p < 0.001$), (Figure 4C).

Lastly, we asked what the mechanism for improved cellular uptake was. Based on previous studies, nanoparticle surface topography has been positively correlated with improved cellular uptake. Given the rough surface topography of the IVLN as compared to the smooth PEGylated surfaces of the Lipid-IONP, we hypothesized the cellular uptake is dependent on the extent of AuNP loading on IVLN surfaces. To test this hypothesis, cellular uptake was evaluated *in-vitro* using RAW264.7 macrophages, DC2.4 dendritic cells and primary B-cells isolated from murine spleens. From this analysis it was determined that, regardless of cell type, cellular uptake was determined by the extent of AuNP loading on IVLN surfaces and matched an exponential function (RAW264.7, $R^2 = 0.902$; DC2.4, $R^2 = 0.893$; B-cells, $R^2 = 0.918$). More specifically, as compared to the IONP-polymer core only treatment, IVLN-HER2 at 30% wt/wt loading ratio improved cellular uptake by 6-fold (30.3 ± 1.1 pg Fe/cell vs. 4.7 ± 0.9 pg Fe/cell, $p < 0.001$), 4.5-fold (12.5 ± 1.4 pg Fe/cell vs. 2.9 ± 0.9 pg Fe/cell, $p < 0.001$), and 4-fold (2.0 ± 0.4 pg Fe/cell vs. 0.5 ± 0.2 pg Fe/cell, $p < 0.001$), for RAW264.7 macrophages, DC2.4 dendritic cells and primary B-cells, respectively. Notably, as directly compared to the Lipid-IONP-HER2 control group, IVLN-HER2 improved cellular

uptake by 3-fold (30.3 ± 1.1 pg Fe/cell vs. 11.8 ± 1.3 pg Fe/cell, $p < 0.001$), 3-fold (12.5 ± 1.4 pg Fe/cell vs. 3.9 ± 1.9 pg Fe/cell, $p < 0.01$), and 2-fold (2.0 ± 0.4 pg Fe/cell vs. 0.8 ± 0.4 pg Fe/cell, $p < 0.01$), for RAW264.7 macrophages, DC2.4 dendritic cells and primary B-cells, respectively.

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Viral-like characteristics are ideal material properties for the rational design and engineering of the delivery vehicles, immunostimulatory agents and cellular uptake vectors desperately needed for the advancement of nanotechnology in biotechnology and medical applications. Accordingly, here we report the development and evaluation of an alternative to viral-like particles with a more holistic approach to viral mimicry material design – inorganic virus-like nanoparticles (IVLN) and IVLN-peptides. In certain embodiments, the IVLNs are composed of a hybrid Au@Fe core-satellite type nanoparticle system, which utilizes a 16-nm polysiloxane containing diblock polymer coated iron-oxide nanoparticle core (IONP-polymer) with 2.5-nm gold nanoparticle satellites (AuNP). Based upon the formulation conditions, IVLNs can be produced with variable surface topography, antigen density and antigen spatial resolution. Moreover, the IVLN has optimal particle size, shape and surface charge for efficient lymph node delivery and retention. As such, these properties inform the viral-like character and functional potential of IVLNs.

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Our results showed that viral-like character is truly significant for B-cell activation and antigen-specific antibody production. Specifically, by manipulating the spatial distribution of AuNPs on IVLN surface and the peptide density regional confined to those AuNPs, it was possible to increase the median antigen-specific IgG antibody titer from 6,300 to 32,500 – a 5-fold increase. This result was further corroborated by direct comparison of IVLNs to Lipid-IONPs. Significantly, as compared to Lipid-IONP-HER2, IVLN-HER2 was determined to have 18.5-fold, 15-fold and 4.5-fold higher antigen-specific IgG, IgG1 and IgG2a titers, respectively. With highly comparable hydrodynamic particle size, surface charge, core shape and peptide loading per unit nanoparticle, any quantifiable differences in antibody production by these two structures could be attributed to increasingly viral-like character. Mechanistically, this viral-like character led to enhanced antigen-specific antibody production as a result of greater delivery to and retention in the lymph nodes due to improved immune cell uptake, which promoted a significant increase in overall B-cell activation and germinal center formation.

EXAMPLE 2

Virus-Like Nanoparticles for Antigen-Specific Antibody Production

This Examples describes the production and use of virus-like nanoparticles to produce antibodies. In order to achieve the viral-like structures, we engineered IVLNs, using a
 5 controllable and robust self-assembly process, to resemble spiky peplomers of virus, which have spiky antigen cluster topography, a certain distance between antigen clusters, and localized high antigen density on the spike.

In order to test IVLNs for viral functional mimicry, we evaluated the IVLNs to activate antigen-specific B cells and durable antigen-specific antibody response. We selected
 10 a well-known HER2 B cell epitope with overlap CD4 T cell epitope since the in vivo model for evaluation of durable antibody response is readily available by monitoring HER2 tumor growth without need of a biological safety level four lab. Three important viral like functions of IVLNs were evaluated: (1) antigen delivery efficiency and B cell zone uptake in the secondary lymph nodes; (2) antigen specific B cell activation by different density and spatial
 15 arrangements of antigen on the IVLN surface; and (3) follicular T helper cell activation in the Germinal center for B cell activation and durable antibody response. The durable function of antigen specific antibody was evaluated in vivo to inhibit HER2 cancer growth.

Materials and Methods

Materials

All reagents were used as obtained from commercial sources without further purification, except for γ -Methacryl oxypropyltrimethoxysilane (98%) that was purified by distillation under reduced pressure and 2,2-Azobis(isobutyronitrile) (98%) that was purified
 25 by recrystallization in ethanol. Iron oxide (III) ($\text{FeO}(\text{OH})$, hydrated, catalyst grade, 30–50 mesh), oleic acid (technical grade, 90%), ammonium iron (II) sulfate hexahydrate (ACS reagent, 99%), 1-octadecene (technical grade, 90%), anhydrous tetrahydrofuran (THF, 99.8%), carbon disulfide (99.9%), magnesium turnings (>99.5%), 2-chloro-2-phenylacetyl chloride (CPAC, 90%), poly(ethylene oxide) monomethyl ether (PEO), anhydrous dioxane
 30 (99.8%), dimethylformamide (DMF, 99.9%), dimethyl sulfoxide (DMSO, 99.9%), o-phenanthroline monohydrate (ACS reagent, 99%), hydroquinone (ACS reagent, 99%, sodium sulfide, chloroauric acid, nitric acid (ACS reagent, 70%), and hydrochloric acid (ACS reagent, 37%) were purchased from Sigma-Aldrich. Mouse uncoated IgG and IgM Total ELISA Kits, 1-Step Ultra TMB-ELISA substrate solution, HRP-conjugated goat anti-mouse

IgG1 secondary antibody, HRP-conjugated goat anti-mouse IgG2a secondary antibody, Nunc Immobilizer Amino 96-well ELISA plates, BupH carbonate bicarbonate buffer packs (coating buffer), Pierce protein free PBS-tween blocking buffer, 20x PBS-tween wash buffer, Geneticin (G418) selective antibiotic, Invitrogen eBioscience fixable viability dye eFluor
 5 780, and Molecular Probes streptavidin Alexa Fluor 647 conjugate were obtained from Thermo Fisher Scientific. HRP conjugated goat anti-mouse IgG secondary antibody, Zombie UV fixable viability kit, FITC anti-mouse CD19, PE/Dazzle 594 anti-mouse IgD, Alexa Fluor 647 anti-mouse/house GL7 antigen, Brilliant Violet 421 and PE/Dazzle 594 anti-mouse/human CD45R/B220, FITC anti-mouse CD95, Brilliant Violet 421 anti-mouse/human
 10 CD11b, FITC anti-mouse CD169 and PE goat anti-mouse IgG secondary antibody were purchased from BioLegend. HER2 peptides (CDDDPESFDGDPASNTAPLQPEQLQ (SEQ ID NO:1), Biotin-PESFDGDPASNTAPLQPEQLQ (SEQ ID NO:2), CDDDPESFDGDPASNTAPLQPEQLQGGGK, SEQ ID NO:3) were custom synthesized by LifeTein. Iron-oxide nanoparticles (30 nm) stabilized by oleic acid in chloroform were
 15 purchased from Ocean Nanotech. DSPE-PEG (2000) and DSPE-PEG (2000)-maleimide were obtained from Avanti Polar Lipids. 2'3'-cGAMP was acquired from InvivoGen. Fluorescamine was purchased from MP Biomedicals. Sulfo-Cy5.5 NHS ester was acquired from Lumiprobe. Microvette 500 Z-Gel serum collection vials with clotting factor were obtained from Sarstedt. Matrigel Basement Membrane Matrix was purchased from Corning.
 20 Gold and iron ICP standards were purchased from Fluka Analytical.

Mice

All animal experiments were conducted according to the protocols approved by the University of Michigan Committee on Use and Care of Animals (UCUCA). BALB/c mice
 25 ages 5–7 weeks were purchased from Charles River Labs.

Cells

All cells were maintained at 37 °C, 5% CO₂/95% air atmosphere and approximately 85% relative humidity. D2F2/E2 cells ((83)) were cultured in complete DMEM high glucose
 30 supplemented with 10% NCTC 109 media, 1% L-glutamine, 1% MEMs non-essential amino acids, 0.5% sodium pyruvate, 2.5% sodium bicarbonate, 1% pen/strep, 5% cosmic calf serum, 5% fetal bovine serum, 500 µg/mL Geneticin and 50 µM 2-mercaptoethanol. RAW264.7 macrophages were cultured in complete RPMI-1640 media supplemented with 10% fetal bovine serum, 1% L-glutamine, 1% MEMs non-essential amino acids, 1% sodium

pyruvate and 1% pen/strep. Primary B-cells were cultured in RPMI-1640 media supplemented with 10% heat-inactivated fetal bovine serum.

Formulation and characterization of inorganic virus-like nanoparticles (IVLN)

5 The IVLN was formulated generally as in Example 1. The final Au to Fe ratio of the formulated IVLN was quantified by inductively coupled plasma mass spectrometry (ICP-MS) using a Perkin-Elmer Nexion 2000 based on previously reported protocols modified from analysis by ICP-OES (78). IVLN formulations were imaged by scanning transmission (electron microscopy (STEM) using a JEOL 2100F with a CEOS probe corrector. The true
10 particle size of AuNPs, IONPs and IVLNs was quantified using ImageJ software. The volume-weighted hydrodynamic particle size, polydispersity index and zeta-potential of all formulations in milliQ water at 25 °C was evaluated with the Malvern Zetasizer Nano-ZS using dynamic light scattering and phase analysis light scattering, respectively.

Lipid-coated iron-oxide nanoparticle formulations (IONP)

 Lipid-coated iron-oxide nanoparticles were prepared as follows. DSPE-PEG (2000)-maleimide (10 mg) was added to 1 mg of 30-nm iron-oxide nanoparticles stabilized by oleic acid in chloroform as gently mixed. The resulting solution was subjected to solvent rotary evaporation to remove all chloroform and form a thin film. Simultaneously, this film and 100
20 mM PBS, pH 7.4 were heated to 75 °C in an oven. Upon reaching temperature, hot PBS was rapidly added to the film and mixed immediately and vigorously to facilitate thin film hydration. The resulting nanoparticle solution was stored at 4 °C to promote lipid self-assembly. Free phospholipid was removed by magnetic separation overnight at 4 °C using the EasySep magnetic separator device (StemCell).

IONP-HER2 and IVLN-HER2 formulations

 HER2 peptides were conjugated to both IONP and IVLN through thiol-mediated chemistries. Specifically, IONP-HER2 was formulated via maleimide chemistry and IVLN-HER2 was formulated via the gold-thiol linkage. HER2 peptide was added to IONP at 1.5x
30 weight ratio excess in milliQ and incubated overnight at 4 °C. HER2 peptide was added to IVLN-HER2 at 5x weight ratio excess in milliQ and incubated overnight at 4 °C. Both materials were purified either by magnetic separation overnight at 4 °C using magnetic separation, or by centrifugal separation at 10,000 x g for 30 minutes at 4 °C. Peptide loading was determined using fluorescent quantification using a modified fluorescamine peptide

quantification assay in the presence of nanoparticles (Ex/Em: 390/465 nm, Biotek Cytation 5)(86). Quantification was performed using a standard curve with increasing peptide concentration with standardized concentration of nanoparticles (IONP or IVLN) to account for quenching effects.

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Immunizations and serum collection

At day 0, mice were immunized with the equivalent of 50 µg or 5 µg of HER2 peptide plus 10 µg of cGAMP regardless of formulation type. Subsequently, at day 14, mice were boosted twice at two-week intervals with 50% of the original dosage for both antigen and adjuvant (day 14 and 28). To evaluate serum antibody titers, blood was collected by submandibular puncture 10 days after each immunization (day 10, 24 and 38). Serum was separated from whole blood by centrifugal separation at 10,000 x g for 5 minutes at 25°C using the Microvette 500 Ser-Gel collection vessels with clotting activator.

Enzyme-linked immunosorbent assay (ELISA)

Absolution quantification of total IgG and total IgM antibody analysis was performed using the mouse uncoated total IgG and total IgM ELISA kits based on manufacturer recommended protocols (Thermo Fisher). Antigen-specific IgG, IgG1 and IgG2a antibody titers were quantified based on previously established protocols for indirect ELISA with minor modifications (87). Specifically, HER2 peptides (200 µL, 100 µg/mL in 100 mM carbonate buffer, pH 9.4) were chemically conjugated to ELISA plates through the terminal amine group utilizing Nunc Immobilizer Amino immunoassay plates by overnight incubation with exposure to light at room temperature. Following overnight incubation, ELISA plates were washed three times with 100 mM PBS, pH 7.4 with 2% Tween-20. Subsequently, ELISA plates were blocked overnight at 4 °C with 300 µL of ELISA blocker (Pierce Protein-Free PBS Blocking Buffer). Following blocking, the ELISA plates were washed 3x. Serum samples containing primary antibodies were serially diluted (10^1 – 10^8 fold) using 100 mM PBS, pH 7.4 containing 10% ELISA blocker reagent and added to each well at 200 µL total for 2 hour incubation at room temperature. Following sample addition, the ELISA plates were washed 3x. 500-fold diluted anti-IgG-HRP, anti-IgG1-HRP, or anti-IgG2a-HRP was added at 100 µL to each well and incubated for 1 hour at room temperature. After 1 hour, the ELISA plates were washed 5x. Next, 100 µL of 1-Step Ultra TMB Substrate Solution was added to each well and allowed to incubate and develop color for 15–20 minutes at room temperature with gentle agitation. After 15–20 minutes, color development was stopped by

the addition of 100 μ L of 100 mM sulfuric acid. Colorimetric development was quantified by absorbance spectroscopy at 450 nm using the BioTek Cytation 5 plate reader. Antibody titers were determined by any absorbance signal at a given dilution factor that was greater than the PBS control absorbance signal plus three standard deviations(88).

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Quantification of nanoparticle delivery to lymph nodes *in-vivo*

Mice were injected subcutaneously in the left hock with either IONP or IVLN at a dose of 200 μ g Fe per mouse. At the designated time intervals, mice were sacrificed and lymph nodes of interest were dissected for *ex-vivo* analysis. The extent of nanoparticle delivery to the lymph nodes was quantified using ICP-MS based on previously reported protocols (77).

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Quantification of peptide delivery to lymph nodes *in-vivo*

To facilitate quantification of peptide delivery to lymph nodes, lysine terminally modified HER2 peptides were chemically conjugated to sulfo-Cy5.5 NHS Ester. This conjugation was carried out at a 5-fold molar excess of sulfo-Cy5.5 NHS Ester to HER2 peptide. IONP-HER2-Cy5.5 and IVLN-HER2-Cy5.5 were subjected to Cy5.5 functionalization after initial peptide conjugation was completed in order to enable facile purification of excess fluorescent dye by magnetic separation. Subsequent to Cy5.5 functionalization, mice were injected as previously stated. After 3 hours, mice were sacrificed and lymph nodes of interest were dissected for *ex-vivo* analysis by IVIS imaging. IVIS imaging was utilized for semi-quantification of peptide delivery in terms of radiant efficiency.

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***In-vivo* cell uptake**

IVLN-HER-Cy5.5 and IONP-HER2-Cy5.5 were injected subcutaneously in the left hock with either Lipid-IONP or IVLN at 200 μ g total Fe per mouse. At 3 hours and 24 hours, mice were sacrificed and lymph nodes of interest were dissected for *ex-vivo* analysis by flow cytometry. Lymph nodes were dissociated by mechanical methods to prepare single cell suspensions. Single cell suspensions of lymph node cells were stained for analysis by flow cytometry using the MoFlo Astrios flow cytometer. Viable cells (Zombie UV) were identified as either B-cells (B220⁺) or subcapsular sinus macrophages (CD169^{high}CD11b⁺) and evaluated for positive nanoparticle interactions (Cy5.5). Flow cytometry data was analyzed by FCS express.

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***In-vitro* cell uptake**

IVLN-HER2 and IONP-HER2 cellular uptakes were evaluated in RAW264.7 macrophages, dendritic cells (DC 2.4), and primary B-cells isolated from murine spleens using an EasySep Mouse B-cell isolation kit. Nanoparticle samples were incubated at 50 $\mu\text{g/mL}$ Fe with cells for 18 hours in blank RPMI media at 37 °C, 5% CO₂/95% air atmosphere and approximately 85% relative humidity. After 18 hours, cells were lifted by cell scraping and washed thrice with PBS. Following the wash steps, resulting cell pellets were re-suspended in 1 mL of PBS, cell counted and then digested in 1 mL aqua regia (1:3 molar ratio nitric acid: hydrochloric acid) for analysis by ICP-MS.

Mass cytometry (CyTOF) to analyze all immune cells

Fixed and frozen cell suspensions were thawed on ice. Samples were stained and prepared for CyTOF analysis as previously described (89, 90), using an optimized cocktail of 40 metal-conjugated antibodies designed to identify major and minor immune cell subsets in lymph nodes. Following acquisition on a CyTOF II (Fluidigm, San Francisco, CA), samples were normalized to internal bead standards. Cell subsets were identified by gating using FlowJo software. Global analysis using SPADE were performed for unsupervised clustering analysis based on the expression of marked genes in different subset of immune cells.

Antigen-specific B-cell and germinal center flow cytometry

Mice were immunized as previously introduced. At day 10, mice were sacrificed and lymph nodes were dissected for *ex-vivo* analysis by flow cytometry. Antigen-specific B-cell analysis was accomplished using tetramer staining based on previously established protocols with minor modifications (63). HER2/neu peptide tetramers were prepared by mixture of biotin-labeled HER2 peptide with Alexa Fluor 647 labeled streptavidin at a 4:1 molar ratio at room temperature for 1 hour without further purification. Antigen-specific B-cell population was identified using CD19, and the HER2-peptide tetramer using flow cytometry. Germinal center B-cell populations were identified using the following markers B220, IgD, GL7 and CD95 (B220⁺IgD^{low}GL7⁺CD95⁺).

Tumor studies

Forty-nine days after the primary immunization, mice were inoculated with 2.5×10^5 D2F2/E2 cells subcutaneously in the right flank. D2F2/E2 cells were prepared at 2.5×10^6

cells/mL in 100 μ L and mixed at equal volume with Matrigel matrix. Tumor size was quantified by caliper measurements every 7 days. Tumor volumes were calculated by volume = (width)²×length/2. End points were determined by using the End-Stage Illness Scoring System; mice receiving an End-Stage Illness Score greater than 6 were euthanized by CO₂ asphyxiation.

Statistics

Data are expressed as mean $\pm$ standard deviation (SD), unless otherwise specified. Comparisons between two groups were made using the unpaired Student's *t*-test. Means of multiple groups were compared with the one-way analysis of variance (ANOVA), followed by post hoc Tukey's pairwise comparisons. All probability values are two-sided, and values of *p* < 0.05 were considered statistically significant. Statistical analyses were carried out using the GraphPad Prism 7 software package.

Results

Engineer inorganic viral-like nanoparticles (IVLNs) to mimic viral-like spiky structure

We have developed a controllable and robust process to manufacture IVLNs using a self-assembly process. To achieve viral-like spiky topography, the AuNPs (2 nm) were attached onto the surface of IONP (15 nm) to produce IVLN (**Fig 7A**). The attachment of AuNP and IONP was achieved by self-assembly from the interaction between reactive AuNP surfaces and free siloxane moieties present in the polymer used to coat the IONP. This process is controlled and robust for large-scale manufacture.

The IONP was synthesized by thermal decomposition to produce a 15-nm spherical core stabilized by oleic acid in chloroform. To achieve aqueous stabilization, the IONP was coated with a poly(siloxane) and poly(ethylene glycol) containing di-block co-polymer based on procedures previously reported (51). The ultra-small gold nanoparticles or satellites (AuNPs) with ~2-3 nm sizes were prepared using a modified precipitation method by reduction of chloroauric acid in aged sodium sulfide (53). The AuNP solution was added to an IONP solution at defined weight ratios and incubated overnight at 4 °C to allow for self-assembly of IVLNs. To control the number of viral-like spiky structures on IVLN from 4-14 (**Fig 7B, 7C**), the ratios of AuNPs to IONPs were adjusted to 10%, 20% and 30% AuNP/IONP, as measured by ICP-MS (54, 55), yielded IVLNs with 4 ± 2 , 9 ± 3 and 13 ± 5 AuNPs per IVLN (**Fig 7B**). The viral-like structure of IVLN was confirmed by scanning

transmission electron microscopy (STEM) (**Fig 7C**). The high-angle annular dark-field (HAADF) image of single IVLN (with 14 AuNPs) showed close resemblances of viral-like structure (**Fig 8C**).

5 **IVLNs conjugated with non-capsid antigen peptides resemble spiky peplomer structure of a virus with three viral-like features**

In order to mimic antigen structure similar to peplomers of virus, three features are employed: spiky antigen cluster topography, optimal distance (5 nm) between antigen clusters, and localized high antigen density on the spike.

10 The spiky antigen cluster topography was achieved by conjugating antigen peptides only to the spike AuNPs of IVLNs, but not on the polymer of IONP core. We used a non-viral-capsid and well-known HER2 B cell epitope with an overlapping CD4 T-cell epitope (CDDD-PESFDGDPASNTAPLQPEQLQ-(GGK) (56-58). We selected HER2 B cell epitopes as a proof of concept study to study viral like structure and functional mimicry of
15 IVLNs since the in vivo model is readily available to test antibody function by monitoring tumor growth without need a biosafety level 4 lab. The conjugation of HER2 peptides (with cysteine at the N-terminus) was achieved only to the spiky AuNP through S-Au reaction on IVLN, but not on the adjacent polymer coating on INOP (**Fig 7F, 1H**). Polymer-coated IONP alone without AuNPs were used as control. High levels of peptide conjugation were observed
20 for IVLNs with AuNPs, but not on the IONP core alone (**Fig 7F**, black symbols). Additionally, a positive correlation between peptide loading and AuNP number were observed ($R = 0.95$). These results suggest that, although there is a low-level non-specific association of HER2 peptides to INOP core (~12%), peptide conjugation is AuNP dependent, which achieved antigen spiky cluster topography on IVLN; these viral mimicry feature
25 cannot be achieved by traditional nanoparticles that only have uniform Antigen distribution on their surface (**Fig 7I**).

To control the distance between two spiky antigen clusters at 5-10 nm, which is an ideal distance for B cell receptor (BCR) cross-linking and activation (41, 59), we adjusted the number of AuNP at 14 on the IVLN surfaces using different ratios of AuNP/IONP, which
30 produced distance between 5.1-6.3 nm (**Fig 7D**).

To control the highly localized antigen density on the spike, we conjugated different amount of HER2 peptides on IVLN with 0%, 10% and 30% AuNP/IONP ratios, which correspond to 0, 4, 13 AuNP on the IVLN surface, respectively (**Fig 7F**). The peptide loadings were 232 ± 73 , 888 ± 42 and 1954 ± 157 peptides per IVLN (227 ± 5 peptides per

AuNP, **Fig 7F**). Therefore, IVLN achieved an density of 20,000-25,000 antigen clusters per μ^2 , which is comparable to the antigen density reported for VLPs(9) (e.g. Hepatitis B Virus, ~20,000 antigens) (**Fig 7E**).

To mimic the optimal viral size and surface charge (32, 34), IVLNs have a 50-60 nm particle size, 0.2 PDI and a -16 mV zeta-potential (**Fig 7H**). In addition, under *in-vivo* relevant serum conditions, IVLN-HER2 were shown to be stable between 12 and 24 hours.

To effectively evaluate these three features of viral-mimicry structures of IVLNs, a traditional lipid-coated IONP (IONP-HER2) with similar size, charge, peptide density (2323 ± 394 peptides per IONP, but a uniform antigen distribution) on the surface was generated as a control (**Fig. 7G, 7I**). IONP-HER2 has a 30-nm IONP core and a functionalized DSPE-PEG (2000)-maleimide shell that facilitates facile peptide conjugation. IONP-HER2 has similar material properties in terms of volume-weighted hydrodynamic particle size (68 ± 5 nm), PDI (0.22 ± 0.02) and maximal number per particle (2323 ± 394 peptides per IONP) (**Fig. 7G**). Therefore, the side-by-side comparison of IVLN-HER2 and IONP-HER2 would offer valuable insights into the role of viral mimicry function.

IVLN-HER2 enhanced 7 to 18-fold HER2-specific antibody production vs. IONP-HER2

Viral mimicking nanoparticles have been utilized in a wide-range of *in-vitro* and *in-vivo* applications, but the most significant application of viral-like structure and function is to activate B-cells for antigen-specific antibody production (2, 6, 13, 57, 60-62). Therefore, we first tested if the IVLN-HER2 induced antigen-specific IgG production *in-vivo* against a non-capsid oncogenic human HER2-specific peptide (HER2).

The optimized IVLNs (~14 spiky antigen clusters, distance between two antigen clusters 5-6 nm, ~2000 peptides/IVLN, 150 peptides/AuNP) were used to immunized BALB/c mice to produce HER2-specific antibody, in comparison with a traditional lipid-coated IONP-HER2 with similar HER2 peptide density (~2000 peptides /IONP, uniform antigen distribution). IVLN-HER2 and IONP-HER2 have similar size under TEM (30 nm) and DLS (65 nm). The same dose of HER2 peptides in all groups were used for immunization of BALB/c mice (5 ug, or 50 ug peptide, 10 μ g cGAMP as adjuvant) at day 0 and boosted twice at 14-day intervals (**Fig 8A**). Two doses (5 ug and 50 ug) of HER2 were used for immunization. Complete serum analysis was performed after two booster immunizations (day 38) because this time point was determined to be most responsive and therefore most relevant. Antibody responses were analyzed using ELISA after two booster immunizations

(day 38) for total IgM, total IgG, HER2-specific IgG and the HER2-specific IgG isotypes (IgG1 and IgG2a).

At a low dose, IVLN-HER2 (5 ug) generated an 8-fold higher HER2-specific IgG titer, an 18-fold higher HER2-specific IgG1 titer, and a 13-fold higher HER2-specific IgG2a titer as compared to IONP-HER2. Moreover, IVLN-HER2 yielded a 14-fold higher Ag-specific IgG titer, a 7-fold higher Ag-specific IgG1 titer, and a 14-fold higher Ag-specific IgG2a titer as compared to soluble HER2 peptide (**Fig 8B**).

Similarly, at a high dose (50 ug), IVLN-HER2 (50 ug) enhanced a 12-fold higher antigen-specific IgG titer, an 8-fold higher antigen-specific IgG1 titer, and a 14-fold higher antigen-specific IgG2a titer as compared to soluble HER2 peptide. In comparison with IONP-HER2, IVLN-HER2 (50 ug) enhanced 4 to 5-fold higher antigen-specific IgG titer, a 3-fold higher antigen-specific IgG1 titer, and a 5-fold higher antigen-specific IgG2a titer (**Fig 8C**). No statistically significant difference in total IgM and total IgG antibody production was observed between any treatment groups. Overall, these data indicate that the viral-like properties of IVLNs are more efficient for antigen-specific antibody production.

The spiky antigen cluster numbers, distance between two antigen clusters, and localized antigen density on IVLNs affect their ability to produce antigen-specific antibody

Viral-like features are important for B-cell activation through multivalent B-cell receptor crosslinking (9, 40, 41), which includes different numbers of spiky antigen clusters, different distances between clusters, and different localized antigen density (2, 6, 13, 57, 60-62). Therefore, we tested if different IVLN-HER2 viral-mimic features influence anti-HER2 antibody production in BALB/c mice. We immunized mice at day 0 and boosted once at day 14 using IVLN-HER2 with different spiky cluster numbers and distance but using the same amount of HER2 peptides (50 µg HER2 peptide, 10 µg cGAMP as adjuvant) (**Fig 9A**).

We first evaluated the effect of the numbers of spiky antigen clusters and distance between antigen clusters on HER2-specific IgG antibody production using two different AuNP/IONP ratios: 10% and 30%, which corresponds with AuNP numbers on IONP ratios from 4, 14, and distances between AuNPs is ~15 and ~5 nm. The IVLNs (with 14 antigen cluster and optimal distances between clusters is 5 nm) produced 6-fold higher HER2-specific IgG titers (64,500) compared to IVLN (with 4 antigen clusters, 15 nm distance between clusters) that generated HER2-specific IgG titer at 10,540 (**Fig 9B**) although same dose of HER2 antigen was used in immunization.

Subsequently, we evaluated the effect of localized antigen density on IVLN on HER2-specific antibody production. IVLNs (14 antigen clusters with distance between clusters is ~5 nm, high density 150 peptides/cluster) generated 4-fold higher titer of antigen-specific antibody than IVLNs (with 4 antigen clusters with distance between clusters is 15 nm, low antigen density 30 peptides/cluster) although same HER2 antigen dose was used in immunization (**Fig 9B**). The data suggest that the number of antigen clusters (14 clusters in this Example), distance between antigen clusters (5-6 nm in this Example), and localized antigen density (2000 peptides/IVLN, ~150 peptides/AuNP in this Example) generated high HER2-specific antibody.

IVLN-HER2 increased 6-fold higher antigen-specific B cell activation and GC formation vs. IONP-HER2

In order to generate high antibody response, antigen-specific B cell activation in the germinal center is required (9, 40, 41). Therefore, we tested the effect of IVLN-HER2 on both GC formation and antigen-specific B-cells in the draining lymph nodes of immunized BALB/c mice. HER2-specific B-cells in immune response in lymph nodes was measured utilizing fluorescently-labeled streptavidin HER2 peptide tetramer staining(63) (**Fig 10A**). Antigen-specific B-cells were identified as double positive for CD19 and the HER2 peptide tetramer.

The data showed that IVLN-HER2 produced 6-fold higher HER2-specific B-cells in the lymph node (3%) in comparison with IONP-HER2 immunized group (**Fig 10B**). No differences in the HER-specific B-cells were detected in IONP-HER2 vs. HER2 peptide immunized mice. In addition, we also assessed GC formation at 10 days (peak of GC response) after the primary immunization with IVLN-HER2, IONP-HER2 and soluble HER2 peptide by flow cytometry analysis. GC B cell were identified as B220⁺IgD_{low} cells that are double-positive for CD95 and GL-7 markers (64, 65) (**Fig 10C**). IVLN-HER2 resulted in a 2.6-fold and an 8-fold increase in the GC formation in comparison with IONP-HER2 and HER2 peptide immunized groups (**Fig 10D**). Very importantly, the 3% antigen specific B cells activation and more than 17% Germinal enter formation are rarely seen by any other delivery systems. These data suggest that the viral mimicking features of IVLN-HER2 uniquely enhanced antigen-specific B cells in comparison with traditional nanodelivery systems.

CyTOF analysis of immune cells reveals that IVLN-HER2 enhanced Tfh-dependent B cell activation in the lymph node

In the germinal center (GC), B cell activation needs the interaction with follicular T cells to generate long lived plasma cells (PC), which produces long-term durable antibody response. Therefore, CyTOF analysis was used to evaluate the T cell dependent B cell activation by evaluating immune cells in the lymph nodes after immunization, which include macrophage, dendritic cells, B cell, CD4+, CD8+ T cells, NK cells in the lymph nodes and spleen using 40-makers with heavy medal labeled antibodies. (66-68).

Global analysis using SPADE showed that IVLN-HER increased GC, plasma B cells, and follicular T cells (**Fig 11A, 11B**) in the lymph node, but it showed no significance other changes in the immune cells in lymph node and spleen. Detail analysis revealed that IVLN-HER2 stimulated more germinal center B cells (CD19+/GL7+ or B220+/GL7+) (**Fig 11C**), T follicular helper cells (Tfh) (CD4+/CXCR5+/PD-1+) (**Fig 11D**), and plasma cells (PC) (**Fig 11E**) in comparison with IONP-HER2 immunized group, which is critical for antibody secretion. These data provide strong evidence that IVLN-HER2 induced Tfh-dependent B cell activation in the GC of the lymph nodes, explaining why IVLN-HER2 produced higher titer antigen-specific antibody.

IVLN-HER2 improved lymph node delivery efficiency and B cell zone uptake in comparison with IONP-HER2

Efficient antigen delivery to lymph node is pre-requisite for effective B cell activation and antibody responses. We first evaluated IVLN-HER2 delivery efficiency and retention in the lymph nodes (69, 70). Second, within the lymph node, we determined if IVLN-HER2 can be specifically targeted to B-cell zones since the lymph nodes are primary sites for B-cell activation and the formation of germinal centers that are ultimately responsible for initiating antigen-specific IgG antibody production (71-73). Third, we also tested if IVLNs had viral-like cellular distribution patterns within lymph nodes. As sites with dense populations of antigen-presenting cells and lymphocytes, the lymph nodes are known to be critically important in viral sequestration and directed immune activation (74, 75). This functionality is the result of unique physiological features that have been developed for viral recognition and viral-specific immune activation. For example, subcapsular sinus macrophages are a highly specialized phenotype of macrophage that is responsible for viral uptake and direct presentation to B-cells to promote directed viral clearance via antigen-specific antibody production (75, 76).

The delivery efficiency and retention of IVLN-HER2 in the lymph nodes in comparison with IONP-HER2 was evaluated using two different methods (69, 70): ICP-MS quantification of Fe in excised lymph node (77, 78) and IVIS imaging of fluorescent labeled IVLN-HER2 peptide (79). The t_{max} of both IVLN-HER2 and IONP-HER2 was 3 hours post-administration that suggests rapid direct trafficking to the lymph nodes. Over 48 hours, IVLN-HER2 has a 3.5-fold higher in overall exposure vs. IONP-HER2 based on area under the curve (AUC) (**Fig 12A**). In addition, fluorescently labeled peptides were also used to monitor the lymph node delivery for IVLN-HER2, IONP-HER2 and soluble HER2 peptides at 3 hours using IVIS imaging of excised popliteal and inguinal lymph nodes (**Fig. 12B**). IVIS imaging revealed that IVLN-HER2 led to a 4.3-fold improvement in lymph node delivery as compared to both the IONP-HER2 and soluble HER2 peptide, where IONP-HER2 and HER2 have no statistically significant difference in delivery.

Subsequently, we tested if IVLN-HER2 had viral-like distributions within the lymph node, especially in subcapsular sinus macrophage and B-cell populations, as compared to IONP-HER2 (72, 73, 76). Fluorescently labeled IVLN-HER2 were injected by subcutaneous hock immunization and flow cytometry was applied 3 hours post-administration to identify IVLN-HER2 or IONP-HER2 positive cells of different phenotypes. Subcapsular sinus macrophages were identified as CD11b⁺CD169^{high} double-positive and B-cells were identified as B220⁺ (76, 80). IVLN-HER2 improved subcapsular sinus macrophage uptake by 1.7-fold and B-cell uptake by 3.4-fold (**Fig. 12C**) in comparison with IONP-HER2. The intracellular uptake of IVLN-HER2 and IONP-HER2 was confirmed *in-vitro* in RAW 264.7 macrophages and primary B-cells isolated from murine spleens. Compared to the IONP-HER2 control group, IVLN-HER2 improved cellular uptake by 3-fold in macrophages and 2-fold in B-cells (**Fig. 12D**). Taken together, these data suggest that viral structural mimicry of IVLNs improved lymph node delivery efficiency and preferred B cell zone distribution in the lymph node.

IVLN-HER2 induced antigen-specific antibody with durable function

We used a well-known B cell epitope of HER2 antigen so that we can easily test the function of the induced antibody in an established model by monitoring the tumor growth after IVLN-HER2 immunization *in vivo*. The HER2 peptide on IVLNs is a B cell epitope to produce pertuzumab (Perjeta[®])(56), which is currently used to treat HER2⁺ breast cancer in human(81, 82). Therefore, we employed IVLN-HER2 as a vaccine for its *in-vivo* prophylactic efficacy to prevent tumor growth of HER2 breast cancer xenograft model

(D2F2/E2 murine breast cancer with high human HER2 expression) (83). The prophylactic tumor inhibition was initiated by subcutaneous flank inoculation with 2.5×10^5 cells per mouse at day 49 following a primary immunization plus three additional booster administrations at 14-day intervals (**Fig 13A**). IVLN-HER2 immunization significantly inhibited tumor growth over 6-weeks at a dose of 50 μg ($125 \pm 239 \text{ mm}^2$ vs. $1843 \pm 661 \text{ mm}^2$, $p < 0.001$) (**Fig. 13B**) and 5 μg ($583 \pm 392 \text{ mm}^2$ vs. $1843 \pm 661 \text{ mm}^2$, $p < 0.001$) (**Fig. 13C**), which was superior than INOP-HER2 and HER2 peptide only group. In addition, the prophylactic anti-cancer efficacy appears to be directly correlated not only to the specificity of these endogenous antibodies to the D2F2/E2 cell line, but also to the titer of antigen-specific antibody. These data suggest that the antigen specific antibody by IVLN-HER2 has durable function in vivo.

B cell immunity against viral capsid protein antigens on the virus surface is highly desired to prevent infections. In such case, virus like structure of the capsid antigens on the inactivated/live attenuated virus and virus like particles (VLPs) using virus capsid proteins is highly effective to active B cell immunity against viral infections (1-4). However, B cell immunity against non-capsid protein antigens is also desired in three other scenarios to against bacteria toxin of deadly bacteria infection, oncogenic proteins of cancers, and peptide antigens for antibody production (20, 21). However, it is very difficult to make virus like particles using these non-capsid antigens and thus activate B cell immunity. B cell vaccine against bacterial toxin is highly desired for prevention of deadly bacteria infection such as *C. Anthracis* (Anthrax) and *C. Botulinum* (20, 21). These bacterial toxin B cell vaccines usually use toxoid as antigens to boost neutralizing antibody (20, 21). The successful bacterial toxin vaccines are currently used against Tetanus and Diphtheria. However, the safety and efficacy for bacterial toxoid B cell vaccines of *C. Anthracis* (Anthrax) and *C. Botulinum* are two major concerns (20, 21). Due to highly toxic nature of these two toxins, it is preferably to use peptides antigens of these toxoids as vaccines (22). However, the peptide antigens are very inefficient to boost B cell immunity using nanoparticle delivery system without a virus structure mimicry. In addition, B cell immunity against oncogenic antigen may have potential benefit in prevention/treatment of cancers. For instance, several HER2 B cells vaccines are currently in clinical trials although there is still debate for the benefits/risks of B cell activation in cancers (23, 24). Furthermore, efficient antibody production against various peptide antigens is highly desired in disease detection/treatment (25). However, the efficiency

of these peptide antigens to generate antibody is low and they can only generate low titer of antibody in a short term.

The current strategy to enhance B cell immunity against non-capsid antigens is to use nanodelivery system to mimic viral like structures. However, most nanodelivery systems do not have true virus like structures that are inefficient to activate B cell immunity. Although the nanodelivery system without viral like structure is superior than soluble peptides for B cell immunity, they only able to activate low levels of antigen-specific B cells (less than 1-3%) and have short lived antibody responses (35-38). In contrast, the inorganic virus like nanoparticles (IVLNs) herein with HER2 peptides generated more than 17% antigen specific B cells in a follicular T helper cell dependent manner. These features induced durable antibody response to inhibit HER2 tumor growth in vivo. We selected HER2 B cell epitopes to study viral like structure and functional mimicry of IVLNs since the in vivo model is readily available to test antibody function by monitoring tumor growth without need a biosafety level 4 lab. However, the same principle can be applied to activate B cell immunity for other applications, such as antibody production against peptides, or B cell immunity against bacterial toxins of *C. Anthracis* (Anthrax) and *C. Botulinum*.

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All publications and patents mentioned in the present application are herein incorporated by reference. Various modification and variation of the described methods and

compositions of the invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Indeed, various
5 modifications of the described modes for carrying out the invention that are obvious to those skilled in the relevant fields are intended to be within the scope of the following claims.

TABLE 4

Accession	Antigen Name	Common Name	Comment	Accession	Antigen Name	Common Name	Comment
Ag000001	ERBB2	HER2	ERBB2_i1_id1_v1	Ag002265	TP53	-	Somatic mutation
Ag000002	BIRC5	Survivin	BIRC5_i1_id1_v1	Ag002266	TP53	-	Somatic mutation
Ag000003	BIRC5	Survivin	BIRC5_i2_id1_v1	Ag002267	TP53	-	Somatic mutation
Ag000004	BIRC5	Survivin	BIRC5_i3_id1_v1	Ag002268	TP53	-	Somatic mutation
Ag000005	BIRC5	Survivin	BIRC5_i4_id1_v1	Ag002269	TP53	-	Somatic mutation
Ag000006	BIRC5	Survivin	BIRC5_i5_id1_v1	Ag002270	TP53	-	Somatic mutation
Ag000007	BIRC5	Survivin	BIRC5_i6_id1_v1	Ag002271	TP53	-	Somatic mutation
Ag000008	BIRC5	Survivin	BIRC5_i7_id1_v1	Ag002272	TP53	-	Somatic mutation
Ag000009	CEACAM5	CEA	CEACAM5_i1_id1_v1	Ag002273	TP53	-	Somatic mutation
Ag000010	WDR46	BING4	Alternative ORF	Ag002274	TP53	-	Somatic mutation
Ag000011	BAGE	BAGE1	BAGE_i1_id1_v1	Ag002275	TP53	-	Somatic mutation
Ag000012	CSAG2	TRAG-3	CSAG2_i1_id1_v1	Ag002276	TP53	-	Somatic mutation
Ag000013	CSAG2	TRAG-3	CSAG2_i2_id1_v1	Ag002277	TP53	-	Somatic mutation
Ag000014	DCT	TRP-2	DCT_i1_id1_v1	Ag002278	TP53	-	Somatic mutation
Ag000015	CSAG2	TRAG-3	CSAG2_i3_id1_v1	Ag002279	TP53	-	Somatic mutation
Ag000016	MAGED4	-	MAGED4_i4_id1_v1	Ag002280	TP53	-	Somatic mutation
Ag000017	GAGE1	GAGE-1	GAGE1_i1_id1_v1	Ag002281	TP53	-	Somatic mutation
Ag000018	GAGE2	GAGE-2	GAGE2_i1_id1_v1	Ag002282	TP53	-	Somatic mutation
Ag000019	GAGE3	GAGE-3	GAGE3_i1_id1_v1	Ag002283	TP53	-	Somatic mutation
Ag000020	GAGE4	GAGE-4	GAGE4_i1_id1_v1	Ag002284	TP53	-	Somatic mutation
Ag000021	GAGE5	GAGE-5	GAGE5_i1_id1_v1	Ag002285	TP53	-	Somatic mutation
Ag000022	GAGE6	GAGE-6	GAGE6_i1_id1_v1	Ag002286	TP53	-	Somatic mutation
Ag000023	GAGE7	GAGE-7	GAGE7_i1_id1_v1	Ag002287	TP53	-	Somatic mutation
Ag000024	GAGE8	GAGE-8	GAGE8_i1_id1_v1	Ag002288	TP53	-	Somatic mutation
Ag000025	IL13RA2	Interleukin 13 receptor alpha 2	IL13RA2_i1_id1_v1	Ag002289	TP53	-	Somatic mutation
Ag000026	MAGEA1	MAGE-A1	MAGEA1_i1_id1_v1	Ag002290	TP53	-	Somatic mutation
Ag000027	MAGEA2	MAGE-A2	MAGEA2_i1_id1_v1	Ag002291	TP53	-	Somatic mutation
Ag000028	MAGEA3	MAGE-A3	MAGEA3_i1_id1_v1	Ag002292	TP53	-	Somatic mutation
Ag000029	MAGEA4	MAGE-A4	MAGEA4_i1_id1_v1	Ag002293	TP53	-	Somatic mutation
Ag000030	MAGEA6	MAGE-A6	MAGEA6_i1_id1_v1	Ag002294	TP53	-	Somatic mutation

Ag000031	MAGEA9	MAGE-A9	MAGEA9_i1_id1_v1	Ag002295	TP53	-	Somatic mutation
Ag000032	MAGEA10	MAGE-A10	MAGEA10_i1_id1_v1	Ag002296	TP53	-	Somatic mutation
Ag000033	MAGEA12	MAGE-A12	MAGEA12_i1_id1_v2	Ag002297	TP53	-	Somatic mutation
Ag000034	MAGEB1	MAGE-B1	MAGEB1_i1_id1_v1	Ag002298	TP53	-	Somatic mutation
Ag000035	MAGEB2	MAGE-B2	MAGEB2_i1_id1_v1	Ag002299	TP53	-	Somatic mutation
Ag000036	MAGEC2	MAGE-C2	MAGEC2_i1_id1_v1	Ag002300	TP53	-	Somatic mutation
Ag000037	TP53	-	TP53_i1_id1_v1	Ag002301	TP53	-	Somatic mutation
Ag000038	TP53	-	TP53_i2_id1_v1	Ag002302	TP53	-	Somatic mutation
Ag000039	TYR	Tyrosinase	TYR_i1_id1_v1	Ag002303	TP53	-	Somatic mutation
Ag000040	TYR	Tyrosinase	TYR_i2_id1_v1	Ag002304	TP53	-	Somatic mutation
Ag000041	TYRP1	TRP-1	TYRP1_i1_id1_v1	Ag002305	TP53	-	Somatic mutation
Ag000042	SAGE1	SAGE	SAGE1_i1_id1_v1	Ag002306	TP53	-	Somatic mutation
Ag000043	SYCP1	HOM-TES-14/SCP1	SYCP1_i1_id1_v1	Ag002307	TP53	-	Somatic mutation
Ag000044	SSX2	SSX2 or HOM-MEL-40	SSX2_i1_id1_v1	Ag002308	TP53	-	Somatic mutation
Ag000045	SSX2	SSX2 or HOM-MEL-40	SSX2_i2_id1_v1	Ag002309	TP53	-	Somatic mutation
Ag000046	SSX4	-	SSX4_i1_id1_v1	Ag002310	TP53	-	Somatic mutation
Ag000047	KRAS	K-ras	KRAS_i1_id1_v1	Ag002311	TP53	-	Somatic mutation
Ag000048	KRAS	K-ras	Putative	Ag002312	TP53	-	Somatic mutation
Ag000049	KRAS	K-ras	Putative	Ag002313	TP53	-	Somatic mutation
Ag000051	KRAS	K-ras	KRAS_i2_id1_v1	Ag002314	TP53	-	Somatic mutation
Ag000052	WDR46	BING4	WDR46_i1_id1_v1	Ag002315	TP53	-	Somatic mutation
Ag000053	PRAME	-	PRAME_i1_id1_v1	Ag002316	TP53	-	Somatic mutation
Ag000055	NRAS	N-ras	Putative	Ag002317	TP53	-	Somatic mutation
Ag000056	ACTN4	Alpha-actinin 4	ACTN4_i1_id1_v1	Ag002318	TP53	-	Somatic mutation
Ag000057	ACTN4	Alpha-actinin 4	Putative	Ag002319	TP53	-	Somatic mutation
Ag000058	CTNNB1	-	CTNNB1_i1_id1_v1	Ag002320	TP53	-	Somatic mutation
Ag000059	CTNNB1	-	Putative	Ag002321	TP53	-	Somatic mutation
Ag000060	CTNNB1	-	CTNNB1_i2_id1_v1	Ag002322	TP53	-	Somatic mutation
Ag000061	CASP8	Caspase-8	-	Ag002323	TP53	-	Somatic mutation
Ag000062	CASP8	Caspase-8	CASP8_i1_id1_v1	Ag002324	TP53	-	Somatic mutation
Ag000063	CASP8	Caspase-8	CASP8_i2_id1_v1	Ag002325	TP53	-	Somatic mutation
Ag000064	CASP8	Caspase-8	CASP8_i3_id1_v1	Ag002326	TP53	-	Somatic mutation

Ag000065	CASP8	Caspase-8	CASP8_i4_id1_v1	Ag002327	TP53	-	Somatic mutation
Ag000066	CASP8	Caspase-8	CASP8_i5_id1_v1	Ag002328	TP53	-	Somatic mutation
Ag000067	CASP8	Caspase-8	CASP8_i6_id1_v1	Ag002329	TP53	-	Somatic mutation
Ag000068	CASP8	Caspase-8	CASP8_i7_id1_v1	Ag002330	TP53	-	Somatic mutation
Ag000069	CASP8	Caspase-8	CASP8_i8_id1_v1	Ag002331	TP53	-	Somatic mutation
Ag000070	CASP8	Caspase-8	CASP8_i9_id1_v1	Ag002332	TP53	-	Somatic mutation
Ag000071	CDC27	-	CDC27_i1_id1_v1	Ag002333	TP53	-	Somatic mutation
Ag000072	CDK4	-	CDK4_i1_id1_v1	Ag002334	TP53	-	Somatic mutation
Ag000073	CDK4	-	Putative	Ag002335	TP53	-	Somatic mutation
Ag000074	EEF2	-	EEF2_i1_id1_v1	Ag002336	TP53	-	Somatic mutation
Ag000075	EEF2	-	Putative	Ag002337	TP53	-	Somatic mutation
Ag000077	FN1	Fibronectin	Putative	Ag002338	TP53	-	Somatic mutation
Ag000092	HSPA1B	Hsp70	HSPA1B_i1_id1_v1	Ag002339	TP53	-	Somatic mutation
Ag000093	HSPA1B	Hsp70	Putative	Ag002340	TP53	-	Somatic mutation
Ag000095	LPGAT1	KIAA0205	Putative	Ag002341	TP53	-	Somatic mutation
Ag000097	ME1	Malic enzyme	Putative	Ag002342	TP53	-	Somatic mutation
Ag000099	HHAT	MART-2	Putative	Ag002343	TP53	-	Somatic mutation
Ag000100	TRAPPC1	MUM-2	-	Ag002344	TP53	-	Somatic mutation
Ag000101	TRAPPC1	MUM-2	Putative	Ag002345	TP53	-	Somatic mutation
Ag000104	MUM3	MUM-3	Putative	Ag002346	TP53	-	Somatic mutation
Ag000106	MYO1B	Unconventional myosin class I gene	Putative	Ag002347	TP53	-	Somatic mutation
Ag000108	PAPOLG	neo-PAP	-	Ag002348	TP53	-	Somatic mutation
Ag000110	OS9	OS-9	Putative	Ag002349	TP53	-	Somatic mutation
Ag000114	PTPRK	Receptor-like protein tyrosine phosphatase kappa	Putative	Ag002350	TP53	-	Somatic mutation
Ag000117	TPI1	Triosephosphate isomerase or TPI1	-	Ag002351	TP53	-	Somatic mutation
Ag000119	ADFP	Perilipin-2	ADFP_i1_id1_v1	Ag002352	TP53	-	Somatic mutation
Ag000120	AFP	Alpha-fetoprotein	AFP_i1_id1_v1	Ag002353	TP53	-	Somatic mutation
Ag000121	AIM2	-	Intron encoding	Ag002354	TP53	-	Somatic mutation
Ag000122	ANXA2	Annexin II	ANXA2_i1_id1_v1	Ag002355	TP53	-	Somatic mutation

Ag000123	ART4	Endoplasmic reticulum-resident protein	ART4_i1_id1_v1	Ag002356	TP53	-	Somatic mutation
Ag000124	CLCA2	-	CLCA2_i1_id1_v1	Ag002357	TP53	-	Somatic mutation
Ag000125	CPSF1	CPSF	CPSF_i1_id1_v1	Ag002358	TP53	-	Somatic mutation
Ag000126	PIPB	Cyclophilin B	PIPB_i1_id1_v1	Ag002359	TP53	-	Somatic mutation
Ag000127	EPHA2	EphA2	EPHA2_i1_id1_v1	Ag002360	TP53	-	Somatic mutation
Ag000128	EPHA3	EphA3	EPHA3_i1_id1_v1	Ag002361	TP53	-	Somatic mutation
Ag000129	EPHA3	EphA3	EPHA3_i2_id1_v1	Ag002362	TP53	-	Somatic mutation
Ag000130	FGF5	Fibroblast growth factor 5 or FGF5	FGF5_i1_id1_v1	Ag002363	TP53	-	Somatic mutation
Ag000131	FGF5	Fibroblast growth factor 5 or FGF5	FGF5_i2_id1_v1	Ag002364	TP53	-	Somatic mutation
Ag000132	FGF5	Fibroblast growth factor 5 or FGF5	Putative	Ag002365	TP53	-	Somatic mutation
Ag000133	CA9	Carbonic anhydrase IX	CA9_i1_id1_v1	Ag002366	TP53	-	Somatic mutation
Ag000134	TERT	hTERT	TERT_i1_id1_v1	Ag002367	TP53	-	Somatic mutation
Ag000135	TERT	hTERT	TERT_i2_id1_v1	Ag002368	TP53	-	Somatic mutation
Ag000136	TERT	hTERT	TERT_i3_id1_v1	Ag002369	TP53	-	Somatic mutation
Ag000137	MGAT5	GNT-V or N-acetylglucosaminyltransferase V	MGAT5_i1_id1_v1	Ag002370	TP53	-	Somatic mutation
Ag000138	MGAT5	GNT-V or N-acetylglucosaminyltransferase V	Intron encoding	Ag002371	TP53	-	Somatic mutation
Ag000139	CEL	intestinal carboxylesterase	CEL_i1_id1_v1	Ag002372	TP53	-	Somatic mutation
Ag000140	CEL	intestinal carboxylesterase	CEL_i2_id1_v1	Ag002373	TP53	-	Somatic mutation
Ag000141	CEL	intestinal carboxylesterase	Alternative ORF	Ag002374	TP53	-	Somatic mutation
Ag000142	F4.2	-	Putative	Ag002375	TP53	-	Somatic mutation
Ag000143	CAN	CAN protein	CAN_i1_id1_v1	Ag002376	TP53	-	Somatic mutation
Ag000144	ETV6	TEL1 or ETV6	ETV6_i1_id1_v1	Ag002377	TP53	-	Somatic mutation
Ag000145	BIRC7	Livin/ML-IAP	BIRC7_i1_id1_v1	Ag002378	TP53	-	Somatic mutation

Ag000146	CSF1	Macrophage colony stimulating factor	CSF1_i1_id1_v1	Ag002379	TP53	-	Somatic mutation
Ag000147	CSF1	Macrophage colony stimulating factor	CSF1_i2_id1_v1	Ag002380	TP53	-	Somatic mutation
Ag000148	CSF1	Macrophage colony stimulating factor	CSF1_i3_id1_v1	Ag002381	TP53	-	Somatic mutation
Ag000149	CSF1	Macrophage colony stimulating factor	Alternative ORF	Ag002382	TP53	-	Somatic mutation
Ag000150	OGT	-	OGT_i1_id1_v1	Ag002383	TP53	-	Somatic mutation
Ag000151	OGT	-	OGT_i2_id1_v1	Ag002384	TP53	-	Somatic mutation
Ag000152	OGT	-	OGT_i3_id1_v1	Ag002385	TP53	-	Somatic mutation
Ag000153	OGT	-	OGT_i4_id1_v1	Ag002386	TP53	-	Somatic mutation
Ag000154	MUC1	Mucin or MUC1	MUC1_i1_id1_v1	Ag002387	TP53	-	Somatic mutation
Ag000155	MUC1	Mucin or MUC1	MUC1_i2_id1_v1	Ag002388	TP53	-	Somatic mutation
Ag000156	MUC1	Mucin or MUC1	MUC1_i3_id1_v1	Ag002389	TP53	-	Somatic mutation
Ag000157	MUC1	Mucin or MUC1	MUC1_i4_id1_v1	Ag002390	TP53	-	Somatic mutation
Ag000158	MUC1	Mucin or MUC1	MUC1_i5_id1_v1	Ag002391	TP53	-	Somatic mutation
Ag000159	MUC1	Mucin or MUC1	MUC1_i6_id1_v1	Ag002392	TP53	-	Somatic mutation
Ag000160	MUC1	Mucin or MUC1	MUC1_i7_id1_v1	Ag002393	TP53	-	Somatic mutation
Ag000161	MUC1	Mucin or MUC1	MUC1_i8_id1_v1	Ag002394	TP53	-	Somatic mutation
Ag000162	MUC1	Mucin or MUC1	MUC1_i9_id1_v1	Ag002395	TP53	-	Somatic mutation
Ag000163	MUC2	-	MUC2_i1_id1_v1	Ag002396	TP53	-	Somatic mutation
Ag000164	MUM1	MUM-1	MUM1_i1_id1_v1	Ag002397	TP53	-	Somatic mutation
Ag000165	MUM1	MUM-1	MUM1_i2_id1_v1	Ag002398	TP53	-	Somatic mutation
Ag000166	MUM1	MUM-1	Intron encoding	Ag002399	TP53	-	Somatic mutation
Ag000167	MUM1	MUM-1	Intron encoding	Ag002400	TP53	-	Somatic mutation
Ag000168	CTAG1	NY-ESO-1 or LAGE-2	CTAG1_i1_id1_v1	Ag002401	TP53	-	Somatic mutation
Ag000169	CTAG1	NY-ESO-1 or LAGE-2	CTAG1_i2_id1_v1	Ag002402	TP53	-	Somatic mutation
Ag000170	CTAG2	NY-ESO-ORF2 or LAGE-1	CTAG2_i2_id1_v1	Ag002403	TP53	-	Somatic mutation
Ag000171	CTAG2	NY-ESO-ORF2 or LAGE-1	CTAG2_i1_id1_v1	Ag002404	TP53	-	Somatic mutation
Ag000172	CAMEL	-	CAMEL_i2_id1_v1	Ag002405	TP53	-	Somatic mutation
Ag000173	CAMEL	-	CAMEL_i1_id1_v1	Ag002406	TP53	-	Somatic mutation

Ag000174	MRPL28	Melanoma antigen p15	MRPL28_i1_id1_v1	Ag002407	TP53	-	Somatic mutation
Ag000175	FOLH1	Prostate-specific membrane antigen	FOLH1_i1_id1_v1	Ag002408	TP53	-	Somatic mutation
Ag000176	FOLH1	Prostate-specific membrane antigen	FOLH1_i2_id1_v1	Ag002409	TP53	-	Somatic mutation
Ag000177	FOLH1	Prostate-specific membrane antigen	FOLH1_i3_id1_v1	Ag002410	TP53	-	Somatic mutation
Ag000178	FOLH1	Prostate-specific membrane antigen	FOLH1_i4_id1_v1	Ag002411	TP53	-	Somatic mutation
Ag000179	FOLH1	Prostate-specific membrane antigen	FOLH1_i5_id1_v1	Ag002412	TP53	-	Somatic mutation
Ag000180	FOLH1	Prostate-specific membrane antigen	FOLH1_i6_id1_v1	Ag002413	TP53	-	Somatic mutation
Ag000181	FOLH1	Prostate-specific membrane antigen	Putative	Ag002414	TP53	-	Somatic mutation
Ag000182	RAGE	-	RAGE_i1_id1_v1	Ag002415	TP53	-	Somatic mutation
Ag000183	RAGE	-	RAGE_i2_id1_v1	Ag002416	TP53	-	Somatic mutation
Ag000184	RAGE	-	RAGE_i3_id1_v1	Ag002417	TP53	-	Somatic mutation
Ag000185	RAGE	-	RAGE_i4_id1_v1	Ag002418	TP53	-	Somatic mutation
Ag000186	RAGE	-	Alternative ORF	Ag002419	TP53	-	Somatic mutation
Ag000187	RAGE	-	Alternative ORF	Ag002420	TP53	-	Somatic mutation
Ag000188	SFMBT1	Renal ubiquitous protein 1	SFMBT1_i1_id1_v1	Ag002421	TP53	-	Somatic mutation
Ag000189	SFMBT1	Renal ubiquitous protein 1	SFMBT1_i2_id1_v1	Ag002422	TP53	-	Somatic mutation
Ag000190	TYR	Tyrosinase	Putative	Ag002423	TP53	-	Somatic mutation
Ag000192	TYR	Tyrosinase	Putative	Ag002424	TP53	-	Somatic mutation
Ag000193	TYR	Tyrosinase	Putative	Ag002425	TP53	-	Somatic mutation
Ag000194	MUC1	Mucin or MUC1	MUC1_i10_id1_v1	Ag002426	TP53	-	Somatic mutation
Ag000195	KAAG1	RU2AS	KAAG1_i1_id1_v1	Ag002427	TP53	-	Somatic mutation
Ag000196	SART1	SART-1	SART1_i1_id1_v1	Ag002428	TP53	-	Somatic mutation
Ag000197	TSPYL1	SART-2	TSPYL1_i1_id1_v1	Ag002429	TP53	-	Somatic mutation
Ag000198	SART3	-	SART3_i1_id1_v1	Ag002430	TP53	-	Somatic mutation
Ag000199	SART3	-	SART3_i2_id1_v1	Ag002431	TP53	-	Somatic mutation

Ag000200	SART3	-	SART3_i3_id1_v1	Ag002432	TP53	-	Somatic mutation
Ag000201	SOX10	-	SOX10_i1_id1_v1	Ag002433	TP53	-	Somatic mutation
Ag000202	TRG	-	TRG_i1_id1_v1	Ag002434	TP53	-	Somatic mutation
Ag000203	WT1	-	WT1_i1_id1_v1	Ag002435	TP53	-	Somatic mutation
Ag000204	WT1	-	WT1_i2_id1_v1	Ag002436	TP53	-	Somatic mutation
Ag000205	WT1	-	WT1_i3_id1_v1	Ag002437	TP53	-	Somatic mutation
Ag000206	WT1	-	WT1_i4_id1_v1	Ag002438	TP53	-	Somatic mutation
Ag000207	WT1	-	WT1_i5_id1_v1	Ag002439	TP53	-	Somatic mutation
Ag000208	TACSTD1	Ep-CAM	TACSTD1_i1_id1_v1	Ag002440	TP53	-	-
Ag000209	SILV	Pmel 17 or gp100	SILV_i1_id1_v1	Ag002441	TP53	-	Somatic mutation
Ag000210	SILV	Pmel 17 or gp100	Intron encoding	Ag002442	TP53	-	Somatic mutation
Ag000211	SILV	Pmel 17 or gp100	Putative	Ag002443	TP53	-	Somatic mutation
Ag000212	SCGB2A2	Mammaglobin A	SCGB2A2_i1_id1_v1	Ag002444	TP53	-	Somatic mutation
Ag000213	SCGB2A2	Mammaglobin A	SCGB2A2_i2_id1_v1	Ag002445	TP53	-	Somatic mutation
Ag000214	MC1R	-	MC1R_i1_id1_v1	Ag002446	TP53	-	Somatic mutation
Ag000215	MLANA	MART-1 or Melan-A	MLANA_i1_id1_v1	Ag002447	TP53	-	Somatic mutation
Ag000216	GPR143	OA1	GPR143_i1_id1_v1	Ag002448	TP53	-	Somatic mutation
Ag000217	OCA2	P polypeptide	OCA2_i1_id1_v1	Ag002449	TP53	-	Somatic mutation
Ag000218	OCA2	P polypeptide	OCA2_i2_id1_v1	Ag002450	TP53	-	Somatic mutation
Ag000219	OCA2	P polypeptide	OCA2_i3_id1_v1	Ag002451	TP53	-	Somatic mutation
Ag000220	KLK3	PSA or Prostate-specific antigen	KLK3_i1_id1_v1	Ag002452	TP53	-	Somatic mutation
Ag000221	KLK3	PSA or Prostate-specific antigen	Putative	Ag002453	TP53	-	Somatic mutation
Ag000222	KLK3	PSA or Prostate-specific antigen	Putative	Ag002454	TP53	-	Somatic mutation
Ag000223	KLK3	PSA or Prostate-specific antigen	Putative	Ag002455	TP53	-	Somatic mutation
Ag000224	KLK3	PSA or Prostate-specific antigen	Putative	Ag002456	TP53	-	Somatic mutation
Ag000225	SUPT7L	ART-1	SUPT7L_i2_id1_v1	Ag002457	TP53	-	Somatic mutation
Ag000226	SUPT7L	ART-1	SUPT7L_i1_id1_v1	Ag002458	TP53	-	Somatic mutation
Ag000227	ARTC1	-	-	Ag002459	TP53	-	Somatic mutation

Ag000228	BRAF	-	BRAF_i1_id1_v1	Ag002460	TP53	-	Somatic mutation
Ag000229	BRAF	-	Putative	Ag002461	TP53	-	Somatic mutation
Ag000230	CASP5	Caspase-5	CASP5_i1_id1_v1	Ag002462	TP53	-	Somatic mutation
Ag000231	CASP5	Caspase-5	-	Ag002463	TP53	-	Somatic mutation
Ag000232	CASP5	Caspase-5	-	Ag002464	TP53	-	Somatic mutation
Ag000233	CASP5	Caspase-5	-	Ag002465	TP53	-	Somatic mutation
Ag000234	CASP5	Caspase-5	Alternative ORF	Ag002466	TP53	-	Somatic mutation
Ag000235	CDKN2A	-	CDKN2A_i1_id1_v1	Ag002467	TP53	-	Somatic mutation
Ag000236	CDKN2A	-	CDKN2A_i2_id1_v1	Ag002468	TP53	-	Somatic mutation
Ag000237	CDKN2A	-	CDKN2A_i3_id1_v1	Ag002469	TP53	-	Somatic mutation
Ag000238	CDKN2A	-	CDKN2A_i4_id1_v1	Ag002470	TP53	-	Somatic mutation
Ag000239	CDKN2A	-	Alternative ORF	Ag002471	TP53	-	Somatic mutation
Ag000240	UBXD5	COA-1	UBXD5_i1_id1_v1	Ag002472	TP53	-	Somatic mutation
Ag000241	UBXD5	COA-1	UBXD5_i2_id1_v1	Ag002473	TP53	-	Somatic mutation
Ag000242	UBXD5	COA-1	UBXD5_i3_id1_v1	Ag002474	TP53	-	Somatic mutation
Ag000243	UBXD5	COA-1	UBXD5_i4_id1_v1	Ag002475	TP53	-	Somatic mutation
Ag000244	UBXD5	COA-1	UBXD5_i5_id1_v1	Ag002476	TP53	-	Somatic mutation
Ag000245	UBXD5	COA-1	UBXD5_i6_id1_v1	Ag002477	TP53	-	Somatic mutation
Ag000246	UBXD5	COA-1	UBXD5_i7_id1_v1	Ag002478	TP53	-	Somatic mutation
Ag000247	UBXD5	COA-1	UBXD5_i8_id1_v1	Ag002479	TP53	-	Somatic mutation
Ag000249	EFTUD2	Elongation factor Tu GTP binding domain containing or SNRP116	Putative	Ag002480	TP53	-	Somatic mutation
Ag000250	GPNUMB	-	GPNUMB_i1_id1_v1	Ag002481	TP53	-	Somatic mutation
Ag000251	GPNUMB	-	GPNUMB_i2_id1_v1	Ag002482	TP53	-	Somatic mutation
Ag000252	GPNUMB	-	GPNUMB_i3_id1_v1	Ag002483	TP53	-	Somatic mutation
Ag000253	GPNUMB	-	GPNUMB_i3_id1_v2	Ag002484	TP53	-	Somatic mutation
Ag000257	NFYC	-	Putative	Ag002485	TP53	-	Somatic mutation
Ag000260	PRDX5	Peroxioredoxin 5	Putative	Ag002486	TP53	-	Somatic mutation
Ag000268	ZUBR1	E3 ubiquitin-protein ligase UBR4	Putative	Ag002487	TP53	-	Somatic mutation
Ag000273	SIRT2	-	Putative	Ag002488	TP53	-	Somatic mutation

Ag000275	SNRPD1	-	Putative	Ag0002489	TP53	-	Somatic mutation
Ag000276	HERV-K-MEL	-	Putative	Ag0002490	TP53	-	Somatic mutation
Ag000277	CXorf61	Kita-kyushu lung cancer antigen 1;	CXorf61_i1_id1_v1	Ag0002491	TP53	-	Somatic mutation
Ag000278	CCDC110	KM-HN-1	CCDC110_i1_id1_v1	Ag0002492	TP53	-	Somatic mutation
Ag000279	CCDC110	KM-HN-1	CCDC110_i2_id1_v1	Ag0002493	TP53	-	Somatic mutation
Ag000280	VENTXP1	NA88-A	-	Ag0002494	TP53	-	Somatic mutation
Ag000281	SPA17	Sperm protein 17	SPA17_i1_id1_v1	Ag0002495	TP53	-	Somatic mutation
Ag000282	KLK4	-	KLK4_i1_id1_v1	Ag0002496	TP53	-	Somatic mutation
Ag000283	ANKRD30A	NY-BR-1	ANKRD30A_i1_id1_v1	Ag0002497	TP53	-	Somatic mutation
Ag000284	RAB38	NY-MEL-1 or RAB38	RAB38_i1_id1_v1	Ag0002498	TP53	-	Somatic mutation
Ag000285	CCND1	Cyclin D1	CCND1_i1_id1_v1	Ag0002499	TP53	-	Somatic mutation
Ag000286	CYP1B1	P450 1B1 or CYP1B1	CYP1B1_i1_id1_v1	Ag0002500	TP53	-	Somatic mutation
Ag000287	MDM2	-	MDM2_i1_id1_v1	Ag0002501	TP53	-	Somatic mutation
Ag000288	MDM2	-	MDM2_i2_id1_v1	Ag0002502	TP53	-	Somatic mutation
Ag000289	MDM2	-	MDM2_i3_id1_v1	Ag0002503	TP53	-	Somatic mutation
Ag000290	MDM2	-	MDM2_i4_id1_v1	Ag0002504	TP53	-	Somatic mutation
Ag000291	MDM2	-	MDM2_i5_id1_v1	Ag0002505	TP53	-	Somatic mutation
Ag000292	MDM2	-	MDM2_i6_id1_v1	Ag0002506	TP53	-	Somatic mutation
Ag000293	MDM2	-	MDM2_i7_id1_v1	Ag0002507	TP53	-	Somatic mutation
Ag000294	MDM2	-	MDM2_i8_id1_v1	Ag0002508	TP53	-	Somatic mutation
Ag000295	MDM2	-	MDM2_i9_id1_v1	Ag0002509	TP53	-	Somatic mutation
Ag000296	MDM2	-	MDM2_i10_id1_v1	Ag0002510	TP53	-	Somatic mutation
Ag000297	MMP2	Matrix metalloproteinase-2	MMP2_i1_id1_v1	Ag0002511	TP53	-	Somatic mutation
Ag000298	ZNF395	Papillomavirus binding factor (PBF)	ZNF395_i1_id1_v1	Ag0002512	TP53	-	Somatic mutation
Ag000299	RNF43	-	RNF43_i1_id1_v1	Ag0002513	TP53	-	Somatic mutation
Ag000300	SCRN1	Secernin 1	SCRN1_i1_id1_v1	Ag0002514	TP53	-	Somatic mutation
Ag000301	STEAP1	STEAP	STEAP1_i1_id1_v1	Ag0002515	TP53	-	Somatic mutation
Ag000302	707-AP	-	Putative	Ag0002516	TP53	-	Somatic mutation
Ag000303	TGFBR2	TGF-beta receptor type IIB	TGFBR2_i1_id1_v1	Ag0002517	TP53	-	Somatic mutation

Ag000304	TGFB2	TGF-beta receptor type IIB	TGFB2_i2_id1_v1	Ag002518	TP53	-	Somatic mutation
Ag000305	TGFB2	TGF-beta receptor type IIB	Alternative ORF	Ag002519	TP53	-	Somatic mutation
Ag000306	PXDNL	MG50	-	Ag002520	TP53	-	Somatic mutation
Ag000307	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	AKAP13_i1_id1_v1	Ag002521	TP53	-	Somatic mutation
Ag000308	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	AKAP13_i2_id1_v1	Ag002522	TP53	-	Somatic mutation
Ag000309	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	AKAP13_i3_id1_v1	Ag002523	TP53	-	Somatic mutation
Ag000310	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	AKAP13_i4_id1_v1	Ag002524	TP53	-	Somatic mutation
Ag000311	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	AKAP13_i5_id1_v1	Ag002525	TP53	-	Somatic mutation
Ag000312	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	AKAP13_i6_id1_v1	Ag002526	TP53	-	Somatic mutation
Ag000313	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	AKAP13_i7_id1_v1	Ag002527	TP53	-	Somatic mutation
Ag000314	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	Putative	Ag002528	TP53	-	Somatic mutation
Ag000315	PRTN3	Proteinase 3	PRTN3_i1_id1_v1	Ag002529	TP53	-	Somatic mutation
Ag000316	PSCA	Prostate stem cell antigen	PSCA_i1_id1_v1	Ag002530	TP53	-	Somatic mutation
Ag000317	PSCA	Prostate stem cell antigen	Putative	Ag002531	TP53	-	Somatic mutation
Ag000318	RHAMM	RHAMM/C D168	RHAMM_i1_id1_v1	Ag002532	TP53	-	Somatic mutation

Ag000319	RHAMM	RHAMM/C D168	RHAMM_i2_id1_v1	Ag002533	TP53	-	Somatic mutation
Ag000320	ACPP	Prostatic acid phosphatase	ACPP_i1_id1_v1	Ag002534	TP53	-	Somatic mutation
Ag000321	ACRBP	OY-TES-1	ACRBP_i1_id1_v1	Ag002535	TP53	-	Somatic mutation
Ag000322	LCK	Lck	LCK_i1_id1_v1	Ag002536	TP53	-	Somatic mutation
Ag000323	LCK	Lck	LCK_i2_id1_v1	Ag002537	TP53	-	Somatic mutation
Ag000324	LCK	Lck	LCK_i3_id1_v1	Ag002538	TP53	-	Somatic mutation
Ag000325	RCVRN	Recoverin	RCVRN_i1_id1_v1	Ag002539	TP53	-	Somatic mutation
Ag000326	RPS2	Ribosomal protein S2	RPS2_i1_id1_v1	Ag002540	TP53	-	Somatic mutation
Ag000327	RPS2	Ribosomal protein S2	Putative	Ag002541	TP53	-	Somatic mutation
Ag000328	RPL10A	Ribosomal protein L10a	RPL10A_i1_id1_v1	Ag002542	TP53	-	Somatic mutation
Ag000329	RPL10A	Ribosomal protein L10a	Putative	Ag002543	TP53	-	Somatic mutation
Ag000330	SLC45A3	Protein	SLC45A3_i1_id1_v1	Ag002544	TP53	-	Somatic mutation
Ag000331	BCL2L1	Bcl-xL	BCL2L1_i1_id1_v1	Ag002545	TP53	-	Somatic mutation
Ag000332	BCL2L1	Bcl-xL	BCL2L1_i2_id1_v1	Ag002546	TP53	-	Somatic mutation
Ag000333	BCL2L1	Bcl-xL	BCL2L1_i3_id1_v1	Ag002547	TP53	-	Somatic mutation
Ag000334	DKK1	Dickkopf-1 (DKK1)	DKK_i1_id1_v1	Ag002548	TP53	-	Somatic mutation
Ag000335	ENAH	Human Mena protein	ENAH_i1_id1_v1	Ag002549	TP53	-	Somatic mutation
Ag000336	ENAH	Human Mena protein	ENAH_i2_id1_v1	Ag002550	TP53	-	Somatic mutation
Ag000337	CSPG4	Melanoma-associated chondroitin sulfate proteoglycan (MCSP)	CSPG4_i1_id1_v1	Ag002551	TP53	-	Somatic mutation
Ag000338	RGS5	-	RGS5_i1_id1_v1	Ag002552	TP53	-	Somatic mutation
Ag000339	BCR	Breakpoint cluster region	BCR_i1_id1_v1	Ag002553	TP53	-	Somatic mutation
Ag000340	BCR	Breakpoint cluster region	BCR_i2_id1_v1	Ag002554	TP53	-	Somatic mutation
Ag000341	BCR-ABL	-	Chromosomal translocation	Ag002555	TP53	-	Somatic mutation
Ag000345	ABL-BCR	-	Chromosomal translocation	Ag002556	TP53	-	Somatic mutation
Ag000346	ABL-BCR	-	Chromosomal translocation	Ag002557	TP53	-	Somatic mutation
Ag000347	DEK	DEK oncogene	DEK_i1_id1_v1	Ag002558	TP53	-	Somatic mutation
Ag000348	DEK-CAN	-	Chromosomal translocation	Ag002559	TP53	-	Somatic mutation

Ag000349	ETV6-AML1	-	Chromosomal translocation	Ag002560	TP53	-	Somatic mutation
Ag000350	LDLR-FUT	-	Chromosomal translocation	Ag002561	TP53	-	Somatic mutation
Ag000351	NPM1-ALK1	-	Chromosomal translocation	Ag002562	TP53	-	Somatic mutation
Ag000352	PML-RARA	-	Chromosomal translocation	Ag002563	TP53	-	Somatic mutation
Ag000353	SYT-SSX1	-	Chromosomal translocation	Ag002564	TP53	-	Somatic mutation
Ag000354	SYT-SSX1	-	Chromosomal translocation	Ag002565	TP53	-	Somatic mutation
Ag000355	SYT-SSX2	-	Chromosomal translocation	Ag002566	TP53	-	Somatic mutation
Ag000356	SYT-SSX2	-	Chromosomal translocation	Ag002567	TP53	-	Somatic mutation
Ag000357	FLT3	FLT1	Internal tandem repeat	Ag002568	TP53	-	Somatic mutation
Ag000359	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	ABL1_i1_id1_v1	Ag002569	TP53	-	Somatic mutation
Ag000360	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	ABL1_i2_id1_v1	Ag002570	TP53	-	Somatic mutation
Ag000361	AML1	AML	AML1_i1_id1_v1	Ag002571	TP53	-	Somatic mutation
Ag000362	AML1	AML	AML1_i2_id1_v1	Ag002572	TP53	-	Somatic mutation
Ag000363	AML1	AML	AML1_i3_id1_v1	Ag002573	TP53	-	Somatic mutation
Ag000364	AML1	AML	AML1_i4_id1_v1	Ag002574	TP53	-	Somatic mutation
Ag000365	AML1	AML	AML1_i5_id1_v1	Ag002575	TP53	-	Somatic mutation
Ag000366	AML1	AML	AML1_i6_id1_v1	Ag002576	TP53	-	Somatic mutation
Ag000367	AML1	AML	AML1_i7_id1_v1	Ag002577	TP53	-	Somatic mutation
Ag000368	AML1	AML	AML1_i8_id1_v1	Ag002578	TP53	-	Somatic mutation
Ag000369	AML1	AML	AML1_i9_id1_v1	Ag002579	TP53	-	Somatic mutation
Ag000370	AML1	AML	AML1_i10_id1_v1	Ag002580	TP53	-	Somatic mutation
Ag000371	AML1	AML	AML1_i11_id1_v1	Ag002581	TP53	-	Somatic mutation
Ag000372	LDLR	Low density lipid receptor (LDLR)	LDLR_i1_id1_v1	Ag002582	TP53	-	Somatic mutation
Ag000373	FUT1	GDP-L-fucose	FUT1_i1_id1_v1	Ag002583	TP53	-	Somatic mutation
Ag000374	NPM1	NPM	NPM1_i1_id1_v1	Ag002584	TP53	-	Somatic mutation
Ag000375	NPM1	NPM	NPM1_i2_id1_v1	Ag002585	TP53	-	Somatic mutation
Ag000376	ALK	-	ALK_i1_id1_v1	Ag002586	TP53	-	Somatic mutation

Ag000377	PML1	promyelocytic leukemia or PML	PML1_i1_id1_v1	Ag002587	TP53	-	Somatic mutation
Ag000378	RARA	RAR alpha	RARA_i1_id1_v1	Ag002588	TP53	-	Somatic mutation
Ag000379	RARA	RAR alpha	RARA_i2_id1_v1	Ag002589	TP53	-	Somatic mutation
Ag000380	SYT	-	SYT_i1_id1_v1	Ag002590	TP53	-	Somatic mutation
Ag000381	SYT	-	SYT_i2_id1_v1	Ag002591	TP53	-	Somatic mutation
Ag000382	SSX1	-	SSX1_i1_id1_v1	Ag002592	TP53	-	Somatic mutation
Ag000383	MSLN	Mesothelin	MSLN_i1_id1_v1	Ag002593	TP53	-	Somatic mutation
Ag000384	MSLN	Mesothelin	MSLN_i2_id1_v1	Ag002594	TP53	-	Somatic mutation
Ag000385	MSLN	Mesothelin	MSLN_i3_id1_v1	Ag002595	TP53	-	Somatic mutation
Ag000386	MSLN	Mesothelin	MSLN_i2_id1_v2	Ag002596	TP53	-	Somatic mutation
Ag000387	UBE2V1	Ubiquitin-conjugating enzyme variant Kua	UBE2V1_i1_id1_v1	Ag002597	TP53	-	Somatic mutation
Ag000388	UBE2V1	Ubiquitin-conjugating enzyme variant Kua	UBE2V1_i2_id1_v1	Ag002598	TP53	-	Somatic mutation
Ag000389	UBE2V1	Ubiquitin-conjugating enzyme variant Kua	UBE2V1_i3_id1_v1	Ag002599	TP53	-	Somatic mutation
Ag000390	UBE2V1	Ubiquitin-conjugating enzyme variant Kua	UBE2V1_i4_id1_v1	Ag002600	TP53	-	Somatic mutation
Ag000391	UBE2V1	Ubiquitin-conjugating enzyme variant Kua	UBE2V1_i3_id1_v2	Ag002601	TP53	-	Somatic mutation
Ag000392	UBE2V1	Ubiquitin-conjugating enzyme variant Kua	UBE2V1_i5_id1_v1	Ag002602	TP53	-	Somatic mutation
Ag000393	UBE2V1	Ubiquitin-conjugating enzyme variant Kua	UBE2V1_i2_id1_v2	Ag002603	TP53	-	Somatic mutation
Ag000394	HNRPL	-	HNRPL_i1_id1_v1	Ag002604	TP53	-	Somatic mutation
Ag000395	WHSC2	-	WHSC2_i1_id1_v1	Ag002605	TP53	-	Somatic mutation
Ag000396	WHSC2	-	WHSC2_i2_id1_v1	Ag002606	TP53	-	Somatic mutation
Ag000397	WHSC2	-	WHSC2_i3_id1_v1	Ag002607	TP53	-	Somatic mutation
Ag000398	EIF4EBP1	-	EIF4EBP1_i1_id1_v1	Ag002608	TP53	-	Somatic mutation
Ag000399	WNK2	-	WNK2_i1_id1_v1	Ag002609	TP53	-	Somatic mutation
Ag000400	WNK2	-	WNK2_i2_id1_v1	Ag002610	TP53	-	Somatic mutation
Ag000401	WNK2	-	WNK2_i3_id1_v1	Ag002611	TP53	-	Somatic mutation

Ag000402	WNK2	-	WNK2_i4_id1_v1	Ag002612	TP53	-	Somatic mutation
Ag000403	OAS3	-	OAS3_i1_id1_v1	Ag002613	TP53	-	Somatic mutation
Ag000404	BCL-2	Bcl-2	BCL2_i1_id1_v1	Ag002614	TP53	-	Somatic mutation
Ag000405	BCL-2	Bcl-2	BCL2_i2_id1_v1	Ag002615	TP53	-	Somatic mutation
Ag000406	MCL1	Mcl-1	MCL1_i1_id1_v1	Ag002616	TP53	-	Somatic mutation
Ag000407	MCL1	Mcl-1	MCL1_i2_id1_v1	Ag002617	TP53	-	Somatic mutation
Ag000408	CTSH	Cathepsin H	CTSH_i1_id1_v1	Ag002618	TP53	-	Somatic mutation
Ag000409	CTSH	Cathepsin H	Putative	Ag002619	TP53	-	Somatic mutation
Ag000410	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	ABCC3_i1_id1_v1	Ag002620	TP53	-	Somatic mutation
Ag000411	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	ABCC3_i2_id1_v1	Ag002621	TP53	-	Somatic mutation
Ag000412	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	ABCC3_i3_id1_v1	Ag002622	TP53	-	Somatic mutation
Ag000413	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	ABCC3_i4_id1_v1	Ag002623	TP53	-	Somatic mutation
Ag000414	BST2	HM1.24	BST2_i1_id1_v1	Ag002624	TP53	-	Somatic mutation
Ag000415	MFGE8	Milk fat globule membrane protein BA46 (lactadherin)	MFGE8_i1_id1_v1	Ag002625	TP53	-	Somatic mutation
Ag000416	TPBG	5T4 oncofetal antigen	TPBG_i1_id1_v1	Ag002626	TP53	-	Somatic mutation
Ag000417	FMOD	Fibromodulin (FMOD)	FMOD_i1_id1_v1	Ag002627	TP53	-	Somatic mutation
Ag000418	XAGE1	XAGE antigen	XAGE1_i1_id1_v1	Ag002628	TP53	-	Somatic mutation
Ag000419	XAGE1	XAGE antigen	XAGE1_i2_id1_v1	Ag002629	TP53	-	Somatic mutation
Ag000420	XAGE1	XAGE antigen	XAGE1_i3_id1_v1	Ag002630	TP53	-	Somatic mutation
Ag000421	RPSA	Oncofetal Ag immature laminin receptor (OFA-iLR)	RPSA_i1_id1_v1	Ag002631	TP53	-	Somatic mutation
Ag000422	COTL1	Coactosin-like 1	COTL1_i1_id1_v1	Ag002632	TP53	-	Somatic mutation
Ag000426	CALR3	CRT2	CALR3_i1_id1_v1	Ag002633	TP53	-	Somatic mutation

Ag000427	PA2G4	ErbB3-binding protein 1	PA2G4_i1_id1_v1	Ag002634	TP53	-	Somatic mutation
Ag000428	EZH2	Polycomb group protein enhancer of zeste homolog 2 (EZH2)	EZH2_i1_id1_v1	Ag002635	TP53	-	Somatic mutation
Ag000429	FMNL1	Formin-related protein in leukocytes 1 (FMNL1)	FMNL1_i1_id1_v1	Ag002636	TP53	-	Somatic mutation
Ag000430	FMNL1	Formin-related protein in leukocytes 1 (FMNL1)	FMNL1_i2_id1_v1	Ag002637	TP53	-	Somatic mutation
Ag000431	HPSE	Heparanase	HPSE_i1_id1_v1	Ag002638	TP53	-	Somatic mutation
Ag000432	APC	-	APC_i1_id1_v1	Ag002639	TP53	-	Somatic mutation
Ag000433	APC	-	APC_i2_id1_v1	Ag002640	TP53	-	Somatic mutation
Ag000434	UBE2A	-	UBE2A_i1_id1_v1	Ag002641	TP53	-	Somatic mutation
Ag000435	BCAP31	-	BCAP31_i1_id1_v1	Ag002642	TP53	-	Somatic mutation
Ag000436	TOP2A	-	TOP2A_i1_id1_v1	Ag002643	TP53	-	Somatic mutation
Ag000437	TOP2A	-	TOP2A_i2_id1_v1	Ag002644	TP53	-	Somatic mutation
Ag000438	TOP2A	-	TOP2A_i3_id1_v1	Ag002645	TP53	-	Somatic mutation
Ag000439	TOP2A	-	TOP2A_i4_id1_v1	Ag002646	TP53	-	Somatic mutation
Ag000440	TOP2B	-	TOP2B_i1_id1_v1	Ag002647	TP53	-	Somatic mutation
Ag000441	TOP2B	-	TOP2B_i2_id1_v1	Ag002648	TP53	-	Somatic mutation
Ag000442	ITGB8	-	ITGB8_i1_id1_v1	Ag002649	TP53	-	Somatic mutation
Ag000443	RPA1	-	RPA1_i1_id1_v1	Ag002650	TP53	-	Somatic mutation
Ag000444	ABI2	-	ABI2_i1_id1_v1	Ag002651	TP53	-	Somatic mutation
Ag000445	ABI2	-	ABI2_i2_id1_v1	Ag002652	TP53	-	Somatic mutation
Ag000446	ABI2	-	ABI2_i3_id1_v1	Ag002653	TP53	-	Somatic mutation
Ag000447	CCNI	-	CCNI_i1_id1_v1	Ag002654	TP53	-	Somatic mutation
Ag000448	CDC2	-	CDC2_i1_id1_v1	Ag002655	TP53	-	Somatic mutation
Ag000449	CDC2	-	CDC2_i2_id1_v1	Ag002656	TP53	-	Somatic mutation
Ag000450	2-Sep	-	SEPT2_i1_id1_v1	Ag002657	TP53	-	Somatic mutation
Ag000451	STAT1	-	STAT1_i1_id1_v1	Ag002658	TP53	-	Somatic mutation
Ag000452	STAT1	-	STAT1_i2_id1_v1	Ag002659	TP53	-	Somatic mutation
Ag000453	LRP1	-	LRP1_i1_id1_v1	Ag002660	TP53	-	Somatic mutation

Ag000454	ADAM17	-	ADAM17_i1_id1_v1	Ag002661	TP53	-	Somatic mutation
Ag000455	ADAM17	-	ADAM17_i2_id1_v1	Ag002662	TP53	-	Somatic mutation
Ag000456	JUP	-	JUP_i1_id1_v1	Ag002663	TP53	-	Somatic mutation
Ag000457	DDR1	-	DDR1_i1_id1_v1	Ag002664	TP53	-	Somatic mutation
Ag000458	DDR1	-	DDR1_i2_id1_v1	Ag002665	TP53	-	Somatic mutation
Ag000459	ITPR2	-	ITPR2_i1_id1_v1	Ag002666	TP53	-	Somatic mutation
Ag000460	ITPR2	-	ITPR2_i2_id1_v1	Ag002667	TP53	-	Somatic mutation
Ag000461	HMOX1	heme oxygenase-1 (HO-1)	HMOX1_i1_id1_v1	Ag002668	TP53	-	Somatic mutation
Ag000463	TPM4	Tropomyosin-4	TPM4_i1_id1_v1	Ag002669	TP53	-	Somatic mutation
Ag000464	TPM4	Tropomyosin-4	TPM4_i2_id1_v1	Ag002670	TP53	-	Somatic mutation
Ag000465	BAAT	-	BAAT_i1_id1_v1	Ag002671	TP53	-	Somatic mutation
Ag000466	DNAJC8	-	DNAJC8_i1_id1_v1	Ag002672	TP53	-	Somatic mutation
Ag000467	TAPBP	-	TAPBP_i1_id1_v1	Ag002673	TP53	-	Somatic mutation
Ag000468	TAPBP	-	TAPBP_i2_id1_v1	Ag002674	TP53	-	Somatic mutation
Ag000469	TAPBP	-	TAPBP_i3_id1_v1	Ag002675	TP53	-	Somatic mutation
Ag000470	LGALS3BP	Mac-2-binding protein	LGALS3BP_i1_id1_v1	Ag002676	TP53	-	Somatic mutation
Ag000471	PAGE4	PAGE-4	PAGE4_i1_id1_v1	Ag002677	TP53	-	Somatic mutation
Ag000472	PAK2	P21-activated serin kinase 2 (PAK2)	PAK2_i1_id1_v1	Ag002678	TP53	-	Somatic mutation
Ag000473	CDKN1A	cyclin-dependent kinase inhibitor 1A (CDKN1A)	CDKN1A_i1_id1_v1	Ag002679	TP53	-	Somatic mutation
Ag000474	PTH1H	Parathyroid hormone-related protein (PTHrP)	PTH1H_i1_id1_v1	Ag002680	TP53	-	Somatic mutation
Ag000475	PTH1H	Parathyroid hormone-related protein (PTHrP)	PTH1H_i2_id1_v1	Ag002681	TP53	-	Somatic mutation
Ag000476	PTH1H	Parathyroid hormone-related protein (PTHrP)	PTH1H_i3_id1_v1	Ag002682	TP53	-	Somatic mutation
Ag000477	SOX2	-	SOX2_i1_id1_v1	Ag002683	TP53	-	Somatic mutation
Ag000478	SOX11	-	SOX11_i1_id1_v1	Ag002684	TP53	-	Somatic mutation

Ag000479	TRPM8	Prostate-specific protein transient receptor potential-p8 (trp-p8)	TRPM8_i1_id1_v1	Ag002685	TP53	-	Somatic mutation
Ag000480	TRPM8	Prostate-specific protein transient receptor potential-p8 (trp-p8)	TRPM8_i3_id1_v1	Ag002686	TP53	-	Somatic mutation
Ag000481	TRPM8	Prostate-specific protein transient receptor potential-p8 (trp-p8)	TRPM8_i2_id1_v1	Ag002687	TP53	-	Somatic mutation
Ag000482	TRPM8	Prostate-specific protein transient receptor potential-p8 (trp-p8)	Putative	Ag002688	TP53	-	Somatic mutation
Ag000483	TYMS	Thymidylate synthase (TYMS)	TYMS_i1_id1_v1	Ag002689	TP53	-	Somatic mutation
Ag000484	ATIC	5'-aminoimidazole-4-carboxamide-1-beta-d-ribose nucleotide transferase/inosinase (AICRT/I)	AITC_i1_id1_v1	Ag002690	TP53	-	Somatic mutation
Ag000485	PGK1	phosphoglycerate kinase 1 (PGK1)	PGK1_i1_id1_v1	Ag002691	TP53	-	Somatic mutation
Ag000486	SOX4	SOX-4	SOX4_i1_id1_v1	Ag002692	TP53	-	Somatic mutation
Ag000487	TOR3A	ATP-dependent interferon-responsive (ADIR)	TOR3A_i1_id1_v1	Ag002693	TP53	-	Somatic mutation
Ag000488	TOR3A	ATP-dependent interferon-responsive (ADIR)	TOR3A_i2_id1_v1	Ag002694	TP53	-	Somatic mutation
Ag000489	TOR3A	ATP-dependent interferon-responsive (ADIR)	TOR3A_i3_id1_v1	Ag002695	TP53	-	Somatic mutation

Ag000490	TOR3A	ATP-dependent interferon-responsive (ADIR)	Alternative ORF	Ag002696	TP53	-	Somatic mutation
Ag000491	TRGC2	T-cell receptor gamma alternate reading frame protein (TARP)	TRGC2_i1_id1_v1	Ag002697	TP53	-	Somatic mutation
Ag000492	TRGC2	T-cell receptor gamma alternate reading frame protein (TARP)	Alternative ORF	Ag002698	TP53	-	Somatic mutation
Ag000493	TRGC2	T-cell receptor gamma alternate reading frame protein (TARP)	Alternative ORF	Ag002699	TP53	-	Somatic mutation
Ag000494	BTBD2	BTB domain containing 2 (BTBD2)	BTBD2_i1_id1_v1	Ag002700	TP53	-	Somatic mutation
Ag000495	BTBD2	BTB domain containing 2 (BTBD2)	BTBD2_i2_id1_v1	Ag002701	TP53	-	Somatic mutation
Ag000496	BTBD2	BTB domain containing 2 (BTBD2)	Alternative ORF	Ag002702	TP53	-	Somatic mutation
Ag000497	SLBP	hairpin-binding protein	SLBP_i1_id1_v1	Ag002703	TP53	-	Somatic mutation
Ag000498	SLBP	hairpin-binding protein	Alternative ORF	Ag002704	TP53	-	Somatic mutation
Ag000499	EGFR	Epidermal growth factor receptor (EGFR)	EGFR_i1_id1_v1	Ag002705	TP53	-	Somatic mutation
Ag000500	EGFR	Epidermal growth factor receptor (EGFR)	EGFR_i2_id1_v1	Ag002706	TP53	-	Somatic mutation
Ag000501	EGFR	Epidermal growth factor receptor (EGFR)	EGFR_i3_id1_v1	Ag002707	TP53	-	Somatic mutation

Ag000502	EGFR	Epidermal growth factor receptor (EGFR)	EGFR_i4_id1_v1	Ag002708	TP53	-	Somatic mutation
Ag000503	IER3	immediate early response gene X-1 (IEX-1)	IER3_i1_id1_v1	Ag002709	TP53	-	Somatic mutation
Ag000504	TTK	TTK protein kinase (TTK)	TTK_i1_id1_v1	Ag002710	TP53	-	Somatic mutation
Ag000505	LY6K	lymphocyte antigen 6 complex locus K (LY6K)	LY6K_i1_id1_v1	Ag002711	TP53	-	Somatic mutation
Ag000506	IGF2BP3	insulin-like growth factor (IGF)-II mRNA binding protein 3 (IMP-3)	IGF2BP3_i1_id1_v1	Ag002712	TP53	-	Somatic mutation
Ag000507	IGF2BP3	insulin-like growth factor (IGF)-II mRNA binding protein 3 (IMP-3)	IGF2BP3_i2_id1_v1	Ag002713	TP53	-	Somatic mutation
Ag000508	IGF2BP3	insulin-like growth factor (IGF)-II mRNA binding protein 3 (IMP-3)	IGF2BP3_i3_id1_v1	Ag002714	TP53	-	Somatic mutation
Ag000510	GPC3	glypican-3 (GPC3)	GPC3_i1_id1_v1	Ag002715	TP53	-	Somatic mutation
Ag000511	SLC35A4	-	Alternative ORF	Ag002716	TP53	-	Somatic mutation
Ag000512	HSMD	HMSD-v-encoded mHA	SERPINB8_i1_id1_v1	Ag002717	TP53	-	Somatic mutation
Ag000513	HSMD	HMSD-v-encoded mHA	-	Ag002718	TP53	-	Somatic mutation
Ag000514	H3F3A	-	H3F3A_i1_id1_v1	Ag002719	TP53	-	Somatic mutation
Ag000515	ALDH1A1	aldehyde dehydrogenase 1 family member A1 (ALDH1A1)	ALDH1A1_i1_id1_v1	Ag002720	TP53	-	Somatic mutation
Ag000516	MFI2	Melanotransferrin	MFI2_i1_id1_v1	Ag002721	TP53	-	Somatic mutation
Ag000517	MFI2	Melanotransferrin	MFI2_i2_id1_v1	Ag002722	TP53	-	Somatic mutation

Ag000518	MMP14	-	MMP14_i1_id1_v1	Ag002723	TP53	-	Somatic mutation
Ag000519	SDCBP	-	SDCBP_i1_id1_v1	Ag002724	TP53	-	Somatic mutation
Ag000520	MAGED4	-	MAGED4_i1_id1_v1	Ag002725	TP53	-	Somatic mutation
Ag000521	MAGED4	-	MAGED4_i2_id1_v1	Ag002726	TP53	-	Somatic mutation
Ag000522	MAGED4	-	MAGED4_i3_id1_v1	Ag002727	TP53	-	Somatic mutation
Ag000523	PARP12	-	PARP12_i1_id1_v1	Ag002728	TP53	-	Somatic mutation
Ag000524	MET	c-Met protein	MET_i1_id1_v1	Ag002729	TP53	-	Somatic mutation
Ag000525	MET	c-Met protein	MET_i2_id1_v1	Ag002730	TP53	-	Somatic mutation
Ag000526	CCNB1	cyclin B1	CCNB1_i1_id1_v1	Ag002731	TP53	-	Somatic mutation
Ag000529	CCNB1	cyclin B1	Putative	Ag002732	TP53	-	Somatic mutation
Ag000530	CCNB1	cyclin B1	Putative	Ag002733	TP53	-	Somatic mutation
Ag000531	CCNB1	cyclin B1	Putative	Ag002734	TP53	-	Somatic mutation
Ag000532	CCNB1	cyclin B1	Putative	Ag002735	TP53	-	Somatic mutation
Ag000533	PAX3-FKHR	-	Chromosomal translocation	Ag002736	TP53	-	Somatic mutation
Ag000534	PAX3	-	PAX3_i1_id1_v1	Ag002737	TP53	-	Somatic mutation
Ag000535	PAX3	-	PAX3_i2_id1_v1	Ag002738	TP53	-	Somatic mutation
Ag000536	PAX3	-	PAX3_i3_id1_v1	Ag002739	TP53	-	Somatic mutation
Ag000537	FOXO1	FKHR	FOXO1_i1_id1_v1	Ag002740	TP53	-	Somatic mutation
Ag000538	FLT3	FLT1	Internal tandem repeat	Ag002741	TP53	-	Somatic mutation
Ag000539	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	Substitution mutation	Ag002742	TP53	-	Somatic mutation
Ag000540	ALDH1A1	aldehyde dehydrogenase 1 family member A1 (ALDH1A1)	Substitution mutation	Ag002743	TP53	-	Somatic mutation
Ag000541	ALK	-	Substitution mutation	Ag002744	TP53	-	Somatic mutation
Ag000542	ALK	-	Substitution mutation	Ag002745	TP53	-	Somatic mutation
Ag000543	CASP8	Caspase-8	Substitution mutation	Ag002746	TP53	-	Somatic mutation
Ag000544	CASP8	Caspase-8	Substitution mutation	Ag002747	TP53	-	Somatic mutation
Ag000545	CDC27	-	Substitution mutation	Ag002748	TP53	-	Somatic mutation
Ag000546	CDC27	-	Substitution mutation	Ag002749	TP53	-	Somatic mutation
Ag000547	EPHA2	EphA2	Substitution mutation	Ag002750	TP53	-	Somatic mutation

Ag000548	ITPR2	-	Substitution mutation	Ag002751	TP53	-	Somatic mutation
Ag000549	ITPR2	-	Substitution mutation	Ag002752	TP53	-	Somatic mutation
Ag000550	ITPR2	-	Substitution mutation	Ag002753	TP53	-	Somatic mutation
Ag000551	ITPR2	-	Substitution mutation	Ag002754	TP53	-	Somatic mutation
Ag000552	ITPR2	-	Substitution mutation	Ag002755	TP53	-	Somatic mutation
Ag000553	ITGB8	-	Substitution mutation	Ag002756	TP53	-	Somatic mutation
Ag000554	MAGEA1	MAGE-A1	Substitution mutation	Ag002757	TP53	-	Somatic mutation
Ag000555	MAGEC2	MAGE-C2	Substitution mutation	Ag002758	TP53	-	Somatic mutation
Ag000556	NFYC	-	Substitution mutation	Ag002759	TP53	-	Somatic mutation
Ag000557	NPM1	NPM	Substitution mutation	Ag002760	TP53	-	Somatic mutation
Ag000558	PTPRK	Receptor-like protein tyrosine phosphatase kappa	Substitution mutation	Ag002761	TP53	-	Somatic mutation
Ag000559	PTPRK	Receptor-like protein tyrosine phosphatase kappa	Substitution mutation	Ag002762	TP53	-	Somatic mutation
Ag000560	RAGE	-	Substitution mutation	Ag002763	TP53	-	Somatic mutation
Ag000561	RARA	RAR alpha	Substitution mutation	Ag002764	TP53	-	Somatic mutation
Ag000562	STAT1	-	Substitution mutation	Ag002765	TP53	-	Somatic mutation
Ag000563	TERT	hTERT	Substitution mutation	Ag002766	TP53	-	Somatic mutation
Ag000564	TGFBR2	TGF-beta receptor type IIB	Substitution mutation	Ag002767	TP53	-	Somatic mutation
Ag000565	TGFBR2	TGF-beta receptor type IIB	Substitution mutation	Ag002768	TP53	-	Somatic mutation
Ag000566	TGFBR2	TGF-beta receptor type IIB	Substitution mutation	Ag002769	TP53	-	Somatic mutation
Ag000567	TOP2A	-	Substitution mutation	Ag002770	TP53	-	Somatic mutation
Ag000568	TYRP1	TRP-1	Substitution mutation	Ag002771	TP53	-	Somatic mutation
Ag000569	ZUBR1	E3 ubiquitin-protein ligase UBR4	Substitution mutation	Ag002772	TP53	-	Somatic mutation
Ag000570	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002773	TP53	-	Somatic mutation

Ag000571	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002774	TP53	-	Somatic mutation
Ag000572	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002775	TP53	-	Somatic mutation
Ag000573	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002776	TP53	-	Somatic mutation
Ag000574	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002777	TP53	-	Somatic mutation
Ag000575	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002778	TP53	-	Somatic mutation
Ag000576	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002779	TP53	-	Somatic mutation
Ag000577	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002780	TP53	-	Somatic mutation
Ag000578	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002781	TP53	-	Somatic mutation
Ag000579	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002782	TP53	-	Somatic mutation
Ag000580	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002783	TP53	-	Somatic mutation
Ag000581	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002784	TP53	-	Somatic mutation

Ag000582	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002785	TP53	-	Somatic mutation
Ag000583	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002786	TP53	-	Somatic mutation
Ag000584	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002787	TP53	-	Somatic mutation
Ag000585	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002788	TP53	-	Somatic mutation
Ag000586	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002789	TP53	-	Somatic mutation
Ag000587	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002790	TP53	-	Somatic mutation
Ag000588	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002791	TP53	-	Somatic mutation
Ag000589	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002792	TP53	-	Somatic mutation
Ag000590	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002793	TP53	-	Somatic mutation
Ag000591	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002794	TP53	-	Somatic mutation
Ag000592	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002795	TP53	-	Somatic mutation

Ag000593	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002796	TP53	-	Somatic mutation
Ag000594	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002797	TP53	-	Somatic mutation
Ag000595	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002798	TP53	-	Somatic mutation
Ag000596	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002799	TP53	-	Somatic mutation
Ag000597	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002800	TP53	-	Somatic mutation
Ag000598	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002801	TP53	-	Somatic mutation
Ag000599	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002802	TP53	-	Somatic mutation
Ag000600	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002803	TP53	-	Somatic mutation
Ag000601	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002804	TP53	-	Somatic mutation
Ag000602	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002805	TP53	-	Somatic mutation
Ag000603	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002806	TP53	-	Somatic mutation

Ag000604	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002807	TP53	-	Somatic mutation
Ag000605	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002808	TP53	-	Somatic mutation
Ag000606	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	Substitution mutation	Ag002809	TP53	-	Somatic mutation
Ag000607	AML1	AML	Substitution mutation	Ag002810	TP53	-	-
Ag000608	AML1	AML	Substitution mutation	Ag002811	TP53	-	Somatic mutation
Ag000609	AML1	AML	Substitution mutation	Ag002812	TP53	-	Somatic mutation
Ag000610	AML1	AML	Substitution mutation	Ag002813	TP53	-	Somatic mutation
Ag000611	AML1	AML	Substitution mutation	Ag002814	TP53	-	Somatic mutation
Ag000612	AML1	AML	Substitution mutation	Ag002815	TP53	-	Somatic mutation
Ag000613	AML1	AML	Substitution mutation	Ag002816	TP53	-	Somatic mutation
Ag000614	AML1	AML	Substitution mutation	Ag002817	TP53	-	Somatic mutation
Ag000615	AML1	AML	Substitution mutation	Ag002818	TP53	-	Somatic mutation
Ag000616	AML1	AML	Substitution mutation	Ag002819	TP53	-	Somatic mutation
Ag000617	AML1	AML	Substitution mutation	Ag002820	TP53	-	Somatic mutation
Ag000618	AML1	AML	Substitution mutation	Ag002821	TP53	-	Somatic mutation
Ag000619	AML1	AML	Substitution mutation	Ag002822	TP53	-	Somatic mutation
Ag000620	AML1	AML	Substitution mutation	Ag002823	TP53	-	Somatic mutation
Ag000621	AML1	AML	Substitution mutation	Ag002824	TP53	-	Somatic mutation
Ag000622	AML1	AML	Substitution mutation	Ag002825	TP53	-	Somatic mutation
Ag000623	AML1	AML	Substitution mutation	Ag002826	TP53	-	Somatic mutation
Ag000624	AML1	AML	Substitution mutation	Ag002827	TP53	-	Somatic mutation
Ag000625	AML1	AML	Substitution mutation	Ag002828	TP53	-	Somatic mutation
Ag000626	AML1	AML	Substitution mutation	Ag002829	TP53	-	Somatic mutation
Ag000627	AML1	AML	Substitution mutation	Ag002830	TP53	-	Somatic mutation
Ag000628	AML1	AML	Substitution mutation	Ag002831	TP53	-	Somatic mutation
Ag000629	AML1	AML	Substitution mutation	Ag002832	TP53	-	Somatic mutation
Ag000630	AML1	AML	Substitution mutation	Ag002833	TP53	-	Somatic mutation

Ag000631	AML1	AML	Substitution mutation	Ag002834	TP53	-	Somatic mutation
Ag000632	AML1	AML	Substitution mutation	Ag002835	TP53	-	Somatic mutation
Ag000633	AML1	AML	Substitution mutation	Ag002836	TP53	-	Somatic mutation
Ag000634	AML1	AML	Substitution mutation	Ag002837	TP53	-	Somatic mutation
Ag000635	AML1	AML	Substitution mutation	Ag002838	TP53	-	Somatic mutation
Ag000636	AML1	AML	Substitution mutation	Ag002839	TP53	-	Somatic mutation
Ag000637	AML1	AML	Substitution mutation	Ag002840	TP53	-	Somatic mutation
Ag000638	AML1	AML	Substitution mutation	Ag002841	TP53	-	Somatic mutation
Ag000639	AML1	AML	Substitution mutation	Ag002842	TP53	-	Somatic mutation
Ag000640	AML1	AML	Substitution mutation	Ag002843	TP53	-	Somatic mutation
Ag000641	AML1	AML	Substitution mutation	Ag002844	TP53	-	Somatic mutation
Ag000642	AML1	AML	Substitution mutation	Ag002845	TP53	-	Somatic mutation
Ag000643	AML1	AML	Substitution mutation	Ag002846	TP53	-	Somatic mutation
Ag000644	AML1	AML	Substitution mutation	Ag002847	TP53	-	Somatic mutation
Ag000645	AML1	AML	Substitution mutation	Ag002848	TP53	-	Somatic mutation
Ag000646	AML1	AML	Substitution mutation	Ag002849	TP53	-	Somatic mutation
Ag000647	AML1	AML	Substitution mutation	Ag002850	TP53	-	Somatic mutation
Ag000648	AML1	AML	Substitution mutation	Ag002851	TP53	-	Somatic mutation
Ag000649	AML1	AML	Substitution mutation	Ag002852	TP53	-	Somatic mutation
Ag000650	AML1	AML	Substitution mutation	Ag002853	TP53	-	Somatic mutation
Ag000651	AML1	AML	Substitution mutation	Ag002854	TP53	-	Somatic mutation
Ag000652	AML1	AML	Substitution mutation	Ag002855	TP53	-	Somatic mutation
Ag000653	AML1	AML	Substitution mutation	Ag002856	TP53	-	Somatic mutation
Ag000654	AML1	AML	Substitution mutation	Ag002857	TP53	-	Somatic mutation
Ag000655	AML1	AML	Substitution mutation	Ag002858	TP53	-	Somatic mutation
Ag000656	APC	-	Substitution mutation	Ag002859	TP53	-	Somatic mutation
Ag000657	APC	-	Substitution mutation	Ag002860	TP53	-	Somatic mutation
Ag000658	APC	-	Substitution mutation	Ag002861	TP53	-	Somatic mutation
Ag000659	APC	-	Substitution mutation	Ag002862	TP53	-	Somatic mutation
Ag000660	APC	-	Substitution mutation	Ag002863	TP53	-	Somatic mutation
Ag000661	APC	-	Substitution mutation	Ag002864	TP53	-	Somatic mutation
Ag000662	APC	-	Substitution mutation	Ag002865	TP53	-	Somatic mutation
Ag000663	APC	-	Substitution mutation	Ag002866	TP53	-	Somatic mutation

Ag000664	APC	-	Substitution mutation	Ag002867	TP53	-	Somatic mutation
Ag000665	APC	-	Substitution mutation	Ag002868	TP53	-	Somatic mutation
Ag000666	APC	-	Substitution mutation	Ag002869	TP53	-	Somatic mutation
Ag000667	APC	-	Substitution mutation	Ag002870	TP53	-	Somatic mutation
Ag000668	APC	-	Substitution mutation	Ag002871	TP53	-	Somatic mutation
Ag000669	APC	-	Substitution mutation	Ag002872	TP53	-	Somatic mutation
Ag000670	APC	-	Substitution mutation	Ag002873	TP53	-	Somatic mutation
Ag000671	APC	-	Substitution mutation	Ag002874	TP53	-	Somatic mutation
Ag000673	APC	-	Substitution mutation	Ag002875	TP53	-	Somatic mutation
Ag000674	APC	-	Substitution mutation	Ag002876	TP53	-	Somatic mutation
Ag000675	APC	-	Substitution mutation	Ag002877	TP53	-	Somatic mutation
Ag000676	APC	-	Substitution mutation	Ag002878	TP53	-	Somatic mutation
Ag000677	APC	-	Substitution mutation	Ag002879	TP53	-	Somatic mutation
Ag000678	APC	-	Substitution mutation	Ag002880	TP53	-	Somatic mutation
Ag000679	APC	-	Substitution mutation	Ag002881	TP53	-	Somatic mutation
Ag000680	APC	-	Substitution mutation	Ag002882	TP53	-	Somatic mutation
Ag000681	APC	-	Substitution mutation	Ag002883	TP53	-	Somatic mutation
Ag000682	APC	-	Substitution mutation	Ag002884	TP53	-	Somatic mutation
Ag000683	APC	-	Substitution mutation	Ag002885	TP53	-	Somatic mutation
Ag000684	APC	-	Substitution mutation	Ag002886	TP53	-	Somatic mutation
Ag000685	APC	-	Substitution mutation	Ag002887	TP53	-	Somatic mutation
Ag000686	APC	-	Substitution mutation	Ag002888	TP53	-	Somatic mutation
Ag000687	APC	-	Substitution mutation	Ag002889	TP53	-	Somatic mutation
Ag000688	APC	-	Substitution mutation	Ag002890	TP53	-	Somatic mutation
Ag000689	APC	-	Substitution mutation	Ag002891	TP53	-	Somatic mutation
Ag000690	APC	-	Substitution mutation	Ag002892	TP53	-	Somatic mutation
Ag000691	APC	-	Substitution mutation	Ag002893	TP53	-	Somatic mutation
Ag000692	APC	-	Substitution mutation	Ag002894	TP53	-	Somatic mutation
Ag000693	APC	-	Substitution mutation	Ag002895	TP53	-	Somatic mutation
Ag000694	APC	-	Substitution mutation	Ag002896	TP53	-	Somatic mutation
Ag000695	APC	-	Substitution mutation	Ag002897	TP53	-	Somatic mutation
Ag000696	APC	-	Substitution mutation	Ag002898	TP53	-	Somatic mutation
Ag000697	APC	-	Substitution mutation	Ag002899	TP53	-	Somatic mutation

Ag000698	APC	-	Substitution mutation	Ag002900	TP53	-	Somatic mutation
Ag000699	APC	-	Substitution mutation	Ag002901	TP53	-	Somatic mutation
Ag000700	APC	-	Substitution mutation	Ag002902	TP53	-	Somatic mutation
Ag000701	APC	-	Substitution mutation	Ag002903	TP53	-	Somatic mutation
Ag000702	APC	-	Substitution mutation	Ag002904	TP53	-	Somatic mutation
Ag000703	APC	-	Substitution mutation	Ag002905	TP53	-	Somatic mutation
Ag000704	APC	-	Substitution mutation	Ag002906	TP53	-	Somatic mutation
Ag000705	APC	-	Substitution mutation	Ag002907	TP53	-	Somatic mutation
Ag000706	APC	-	Substitution mutation	Ag002908	TP53	-	Somatic mutation
Ag000707	APC	-	Substitution mutation	Ag002909	TP53	-	Somatic mutation
Ag000708	APC	-	Substitution mutation	Ag002910	TP53	-	Somatic mutation
Ag000709	APC	-	Substitution mutation	Ag002911	TP53	-	Somatic mutation
Ag000710	APC	-	Substitution mutation	Ag002912	TP53	-	Somatic mutation
Ag000711	APC	-	Substitution mutation	Ag002913	TP53	-	Somatic mutation
Ag000712	APC	-	Substitution mutation	Ag002914	TP53	-	Somatic mutation
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Ag000715	APC	-	Substitution mutation	Ag002917	TP53	-	Somatic mutation
Ag000716	APC	-	Substitution mutation	Ag002918	TP53	-	Somatic mutation
Ag000717	APC	-	Substitution mutation	Ag002919	TP53	-	Somatic mutation
Ag000718	APC	-	Substitution mutation	Ag002920	TP53	-	Somatic mutation
Ag000719	APC	-	Substitution mutation	Ag002921	TP53	-	Somatic mutation
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Ag000726	APC	-	Substitution mutation	Ag002928	TP53	-	Somatic mutation
Ag000727	APC	-	Substitution mutation	Ag002929	TP53	-	Somatic mutation
Ag000728	APC	-	Substitution mutation	Ag002930	TP53	-	Somatic mutation
Ag000729	APC	-	Substitution mutation	Ag002931	TP53	-	Somatic mutation
Ag000730	APC	-	Substitution mutation	Ag002932	TP53	-	Somatic mutation

Ag000731	APC	-	Substitution mutation	Ag002933	TP53	-	Somatic mutation
Ag000732	APC	-	Substitution mutation	Ag002934	TP53	-	Somatic mutation
Ag000733	APC	-	Substitution mutation	Ag002935	TP53	-	Somatic mutation
Ag000734	APC	-	Substitution mutation	Ag002936	TP53	-	Somatic mutation
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Ag000736	APC	-	Substitution mutation	Ag002938	TP53	-	Somatic mutation
Ag000737	APC	-	Substitution mutation	Ag002939	TP53	-	Somatic mutation
Ag000738	BRAF	-	Substitution mutation	Ag002940	TP53	-	Somatic mutation
Ag000739	BRAF	-	Substitution mutation	Ag002941	TP53	-	Somatic mutation
Ag000740	BRAF	-	Substitution mutation	Ag002942	TP53	-	Somatic mutation
Ag000741	BRAF	-	Substitution mutation	Ag002943	TP53	-	Somatic mutation
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Ag000744	BRAF	-	Substitution mutation	Ag002946	TP53	-	Somatic mutation
Ag000745	BRAF	-	Substitution mutation	Ag002947	TP53	-	Somatic mutation
Ag000746	BRAF	-	Substitution mutation	Ag002948	TP53	-	Somatic mutation
Ag000747	BRAF	-	Substitution mutation	Ag002949	TP53	-	Somatic mutation
Ag000748	BRAF	-	Substitution mutation	Ag002950	TP53	-	Somatic mutation
Ag000749	BRAF	-	Substitution mutation	Ag002951	TP53	-	Somatic mutation
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Ag000751	BRAF	-	Substitution mutation	Ag002953	TP53	-	Somatic mutation
Ag000752	BRAF	-	Substitution mutation	Ag002954	TP53	-	Somatic mutation
Ag000753	BRAF	-	Substitution mutation	Ag002955	TP53	-	Somatic mutation
Ag000754	BRAF	-	Substitution mutation	Ag002956	TP53	-	Somatic mutation
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Ag000756	BRAF	-	Substitution mutation	Ag002958	TP53	-	Somatic mutation
Ag000757	BRAF	-	Substitution mutation	Ag002959	TP53	-	Somatic mutation
Ag000758	BRAF	-	Substitution mutation	Ag002960	TP53	-	Somatic mutation
Ag000759	BRAF	-	Substitution mutation	Ag002961	TP53	-	Somatic mutation
Ag000760	BRAF	-	Substitution mutation	Ag002962	TP53	-	Somatic mutation
Ag000761	BRAF	-	Substitution mutation	Ag002963	TP53	-	Somatic mutation
Ag000762	BRAF	-	Substitution mutation	Ag002964	TP53	-	Somatic mutation
Ag000763	BRAF	-	Substitution mutation	Ag002965	TP53	-	Somatic mutation

Ag000764	BRAF	-	Substitution mutation	Ag002966	TP53	-	Somatic mutation
Ag000765	BRAF	-	Substitution mutation	Ag002967	TP53	-	Somatic mutation
Ag000766	BRAF	-	Substitution mutation	Ag002968	TP53	-	Somatic mutation
Ag000767	BRAF	-	Substitution mutation	Ag002969	TP53	-	Somatic mutation
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Ag000770	BRAF	-	Substitution mutation	Ag002972	TP53	-	Somatic mutation
Ag000771	BRAF	-	Substitution mutation	Ag002973	TP53	-	Somatic mutation
Ag000772	BRAF	-	Substitution mutation	Ag002974	TP53	-	Somatic mutation
Ag000773	BRAF	-	Substitution mutation	Ag002975	TP53	-	Somatic mutation
Ag000774	BRAF	-	Substitution mutation	Ag002976	TP53	-	Somatic mutation
Ag000775	BRAF	-	Substitution mutation	Ag002977	TP53	-	Somatic mutation
Ag000776	BRAF	-	Substitution mutation	Ag002978	TP53	-	Somatic mutation
Ag000777	BRAF	-	Substitution mutation	Ag002979	TP53	-	Somatic mutation
Ag000778	BRAF	-	Substitution mutation	Ag002980	TP53	-	Somatic mutation
Ag000779	BRAF	-	Substitution mutation	Ag002981	TP53	-	Somatic mutation
Ag000780	BRAF	-	Substitution mutation	Ag002982	TP53	-	Somatic mutation
Ag000781	BRAF	-	Substitution mutation	Ag002983	TP53	-	Somatic mutation
Ag000782	BRAF	-	Substitution mutation	Ag002984	TP53	-	Somatic mutation
Ag000783	BRAF	-	Substitution mutation	Ag002985	TP53	-	Somatic mutation
Ag000784	BRAF	-	Substitution mutation	Ag002986	TP53	-	Somatic mutation
Ag000785	BRAF	-	Substitution mutation	Ag002987	TP53	-	Somatic mutation
Ag000786	BRAF	-	Substitution mutation	Ag002988	TP53	-	Somatic mutation
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Ag000791	BRAF	-	Substitution mutation	Ag002993	TP53	-	Somatic mutation
Ag000792	BRAF	-	Substitution mutation	Ag002994	TP53	-	Somatic mutation
Ag000793	BRAF	-	Substitution mutation	Ag002995	TP53	-	Somatic mutation
Ag000794	BRAF	-	Substitution mutation	Ag002996	TP53	-	Somatic mutation
Ag000795	BRAF	-	Substitution mutation	Ag002997	TP53	-	Somatic mutation
Ag000796	BRAF	-	Substitution mutation	Ag002998	TP53	-	Somatic mutation

Ag000797	BRAF	-	Substitution mutation	Ag002999	TP53	-	Somatic mutation
Ag000798	BRAF	-	Substitution mutation	Ag003000	TP53	-	Somatic mutation
Ag000799	BRAF	-	Substitution mutation	Ag003001	TP53	-	Somatic mutation
Ag000800	BRAF	-	Substitution mutation	Ag003002	TP53	-	Somatic mutation
Ag000801	BRAF	-	Substitution mutation	Ag003003	TP53	-	Somatic mutation
Ag000802	BRAF	-	Substitution mutation	Ag003004	TP53	-	Somatic mutation
Ag000803	BRAF	-	Substitution mutation	Ag003005	TP53	-	Somatic mutation
Ag000804	BRAF	-	Substitution mutation	Ag003006	TP53	-	Somatic mutation
Ag000805	BRAF	-	Substitution mutation	Ag003007	TP53	-	Somatic mutation
Ag000806	BRAF	-	Substitution mutation	Ag003008	TP53	-	Somatic mutation
Ag000807	BRAF	-	Substitution mutation	Ag003009	TP53	-	Somatic mutation
Ag000808	BRAF	-	Substitution mutation	Ag003010	TP53	-	-
Ag000809	BRAF	-	Substitution mutation	Ag003011	TP53	-	Somatic mutation
Ag000810	BRAF	-	Substitution mutation	Ag003012	TP53	-	Somatic mutation
Ag000811	CDKN2A	-	Substitution mutation	Ag003013	TP53	-	Somatic mutation
Ag000812	CDKN2A	-	Substitution mutation	Ag003014	TP53	-	Somatic mutation
Ag000813	CDKN2A	-	Substitution mutation	Ag003015	TP53	-	Somatic mutation
Ag000814	CDKN2A	-	Substitution mutation	Ag003016	TP53	-	Somatic mutation
Ag000815	CDKN2A	-	Substitution mutation	Ag003017	TP53	-	Somatic mutation
Ag000816	CDKN2A	-	Substitution mutation	Ag003018	TP53	-	Somatic mutation
Ag000817	CDKN2A	-	Substitution mutation	Ag003019	TP53	-	Somatic mutation
Ag000818	CDKN2A	-	Substitution mutation	Ag003020	TP53	-	Somatic mutation
Ag000819	CDKN2A	-	Substitution mutation	Ag003021	TP53	-	Somatic mutation
Ag000820	CDKN2A	-	Substitution mutation	Ag003022	TP53	-	Somatic mutation
Ag000821	CDKN2A	-	Substitution mutation	Ag003023	TP53	-	Somatic mutation
Ag000822	CDKN2A	-	Substitution mutation	Ag003024	TP53	-	Somatic mutation
Ag000823	CDKN2A	-	Substitution mutation	Ag003025	TP53	-	Somatic mutation
Ag000824	CDKN2A	-	Substitution mutation	Ag003026	TP53	-	Somatic mutation
Ag000825	CDKN2A	-	Substitution mutation	Ag003027	TP53	-	Somatic mutation
Ag000826	CDKN2A	-	Substitution mutation	Ag003028	TP53	-	Somatic mutation
Ag000827	CDKN2A	-	Substitution mutation	Ag003029	TP53	-	Somatic mutation
Ag000828	CDKN2A	-	Substitution mutation	Ag003030	TP53	-	Somatic mutation
Ag000829	CDKN2A	-	Substitution mutation	Ag003031	TP53	-	Somatic mutation

Ag000830	CDKN2A	-	Substitution mutation	Ag003032	TP53	-	Somatic mutation
Ag000831	CDKN2A	-	Substitution mutation	Ag003033	TP53	-	Somatic mutation
Ag000832	CDKN2A	-	Substitution mutation	Ag003034	TP53	-	Somatic mutation
Ag000833	CDKN2A	-	Substitution mutation	Ag003035	TP53	-	Somatic mutation
Ag000834	CDKN2A	-	Substitution mutation	Ag003036	TP53	-	Somatic mutation
Ag000835	CDKN2A	-	Substitution mutation	Ag003037	TP53	-	Somatic mutation
Ag000836	CDKN2A	-	Substitution mutation	Ag003038	TP53	-	Somatic mutation
Ag000837	CDKN2A	-	Substitution mutation	Ag003039	TP53	-	Somatic mutation
Ag000838	CDKN2A	-	Substitution mutation	Ag003040	TP53	-	Somatic mutation
Ag000839	CDKN2A	-	Substitution mutation	Ag003041	TP53	-	Somatic mutation
Ag000840	CDKN2A	-	Substitution mutation	Ag003042	TP53	-	Somatic mutation
Ag000841	CDKN2A	-	Substitution mutation	Ag003043	TP53	-	Somatic mutation
Ag000842	CDKN2A	-	Substitution mutation	Ag003044	TP53	-	Somatic mutation
Ag000843	CDKN2A	-	Substitution mutation	Ag003045	TP53	-	Somatic mutation
Ag000844	CDKN2A	-	Substitution mutation	Ag003046	TP53	-	Somatic mutation
Ag000845	CDKN2A	-	Substitution mutation	Ag003047	TP53	-	Somatic mutation
Ag000846	CDKN2A	-	Substitution mutation	Ag003048	TP53	-	Somatic mutation
Ag000847	CDKN2A	-	Substitution mutation	Ag003049	TP53	-	Somatic mutation
Ag000848	CDKN2A	-	Substitution mutation	Ag003050	TP53	-	Somatic mutation
Ag000849	CDKN2A	-	Substitution mutation	Ag003051	TP53	-	Somatic mutation
Ag000850	CDKN2A	-	Substitution mutation	Ag003052	TP53	-	Somatic mutation
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Ag000856	CDKN2A	-	Substitution mutation	Ag003058	TP53	-	Somatic mutation
Ag000857	CDKN2A	-	Substitution mutation	Ag003059	TP53	-	Somatic mutation
Ag000858	CDKN2A	-	Substitution mutation	Ag003060	TP53	-	Somatic mutation
Ag000859	CDKN2A	-	Substitution mutation	Ag003061	TP53	-	Somatic mutation
Ag000860	CDKN2A	-	Substitution mutation	Ag003062	TP53	-	Somatic mutation
Ag000861	CDKN2A	-	Substitution mutation	Ag003063	TP53	-	Somatic mutation
Ag000862	CDKN2A	-	Substitution mutation	Ag003064	TP53	-	Somatic mutation

Ag000863	CDKN2A	-	Substitution mutation	Ag003065	TP53	-	Somatic mutation
Ag000864	CDKN2A	-	Substitution mutation	Ag003066	TP53	-	Somatic mutation
Ag000865	CDKN2A	-	Substitution mutation	Ag003067	TP53	-	Somatic mutation
Ag000866	CDKN2A	-	Substitution mutation	Ag003068	TP53	-	Somatic mutation
Ag000867	CDKN2A	-	Substitution mutation	Ag003069	TP53	-	Somatic mutation
Ag000868	CDKN2A	-	Substitution mutation	Ag003070	TP53	-	Somatic mutation
Ag000869	CDKN2A	-	Substitution mutation	Ag003071	TP53	-	Somatic mutation
Ag000870	CDKN2A	-	Substitution mutation	Ag003072	TP53	-	Somatic mutation
Ag000871	CDKN2A	-	Substitution mutation	Ag003073	TP53	-	Somatic mutation
Ag000872	CDKN2A	-	Substitution mutation	Ag003074	TP53	-	Somatic mutation
Ag000873	CDKN2A	-	Substitution mutation	Ag003075	TP53	-	Somatic mutation
Ag000874	CDKN2A	-	Substitution mutation	Ag003076	TP53	-	Somatic mutation
Ag000875	CDKN2A	-	Substitution mutation	Ag003077	TP53	-	Somatic mutation
Ag000876	CDKN2A	-	Substitution mutation	Ag003078	TP53	-	Somatic mutation
Ag000877	CDKN2A	-	Substitution mutation	Ag003079	TP53	-	Somatic mutation
Ag000878	CDKN2A	-	Substitution mutation	Ag003080	TP53	-	Somatic mutation
Ag000879	CDKN2A	-	Substitution mutation	Ag003081	TP53	-	Somatic mutation
Ag000880	CDKN2A	-	Substitution mutation	Ag003082	TP53	-	Somatic mutation
Ag000881	CDKN2A	-	Substitution mutation	Ag003083	TP53	-	Somatic mutation
Ag000882	CDKN2A	-	Substitution mutation	Ag003084	TP53	-	Somatic mutation
Ag000883	CDKN2A	-	Substitution mutation	Ag003085	TP53	-	Somatic mutation
Ag000884	CDKN2A	-	Substitution mutation	Ag003086	TP53	-	Somatic mutation
Ag000885	CDKN2A	-	Substitution mutation	Ag003087	TP53	-	Somatic mutation
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Ag000888	CDKN2A	-	Substitution mutation	Ag003090	TP53	-	Somatic mutation
Ag000889	CDKN2A	-	Substitution mutation	Ag003091	TP53	-	Somatic mutation
Ag000890	CDKN2A	-	Substitution mutation	Ag003092	TP53	-	Somatic mutation
Ag000891	CDKN2A	-	Substitution mutation	Ag003093	TP53	-	Somatic mutation
Ag000892	CDKN2A	-	Substitution mutation	Ag003094	TP53	-	Somatic mutation
Ag000893	CDKN2A	-	Substitution mutation	Ag003095	TP53	-	Somatic mutation
Ag000894	CDKN2A	-	Substitution mutation	Ag003096	TP53	-	Somatic mutation
Ag000895	CDKN2A	-	Substitution mutation	Ag003097	TP53	-	Somatic mutation

Ag000896	CDKN2A	-	Substitution mutation	Ag003098	TP53	-	Somatic mutation
Ag000897	CDKN2A	-	Substitution mutation	Ag003099	TP53	-	Somatic mutation
Ag000898	CDKN2A	-	Substitution mutation	Ag003100	TP53	-	Somatic mutation
Ag000899	CDKN2A	-	Substitution mutation	Ag003101	TP53	-	Somatic mutation
Ag000900	CDKN2A	-	Substitution mutation	Ag003102	TP53	-	Somatic mutation
Ag000901	CDKN2A	-	Substitution mutation	Ag003103	TP53	-	Somatic mutation
Ag000902	CDKN2A	-	Substitution mutation	Ag003104	TP53	-	Somatic mutation
Ag000903	CDKN2A	-	Substitution mutation	Ag003105	TP53	-	Somatic mutation
Ag000904	CDKN2A	-	Substitution mutation	Ag003106	TP53	-	Somatic mutation
Ag000905	CDKN2A	-	Substitution mutation	Ag003107	TP53	-	Somatic mutation
Ag000906	CDKN2A	-	Substitution mutation	Ag003108	TP53	-	Somatic mutation
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Ag000908	CDKN2A	-	Substitution mutation	Ag003110	TP53	-	Somatic mutation
Ag000909	CDKN2A	-	Substitution mutation	Ag003111	TP53	-	Somatic mutation
Ag000910	CDKN2A	-	Substitution mutation	Ag003112	TP53	-	Somatic mutation
Ag000911	CDKN2A	-	Substitution mutation	Ag003113	TP53	-	Somatic mutation
Ag000912	CDKN2A	-	Substitution mutation	Ag003114	TP53	-	Somatic mutation
Ag000913	CDKN2A	-	Substitution mutation	Ag003115	TP53	-	Somatic mutation
Ag000914	CDKN2A	-	Substitution mutation	Ag003116	TP53	-	Somatic mutation
Ag000915	CDKN2A	-	Substitution mutation	Ag003117	TP53	-	Somatic mutation
Ag000916	CDKN2A	-	Substitution mutation	Ag003118	TP53	-	Somatic mutation
Ag000917	CDKN2A	-	Substitution mutation	Ag003119	TP53	-	Somatic mutation
Ag000918	CDKN2A	-	Substitution mutation	Ag003120	TP53	-	Somatic mutation
Ag000919	CDKN2A	-	Substitution mutation	Ag003121	TP53	-	Somatic mutation
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Ag000921	CDKN2A	-	Substitution mutation	Ag003123	TP53	-	Somatic mutation
Ag000922	CDKN2A	-	Substitution mutation	Ag003124	TP53	-	Somatic mutation
Ag000923	CDKN2A	-	Substitution mutation	Ag003125	TP53	-	Somatic mutation
Ag000924	CDKN2A	-	Substitution mutation	Ag003126	TP53	-	Somatic mutation
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Ag000926	CDKN2A	-	Substitution mutation	Ag003128	TP53	-	Somatic mutation
Ag000927	CDKN2A	-	Substitution mutation	Ag003129	TP53	-	Somatic mutation
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Ag000929	CDKN2A	-	Substitution mutation	Ag003131	TP53	-	Somatic mutation
Ag000930	CDKN2A	-	Substitution mutation	Ag003132	TP53	-	Somatic mutation
Ag000931	CDKN2A	-	Substitution mutation	Ag003133	TP53	-	Somatic mutation
Ag000932	CDKN2A	-	Substitution mutation	Ag003134	TP53	-	Somatic mutation
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Ag000935	CDKN2A	-	Substitution mutation	Ag003137	TP53	-	Somatic mutation
Ag000936	CDKN2A	-	Substitution mutation	Ag003138	TP53	-	Somatic mutation
Ag000937	CDKN2A	-	Substitution mutation	Ag003139	TP53	-	Somatic mutation
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Ag000941	CDKN2A	-	Substitution mutation	Ag003143	TP53	-	Somatic mutation
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Ag000943	CDKN2A	-	Substitution mutation	Ag003145	TP53	-	Somatic mutation
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Ag000947	CDKN2A	-	Substitution mutation	Ag003149	TP53	-	Somatic mutation
Ag000948	CDKN2A	-	Substitution mutation	Ag003150	TP53	-	Somatic mutation
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Ag000950	CDKN2A	-	Substitution mutation	Ag003152	TP53	-	Somatic mutation
Ag000951	CDKN2A	-	Substitution mutation	Ag003153	TP53	-	Somatic mutation
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Ag000959	CDKN2A	-	Substitution mutation	Ag003161	TP53	-	Somatic mutation
Ag000960	CDKN2A	-	Substitution mutation	Ag003162	TP53	-	Somatic mutation
Ag000961	CDKN2A	-	Substitution mutation	Ag003163	TP53	-	Somatic mutation

Ag000962	CDKN2A	-	Substitution mutation	Ag003164	TP53	-	Somatic mutation
Ag000963	CDKN2A	-	Substitution mutation	Ag003165	TP53	-	Somatic mutation
Ag000964	CDKN2A	-	Substitution mutation	Ag003166	TP53	-	Somatic mutation
Ag000965	CDKN2A	-	Substitution mutation	Ag003167	TP53	-	Somatic mutation
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Ag000967	CDKN2A	-	Substitution mutation	Ag003169	TP53	-	Somatic mutation
Ag000968	CDKN2A	-	Substitution mutation	Ag003170	TP53	-	Somatic mutation
Ag000969	CDKN2A	-	Substitution mutation	Ag003171	TP53	-	Somatic mutation
Ag000970	CDKN2A	-	Substitution mutation	Ag003172	TP53	-	Somatic mutation
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Ag000973	CDKN2A	-	Substitution mutation	Ag003175	TP53	-	Somatic mutation
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Ag000975	CDKN2A	-	Substitution mutation	Ag003177	TP53	-	Somatic mutation
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Ag000978	CDKN2A	-	Substitution mutation	Ag003180	TP53	-	Somatic mutation
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Ag000985	CDKN2A	-	Substitution mutation	Ag003187	TP53	-	Somatic mutation
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Ag000987	CDKN2A	-	Substitution mutation	Ag003189	TP53	-	Somatic mutation
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Ag000990	CDKN2A	-	Substitution mutation	Ag003192	TP53	-	Somatic mutation
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Ag000992	CDKN2A	-	Substitution mutation	Ag003194	TP53	-	Somatic mutation
Ag000993	CDKN2A	-	Substitution mutation	Ag003195	TP53	-	Somatic mutation
Ag000994	CDKN2A	-	Substitution mutation	Ag003196	TP53	-	Somatic mutation

Ag000995	CDKN2A	-	Substitution mutation	Ag003197	TP53	-	Somatic mutation
Ag000996	CDKN2A	-	Substitution mutation	Ag003198	TP53	-	Somatic mutation
Ag000997	CDKN2A	-	Substitution mutation	Ag003199	TP53	-	Somatic mutation
Ag000998	CDKN2A	-	Substitution mutation	Ag003200	TP53	-	Somatic mutation
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Ag001001	CDKN2A	-	Substitution mutation	Ag003203	TP53	-	Somatic mutation
Ag001002	CDKN2A	-	Substitution mutation	Ag003204	TP53	-	Somatic mutation
Ag001003	CDKN2A	-	Substitution mutation	Ag003205	TP53	-	Somatic mutation
Ag001004	CDKN2A	-	Substitution mutation	Ag003206	TP53	-	Somatic mutation
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Ag001007	CDKN2A	-	Substitution mutation	Ag003209	TP53	-	Somatic mutation
Ag001008	CDKN2A	-	Substitution mutation	Ag003210	TP53	-	Somatic mutation
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Ag001019	CDKN2A	-	Substitution mutation	Ag003221	TP53	-	Somatic mutation
Ag001020	CDKN2A	-	Substitution mutation	Ag003222	TP53	-	Somatic mutation
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Ag001025	CTNNB1	-	Substitution mutation	Ag003227	TP53	-	Somatic mutation
Ag001026	CTNNB1	-	Substitution mutation	Ag003228	TP53	-	Somatic mutation
Ag001027	CTNNB1	-	Substitution mutation	Ag003229	TP53	-	Somatic mutation

Ag001028	CTNNB1	-	Substitution mutation	Ag003230	TP53	-	Somatic mutation
Ag001029	CTNNB1	-	Substitution mutation	Ag003231	TP53	-	Somatic mutation
Ag001030	CTNNB1	-	Substitution mutation	Ag003232	TP53	-	Somatic mutation
Ag001031	CTNNB1	-	Substitution mutation	Ag003233	TP53	-	Somatic mutation
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Ag001054	CTNNB1	-	Substitution mutation	Ag003256	TP53	-	Somatic mutation
Ag001055	CTNNB1	-	Substitution mutation	Ag003257	TP53	-	Somatic mutation
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Ag001057	CTNNB1	-	Substitution mutation	Ag003259	TP53	-	Somatic mutation
Ag001058	CTNNB1	-	Substitution mutation	Ag003260	TP53	-	Somatic mutation
Ag001059	CTNNB1	-	Substitution mutation	Ag003261	TP53	-	Somatic mutation
Ag001060	CTNNB1	-	Substitution mutation	Ag003262	TP53	-	Somatic mutation

Ag001061	CTNNB1	-	Substitution mutation	Ag003263	TP53	-	Somatic mutation
Ag001062	CTNNB1	-	Substitution mutation	Ag003264	TP53	-	Somatic mutation
Ag001063	CTNNB1	-	Substitution mutation	Ag003265	TP53	-	Somatic mutation
Ag001064	CTNNB1	-	Substitution mutation	Ag003266	TP53	-	Somatic mutation
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Ag001085	CTNNB1	-	Substitution mutation	Ag003285	TP53	-	Somatic mutation
Ag001086	CTNNB1	-	Substitution mutation	Ag003286	TP53	-	Somatic mutation
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Ag001088	CTNNB1	-	Substitution mutation	Ag003288	TP53	-	Somatic mutation
Ag001089	CTNNB1	-	Substitution mutation	Ag003289	TP53	-	-
Ag001090	CTNNB1	-	Substitution mutation	Ag003290	TP53	-	Somatic mutation
Ag001091	CTNNB1	-	Substitution mutation	Ag003291	TP53	-	Somatic mutation
Ag001092	CTNNB1	-	Substitution mutation	Ag003292	TP53	-	Somatic mutation
Ag001093	CTNNB1	-	Substitution mutation	Ag003293	TP53	-	Somatic mutation
Ag001094	CTNNB1	-	Substitution mutation	Ag003294	TP53	-	Somatic mutation
Ag001095	CTNNB1	-	Substitution mutation	Ag003295	TP53	-	Somatic mutation

Ag001096	CTNNB1	-	Substitution mutation	Ag003296	TP53	-	Somatic mutation
Ag001097	CTNNB1	-	Substitution mutation	Ag003297	TP53	-	Somatic mutation
Ag001098	CTNNB1	-	Substitution mutation	Ag003298	TP53	-	Somatic mutation
Ag001099	CTNNB1	-	Substitution mutation	Ag003299	TP53	-	Somatic mutation
Ag001100	CTNNB1	-	Substitution mutation	Ag003300	TP53	-	Somatic mutation
Ag001101	CTNNB1	-	Substitution mutation	Ag003301	TP53	-	Somatic mutation
Ag001102	CTNNB1	-	Substitution mutation	Ag003302	TP53	-	-
Ag001103	CTNNB1	-	Substitution mutation	Ag003303	TP53	-	Somatic mutation
Ag001104	CTNNB1	-	Substitution mutation	Ag003304	TP53	-	Somatic mutation
Ag001105	CTNNB1	-	Substitution mutation	Ag003305	TP53	-	Somatic mutation
Ag001106	CTNNB1	-	Substitution mutation	Ag003306	TP53	-	Somatic mutation
Ag001107	CTNNB1	-	Substitution mutation	Ag003307	TP53	-	Somatic mutation
Ag001108	CTNNB1	-	Substitution mutation	Ag003308	TP53	-	Somatic mutation
Ag001109	CTNNB1	-	Substitution mutation	Ag003309	TP53	-	Somatic mutation
Ag001110	CTNNB1	-	Substitution mutation	Ag003310	TP53	-	Somatic mutation
Ag001111	CTNNB1	-	Substitution mutation	Ag003311	TP53	-	Somatic mutation
Ag001112	CTNNB1	-	Substitution mutation	Ag003312	TP53	-	Somatic mutation
Ag001113	CTNNB1	-	Substitution mutation	Ag003313	TP53	-	Somatic mutation
Ag001114	CTNNB1	-	Substitution mutation	Ag003314	TP53	-	Somatic mutation
Ag001115	CTNNB1	-	Substitution mutation	Ag003315	TP53	-	Somatic mutation
Ag001116	CTNNB1	-	Substitution mutation	Ag003316	TP53	-	Somatic mutation
Ag001117	CTNNB1	-	Substitution mutation	Ag003317	TP53	-	Somatic mutation
Ag001118	CTNNB1	-	Substitution mutation	Ag003318	TP53	-	Somatic mutation
Ag001119	CTNNB1	-	Substitution mutation	Ag003319	TP53	-	Somatic mutation
Ag001120	CTNNB1	-	Substitution mutation	Ag003320	TP53	-	Somatic mutation
Ag001121	CTNNB1	-	Substitution mutation	Ag003321	TP53	-	-
Ag001122	CTNNB1	-	Substitution mutation	Ag003322	TP53	-	Somatic mutation
Ag001123	CTNNB1	-	Substitution mutation	Ag003323	TP53	-	Somatic mutation
Ag001124	CTNNB1	-	Substitution mutation	Ag003324	TP53	-	Somatic mutation
Ag001125	CTNNB1	-	Substitution mutation	Ag003325	TP53	-	Somatic mutation
Ag001126	CTNNB1	-	Substitution mutation	Ag003326	TP53	-	Somatic mutation
Ag001127	CTNNB1	-	Substitution mutation	Ag003327	TP53	-	Somatic mutation
Ag001128	CTNNB1	-	Substitution mutation	Ag003328	TP53	-	Somatic mutation
Ag001129	CTNNB1	-	Substitution mutation	Ag003329	TP53	-	Somatic mutation

Ag001130	CTNNB1	-	Substitution mutation	Ag003330	TP53	-	Somatic mutation
Ag001131	CTNNB1	-	Substitution mutation	Ag003331	TP53	-	Somatic mutation
Ag001132	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003332	TP53	-	Somatic mutation
Ag001133	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003333	TP53	-	Somatic mutation
Ag001134	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003334	TP53	-	Somatic mutation
Ag001135	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003335	TP53	-	Somatic mutation
Ag001136	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003336	TP53	-	Somatic mutation
Ag001137	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003337	TP53	-	Somatic mutation
Ag001138	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003338	TP53	-	Somatic mutation
Ag001139	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003339	TP53	-	Somatic mutation
Ag001140	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003340	TP53	-	Somatic mutation
Ag001141	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003341	TP53	-	Somatic mutation
Ag001142	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003342	TP53	-	Somatic mutation
Ag001143	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003343	TP53	-	Somatic mutation

Ag001144	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003344	TP53	-	Somatic mutation
Ag001145	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003345	TP53	-	Somatic mutation
Ag001146	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003346	TP53	-	Somatic mutation
Ag001147	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003347	TP53	-	Somatic mutation
Ag001148	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003348	TP53	-	Somatic mutation
Ag001149	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003349	TP53	-	Somatic mutation
Ag001150	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003350	TP53	-	Somatic mutation
Ag001151	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003351	TP53	-	Somatic mutation
Ag001152	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003352	TP53	-	Somatic mutation
Ag001153	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003353	TP53	-	Somatic mutation
Ag001154	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003354	TP53	-	Somatic mutation
Ag001155	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003355	TP53	-	Somatic mutation
Ag001156	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003356	TP53	-	Somatic mutation

Ag001157	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003357	TP53	-	Somatic mutation
Ag001158	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003358	TP53	-	Somatic mutation
Ag001159	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003359	TP53	-	Somatic mutation
Ag001160	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003360	TP53	-	Somatic mutation
Ag001161	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003361	TP53	-	Somatic mutation
Ag001162	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003362	TYR	Tyrosinase	-
Ag001163	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003363	TYR	Tyrosinase	-
Ag001164	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003364	TYR	Tyrosinase	-
Ag001165	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003365	TYR	Tyrosinase	-
Ag001166	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003366	TYR	Tyrosinase	-
Ag001167	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003367	TYR	Tyrosinase	-
Ag001168	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003368	TYR	Tyrosinase	-
Ag001169	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003369	TYR	Tyrosinase	-

Ag001170	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003370	TYR	Tyrosinase	-
Ag001171	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003371	TYR	Tyrosinase	-
Ag001172	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003372	TYR	Tyrosinase	-
Ag001173	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003373	TYR	Tyrosinase	-
Ag001174	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003374	TYR	Tyrosinase	-
Ag001175	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003375	TYR	Tyrosinase	-
Ag001176	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003376	TYR	Tyrosinase	-
Ag001177	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003377	TYR	Tyrosinase	-
Ag001178	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003378	TYR	Tyrosinase	-
Ag001179	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003379	TYR	Tyrosinase	-
Ag001180	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003380	TYR	Tyrosinase	-
Ag001181	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003381	TYR	Tyrosinase	-
Ag001182	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003382	TYR	Tyrosinase	-

Ag001183	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003383	TYR	Tyrosinase	-
Ag001184	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003384	TYR	Tyrosinase	-
Ag001185	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003385	TYR	Tyrosinase	-
Ag001186	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003386	TYR	Tyrosinase	-
Ag001187	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003387	TYR	Tyrosinase	-
Ag001188	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003388	TYR	Tyrosinase	-
Ag001189	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003389	TYR	Tyrosinase	-
Ag001190	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003390	TYR	Tyrosinase	-
Ag001191	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003391	TYR	Tyrosinase	-
Ag001192	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003392	TYR	Tyrosinase	-
Ag001193	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003393	TYR	Tyrosinase	-
Ag001194	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003394	TYR	Tyrosinase	-
Ag001195	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003395	TYR	Tyrosinase	-

Ag001196	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003396	TYR	Tyrosinase	-
Ag001197	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003397	TYR	Tyrosinase	-
Ag001198	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003398	TYR	Tyrosinase	-
Ag001199	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003399	TYR	Tyrosinase	-
Ag001200	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003400	TYR	Tyrosinase	-
Ag001201	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003401	TYR	Tyrosinase	-
Ag001202	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003402	TYR	Tyrosinase	-
Ag001203	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003403	TYR	Tyrosinase	-
Ag001204	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003404	TYR	Tyrosinase	-
Ag001205	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003405	TYR	Tyrosinase	-
Ag001206	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003406	TYR	Tyrosinase	-
Ag001207	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003407	TYR	Tyrosinase	-
Ag001208	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003408	TYR	Tyrosinase	-

Ag001209	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003409	TYR	Tyrosinase	-
Ag001210	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003410	TYR	Tyrosinase	-
Ag001211	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003411	TYR	Tyrosinase	-
Ag001212	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003412	TYR	Tyrosinase	-
Ag001213	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003413	TYR	Tyrosinase	-
Ag001214	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003414	TYR	Tyrosinase	-
Ag001215	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003415	TYR	Tyrosinase	-
Ag001216	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003416	TYR	Tyrosinase	-
Ag001217	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003417	TYR	Tyrosinase	-
Ag001218	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003418	TYR	Tyrosinase	-
Ag001219	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003419	TYR	Tyrosinase	-
Ag001220	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003420	TYR	Tyrosinase	-
Ag001221	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003421	TYR	Tyrosinase	-

Ag001222	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003422	TYR	Tyrosinase	-
Ag001223	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003423	TYR	Tyrosinase	-
Ag001224	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003424	TYR	Tyrosinase	-
Ag001225	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003425	TYR	Tyrosinase	-
Ag001226	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003426	TYR	Tyrosinase	-
Ag001227	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003427	TYR	Tyrosinase	-
Ag001228	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003428	TYR	Tyrosinase	-
Ag001229	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003429	TYR	Tyrosinase	-
Ag001230	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003430	TYR	Tyrosinase	-
Ag001231	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003431	TYR	Tyrosinase	-
Ag001232	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003432	TYR	Tyrosinase	-
Ag001233	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003433	TYR	Tyrosinase	-
Ag001234	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003434	TYR	Tyrosinase	-

Ag001235	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003435	TYR	Tyrosinase	-
Ag001236	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003436	TYR	Tyrosinase	-
Ag001237	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003437	TYR	Tyrosinase	-
Ag001238	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003438	TYR	Tyrosinase	-
Ag001239	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003439	TYR	Tyrosinase	-
Ag001240	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003440	TYR	Tyrosinase	-
Ag001241	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003441	TYR	Tyrosinase	-
Ag001242	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003442	TYR	Tyrosinase	-
Ag001243	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003443	TYR	Tyrosinase	-
Ag001244	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003444	TYR	Tyrosinase	-
Ag001245	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003445	TYR	Tyrosinase	-
Ag001246	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003446	TYR	Tyrosinase	-
Ag001247	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003447	TYR	Tyrosinase	-

Ag001248	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003448	TYR	Tyrosinase	-
Ag001249	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003449	TYR	Tyrosinase	-
Ag001250	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003450	TYR	Tyrosinase	-
Ag001251	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003451	TYR	Tyrosinase	-
Ag001252	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003452	TYR	Tyrosinase	-
Ag001253	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003453	TYR	Tyrosinase	-
Ag001254	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003454	TYR	Tyrosinase	-
Ag001255	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003455	TYR	Tyrosinase	-
Ag001256	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003456	TYR	Tyrosinase	-
Ag001257	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003457	TYR	Tyrosinase	-
Ag001258	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003458	TYR	Tyrosinase	-
Ag001259	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003459	TYR	Tyrosinase	-
Ag001260	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003460	TYR	Tyrosinase	-

Ag001261	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003461	TYR	Tyrosinase	-
Ag001262	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003462	TYR	Tyrosinase	-
Ag001263	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003463	TYR	Tyrosinase	-
Ag001264	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003464	TYR	Tyrosinase	-
Ag001265	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003465	TYR	Tyrosinase	-
Ag001266	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003466	TYR	Tyrosinase	-
Ag001267	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003467	TYR	Tyrosinase	-
Ag001268	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003468	TYR	Tyrosinase	-
Ag001269	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003469	TYR	Tyrosinase	-
Ag001270	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003470	TYRP1	TRP-1	-
Ag001271	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003471	TYRP1	TRP-1	-
Ag001272	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003472	SAGE1	SAGE	-
Ag001273	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003473	SAGE1	SAGE	-

Ag001274	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003474	KRAS	K-ras	-
Ag001275	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003475	KRAS	K-ras	-
Ag001276	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003476	KRAS	K-ras	-
Ag001277	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003477	PRAME	-	-
Ag001278	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003478	ACTN4	Alpha-actinin-4	-
Ag001279	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003479	ACTN4	Alpha-actinin-4	-
Ag001280	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003480	ACTN4	Alpha-actinin-4	-
Ag001281	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003481	CTNNB1	-	-
Ag001282	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003482	CASP8	Caspase-8	-
Ag001283	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003483	CASP8	Caspase-8	-
Ag001284	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003484	CASP8	Caspase-8	-
Ag001285	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003485	CDC27	-	-
Ag001286	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003486	CDK4	-	-

Ag001287	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003487	CDK4	-	-
Ag001288	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003488	CDK4	-	-
Ag001289	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003489	CDK4	-	-
Ag001290	EGFR	Epidermal growth factor receptor (EGFR)	Substitution mutation	Ag003490	FN1	Fibronectin	-
Ag001291	ERBB2	HER2	Substitution mutation	Ag003491	FN1	Fibronectin	Somatic mutation
Ag001292	ERBB2	HER2	Substitution mutation	Ag003492	FN1	Fibronectin	-
Ag001293	ERBB2	HER2	Substitution mutation	Ag003493	FN1	Fibronectin	Somatic mutation
Ag001294	ERBB2	HER2	Substitution mutation	Ag003494	FN1	Fibronectin	-
Ag001295	ERBB2	HER2	Substitution mutation	Ag003495	FN1	Fibronectin	-
Ag001296	ERBB2	HER2	Substitution mutation	Ag003496	FN1	Fibronectin	-
Ag001297	ERBB2	HER2	Substitution mutation	Ag003497	FN1	Fibronectin	Somatic mutation
Ag001298	ERBB2	HER2	Substitution mutation	Ag003498	HSPA1B	Hsp70	-
Ag001299	ERBB2	HER2	Substitution mutation	Ag003499	HSPA1B	Hsp70	-
Ag001300	ERBB2	HER2	Substitution mutation	Ag003500	HSPA1B	Hsp70	-
Ag001301	ERBB2	HER2	Substitution mutation	Ag003501	MUM3	MUM-3	-
Ag001302	ERBB2	HER2	Substitution mutation	Ag003502	MUM3	MUM-3	-
Ag001303	ERBB2	HER2	Substitution mutation	Ag003503	MUM3	MUM-3	-
Ag001304	ERBB2	HER2	Substitution mutation	Ag003504	MUM3	MUM-3	-
Ag001305	ERBB2	HER2	Substitution mutation	Ag003505	MUM3	MUM-3	-
Ag001306	ERBB2	HER2	Substitution mutation	Ag003506	MUM3	MUM-3	-
Ag001307	ERBB2	HER2	Substitution mutation	Ag003507	MYO1B	Unconventional myosin class I gene	Somatic mutation
Ag001308	ERBB2	HER2	Substitution mutation	Ag003508	MYO1B	Unconventional myosin class I gene	Somatic mutation
Ag001309	ERBB2	HER2	Substitution mutation	Ag003509	OS9	OS-9	-
Ag001310	ERBB2	HER2	Substitution mutation	Ag003510	OS9	OS-9	-
Ag001311	ERBB2	HER2	Substitution mutation	Ag003511	TPI1	Triosephosphate isomerase or TPI1	-
Ag001312	ERBB2	HER2	Substitution mutation	Ag003512	TPI1	Triosephosphate isomerase or TPI1	-
Ag001313	ERBB2	HER2	Substitution mutation	Ag003513	TPI1	Triosephosphate isomerase or TPI1	-
Ag001314	ERBB2	HER2	Substitution mutation	Ag003514	TPI1	Triosephosphate isomerase or TPI1	-

Ag001315	KRAS	K-ras	Substitution mutation	Ag003515	TPI1	Triosephosphate isomerase or TPI1	-
Ag001316	KRAS	K-ras	Substitution mutation	Ag003516	TPI1	Triosephosphate isomerase or TPI1	-
Ag001317	KRAS	K-ras	Substitution mutation	Ag003517	TPI1	Triosephosphate isomerase or TPI1	-
Ag001318	KRAS	K-ras	Substitution mutation	Ag003518	TPI1	Triosephosphate isomerase or TPI1	-
Ag001320	KRAS	K-ras	Substitution mutation	Ag003519	AFP	Alpha-fetoprotein	-
Ag001321	KRAS	K-ras	Substitution mutation	Ag003520	AFP	Alpha-fetoprotein	-
Ag001322	KRAS	K-ras	Substitution mutation	Ag003523	ANXA2	Annexin II	-
Ag001323	KRAS	K-ras	Substitution mutation	Ag003524	CLCA2	-	-
Ag001324	KRAS	K-ras	Substitution mutation	Ag003525	CLCA2	-	Somatic mutation
Ag001325	KRAS	K-ras	Substitution mutation	Ag003526	EPHA2	EphA2	-
Ag001326	KRAS	K-ras	Substitution mutation	Ag003527	EPHA2	EphA2	-
Ag001328	KRAS	K-ras	Substitution mutation	Ag003528	EPHA2	EphA2	-
Ag001329	KRAS	K-ras	Substitution mutation	Ag003529	EPHA2	EphA2	-
Ag001330	KRAS	K-ras	Substitution mutation	Ag003530	EPHA3	EphA3	Somatic mutation
Ag001331	KRAS	K-ras	Substitution mutation	Ag003531	EPHA3	EphA3	Somatic mutation
Ag001332	KRAS	K-ras	Substitution mutation	Ag003532	EPHA3	EphA3	Somatic mutation
Ag001333	KRAS	K-ras	Substitution mutation	Ag003533	EPHA3	EphA3	Somatic mutation
Ag001334	KRAS	K-ras	Substitution mutation	Ag003534	EPHA3	EphA3	Somatic mutation
Ag001335	KRAS	K-ras	Substitution mutation	Ag003535	EPHA3	EphA3	-
Ag001336	KRAS	K-ras	Substitution mutation	Ag003536	EPHA3	EphA3	-
Ag001337	KRAS	K-ras	Substitution mutation	Ag003537	EPHA3	EphA3	-
Ag001338	KRAS	K-ras	Substitution mutation	Ag003538	EPHA3	EphA3	Somatic mutation
Ag001339	KRAS	K-ras	Substitution mutation	Ag003539	EPHA3	EphA3	Somatic mutation
Ag001340	KRAS	K-ras	Substitution mutation	Ag003540	EPHA3	EphA3	-
Ag001341	KRAS	K-ras	Substitution mutation	Ag003541	EPHA3	EphA3	Somatic mutation
Ag001342	KRAS	K-ras	Substitution mutation	Ag003542	EPHA3	EphA3	-
Ag001343	KRAS	K-ras	Substitution mutation	Ag003543	EPHA3	EphA3	-
Ag001344	KRAS	K-ras	Substitution mutation	Ag003544	FGF5	Fibroblast growth factor 5 or FGF5	-
Ag001345	KRAS	K-ras	Substitution mutation	Ag003545	CA9	Carbonic anhydrase IX	-
Ag001346	KRAS	K-ras	Substitution mutation	Ag003546	TERT	hTERT	-
Ag001347	KRAS	K-ras	Substitution mutation	Ag003547	TERT	hTERT	-
Ag001348	KRAS	K-ras	Substitution mutation	Ag003548	TERT	hTERT	-
Ag001349	KRAS	K-ras	Substitution mutation	Ag003549	TERT	hTERT	-
Ag001350	KRAS	K-ras	Substitution mutation	Ag003550	TERT	hTERT	-
Ag001351	KRAS	K-ras	Substitution mutation	Ag003551	TERT	hTERT	-
Ag001352	KRAS	K-ras	Substitution mutation	Ag003552	TERT	hTERT	-
Ag001353	KRAS	K-ras	Substitution mutation	Ag003553	TERT	hTERT	-
Ag001355	KRAS	K-ras	Substitution mutation	Ag003554	TERT	hTERT	-

Ag001357	KRAS	K-ras	Substitution mutation	Ag003555	CEL	intestinal carboxylesterase	-
Ag001359	KRAS	K-ras	Substitution mutation	Ag003556	CEL	intestinal carboxylesterase	-
Ag001360	KRAS	K-ras	Substitution mutation	Ag003557	CAN	CAN protein	Somatic mutation
Ag001361	KRAS	K-ras	Substitution mutation	Ag003558	CAN	CAN protein	Somatic mutation
Ag001362	KRAS	K-ras	Substitution mutation	Ag003559	CAN	CAN protein	Somatic mutation
Ag001363	KRAS	K-ras	Substitution mutation	Ag003560	CSF1	Macrophage colony stimulating factor	-
Ag001364	KRAS	K-ras	Substitution mutation	Ag003561	CSF1	Macrophage colony stimulating factor	-
Ag001365	KRAS	K-ras	Substitution mutation	Ag003562	CSF1	Macrophage colony stimulating factor	-
Ag001366	NRAS	N-ras	Substitution mutation	Ag003563	CSF1	Macrophage colony stimulating factor	-
Ag001367	NRAS	N-ras	Substitution mutation	Ag003564	MUC1	Mucin or MUC1	-
Ag001372	NRAS	N-ras	Substitution mutation	Ag003565	MUM1	MUM-1	-
Ag001384	NRAS	N-ras	Substitution mutation	Ag003566	MUM1	MUM-1	-
Ag001386	NRAS	N-ras	Substitution mutation	Ag003567	CTAG2	NY-ESO-ORF2 or LAGE-1	CTAG2_i1_id1_v1
Ag001387	NRAS	N-ras	Substitution mutation	Ag003568	CTAG2	NY-ESO-ORF2 or LAGE-1	-
Ag001395	NRAS	N-ras	Substitution mutation	Ag003569	CTAG2	NY-ESO-ORF2 or LAGE-1	-
Ag001396	NRAS	N-ras	Substitution mutation	Ag003570	FOLH1	Prostate-specific membrane antigen	Somatic mutation
Ag001397	NRAS	N-ras	Substitution mutation	Ag003571	FOLH1	Prostate-specific membrane antigen	-
Ag001398	TP53	-	Substitution mutation	Ag003572	FOLH1	Prostate-specific membrane antigen	-
Ag001399	TP53	-	Substitution mutation	Ag003573	RAGE	-	-
Ag001400	TP53	-	Substitution mutation	Ag003574	RAGE	-	-
Ag001401	TP53	-	Substitution mutation	Ag003575	RAGE	-	-
Ag001402	TP53	-	Substitution mutation	Ag003576	RAGE	-	-
Ag001403	TP53	-	Substitution mutation	Ag003577	RAGE	-	-
Ag001404	TP53	-	Substitution mutation	Ag003578	SART1	SART-1	-
Ag001405	TP53	-	Substitution mutation	Ag003579	SART1	SART-1	-
Ag001406	TP53	-	Substitution mutation	Ag003580	TSPYL1	SART-2	-
Ag001407	TP53	-	Substitution mutation	Ag003581	SART3	-	-
Ag001408	TP53	-	Substitution mutation	Ag003582	SART3	-	-
Ag001409	TP53	-	Substitution mutation	Ag003583	SOX10	-	-
Ag001410	TP53	-	Substitution mutation	Ag003584	WT1	-	-
Ag001411	TP53	-	Substitution mutation	Ag003585	WT1	-	-

[illegible]

Ag001479	TP53	-	Substitution mutation	Ag003653	GPR143	OA1	-
Ag001481	TP53	-	Substitution mutation	Ag003654	GPR143	OA1	-
Ag001482	TP53	-	Substitution mutation	Ag003655	GPR143	OA1	-
Ag001484	TP53	-	Substitution mutation	Ag003656	GPR143	OA1	-
Ag001485	TP53	-	Substitution mutation	Ag003657	GPR143	OA1	-
Ag001486	TP53	-	Substitution mutation	Ag003658	OCA2	P polypeptide	-
Ag001487	TP53	-	Substitution mutation	Ag003659	OCA2	P polypeptide	-
Ag001488	TP53	-	Substitution mutation	Ag003660	OCA2	P polypeptide	-
Ag001489	TP53	-	Substitution mutation	Ag003661	OCA2	P polypeptide	-
Ag001490	TP53	-	Substitution mutation	Ag003662	OCA2	P polypeptide	-
Ag001491	TP53	-	Substitution mutation	Ag003663	OCA2	P polypeptide	-
Ag001492	TP53	-	Substitution mutation	Ag003664	OCA2	P polypeptide	-
Ag001493	TP53	-	Substitution mutation	Ag003665	OCA2	P polypeptide	-
Ag001494	TP53	-	Substitution mutation	Ag003666	OCA2	P polypeptide	-
Ag001495	TP53	-	Substitution mutation	Ag003667	OCA2	P polypeptide	-
Ag001496	TP53	-	Substitution mutation	Ag003668	OCA2	P polypeptide	-
Ag001497	TP53	-	Substitution mutation	Ag003669	OCA2	P polypeptide	-
Ag001498	TP53	-	Substitution mutation	Ag003670	OCA2	P polypeptide	-
Ag001499	TP53	-	Substitution mutation	Ag003671	OCA2	P polypeptide	-
Ag001500	TP53	-	Substitution mutation	Ag003672	OCA2	P polypeptide	-
Ag001501	TP53	-	Substitution mutation	Ag003673	OCA2	P polypeptide	-
Ag001502	TP53	-	Substitution mutation	Ag003674	OCA2	P polypeptide	-
Ag001503	TP53	-	Substitution mutation	Ag003675	OCA2	P polypeptide	-
Ag001504	TP53	-	Substitution mutation	Ag003676	OCA2	P polypeptide	-
Ag001505	TP53	-	Substitution mutation	Ag003677	OCA2	P polypeptide	-
Ag001506	TP53	-	Substitution mutation	Ag003678	OCA2	P polypeptide	-
Ag001507	TP53	-	Substitution mutation	Ag003679	OCA2	P polypeptide	-
Ag001508	TP53	-	Substitution mutation	Ag003680	OCA2	P polypeptide	-
Ag001509	TP53	-	Substitution mutation	Ag003681	OCA2	P polypeptide	-
Ag001510	TP53	-	Substitution mutation	Ag003682	OCA2	P polypeptide	-
Ag001511	TP53	-	Substitution mutation	Ag003683	OCA2	P polypeptide	-
Ag001512	TP53	-	Substitution mutation	Ag003684	OCA2	P polypeptide	-
Ag001513	TP53	-	Substitution mutation	Ag003685	OCA2	P polypeptide	-
Ag001514	TP53	-	Substitution mutation	Ag003686	OCA2	P polypeptide	-
Ag001515	TP53	-	Substitution mutation	Ag003687	OCA2	P polypeptide	-

Ag001516	TP53	-	Substitution mutation	Ag003688	OCA2	P polypeptide	-
Ag001517	TP53	-	Substitution mutation	Ag003689	OCA2	P polypeptide	-
Ag001518	TP53	-	Substitution mutation	Ag003690	OCA2	P polypeptide	-
Ag001519	TP53	-	Substitution mutation	Ag003691	OCA2	P polypeptide	-
Ag001520	TP53	-	Substitution mutation	Ag003692	OCA2	P polypeptide	-
Ag001521	TP53	-	Substitution mutation	Ag003693	OCA2	P polypeptide	-
Ag001522	TP53	-	Substitution mutation	Ag003694	OCA2	P polypeptide	-
Ag001523	TP53	-	Substitution mutation	Ag003695	OCA2	P polypeptide	-
Ag001524	TP53	-	Substitution mutation	Ag003696	OCA2	P polypeptide	-
Ag001525	TP53	-	Substitution mutation	Ag003697	OCA2	P polypeptide	-
Ag001526	TP53	-	Substitution mutation	Ag003698	OCA2	P polypeptide	-
Ag001527	TP53	-	Substitution mutation	Ag003699	OCA2	P polypeptide	-
Ag001528	TP53	-	Substitution mutation	Ag003700	OCA2	P polypeptide	-
Ag001529	TP53	-	Substitution mutation	Ag003701	OCA2	P polypeptide	-
Ag001530	TP53	-	Substitution mutation	Ag003702	OCA2	P polypeptide	-
Ag001531	TP53	-	Substitution mutation	Ag003703	OCA2	P polypeptide	-
Ag001532	TP53	-	Substitution mutation	Ag003704	OCA2	P polypeptide	-
Ag001533	TP53	-	Substitution mutation	Ag003705	OCA2	P polypeptide	-
Ag001534	TP53	-	Substitution mutation	Ag003706	OCA2	P polypeptide	-
Ag001535	TP53	-	Substitution mutation	Ag003707	OCA2	P polypeptide	Somatic mutation
Ag001536	TP53	-	Substitution mutation	Ag003708	OCA2	P polypeptide	-
Ag001537	TP53	-	Substitution mutation	Ag003709	OCA2	P polypeptide	-
Ag001538	TP53	-	Substitution mutation	Ag003710	OCA2	P polypeptide	-
Ag001539	TP53	-	Substitution mutation	Ag003711	OCA2	P polypeptide	-
Ag001540	TP53	-	Substitution mutation	Ag003712	OCA2	P polypeptide	-
Ag001541	TP53	-	Substitution mutation	Ag003713	KLK3	PSA or Prostate-specific antigen	-
Ag001542	WT1	-	Substitution mutation	Ag003714	KLK3	PSA or Prostate-specific antigen	-
Ag001543	WT1	-	Substitution mutation	Ag003715	BRAF	-	-
Ag001544	WT1	-	Substitution mutation	Ag003716	BRAF	-	-
Ag001545	WT1	-	Substitution mutation	Ag003717	BRAF	-	-
Ag001546	WT1	-	Substitution mutation	Ag003718	BRAF	-	-
Ag001547	WT1	-	Substitution mutation	Ag003719	BRAF	-	-
Ag001548	WT1	-	Substitution mutation	Ag003720	BRAF	-	-
Ag001549	WT1	-	Substitution mutation	Ag003721	BRAF	-	-
Ag001550	WT1	-	Substitution mutation	Ag003722	BRAF	-	-

Ag001551	WT1	-	Substitution mutation	Ag003723	BRAF	-	-
Ag001552	WT1	-	Substitution mutation	Ag003724	BRAF	-	-
Ag001553	WT1	-	Substitution mutation	Ag003725	BRAF	-	-
Ag001554	WT1	-	Substitution mutation	Ag003733	CDKN2A	-	-
Ag001555	WT1	-	Substitution mutation	Ag003734	CDKN2A	-	-
Ag001556	WT1	-	Substitution mutation	Ag003735	CDKN2A	-	-
Ag001557	WT1	-	Substitution mutation	Ag003736	CDKN2A	-	-
Ag001558	WT1	-	Substitution mutation	Ag003737	CDKN2A	-	-
Ag001559	WT1	-	Substitution mutation	Ag003738	CDKN2A	-	-
Ag001560	SLC35A4	-	SLC35A4_i1_id1_v1	Ag003739	CDKN2A	-	-
Ag001561	BIRC5	Survivin	-	Ag003740	CDKN2A	-	-
Ag001562	BIRC5	Survivin	-	Ag003741	CDKN2A	-	-
Ag001564	DCT	TRP-2	-	Ag003742	CDKN2A	-	-
Ag001565	MAGEA3	MAGE-A3	-	Ag003743	CDKN2A	-	-
Ag001566	MAGEA6	MAGE-A6	-	Ag003744	CDKN2A	-	-
Ag001567	TP53	-	-	Ag003745	CDKN2A	-	Somatic mutation
Ag001570	TP53	-	-	Ag003746	CDKN2A	-	-
Ag001571	TP53	-	-	Ag003747	CDKN2A	-	-
Ag001572	TP53	-	-	Ag003748	CDKN2A	-	-
Ag001573	TP53	-	-	Ag003749	CDKN2A	-	-
Ag001574	TP53	-	-	Ag003750	CDKN2A	-	-
Ag001575	TP53	-	-	Ag003751	CDKN2A	-	-
Ag001576	TP53	-	-	Ag003752	CDKN2A	-	-
Ag001577	TP53	-	-	Ag003753	CDKN2A	-	Somatic mutation
Ag001578	TYR	Tyrosinase	Putative	Ag003754	CDKN2A	-	-
Ag001580	SSX2	SSX2 or HOM-MEL-40	-	Ag003755	CDKN2A	-	-
Ag001581	WDR46	BING4	-	Ag003756	CDKN2A	-	-
Ag001582	WDR46	BING4	-	Ag003757	CDKN2A	-	-
Ag001583	WDR46	BING4	-	Ag003758	CDKN2A	-	-
Ag001595	HSPA1B	Hsp70	-	Ag003759	CDKN2A	-	-
Ag001597	PAPOLG	neo-PAP	-	Ag003760	CDKN2A	-	-
Ag001604	CEL	intestinal carboxylesterase	-	Ag003761	CDKN2A	-	-
Ag001606	CEL	intestinal carboxylesterase	-	Ag003762	UBXD5	COA-1	-
Ag001607	CAN	CAN protein	-	Ag003763	UBXD5	COA-1	-
Ag001608	CAN	CAN protein	-	Ag003764	UBXD5	COA-1	-
Ag001609	CSF1	Macrophage colony stimulating factor	-	Ag003765	EFTUD2	Elongation factor Tu GTP binding domain containing or SNRP116	-
Ag001610	CSF1	Macrophage colony stimulating factor	-	Ag003766	GPNMB	-	Somatic mutation
Ag001612	MUC1	Mucin or MUC1	-	Ag003767	GPNMB	-	-
Ag001613	MUC2	-	-	Ag003768	GPNMB	-	-
Ag001614	MUC2	-	-	Ag003769	GPNMB	-	Somatic mutation

Ag001615	MUM1	MUM-1	-	Ag003770	PRDX5	Peroxiredoxin 5	-
Ag001616	MUM1	MUM-1	-	Ag003771	PRDX5	Peroxiredoxin 5	Somatic mutation
Ag001617	FOLH1	Prostate-specific membrane antigen	-	Ag003772	ZUBR1	E3 ubiquitin-protein ligase UBR4	-
Ag001618	FOLH1	Prostate-specific membrane antigen	-	Ag003773	ZUBR1	E3 ubiquitin-protein ligase UBR4	Somatic mutation
Ag001619	SOX10	-	-	Ag003774	ZUBR1	E3 ubiquitin-protein ligase UBR4	-
Ag001620	WT1	-	-	Ag003775	ZUBR1	E3 ubiquitin-protein ligase UBR4	-
Ag001622	KLK3	PSA or Prostate-specific antigen	-	Ag003776	KLK4	-	-
Ag001625	CDKN2A	-	-	Ag003777	KLK4	-	-
Ag001626	GPNMB	-	GPNMB_i2_id1_v2	Ag003778	KLK4	-	-
Ag001631	CYP1B1	P450 1B1 or CYP1B1	-	Ag003779	ANKRD30A	NY-BR-1	Somatic mutation
Ag001632	PXDNL	MG50	-	Ag003780	ANKRD30A	NY-BR-1	-
Ag001633	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-	Ag003781	ANKRD30A	NY-BR-1	-
Ag001634	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-	Ag003782	RAB38	NY-MEL-1 or RAB38	Somatic mutation
Ag001635	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-	Ag003783	CYP1B1	P450 1B1 or CYP1B1	-
Ag001636	PRTN3	Proteinase 3	-	Ag003784	CYP1B1	P450 1B1 or CYP1B1	-
Ag001637	RPS2	Ribosomal protein S2	-	Ag003785	CYP1B1	P450 1B1 or CYP1B1	-
Ag001638	RPS2	Ribosomal protein S2	-	Ag003786	CYP1B1	P450 1B1 or CYP1B1	-
Ag001639	RPL10A	Ribosomal protein L10a	-	Ag003787	CYP1B1	P450 1B1 or CYP1B1	-
Ag001640	CSPG4	Melanoma-associated chondroitin sulfate proteoglycan (MCSP)	-	Ag003788	CYP1B1	P450 1B1 or CYP1B1	-

Ag001641	CSPG4	Melanoma-associated chondroitin sulfate proteoglycan (MCSP)	-	Ag003789	CYP1B1	P450 1B1 or CYP1B1	-
Ag001642	CSPG4	Melanoma-associated chondroitin sulfate proteoglycan (MCSP)	-	Ag003790	CYP1B1	P450 1B1 or CYP1B1	-
Ag001643	CSPG4	Melanoma-associated chondroitin sulfate proteoglycan (MCSP)	-	Ag003791	CYP1B1	P450 1B1 or CYP1B1	-
Ag001644	BCR	Breakpoint cluster region	-	Ag003792	CYP1B1	P450 1B1 or CYP1B1	-
Ag001645	BCR	Breakpoint cluster region	-	Ag003793	CYP1B1	P450 1B1 or CYP1B1	-
Ag001646	BCR-ABL	-	BCR-ABL_i1_id1_v1	Ag003794	CYP1B1	P450 1B1 or CYP1B1	-
Ag001647	BCR-ABL	-	BCR-ABL_i2_id1_v1	Ag003795	CYP1B1	P450 1B1 or CYP1B1	-
Ag001648	BCR	Breakpoint cluster region	-	Ag003796	CYP1B1	P450 1B1 or CYP1B1	-
Ag001649	BCR	Breakpoint cluster region	-	Ag003797	CYP1B1	P450 1B1 or CYP1B1	-
Ag001650	BCR	Breakpoint cluster region	-	Ag003798	CYP1B1	P450 1B1 or CYP1B1	-
Ag001651	BCR-ABL	-	BCR-ABL_i3_id1_v1	Ag003799	CYP1B1	P450 1B1 or CYP1B1	-
Ag001652	BCR-ABL	-	BCR-ABL_i4_id1_v1	Ag003800	CYP1B1	P450 1B1 or CYP1B1	-
Ag001653	BCR-ABL	-	BCR-ABL_i5_id1_v1	Ag003801	CYP1B1	P450 1B1 or CYP1B1	-
Ag001654	BCR	Breakpoint cluster region	-	Ag003802	MMP2	Matrix metalloprotease-2	-
Ag001655	BCR-ABL	-	BCR-ABL_i6_id1_v1	Ag003803	MMP2	Matrix metalloprotease-2	-
Ag001656	BCR	Breakpoint cluster region	-	Ag003804	MMP2	Matrix metalloprotease-2	Somatic mutation
Ag001657	BCR	Breakpoint cluster region	-	Ag003805	MMP2	Matrix metalloprotease-2	-
Ag001659	BCR-ABL	-	BCR-ABL_i7_id1_v1	Ag003806	MMP2	Matrix metalloprotease-2	-
Ag001660	BCR	Breakpoint cluster region	-	Ag003807	MMP2	Matrix metalloprotease-2	Somatic mutation
Ag001662	BCR-ABL	-	BCR-ABL_i8_id1_v1	Ag003808	MMP2	Matrix metalloprotease-2	-

Ag001663	BCR-ABL	-	BCR-ABL_i9_id1_v1	Ag003809	MMP2	Matrix metalloproteinase-2	Somatic mutation
Ag001664	BCR-ABL	BCR-ABL fusion protein	BCR-ABL_i10_id1_v1	Ag003810	RNF43	-	-
Ag001665	BCR-ABL	-	BCR-ABL_i11_id1_v1	Ag003811	RNF43	-	-
Ag001666	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	-	Ag003812	RNF43	-	-
Ag001667	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	-	Ag003813	RNF43	-	-
Ag001668	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	-	Ag003814	RNF43	-	-
Ag001669	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	-	Ag003815	SCRN1	Secernin 1	-
Ag001670	LDLR	Low density lipid receptor (LDLR)	-	Ag003816	TGFBR2	TGF-beta receptor type IIB	-
Ag001671	LDLR	Low density lipid receptor (LDLR)	-	Ag003817	TGFBR2	TGF-beta receptor type IIB	Somatic mutation
Ag001672	NPM1	NPM	-	Ag003818	TGFBR2	TGF-beta receptor type IIB	-
Ag001673	WNK2	-	-	Ag003819	TGFBR2	TGF-beta receptor type IIB	-
Ag001675	WNK2	-	-	Ag003820	TGFBR2	TGF-beta receptor type IIB	-
Ag001676	CTSH	Cathepsin H	-	Ag003821	TGFBR2	TGF-beta receptor type IIB	-
Ag001677	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-	Ag003822	TGFBR2	TGF-beta receptor type IIB	-
Ag001678	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-	Ag003823	TGFBR2	TGF-beta receptor type IIB	-

Ag001679	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-	Ag003824	TGFR2	TGF-beta receptor type IIB	-
Ag001680	RPSA	Oncofetal Ag immature laminin receptor (OFA-iLR)	-	Ag003825	TGFR2	TGF-beta receptor type IIB	-
Ag001681	RPSA	Oncofetal Ag immature laminin receptor (OFA-iLR)	-	Ag003826	TGFR2	TGF-beta receptor type IIB	-
Ag001682	RPSA	Oncofetal Ag immature laminin receptor (OFA-iLR)	-	Ag003827	TGFR2	TGF-beta receptor type IIB	-
Ag001683	PA2G4	ErbB3-binding protein 1	-	Ag003828	TGFR2	TGF-beta receptor type IIB	-
Ag001685	EZH2	Polycomb group protein enhancer of zeste homolog 2 (EZH2)	-	Ag003829	TGFR2	TGF-beta receptor type IIB	-
Ag001686	FMNL1	Formin-related protein in leukocytes 1 (FMNL1)	-	Ag003830	TGFR2	TGF-beta receptor type IIB	-
Ag001687	APC	-	-	Ag003831	TGFR2	TGF-beta receptor type IIB	-
Ag001688	APC	-	-	Ag003832	TGFR2	TGF-beta receptor type IIB	-
Ag001690	APC	-	-	Ag003833	TGFR2	TGF-beta receptor type IIB	-
Ag001691	TOP2A	-	-	Ag003834	TGFR2	TGF-beta receptor type IIB	-
Ag001692	TOP2B	-	-	Ag003835	TGFR2	TGF-beta receptor type IIB	-
Ag001693	TOP2B	-	-	Ag003836	TGFR2	TGF-beta receptor type IIB	-
Ag001694	CCNI	-	-	Ag003837	PXDNL	MG50	-
Ag001695	CCNI	-	-	Ag003838	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-

Ag001696	STAT1	-	-	Ag003839	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001697	STAT1	-	-	Ag003840	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001698	LRP1	-	-	Ag003841	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001699	JUP	-	-	Ag003842	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001701	DDR1	-	-	Ag003843	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001702	DDR1	-	-	Ag003844	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001703	DDR1	-	-	Ag003845	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001704	DDR1	-	-	Ag003846	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001705	PAK2	P21-activated serin kinase 2 (PAK2)	-	Ag003847	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001706	CDKN1A	cyclin- dependent kinase inhibitor 1A (CDKN1A)	-	Ag003848	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-
Ag001707	PGK1	phosphoglyce rate kinase 1 (PGK1)	-	Ag003849	PRTN3	Proteinase 3	-

Ag001708	TRGC2	T-cell receptor gamma alternate reading frame protein (TARP)	-	Ag003850	PRTN3	Proteinase 3	-
Ag001709	TRGC2	T-cell receptor gamma alternate reading frame protein (TARP)	-	Ag003851	PSCA	Prostate stem cell antigen	-
Ag001711	EGFR	Epidermal growth factor receptor (EGFR)	-	Ag003852	RHAMM	RHAMM/CD 168	-
Ag001712	EGFR	Epidermal growth factor receptor (EGFR)	-	Ag003853	RHAMM	RHAMM/CD 168	-
Ag001716	H3F3A	-	-	Ag003854	RHAMM	RHAMM/CD 168	-
Ag001717	ALDH1A1	aldehyde dehydrogenase 1 family member A1 (ALDH1A1)	-	Ag003855	LCK	Lck	-
Ag001718	MET	c-Met protein	-	Ag003856	LCK	Lck	-
Ag001719	CCNB1	cyclin B1	CCNB1_i3_id1_v2	Ag003857	LCK	Lck	-
Ag001720	PAX3	-	-	Ag003858	RPL10A	Ribosomal protein L10a	-
Ag001721	PML1	promyelocytic leukemia or PML	-	Ag003859	BCR	Breakpoint cluster region	Somatic mutation
Ag001722	PML1	promyelocytic leukemia or PML	-	Ag003860	BCR	Breakpoint cluster region	-
Ag001723	PML1	promyelocytic leukemia or PML	-	Ag003861	BCR	Breakpoint cluster region	-
Ag001724	PML1	promyelocytic leukemia or PML	-	Ag003862	BCR	Breakpoint cluster region	-
Ag001727	STEAP1	STEAP	-	Ag003863	BCR	Breakpoint cluster region	-
Ag001729	STEAP1	STEAP	-	Ag003864	BCR	Breakpoint cluster region	-
Ag001730	STEAP1	STEAP	-	Ag003865	BCR	Breakpoint cluster region	-

Ag001732	ERBB2	HER2	ERBB2_i2_id1_v1	Ag003866	BCR	Breakpoint cluster region	-
Ag001733	CEACAM5	CEA	CEACAM5_i1_id1_v2	Ag003867	BCR	Breakpoint cluster region	-
Ag001734	CEACAM5	CEA	CEACAM5_i1_id1_v3	Ag003868	BCR	Breakpoint cluster region	-
Ag001735	CEACAM5	CEA	CEACAM5_i2_id1_v1	Ag003869	BCR	Breakpoint cluster region	-
Ag001736	BAGE	BAGE1	BAGE_i2_id1_v1	Ag003870	BCR	Breakpoint cluster region	-
Ag001737	CSAG2	TRAG-3	CSAG2_i2_id1_v2	Ag003871	BCR	Breakpoint cluster region	-
Ag001738	GAGE1	GAGE-1	GAGE1_i1_id2_v1	Ag003872	BCR	Breakpoint cluster region	-
Ag001739	GAGE2	GAGE-2	GAGE2_i1_id1_v2	Ag003873	BCR	Breakpoint cluster region	-
Ag001740	GAGE2	GAGE-2	GAGE2_i2_id1_v1	Ag003874	BCR	Breakpoint cluster region	-
Ag001741	DCT	TRP-2	DCT_i1_id1_v2	Ag003875	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	-
Ag001742	DCT	TRP-2	DCT_i2_id1_v1	Ag003876	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	-
Ag001743	DCT	TRP-2	DCT_i3_id1_v1	Ag003877	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	-
Ag001744	DCT	TRP-2	DCT_i4_id1_v1	Ag003878	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	-
Ag001745	IL13RA2	Interleukin 13 receptor alpha 2	IL13RA2_i1_id1_v2	Ag003879	ABL1	Proto-oncogene tyrosine-protein kinase ABL1	-
Ag001746	MAGEA1	MAGE-A1	-	Ag003880	AML1	AML	-
Ag001747	MAGEA2	MAGE-A2	MAGEA2_i1_id1_v2	Ag003881	AML1	AML	-
Ag001748	MAGEA2	MAGE-A2	MAGEA2_i1_id1_v3	Ag003882	AML1	AML	-

Ag001749	MAGEA3	MAGE-A3	MAGEA3_i1_id1_v2	Ag003883	LDLR	Low density lipid receptor (LDLR)	-
Ag001750	MAGEA6	MAGE-A6	MAGEA6_i1_id1_v2	Ag003884	LDLR	Low density lipid receptor (LDLR)	-
Ag001751	MAGEA6	MAGE-A6	MAGEA6_i1_id1_v3	Ag003885	LDLR	Low density lipid receptor (LDLR)	-
Ag001752	MAGEA6	MAGE-A6	MAGEA6_i1_id1_v4	Ag003886	LDLR	Low density lipid receptor (LDLR)	-
Ag001753	MAGEA6	MAGE-A6	MAGEA6_i1_id1_v5	Ag003887	LDLR	Low density lipid receptor (LDLR)	-
Ag001754	MAGEA6	MAGE-A6	MAGEA6_i1_id2_v1	Ag003888	LDLR	Low density lipid receptor (LDLR)	-
Ag001755	MAGEA9	MAGE-A9	MAGEA9_i1_id1_v2	Ag003889	LDLR	Low density lipid receptor (LDLR)	-
Ag001756	MAGEB2	MAGE-B2	MAGEB2_i1_id1_v2	Ag003890	LDLR	Low density lipid receptor (LDLR)	-
Ag001757	MAGEC2	MAGE-C2	MAGEC2_i1_id1_v2	Ag003891	LDLR	Low density lipid receptor (LDLR)	-
Ag001758	TP53	-	TP53_i1_id1_v2	Ag003892	LDLR	Low density lipid receptor (LDLR)	-
Ag001759	TP53	-	TP53_i1_id1_v3	Ag003893	LDLR	Low density lipid receptor (LDLR)	-
Ag001760	TP53	-	TP53_i1_id1_v4	Ag003894	LDLR	Low density lipid receptor (LDLR)	-
Ag001761	TP53	-	TP53_i3_id1_v1	Ag003895	LDLR	Low density lipid receptor (LDLR)	-
Ag001762	TP53	-	TP53_i4_id1_v1	Ag003896	LDLR	Low density lipid receptor (LDLR)	-
Ag001763	TP53	-	TP53_i2_id1_v2	Ag003897	LDLR	Low density lipid receptor (LDLR)	-
Ag001764	TP53	-	TP53_i5_id1_v1	Ag003898	LDLR	Low density lipid receptor (LDLR)	-

Ag001765	TP53	-	TP53_i6_id1_v1	Ag003899	LDLR	Low density lipid receptor (LDLR)	-
Ag001768	TP53	-	-	Ag003900	LDLR	Low density lipid receptor (LDLR)	-
Ag001769	TP53	-	-	Ag003901	LDLR	Low density lipid receptor (LDLR)	-
Ag001770	TYRP1	TRP-1	TYRP1_i1_id1_v2	Ag003902	LDLR	Low density lipid receptor (LDLR)	-
Ag001771	TYRP1	TRP-1	-	Ag003903	LDLR	Low density lipid receptor (LDLR)	-
Ag001772	TYRP1	TRP-1	TYRP1_i2_id1_v1	Ag003904	LDLR	Low density lipid receptor (LDLR)	-
Ag001773	SYCP1	HOM-TES-14/SCP1	SYCP1_i1_id1_v2	Ag003905	LDLR	Low density lipid receptor (LDLR)	-
Ag001774	SYCP1	HOM-TES-14/SCP1	SYCP1_i2_id1_v1	Ag003906	LDLR	Low density lipid receptor (LDLR)	-
Ag001776	SYCP1	HOM-TES-14/SCP1	SYCP1_i1_id1_v3	Ag003907	LDLR	Low density lipid receptor (LDLR)	-
Ag001777	KRAS	K-ras	-	Ag003908	LDLR	Low density lipid receptor (LDLR)	-
Ag001778	KRAS	K-ras	-	Ag003909	LDLR	Low density lipid receptor (LDLR)	-
Ag001779	KRAS	K-ras	-	Ag003910	LDLR	Low density lipid receptor (LDLR)	-
Ag001780	WDR46	BING4	WDR46_i1_id1_v2	Ag003911	LDLR	Low density lipid receptor (LDLR)	-
Ag001781	WDR46	BING4	WDR46_i1_id1_v3	Ag003912	LDLR	Low density lipid receptor (LDLR)	-
Ag001782	WDR46	BING4	WDR46_i1_id1_v4	Ag003913	LDLR	Low density lipid receptor (LDLR)	-
Ag001783	WDR46	BING4	WDR46_i1_id1_v5	Ag003914	LDLR	Low density lipid receptor (LDLR)	-

Ag001786	CASP8	Caspase-8	CASP8_i10_id1_v1	Ag003915	LDLR	Low density lipid receptor (LDLR)	-
Ag001787	CASP8	Caspase-8	CASP8_i10_id1_v2	Ag003916	LDLR	Low density lipid receptor (LDLR)	-
Ag001788	CDK4	-	CDK4_i2_id1_v1	Ag003917	LDLR	Low density lipid receptor (LDLR)	-
Ag001789	EEF2	-	-	Ag003918	LDLR	Low density lipid receptor (LDLR)	-
Ag001793	HSPA1B	Hsp70	HSPA1B_i2_id1_v1	Ag003919	LDLR	Low density lipid receptor (LDLR)	-
Ag001801	PAPOLG	neo-PAP	-	Ag003920	LDLR	Low density lipid receptor (LDLR)	-
Ag001802	PAPOLG	neo-PAP	-	Ag003921	LDLR	Low density lipid receptor (LDLR)	-
Ag001814	ADFP	Perilipin-2	ADFP_i1_id1_v1	Ag003922	LDLR	Low density lipid receptor (LDLR)	-
Ag001815	ADFP	Perilipin-2	ADFP_i1_id1_v1	Ag003923	LDLR	Low density lipid receptor (LDLR)	-
Ag001816	ANXA2	Annexin II	ANXA2_i1_id1_v2	Ag003924	LDLR	Low density lipid receptor (LDLR)	-
Ag001817	ANXA2	Annexin II	ANXA2_i2_id1_v1	Ag003925	LDLR	Low density lipid receptor (LDLR)	-
Ag001818	ANXA2	Annexin II	ANXA2_i1_id1_v3	Ag003926	LDLR	Low density lipid receptor (LDLR)	-
Ag001819	CLCA2	-	CLCA2_i1_id1_v2	Ag003927	LDLR	Low density lipid receptor (LDLR)	-
Ag001820	CLCA2	-	CLCA2_i1_id1_v3	Ag003928	LDLR	Low density lipid receptor (LDLR)	-
Ag001821	PPIB	Cyclophilin B	PIPB_i2_id1_v1	Ag003929	LDLR	Low density lipid receptor (LDLR)	-
Ag001822	PPIB	Cyclophilin B	PIPB_i2_id1_v2	Ag003930	LDLR	Low density lipid receptor (LDLR)	-

Ag001823	EPHA2	EphA2	EPHA2_i1_id1_v2	Ag003931	LDLR	Low density lipid receptor (LDLR)	-
Ag001824	EPHA3	EphA3	EPHA3_i1_id1_v2	Ag003932	LDLR	Low density lipid receptor (LDLR)	-
Ag001825	EPHA3	EphA3	EPHA3_i1_id1_v3	Ag003933	LDLR	Low density lipid receptor (LDLR)	-
Ag001826	FGF5	Fibroblast growth factor 5 or FGF5	FGF5_i3_id1_v1	Ag003934	LDLR	Low density lipid receptor (LDLR)	-
Ag001827	CA9	Carbonic anhydrase IX	CA9_i2_id1_v1	Ag003935	LDLR	Low density lipid receptor (LDLR)	-
Ag001828	TERT	hTERT	TERT_i4_id1_v1	Ag003936	LDLR	Low density lipid receptor (LDLR)	-
Ag001829	TERT	hTERT	TERT_i5_id1_v1	Ag003937	LDLR	Low density lipid receptor (LDLR)	-
Ag001830	CEL	intestinal carboxylesterase	CEL_i3_id1_v1	Ag003938	LDLR	Low density lipid receptor (LDLR)	-
Ag001831	CAN	CAN protein	CAN_i1_id1_v2	Ag003939	LDLR	Low density lipid receptor (LDLR)	-
Ag001833	CAN	CAN protein	CAN_i4_id1_v1	Ag003940	LDLR	Low density lipid receptor (LDLR)	-
Ag001834	CAN	CAN protein	CAN_i3_id1_v1	Ag003941	LDLR	Low density lipid receptor (LDLR)	-
Ag001835	CAN	CAN protein	CAN_i2_id1_v1	Ag003942	LDLR	Low density lipid receptor (LDLR)	-
Ag001836	ETV6	TEL1 or ETV6	-	Ag003943	LDLR	Low density lipid receptor (LDLR)	-
Ag001837	BIRC7	Livin/ML-IAP	BIRC7_i3_id1_v1	Ag003944	LDLR	Low density lipid receptor (LDLR)	-
Ag001838	BIRC7	Livin/ML-IAP	BIRC7_i2_id1_v1	Ag003945	LDLR	Low density lipid receptor (LDLR)	-
Ag001839	CSF1	Macrophage colony stimulating factor	CSF1_i1_id1_v2	Ag003946	LDLR	Low density lipid receptor (LDLR)	-

Ag001840	CSF1	Macrophage colony stimulating factor	CSF1_i2_id1_v2	Ag003947	LDLR	Low density lipid receptor (LDLR)	-
Ag001841	OGT	-	-	Ag003948	LDLR	Low density lipid receptor (LDLR)	-
Ag001842	MUC1	Mucin or MUC1	MUC1_i25_id1_v1	Ag003949	LDLR	Low density lipid receptor (LDLR)	-
Ag001843	MUC1	Mucin or MUC1	MUC1_i26_id1_v1	Ag003950	LDLR	Low density lipid receptor (LDLR)	-
Ag001844	MUC1	Mucin or MUC1	MUC1_i28_id1_v1	Ag003951	LDLR	Low density lipid receptor (LDLR)	-
Ag001845	MUC1	Mucin or MUC1	MUC1_i26_id1_v2	Ag003952	LDLR	Low density lipid receptor (LDLR)	-
Ag001846	MUC1	Mucin or MUC1	MUC1_i24_id1_v1	Ag003953	LDLR	Low density lipid receptor (LDLR)	-
Ag001847	MUC1	Mucin or MUC1	MUC1_i14_id1_v1	Ag003954	LDLR	Low density lipid receptor (LDLR)	-
Ag001848	MUC1	Mucin or MUC1	MUC1_i23_id1_v1	Ag003955	LDLR	Low density lipid receptor (LDLR)	-
Ag001849	MUC1	Mucin or MUC1	MUC1_i11_id1_v1	Ag003956	LDLR	Low density lipid receptor (LDLR)	-
Ag001850	MUC1	Mucin or MUC1	MUC1_i27_id1_v1	Ag003957	LDLR	Low density lipid receptor (LDLR)	-
Ag001851	MUC1	Mucin or MUC1	MUC1_i17_id1_v1	Ag003958	LDLR	Low density lipid receptor (LDLR)	-
Ag001852	MUC1	Mucin or MUC1	MUC1_i22_id1_v1	Ag003959	LDLR	Low density lipid receptor (LDLR)	-
Ag001853	MUC1	Mucin or MUC1	MUC1_i6_id1_v2	Ag003960	LDLR	Low density lipid receptor (LDLR)	-
Ag001854	MUC1	Mucin or MUC1	MUC1_i15_id1_v1	Ag003961	LDLR	Low density lipid receptor (LDLR)	-
Ag001855	MUC1	Mucin or MUC1	MUC1_i10_id1_v2	Ag003962	LDLR	Low density lipid receptor (LDLR)	-

Ag001856	MUC1	Mucin or MUC1	MUC1_i16_id1_v1	Ag003963	LDLR	Low density lipid receptor (LDLR)	-
Ag001857	MUC1	Mucin or MUC1	MUC1_i12_id1_v1	Ag003964	LDLR	Low density lipid receptor (LDLR)	-
Ag001858	MUC1	Mucin or MUC1	MUC1_i18_id1_v1	Ag003965	LDLR	Low density lipid receptor (LDLR)	-
Ag001859	MUC1	Mucin or MUC1	MUC1_i20_id1_v1	Ag003966	LDLR	Low density lipid receptor (LDLR)	-
Ag001860	MUC1	Mucin or MUC1	MUC1_i13_id1_v1	Ag003967	LDLR	Low density lipid receptor (LDLR)	-
Ag001861	MUC1	Mucin or MUC1	MUC1_i21_id1_v1	Ag003968	LDLR	Low density lipid receptor (LDLR)	-
Ag001862	MUC1	Mucin or MUC1	MUC1_i19_id1_v1	Ag003969	LDLR	Low density lipid receptor (LDLR)	-
Ag001863	MUM1	MUM-1	-	Ag003970	LDLR	Low density lipid receptor (LDLR)	-
Ag001864	MRPL28	Melanoma antigen p15	MRPL28_i1_id1_v2	Ag003971	LDLR	Low density lipid receptor (LDLR)	-
Ag001865	MRPL28	Melanoma antigen p15	MRPL28_i2_id1_v1	Ag003972	LDLR	Low density lipid receptor (LDLR)	-
Ag001867	FOLH1	Prostate-specific membrane antigen	FOLH1_i2_id1_v2	Ag003973	LDLR	Low density lipid receptor (LDLR)	-
Ag001868	FOLH1	Prostate-specific membrane antigen	FOLH1_i2_id1_v3	Ag003974	LDLR	Low density lipid receptor (LDLR)	-
Ag001869	FOLH1	Prostate-specific membrane antigen	FOLH1_i8_id1_v1	Ag003975	LDLR	Low density lipid receptor (LDLR)	-
Ag001870	FOLH1	Prostate-specific membrane antigen	FOLH1_i7_id1_v1	Ag003976	LDLR	Low density lipid receptor (LDLR)	-
Ag001871	FOLH1	Prostate-specific membrane antigen	FOLH1_i9_id1_v1	Ag003977	LDLR	Low density lipid receptor (LDLR)	-
Ag001872	SART3	-	SART3_i1_id1_v2	Ag003978	LDLR	Low density lipid receptor (LDLR)	-

Ag001873	SOX10	-	SOX10_i1_id1_v2	Ag003979	LDLR	Low density lipid receptor (LDLR)	-
Ag001874	WT1	-	WT1_i6_id1_v1	Ag003980	LDLR	Low density lipid receptor (LDLR)	-
Ag001875	WT1	-	WT1_i8_id1_v1	Ag003981	LDLR	Low density lipid receptor (LDLR)	-
Ag001876	WT1	-	WT1_i7_id1_v1	Ag003982	LDLR	Low density lipid receptor (LDLR)	-
Ag001877	TACSTD1	Ep-CAM	TACSTD1_i1_id1_v2	Ag003983	LDLR	Low density lipid receptor (LDLR)	-
Ag001878	SCGB2A2	Mammaglobin A	SCGB2A2_i3_id1_v1	Ag003984	LDLR	Low density lipid receptor (LDLR)	-
Ag001879	MC1R	-	MC1R_i1_id1_v2	Ag003985	LDLR	Low density lipid receptor (LDLR)	-
Ag001880	MC1R	-	MC1R_i1_id1_v3	Ag003986	LDLR	Low density lipid receptor (LDLR)	-
Ag001881	MC1R	-	MC1R_i1_id1_v4	Ag003987	LDLR	Low density lipid receptor (LDLR)	-
Ag001882	MC1R	-	MC1R_i1_id1_v5	Ag003988	LDLR	Low density lipid receptor (LDLR)	-
Ag001883	MC1R	-	MC1R_i1_id1_v6	Ag003989	LDLR	Low density lipid receptor (LDLR)	-
Ag001884	MC1R	-	MC1R_i1_id1_v7	Ag003990	LDLR	Low density lipid receptor (LDLR)	-
Ag001885	MC1R	-	MC1R_i1_id1_v8	Ag003991	LDLR	Low density lipid receptor (LDLR)	-
Ag001886	MC1R	-	MC1R_i1_id1_v9	Ag003992	LDLR	Low density lipid receptor (LDLR)	-
Ag001887	MC1R	-	MC1R_i1_id1_v10	Ag003993	LDLR	Low density lipid receptor (LDLR)	-
Ag001888	MC1R	-	MC1R_i1_id1_v11	Ag003994	LDLR	Low density lipid receptor (LDLR)	-

Ag001889	MC1R	-	MC1R_i1_id1_v12	Ag003995	LDLR	Low density lipid receptor (LDLR)	-
Ag001890	MC1R	-	MC1R_i1_id1_v13	Ag003996	LDLR	Low density lipid receptor (LDLR)	-
Ag001891	MC1R	-	MC1R_i1_id1_v14	Ag003997	LDLR	Low density lipid receptor (LDLR)	-
Ag001892	MC1R	-	MC1R_i1_id1_v15	Ag003998	LDLR	Low density lipid receptor (LDLR)	-
Ag001893	MC1R	-	MC1R_i1_id1_v16	Ag003999	LDLR	Low density lipid receptor (LDLR)	-
Ag001894	MC1R	-	MC1R_i1_id1_v17	Ag004000	LDLR	Low density lipid receptor (LDLR)	-
Ag001895	MC1R	-	MC1R_i1_id1_v18	Ag004001	LDLR	Low density lipid receptor (LDLR)	-
Ag001897	MC1R	-	MC1R_i1_id1_v19	Ag004002	LDLR	Low density lipid receptor (LDLR)	-
Ag001898	MC1R	-	MC1R_i1_id1_v20	Ag004003	LDLR	Low density lipid receptor (LDLR)	-
Ag001899	MC1R	-	MC1R_i2_id1_v1	Ag004004	LDLR	Low density lipid receptor (LDLR)	-
Ag001900	GPR143	OA1	GPR143_i2_id1_v1	Ag004005	LDLR	Low density lipid receptor (LDLR)	-
Ag001901	KLK3	PSA or Prostate-specific antigen	KLK3_i2_id1_v1	Ag004006	LDLR	Low density lipid receptor (LDLR)	-
Ag001902	KLK3	PSA or Prostate-specific antigen	KLK3_i3_id1_v1	Ag004007	LDLR	Low density lipid receptor (LDLR)	-
Ag001903	KLK3	PSA or Prostate-specific antigen	KLK3_i4_id1_v1	Ag004008	LDLR	Low density lipid receptor (LDLR)	-
Ag001904	CDKN2A	-	CDKN2A_i5_id1_v1	Ag004009	LDLR	Low density lipid receptor (LDLR)	-
Ag001905	CDKN2A	-	-	Ag004010	LDLR	Low density lipid receptor (LDLR)	-

Ag001906	CDKN2A	-	-	Ag004011	LDLR	Low density lipid receptor (LDLR)	-
Ag001907	UBXD5	COA-1	UBXD5_i7_id1_v2	Ag004012	LDLR	Low density lipid receptor (LDLR)	-
Ag001908	UBXD5	COA-1	-	Ag004013	LDLR	Low density lipid receptor (LDLR)	-
Ag001909	UBXD5	COA-1	-	Ag004014	LDLR	Low density lipid receptor (LDLR)	-
Ag001923	SPA17	Sperm protein 17	-	Ag004015	LDLR	Low density lipid receptor (LDLR)	-
Ag001924	KLK4	-	KLK4_i1_id1_v2	Ag004016	LDLR	Low density lipid receptor (LDLR)	-
Ag001925	KLK4	-	KLK4_i2_id1_v1	Ag004017	LDLR	Low density lipid receptor (LDLR)	-
Ag001926	KLK4	-	KLK4_i2_id2_v1	Ag004018	FUT1	GDP-L-fucose	-
Ag001927	KLK4	-	KLK4_i3_id1_v1	Ag004019	FUT1	GDP-L-fucose	-
Ag001928	KLK4	-	-	Ag004020	FUT1	GDP-L-fucose	-
Ag001930	ANKRD30A	NY-BR-1	ANKRD30A_i2_id1_v1	Ag004021	FUT1	GDP-L-fucose	-
Ag001931	ANKRD30A	NY-BR-1	-	Ag004022	FUT1	GDP-L-fucose	-
Ag001932	RAB38	NY-MEL-1 or RAB38	RAB38_i2_id1_v1	Ag004023	FUT1	GDP-L-fucose	-
Ag001933	CCND1	Cyclin D1	-	Ag004024	FUT1	GDP-L-fucose	-
Ag001934	CYP1B1	P450 1B1 or CYP1B1	CYP1B1_i1_id1_v2	Ag004025	FUT1	GDP-L-fucose	-
Ag001935	CYP1B1	P450 1B1 or CYP1B1	CYP1B1_i1_id1_v3	Ag004026	FUT1	GDP-L-fucose	-
Ag001936	CYP1B1	P450 1B1 or CYP1B1	CYP1B1_i1_id1_v4	Ag004027	FUT1	GDP-L-fucose	-
Ag001937	CYP1B1	P450 1B1 or CYP1B1	-	Ag004028	FUT1	GDP-L-fucose	-
Ag001938	CYP1B1	P450 1B1 or CYP1B1	CYP1B1_i2_id1_v1	Ag004029	ALK	-	-
Ag001939	MDM2	-	-	Ag004030	ALK	-	-
Ag001940	MDM2	-	-	Ag004031	ALK	-	-
Ag001941	MDM2	-	MDM2_i22_id1_v1	Ag004032	ALK	-	-
Ag001942	MDM2	-	MDM2_i12_id1_v1	Ag004033	ALK	-	-
Ag001943	MDM2	-	MDM2_i17_id1_v1	Ag004034	ALK	-	-
Ag001944	MDM2	-	MDM2_i23_id1_v1	Ag004035	ALK	-	-
Ag001945	MDM2	-	MDM2_i24_id1_v1	Ag004036	ALK	-	-
Ag001946	MDM2	-	-	Ag004037	ALK	-	-
Ag001947	MDM2	-	MDM2_i18_id1_v1	Ag004038	ALK	-	-
Ag001948	MDM2	-	MDM2_i19_id1_v1	Ag004039	ALK	-	-
Ag001949	MDM2	-	MDM2_i20_id1_v1	Ag004040	ALK	-	-
Ag001950	MDM2	-	MDM2_i16_id1_v1	Ag004041	ALK	-	-
Ag001951	MDM2	-	MDM2_i25_id1_v1	Ag004042	ALK	-	-
Ag001952	MDM2	-	MDM2_i26_id1_v1	Ag004043	ALK	-	-

Ag001953	MDM2	-	-	Ag004044	ALK	-	-
Ag001954	MDM2	-	MDM2_i27_id1_v1	Ag004045	MSLN	Mesothelin	-
Ag001955	MDM2	-	MDM2_i13_id1_v1	Ag004046	MSLN	Mesothelin	-
Ag001956	MDM2	-	MDM2_i28_id1_v1	Ag004047	MSLN	Mesothelin	-
Ag001957	MDM2	-	MDM2_i15_id1_v1	Ag004048	BCL-2	Bcl-2	-
Ag001958	MDM2	-	MDM2_i14_id1_v1	Ag004049	BCL-2	Bcl-2	-
Ag001959	MDM2	-	MDM2_i11_id1_v1	Ag004050	BCL-2	Bcl-2	Somatic mutation
Ag001960	MDM2	-	MDM2_i21_id1_v1	Ag004051	BCL-2	Bcl-2	Somatic mutation
Ag001961	MDM2	-	MDM2_i29_id1_v1	Ag004052	MCL1	Mcl-1	-
Ag001962	MDM2	-	MDM2_i30_id1_v1	Ag004053	CTSH	Cathepsin H	Somatic mutation
Ag001963	MDM2	-	MDM2_i31_id1_v1	Ag004054	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-
Ag001964	RNF43	-	RNF43_i1_id1_v2	Ag004055	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-
Ag001965	AKAP13	Lymphoid blast crisis oncogene (Lbc) oncoprotein	-	Ag004056	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-
Ag001966	PRTN3	Proteinase 3	PRTN3_i2_id1_v1	Ag004057	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-
Ag001967	RHAMM	RHAMM/C D168	RHAMM_i1_id1_v2	Ag004058	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-
Ag001968	RHAMM	RHAMM/C D168	RHAMM_i2_id1_v2	Ag004059	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-
Ag001969	RHAMM	RHAMM/C D168	-	Ag004060	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-
Ag001970	RHAMM	RHAMM/C D168	-	Ag004061	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	-
Ag001971	RHAMM	RHAMM/C D168	-	Ag004062	BST2	HM1.24	-
Ag001972	RHAMM	RHAMM/C D168	-	Ag004063	MFGE8	Milk fat globule membrane protein BA46 (lactadherin)	-

Ag001973	RHAMM	RHAMM/C D168	-	Ag004064	MFGE8	Milk fat globule membrane protein BA46 (lactadherin)	-
Ag001974	ACPP	Prostatic acid phosphatase	ACPP_i1_id1_v2	Ag004065	CALR3	CRT2	-
Ag001975	ACPP	Prostatic acid phosphatase	ACPP_i1_id1_v3	Ag004066	CALR3	CRT2	-
Ag001976	ACPP	Prostatic acid phosphatase	ACPP_i2_id1_v1	Ag004067	CALR3	CRT2	-
Ag001977	ACPP	Prostatic acid phosphatase	ACPP_i3_id1_v1	Ag004068	HPSE	Heparanase	-
Ag001978	ACPP	Prostatic acid phosphatase	-	Ag004069	APC	-	-
Ag001979	LCK	Lck	LCK_i4_id1_v1	Ag004070	APC	-	-
Ag001980	RPS2	Ribosomal protein S2	RPS2_i1_id1_v2	Ag004071	APC	-	-
Ag001981	RPS2	Ribosomal protein S2	RPS2_i1_id1_v3	Ag004072	APC	-	-
Ag001982	RPS2	Ribosomal protein S2	RPS2_i1_id1_v4	Ag004073	APC	-	-
Ag001983	RPS2	Ribosomal protein S2	RPS2_i1_id2_v1	Ag004074	APC	-	-
Ag001985	RPS2	Ribosomal protein S2	RPS2_i2_id1_v1	Ag004075	APC	-	-
Ag001986	RPS2	Ribosomal protein S2	RPS2_i3_id1_v1	Ag004076	APC	-	-
Ag001987	RPS2	Ribosomal protein S2	RPS2_i4_id1_v1	Ag004077	APC	-	-
Ag001988	RPS2	Ribosomal protein S2	RPS2_i5_id1_v1	Ag004078	APC	-	-
Ag001989	RPL10A	Ribosomal protein L10a	RPL10A_i1_id1_v2	Ag004079	APC	-	Somatic mutation
Ag001990	RPL10A	Ribosomal protein L10a	RPL10A_i2_id2_v1	Ag004080	APC	-	-
Ag001992	BCL2L1	Bcl-xL	BCL2L1_i1_id1_v2	Ag004081	APC	-	-
Ag001994	ENAH	Human Mena protein	ENAH_i2_id1_v2	Ag004082	APC	-	-
Ag001995	ENAH	Human Mena protein	ENAH_i3_id1_v1	Ag004083	APC	-	-
Ag001996	ENAH	Human Mena protein	ENAH_i4_id1_v1	Ag004084	APC	-	-
Ag001997	ENAH	Human Mena protein	ENAH_i5_id1_v1	Ag004085	APC	-	-

Ag001998	CSPG4	Melanoma-associated chondroitin sulfate proteoglycan (MCSP)	-	Ag004086	APC	-	-
Ag001999	BCR-ABL	-	BCR-ABL_i13_id1_v1	Ag004087	APC	-	-
Ag002000	BCR	Breakpoint cluster region	-	Ag004088	APC	-	-
Ag002001	BCR-ABL	-	BCR-ABL_i12_id1_v1	Ag004089	APC	-	-
Ag002002	BCR-ABL	-	BCR-ABL_i17_id1_v1	Ag004090	APC	-	-
Ag002003	BCR	Breakpoint cluster region	-	Ag004091	TOP2A	-	-
Ag002004	BCR-ABL	-	BCR-ABL_i15_id1_v1	Ag004092	TOP2A	-	-
Ag002005	BCR-ABL	-	BCR-ABL_i21_id1_v1	Ag004093	TOP2A	-	-
Ag002006	BCR-ABL	-	BCR-ABL_i22_id1_v1	Ag004094	ITGB8	-	-
Ag002007	BCR-ABL	-	BCR-ABL_i19_id1_v1	Ag004095	RPA1	-	-
Ag002008	BCR-ABL	-	BCR-ABL_i18_id1_v1	Ag004096	CCNI	-	-
Ag002009	BCR-ABL	-	BCR-ABL_i14_id1_v1	Ag004097	STAT1	-	-
Ag002010	BCR	Breakpoint cluster region	-	Ag004098	STAT1	-	-
Ag002011	BCR-ABL	-	BCR-ABL_i20_id1_v1	Ag004099	STAT1	-	-
Ag002012	BCR-ABL	-	BCR-ABL_i8_id1_v1	Ag004100	LRP1	-	-
Ag002013	BCR	Breakpoint cluster region	-	Ag004101	LRP1	-	-
Ag002014	BCR-ABL	-	BCR-ABL_i23_id1_v1	Ag004102	LRP1	-	Somatic mutation
Ag002018	DEK	DEK oncogene	DEK_i2_id1_v1	Ag004103	LRP1	-	-
Ag002021	AML1	AML	AML1_i14_id1_v1	Ag004104	LRP1	-	Somatic mutation
Ag002022	AML1	AML	AML1_i13_id1_v1	Ag004105	DDR1	-	-
Ag002023	AML1	AML	AML1_i12_id1_v1	Ag004106	DDR1	-	-
Ag002024	FUT1	GDP-L-fucose	FUT1_i1_id1_v2	Ag004107	DDR1	-	-
Ag002025	FUT1	GDP-L-fucose	FUT1_i1_id1_v3	Ag004108	DDR1	-	-
Ag002026	FUT1	GDP-L-fucose	FUT1_i1_id1_v4	Ag004109	DDR1	-	-
Ag002027	FUT1	GDP-L-fucose	FUT1_i1_id1_v5	Ag004110	DDR1	-	Somatic mutation
Ag002028	FUT1	GDP-L-fucose	FUT1_i2_id1_v1	Ag004111	HMOX1	heme oxygenase-1 (HO-1)	-
Ag002029	FUT1	GDP-L-fucose	FUT1_i3_id1_v1	Ag004112	HMOX1	heme oxygenase-1 (HO-1)	-
Ag002030	NPM1	NPM	NPM1_i3_id1_v1	Ag004113	TPM4	Tropomyosin-4	Somatic mutation
Ag002031	NPM1	NPM	NPM1_i4_id1_v1	Ag004114	BAAT	-	-

Ag002032	NPM1	NPM	NPM1_i5_id1_v1	Ag004115	CDKN1A	cyclin-dependent kinase inhibitor 1A (CDKN1A)	-
Ag002034	RARA	RAR alpha	RARA_i1_id1_v2	Ag004116	CDKN1A	cyclin-dependent kinase inhibitor 1A (CDKN1A)	-
Ag002035	RARA	RAR alpha	RARA_i3_id1_v1	Ag004117	PTH1H	Parathyroid hormone-related protein (PTHrP)	Somatic mutation
Ag002036	SYT	-	SYT_i1_id1_v2	Ag004118	ATIC	5'-aminoimidazole-4-carboxamide-1-beta-d-ribose nucleotide transferase/inosinase (ATIC/IT)	-
Ag002037	SYT	-	SYT_i1_id1_v3	Ag004119	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002038	SYT	-	-	Ag004120	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002039	SYT	-	SYT_i3_id1_v1	Ag004121	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002040	UBE2V1	Ubiquitin-conjugating enzyme variant Kua	UBE2V1_i4_id1_v1	Ag004122	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002042	HNRPL	-	HNRPL_i2_id1_v1	Ag004123	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002044	WHSC2	-	WHSC2_i4_id1_v1	Ag004124	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002045	WHSC2	-	WHSC2_i2_id1_v2	Ag004125	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002046	WNK2	-	WNK2_i5_id1_v1	Ag004126	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002047	WNK2	-	-	Ag004127	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002049	OAS3	-	OAS3_i1_id1_v2	Ag004128	PGK1	phosphoglycerate kinase 1 (PGK1)	-

Ag002050	OAS3	-	OAS3_i1_id1_v3	Ag004129	PGK1	phosphoglycerate kinase 1 (PGK1)	-
Ag002051	BCL-2	Bcl-2	BCL2_i1_id1_v2	Ag004130	TOR3A	ATP-dependent interferon-responsive (ADIR)	-
Ag002052	CTSH	Cathepsin H	CTSH_i1_id1_v2	Ag004131	EGFR	Epidermal growth factor receptor (EGFR)	-
Ag002053	CTSH	Cathepsin H	CTSH_i1_id1_v3	Ag004132	EGFR	Epidermal growth factor receptor (EGFR)	-
Ag002054	ABCC3	Multidrug resistance-associated protein 3 (MRP3)	ABCC3_i6_id1_v1	Ag004133	EGFR	Epidermal growth factor receptor (EGFR)	-
Ag002055	MFGE8	Milk fat globule membrane protein BA46 (lactadherin)	MFGE8_i2_id1_v1	Ag004134	EGFR	Epidermal growth factor receptor (EGFR)	-
Ag002056	MFGE8	Milk fat globule membrane protein BA46 (lactadherin)	MFGE8_i3_id1_v1	Ag004135	EGFR	Epidermal growth factor receptor (EGFR)	-
Ag002057	FMOD	Fibromodulin (FMOD)	FMOD_i1_id1_v2	Ag004136	EGFR	Epidermal growth factor receptor (EGFR)	-
Ag002058	RPSA	Oncofetal Ag immature laminin receptor (OFA-iLR)	RPSA_i1_id1_v2	Ag004137	EGFR	Epidermal growth factor receptor (EGFR)	-
Ag002059	RPSA	Oncofetal Ag immature laminin receptor (OFA-iLR)	RPSA_i1_id1_v3	Ag004138	EGFR	Epidermal growth factor receptor (EGFR)	-
Ag002061	PA2G4	ErbB3-binding protein 1	-	Ag004139	EGFR	Epidermal growth factor receptor (EGFR)	-

Ag002062	EZH2	Polycomb group protein enhancer of zeste homolog 2 (EZH2)	EZH2_i2_id1_v1	Ag004140	EGFR	Epidermal growth factor receptor (EGFR)	-
Ag002063	FMNL1	Formin-related protein in leukocytes 1 (FMNL1)	FMNL1_i3_id1_v1	Ag004141	TTK	TTK protein kinase (TTK)	-
Ag002064	HPSE	Heparanase	HPSE_i2_id1_v1	Ag004142	TTK	TTK protein kinase (TTK)	-
Ag002065	HPSE	Heparanase	-	Ag004143	GPC3	glypican-3 (GPC3)	-
Ag002066	APC	-	-	Ag004144	ALDH1A1	aldehyde dehydrogenase 1 family member A1 (ALDH1A1)	-
Ag002067	APC	-	-	Ag004145	MF12	Melanotransferrin	-
Ag002068	UBE2A	-	UBE2A_i1_id1_v2	Ag004146	MMP14	-	-
Ag002069	UBE2A	-	UBE2A_i1_id1_v3	Ag004147	MMP14	-	-
Ag002070	UBE2A	-	UBE2A_i1_id1_v4	Ag004148	MMP14	-	-
Ag002071	UBE2A	-	UBE2A_i2_id1_v1	Ag004149	MMP14	-	-
Ag002072	BCAP31	-	BCAP31_i1_id1_v2	Ag004150	MMP14	-	-
Ag002073	BCAP31	-	BCAP31_i1_id1_v3	Ag004151	MMP14	-	-
Ag002074	TOP2B	-	-	Ag004152	MMP14	-	-
Ag002075	ITGB8	-	ITGB8_i2_id1_v1	Ag004153	MMP14	-	-
Ag002076	ABI2	-	ABI2_i4_id1_v1	Ag004154	SDCBP	-	-
Ag002077	CCNI	-	CCNI_i1_id1_v2	Ag004155	MET	c-Met protein	-
Ag002078	CDC2	-	CDC2_i1_id2_v1	Ag004156	MET	c-Met protein	-
Ag002079	CDC2	-	CDC2_i3_id1_v1	Ag004157	MET	c-Met protein	-
Ag002080	2-Sep	-	-	Ag004158	MET	c-Met protein	-
Ag002081	STAT1	-	STAT1_i1_id1_v2	Ag004159	MET	c-Met protein	-
Ag002082	STAT1	-	STAT1_i1_id1_v3	Ag004160	MET	c-Met protein	-
Ag002083	ADAM17	-	ADAM17_i5_id1_v1	Ag004161	MET	c-Met protein	-
Ag002084	ADAM17	-	ADAM17_i3_id1_v1	Ag004162	MET	c-Met protein	-
Ag002085	ADAM17	-	ADAM17_i4_id1_v1	Ag004163	MET	c-Met protein	-
Ag002086	JUP	-	JUP_i1_id1_v2	Ag004164	MET	c-Met protein	-
Ag002088	JUP	-	JUP_i1_id1_v3	Ag004165	MET	c-Met protein	-
Ag002089	DDR1	-	DDR1_i2_id1_v2	Ag004166	MET	c-Met protein	-
Ag002090	DDR1	-	DDR1_i3_id1_v1	Ag004167	MET	c-Met protein	-
Ag002091	HMOX1	heme oxygenase-1 (HO-1)	HMOX1_i1_id1_v2	Ag004168	MET	c-Met protein	-
Ag002092	BAAT	-	BAAT_i1_id1_v2	Ag004169	MET	c-Met protein	-

Ag002093	TAPBP	-	TAPBP_i4_id1_v1	Ag004170	MET	c-Met protein	-
Ag002094	TAPBP	-	TAPBP_i3_id1_v2	Ag004171	MET	c-Met protein	-
Ag002095	TAPBP	-	TAPBP_i5_id1_v1	Ag004172	MET	c-Met protein	-
Ag002096	TAPBP	-	TAPBP_i5_id1_v2	Ag004173	MET	c-Met protein	-
Ag002097	TAPBP	-	-	Ag004174	MET	c-Met protein	Somatic mutation
Ag002098	TAPBP	-	-	Ag004175	MET	c-Met protein	-
Ag002099	TAPBP	-	-	Ag004176	MET	c-Met protein	Somatic mutation
Ag002100	TAPBP	-	TAPBP_i6_id1_v1	Ag004177	MET	c-Met protein	-
Ag002101	PAK2	P21-activated serin kinase 2 (PAK2)	PAK2_i1_id1_v2	Ag004178	MET	c-Met protein	-
Ag002102	CDKN1A	cyclin-dependent kinase inhibitor 1A (CDKN1A)	CDKN1A_i2_id1_v1	Ag004179	MET	c-Met protein	-
Ag002103	TRPM8	Prostate-specific protein transient receptor potential-p8 (trp-p8)	TRPM8_i4_id1_v1	Ag004180	MET	c-Met protein	Somatic mutation
Ag002104	TYMS	Thymidylate synthase (TYMS)	TYMS_i1_id1_v2	Ag004181	MET	c-Met protein	-
Ag002105	TYMS	Thymidylate synthase (TYMS)	TYMS_i1_id1_v3	Ag004182	MET	c-Met protein	-
Ag002106	TYMS	Thymidylate synthase (TYMS)	TYMS_i2_id1_v1	Ag004183	MET	c-Met protein	Somatic mutation
Ag002107	TYMS	Thymidylate synthase (TYMS)	TYMS_i3_id1_v1	Ag004184	PAX3	-	-
Ag002108	ATIC	5'-aminoimidazole-4-carboxamide-1-beta-d-ribonucleotide transfolmylase/inosinase (AICRT/I)	AITC_i2_id1_v1	Ag004185	PAX3	-	-
Ag002109	TOR3A	ATP-dependent interferon-responsive (ADIR)	-	Ag004186	PAX3	-	-
Ag002110	TOR3A	ATP-dependent interferon-responsive (ADIR)	-	Ag004187	PAX3	-	-

Ag002111	TRGC2	T-cell receptor gamma alternate reading frame protein (TARP)	TRGC2_i2_id1_v1	Ag004188	PAX3	-	-
Ag002112	TRGC2	T-cell receptor gamma alternate reading frame protein (TARP)	-	Ag004189	PAX3	-	-
Ag002113	TRGC2	T-cell receptor gamma alternate reading frame protein (TARP)	-	Ag004190	PAX3	-	-
Ag002115	EGFR	Epidermal growth factor receptor (EGFR)	EGFR_i1_id1_v2	Ag004191	PAX3	-	-
Ag002116	EGFR	Epidermal growth factor receptor (EGFR)	EGFR_i1_id1_v3	Ag004192	PAX3	-	-
Ag002117	EGFR	Epidermal growth factor receptor (EGFR)	EGFR_i1_id1_v4	Ag004193	PAX3	-	-
Ag002118	EGFR	Epidermal growth factor receptor (EGFR)	EGFR_i5_id1_v1	Ag004194	PAX3	-	-
Ag002119	EGFR	Epidermal growth factor receptor (EGFR)	-	Ag004195	PAX3	-	-
Ag002120	EGFR	Epidermal growth factor receptor (EGFR)	EGFR_i6_id1_v1	Ag004196	PAX3	-	-
Ag002121	IER3	immediate early response gene X-1 (IEX-1)	IER3_i1_id1_v2	Ag004197	PAX3	-	-
Ag002122	IER3	immediate early response gene X-1 (IEX-1)	IER3_i1_id1_v3	Ag004198	PAX3	-	-

Ag002123	IER3	immediate early response gene X-1 (IEX-1)	IER3_i1_id1_v4	Ag004199	PAX3	-	-
Ag002124	IER3	immediate early response gene X-1 (IEX-1)	IER3_i2_id1_v1	Ag004200	PAX3	-	-
Ag002125	IER3	immediate early response gene X-1 (IEX-1)	IER3_i3_id1_v1	Ag004201	PAX3	-	-
Ag002126	IER3	immediate early response gene X-1 (IEX-1)	IER3_i4_id1_v1	Ag004202	PAX3	-	-
Ag002127	TTK	TTK protein kinase (TTK)	TTK_i1_id1_v2	Ag004203	PAX3	-	-
Ag002128	LY6K	lymphocyte antigen 6 complex locus K (LY6K)	-	Ag004204	PAX3	-	-
Ag002131	GPC3	glypican-3 (GPC3)	GPC3_i1_id1_v2	Ag004205	PAX3	-	-
Ag002132	GPC3	glypican-3 (GPC3)	GPC3_i1_id1_v3	Ag004206	PAX3	-	-
Ag002133	GPC3	glypican-3 (GPC3)	GPC3_i3_id1_v3	Ag004207	PAX3	-	-
Ag002134	GPC3	glypican-3 (GPC3)	GPC3_i2_id1_v1	Ag004208	PAX3	-	-
Ag002135	H3F3A	-	H3F3A_i1_id1_v2	Ag004209	PAX3	-	-
Ag002136	H3F3A	-	H3F3A_i1_id1_v3	Ag004210	PAX3	-	-
Ag002138	H3F3A	-	H3F3A_i1_id1_v4	Ag004211	STEAP1	STEAP	-
Ag002140	H3F3A	-	H3F3A_i1_id1_v5	Ag004212	STEAP1	STEAP	-
Ag002141	H3F3A	-	H3F3A_i1_id1_v6	Ag004213	STEAP1	STEAP	-
Ag002142	H3F3A	-	H3F3A_i1_id1_v7	Ag004214	STEAP1	STEAP	-
Ag002143	ALDH1A1	aldehyde dehydrogenase 1 family member A1 (ALDH1A1)	ALDH1A1_i2_id1_v1	Ag004215	BIRC7	Livin/ML-IAP	-
Ag002144	MAGED4	-	MAGED4_i1_id1_v2	Ag004216	CSPG4	Melanoma-associated chondroitin sulfate proteoglycan (MCSP)	-
Ag002145	MAGED4	-	MAGED4_i5_id1_v1	Ag004217	XBP1	XBP1	XBP1_i1_id1_v1
Ag002146	MET	c-Met protein	MET_i1_id1_v2	Ag004218	XBP1	XBP1	XBP1_i2_id1_v1
Ag002147	CCNB1	cyclin B1	CCNB1_i1_id1_v2	Ag004219	SYND1	CD138	SYND1_i1_id1_v1
Ag002148	CCNB1	cyclin B1	CCNB1_i2_id1_v1	Ag004220	SYND1	CD138	SYND1_i1_id1_v1
Ag002149	CCNB1	cyclin B1	CCNB1_i3_id1_v1	Ag004221	ETV5	-	-
Ag002150	CCNB1	cyclin B1	-	Ag004222	HSPA1A	-	-

Ag002151	CCNB1	cyclin B1	CCNB1_i3_id1_v3	Ag004223	HMHA1	-	-
Ag002152	PAX3	-	PAX3_i4_id1_v1	Ag004224	TRIM68	-	-
Ag002153	PAX3	-	PAX3_i4_id1_v2	Ag004225	ACSM2A	ACSM2A	-
Ag002154	PAX3	-	PAX3_i5_id1_v1	Ag004227	ATR	ATR	-
Ag002155	PAX3	-	PAX3_i6_id1_v1	Ag004228	USB1	USB1	-
Ag002156	PML1	promyelocytic leukemia or PML	PML1_i2_id1_v1	Ag004229	RTCB	RTCB	-
Ag002157	PML1	promyelocytic leukemia or PML	PML1_i3_id1_v1	Ag004230	C6ORF89	C6ORF89	-
Ag002158	PML1	promyelocytic leukemia or PML	PML1_i4_id1_v1	Ag004231	CDC25A	CDC25A	-
Ag002159	PML1	promyelocytic leukemia or PML	PML1_i5_id1_v1	Ag004232	CDK12	CDK12	-
Ag002160	PML1	promyelocytic leukemia or PML	PML1_i6_id1_v1	Ag004233	CRYBA1	CRYBA1	-
Ag002161	PML1	promyelocytic leukemia or PML	PML1_i12_id1_v1	Ag004234	CSNK1A1	CSNK1A1	-
Ag002162	PML1	promyelocytic leukemia or PML	PML1_i11_id1_v1	Ag004235	DSCAML1	DSCAML1	-
Ag002163	PML1	promyelocytic leukemia or PML	PML1_i13_id1_v1	Ag004236	F2R	F2R	-
Ag002164	PML1	promyelocytic leukemia or PML	PML1_i2_id1_v2	Ag004237	FNDC3B	FNDC3B	-
Ag002165	PML1	promyelocytic leukemia or PML	PML1_i8_id1_v1	Ag004238	GAS7	GAS7	-
Ag002166	PML1	promyelocytic leukemia or PML	PML1_i7_id1_v1	Ag004239	HAUS3	HAUS3	-
Ag002167	PML1	promyelocytic leukemia or PML	PML1_i9_id1_v1	Ag004240	HERC1	HERC1	-
Ag002168	PML1	promyelocytic leukemia or PML	PML1_i10_id1_v1	Ag004241	HMG2	HMG2	-
Ag002169	PML1	promyelocytic leukemia or PML	PML1_i14_id1_v1	Ag004242	SZT2	SZT2	-
Ag002170	CEACAM5	CEA	Putative	Ag004243	LRRC41	LRRC41	-
Ag002171	MAGEA3	MAGE-A3	Putative	Ag004244	MATN2	Matrilin-2	-

Ag002172	MAGEA4	MAGE-A4	Putative	Ag004245	NIN	Ninein	-
Ag002173	CAMEL	-	Putative	Ag004246	PLEKHM2	PLEKHM2	-
Ag002174	MCL1	Mcl-1	Putative	Ag004247	POLR2A	POLR2A	-
Ag002175	FMOD	Fibromodulin (FMOD)	Putative	Ag004248	PPP1R3B	PPP1R3B	-
Ag002176	ERBB2	HER2	-	Ag004249	RALGAPB	RALGAPB	-
Ag002177	ERBB2	HER2	-	Ag004250	SF3B1	SF3B1	-
Ag002178	ERBB2	HER2	-	Ag004251	SLC46A1	SLC46A1	-
Ag002179	ERBB2	HER2	-	Ag004252	STRAP	STRAP	-
Ag002180	ERBB2	HER2	-	Ag004253	SYT15	SYT15	-
Ag002181	ERBB2	HER2	-	Ag004254	TBC1D9B	TBC1D9B	-
Ag002182	BIRC5	Survivin	-	Ag004255	THNSL2	THNSL2	-
Ag002183	CEACAM5	CEA	-	Ag004256	THOC6	THOC6	-
Ag002184	CEACAM5	CEA	-	Ag004257	WHSC1L1	WHSC1L1	-
Ag002185	CEACAM5	CEA	-	Ag004258	XPO1	XPO1	-
Ag002186	IL13RA2	Interleukin 13 receptor alpha 2	-	Ag004259	C6ORF89	C6ORF89	-
Ag002187	MAGEA1	MAGE-A1	-	Ag004260	C6ORF89	C6ORF89	-
Ag002188	MAGEA1	MAGE-A1	Somatic mutation	Ag004261	BCL11A	BCL11A	-
Ag002189	MAGEA4	MAGE-A4	Somatic mutation	Ag004262	SPEN	SPEN	-
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Ag002191	MAGEB2	MAGE-B2	-	Ag004264	SOGA1	SOGA1	-
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Ag002197	TP53	-	Somatic mutation	Ag004270	HIVEP2	HIVEP2	-
Ag002198	TP53	-	Somatic mutation	Ag004271	NCOA1	NCOA1	-
Ag002199	TP53	-	Somatic mutation	Ag004272	LPP	LPP	-
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Ag002226	TP53	-	Somatic mutation	Ag004299	KANSL3	KANSL3	-
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Ag002229	TP53	-	Somatic mutation	Ag004302	TNS3	TNS3	-
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Ag002259	TP53	-	Somatic mutation	Ag004332	RBM17	RBM17	-
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Ag002262	TP53	-	Somatic mutation	Ag004335	RBM17	RBM17	-
Ag002263	TP53	-	Somatic mutation	Ag004336	MYC	MYC	-
Ag002264	TP53	-	Somatic mutation	Ag004337	ANKRD17	ANKRD17	-

CLAIMS

We claim:

1. A composition comprising: a nano-satellite complex, wherein said nano-satellite complex comprises:
 - a) a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core;
 - b) 3-25 satellite particles attached to, or absorbed to, said biocompatible coating;
 - c) a plurality of antigenic peptides conjugated to, or absorbed to, said satellite particles; and
 - d) wherein said nano-satellite complex comprises at least one of the following properties:
 - i) wherein the weight-to-weight ratio of all of said satellite particles to said nanoparticle core is 10-40%;
 - ii) wherein the diameter of each of said satellite particles is 2-20 nm;
 - iii) wherein said plurality of antigenic peptides is 100-4000 antigenic peptides;
 - iv) wherein 10-300 of said plurality of said antigenic peptides are present on each of said satellite particles; and
 - v) wherein the average distance between each of said satellite particles is 5-20 nm.

2. A composition comprising: a nano-satellite complex, wherein said nano-satellite complex comprises:
 - a) a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core;
 - b) 10-20 satellite particles attached to, or absorbed to, said biocompatible coating;
 - c) a plurality of antigenic peptides conjugated to, or absorbed to, said satellite particles; and
 - d) wherein said nano-satellite complex comprises at least one of the following properties:
 - i) wherein the weight-to-weight ratio of all of said satellite particles to said nanoparticle core is 10-40%;
 - ii) wherein the diameter of each of said satellite particles is 1-5 nm;
 - iii) wherein said satellite particles are present at density of 15,00-30,000 per square micron;
 - iv) wherein said plurality of antigenic peptides is 1500-3000 antigenic peptides;
 - v) wherein 100-400 of said plurality of said antigenic peptides are present on each of said satellite particles; and
 - vi) wherein the average distance between each of said satellite particles is 4-7 nm.
3. The composition of claims 1-2, wherein said core nanoparticle comprises Fe_3O_4 and/or said satellite particles comprise gold.
4. The composition of claims 1-2, wherein said biocompatible coating comprises polysiloxane.
5. The composition of claims 1-2, wherein said nanoparticle core comprises Fe_3O_4 , said biocompatible coating comprises polysiloxane, and said at least one satellite particle comprises a plurality of satellite particles composed of gold.
6. The composition of claims 1, wherein said 3-25 satellite particles is 10-15 satellite particles.

7. The composition of claims 1-2, wherein said at least one property is wherein said weight-to-weight ratio of all of said satellite particles to said nanoparticle core is 10-40%.
8. The composition of claim 7, wherein said weight-to-weight ratio of all of said satellite particles to said nanoparticle core is 25-35%.
9. The composition of claim 7, wherein said weight-to-weight ratio of all of said satellite particles to said nanoparticle core is 29-31%.
10. The composition of claim 1, wherein said at least one property is wherein said diameter of each of said satellite particles is 2-20 nm.
11. The composition of claim 10, wherein said diameter of each of said satellite particles is 5-15 nm.
12. The composition of claim 10, wherein said diameter of each of said satellite particles is 4-6 nm.
13. The composition of claim 1, wherein said at least one property is wherein said satellite particles are present at density of 500-20,000 per square micron.
14. The composition of claim 13, wherein said satellite particles are present at a density of 13,000 to 17,000 per square micron.
15. The composition of claim 1, wherein said at least one property is wherein said plurality of antigenic peptides is 100-4000 antigenic peptides.
16. The composition of claim 15, wherein said plurality of antigenic peptides is 1500-2500 antigenic peptides.
17. The composition of claim 1, wherein said at least one property is wherein 10-300 of said plurality of said antigenic peptides are present on each of said satellite particles.

18. The composition of claim 17, wherein 225-275 of said plurality of antigenic peptides are present on each of said satellite particles.
19. The composition of claim 1, wherein said at least one property is wherein the average distance between each of said satellite particles is 5-20 nm.
20. The composition of claim 1, wherein said average distance between each of said satellite particles is 5-7 nm.
21. The composition of claims 1-2, wherein said at least one property is at least two of said properties.
22. The composition of claims 1-2, wherein said at least one property is at least four of said properties.
23. The composition of claims 1-2, wherein said at least one property is at least five of said properties.
24. The composition of claims 1-2, wherein said antigenic peptide comprises: i) a neoantigenic determinant, ii) at least one epitope from a tumor antigen, iii) at least one epitope from a viral oncoprotein, iv) a least one epitope from an infectious virus, v) at least one epitope from a parasite, or vi) at least one epitope from an infectious bacteria.
25. The composition of claims 1-2, further comprising a physiologically compatible aqueous solution.
26. The composition of claims 1-2, further comprising cancer cells or antigen presenting cells.
27. The composition of claims 1-2, wherein said plurality of antigenic peptides are not uniformly distributed on said satellite particles.
28. The composition of claims 1-2, wherein said nano-satellite complex is a diameter of 50-100 nm.

29. The composition of claim 28, wherein said diameter is 55-65 nm.
30. The composition of claims 1-2, wherein the surface of said nano-satellite complex is negatively charged.
31. The composition of claims 1-2, wherein said core nanoparticle has a diameter of 10-25 nm.
32. The composition of claim 31, wherein said diameter is 15-20 nm.
33. The composition of claims 1-2, wherein said composition further comprises a type I interferon agonist agent.
34. The composition of claim 33, wherein said type I interferon agonist agent is electrostatically attracted to, or absorbed to, i) said antigenic peptides, ii) said plurality of satellite particles, and/or iii) said core nanoparticle.
35. The composition of claims 1-2, wherein said composition is adjuvant-free.
36. The composition of claims 1-2, further comprising an immune checkpoint inhibitor.
37. A method of eliciting an immune response in a subject comprising: administering to a subject said composition of any of claims 1-36 such that antibodies to said antigenic peptides are generated.
38. The method of claim 37, wherein said subject is a human.
39. The method of claim 37, wherein said subject is an animal.
40. The method of claim 37, further comprising taking a sample from said subject, and purifying at least some of said antibodies from said sample.

41. The method of claim 37, wherein no adjuvant is administered as part of said composition or otherwise.
42. The method of claim 37, wherein said subject is administering a type I interferon agonist agent, either in said composition or separately.
43. The method of claim 37, wherein said subject is administering an immune checkpoint inhibitor, either in said composition or separately.
45. The method of claim 37, wherein said antigenic peptides comprise B-Cell epitopes.
46. The method of claim 37, wherein said nanosatellite complex does not generate detectable non-specific antibody against said nano-satellite complex.
47. The method of claim 37, wherein said nanosatellite complex homes to a lymph node of said subject.
48. The method of claim 37, wherein said nanosatellite complex homes to a B-cell zone or T-cell zone of a lymph node of said subject.
49. The method of claim 37, wherein said nanosatellite complex is taken up by subcapsular sinus macrophages in said subject at a rate equal to a virus.

FIG. 1

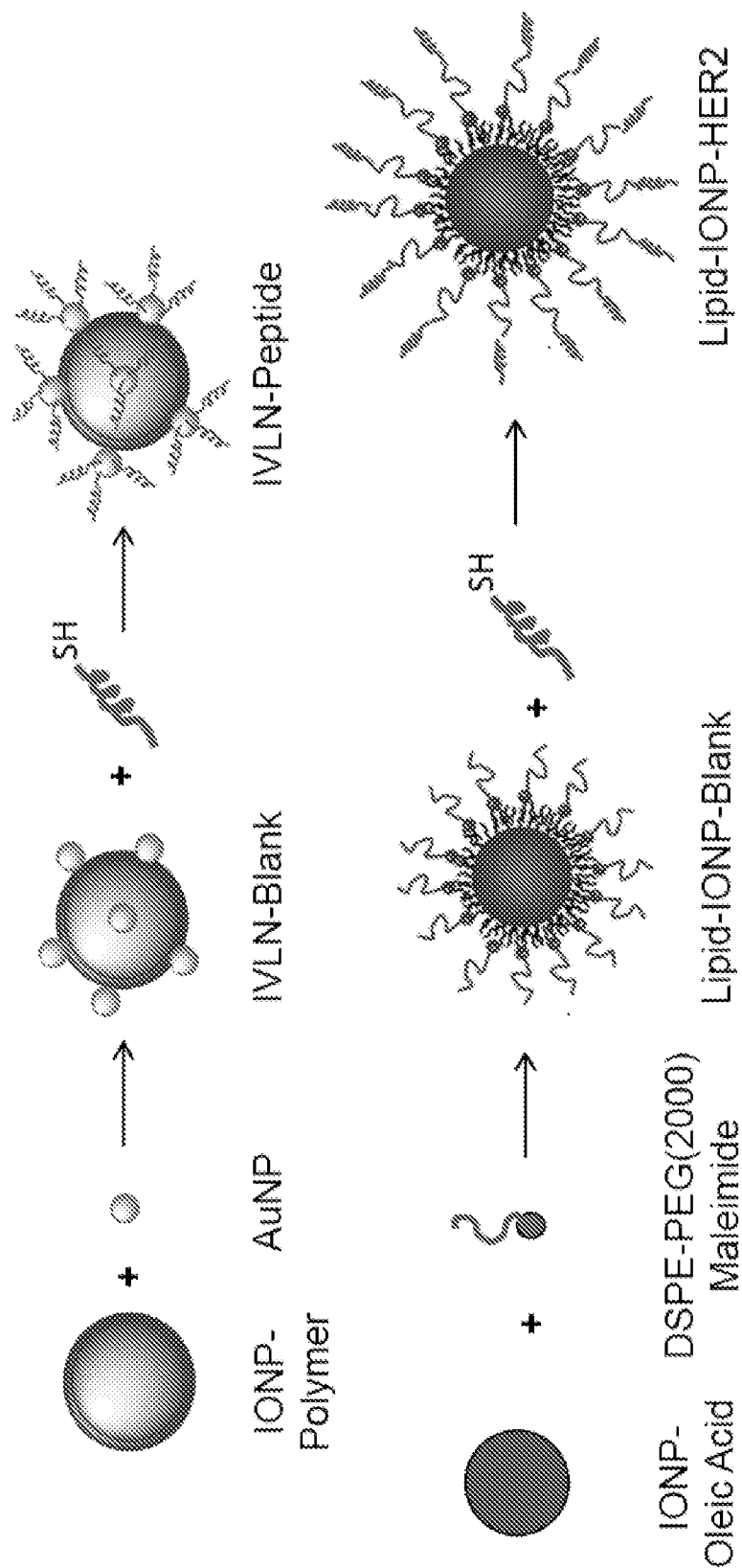


FIG. 2

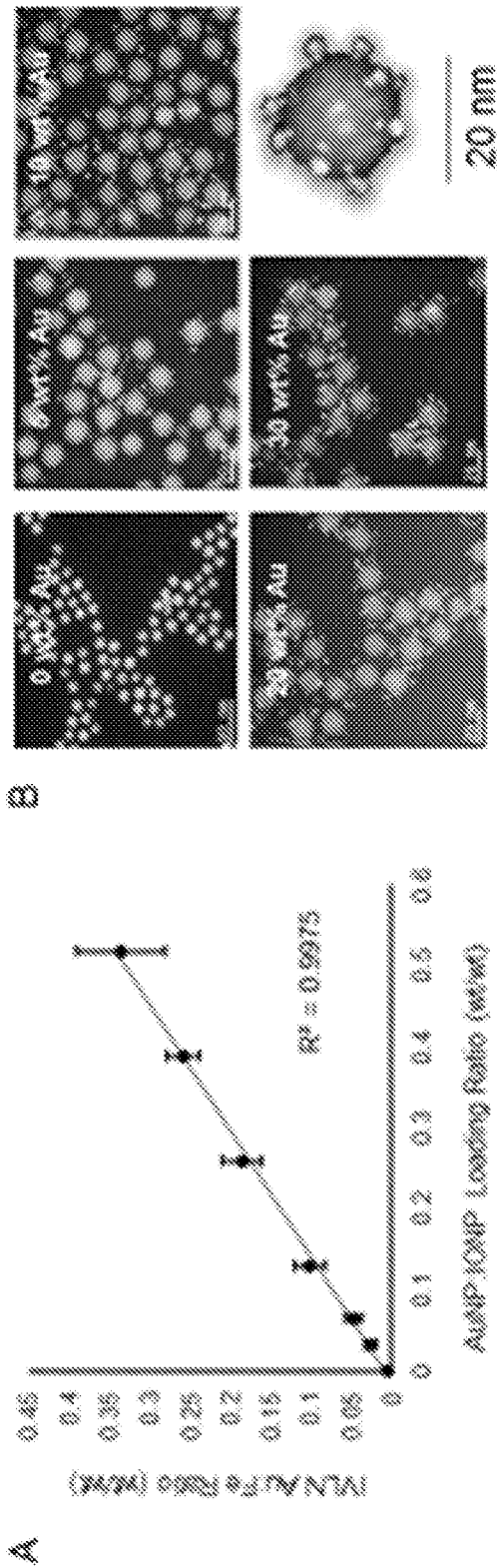


FIG. 2 (cont.)

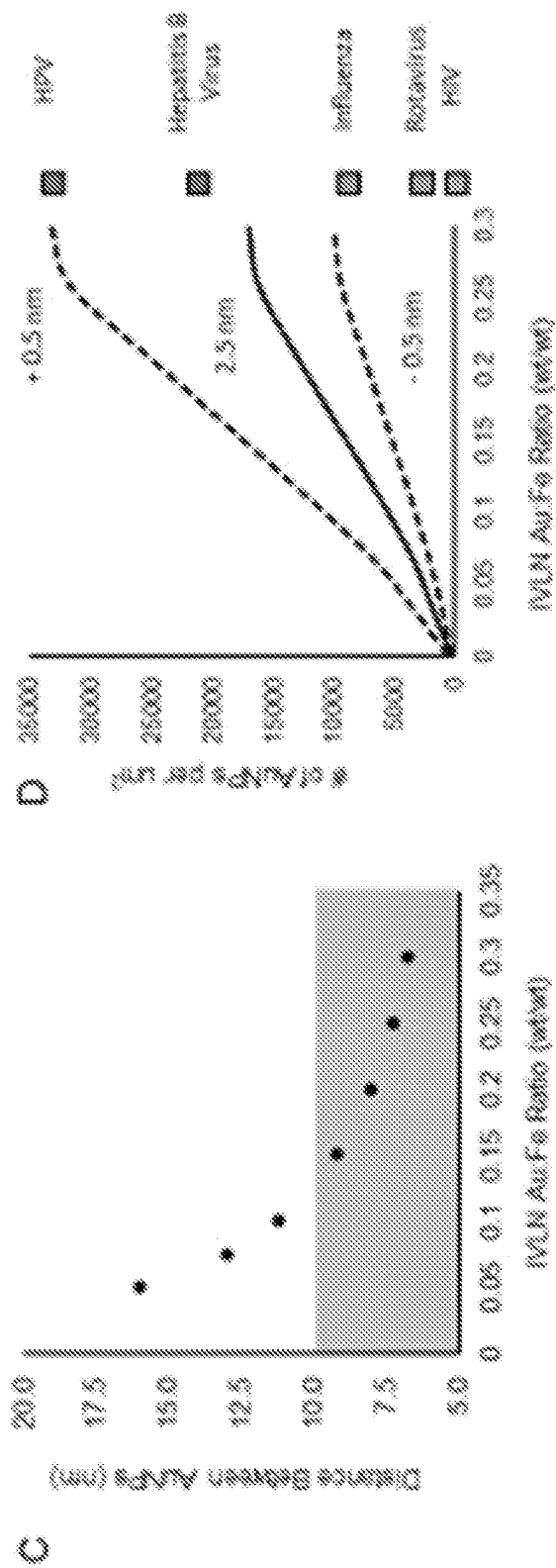


FIG. 2 (cont.)

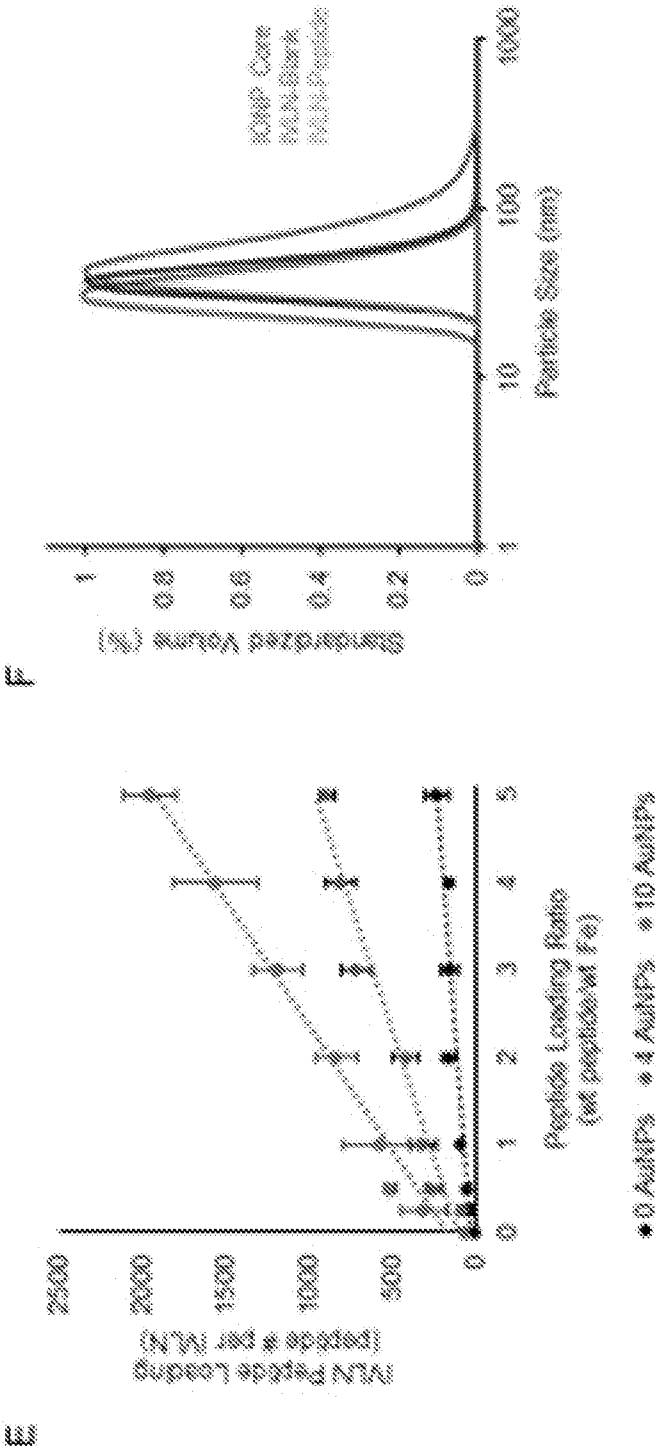


FIG. 4

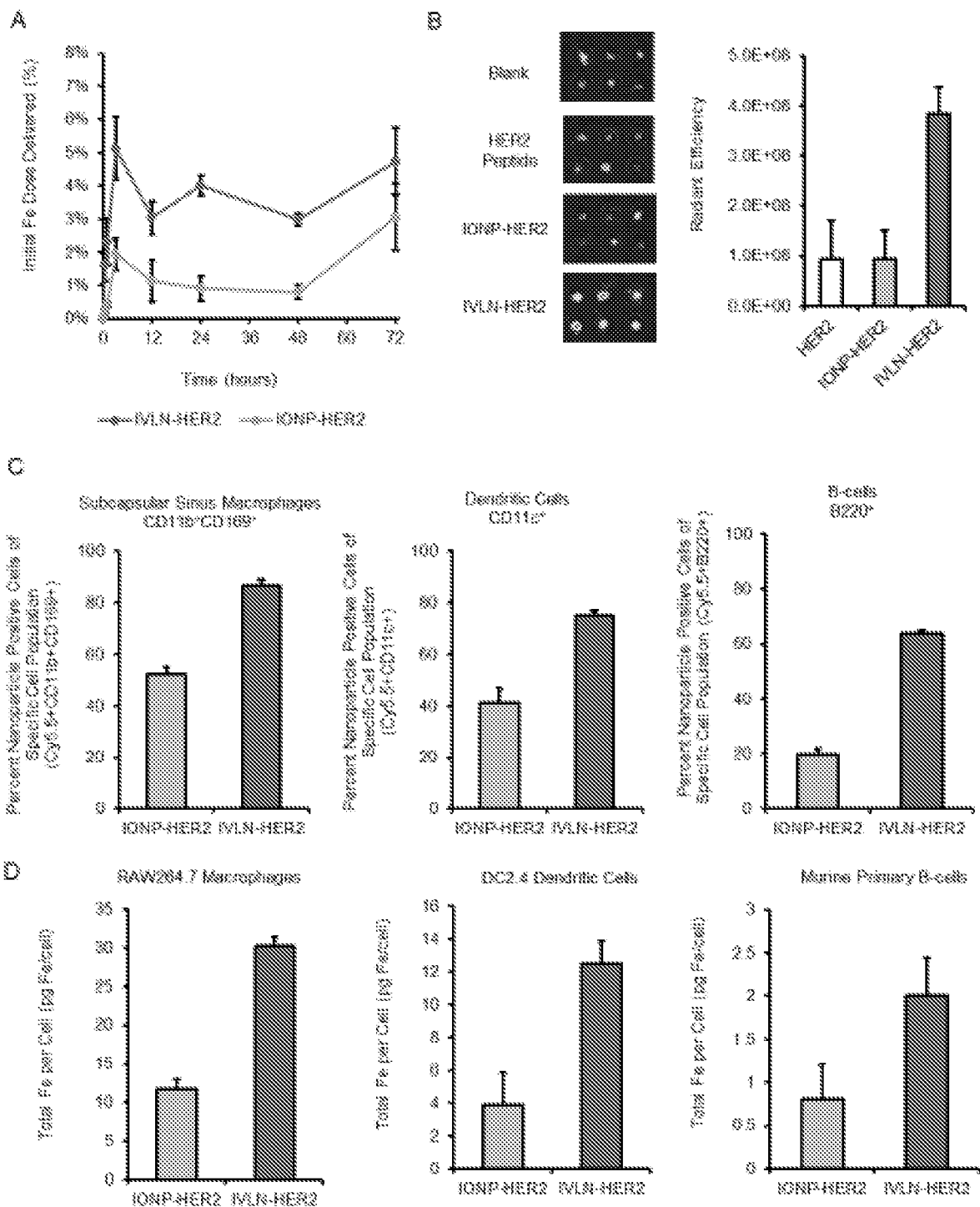


FIG. 5

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>Ag000001_KRBB2
MELAAICRWGLLALLPPGAASTOVCTGTDMLRLPASPEETHDMLRHLYQCCQVQCNLELTYLPTNAS
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QLRSLTEILKGGVLIQRNPQLCYQDTILWKDIFHKNNQLALTLDITNRSRACHPCSEPMCKGSRGWGESSE
DCQSLTRTVACGSCARCKGPLEPTDCCHEQCAAGCTGPKHSDCLACHFNHSGICEHCPALVTYNTDTEE
SMPNPEGRTYTFGASCVTACPNYVLTSDVGSCTLVCPLHNQEVTAEDGTQRCCEKCKPCARVCYCYGLGMEHL
REVRAVTSANIQEFAGCKKIFGSLAFLPESFDGDPASNTAPLQPEQLQVFETLEBITGXYLXISAWPDSLP
DLSVFQNLQVIRGRILHNGAYSILTQCLGISWLGRLSLRELSGSLALIHNNTHLCFVHTVPWDQLFRNFH
QALLHTANRPEDECVGEGLAHQLCARGHCWGPPTQCVCNCSQFLRGQECVEECRVLQGLPREYVVARHC
LPCHECQPNQSVTCFGEADQCVAHAHYKDPPEFCVARCPSGVKPDLSYMPINWKEFDEECACQPCPINC
THSCVDLDDKGCPAEQRASPLTSIISAVVGILLVVVLGVVFGILIKRRQOKIRKYYTMRRLLQETELVEPL
TPSGAMENQACMRILKETELRKVKVLCSGAFGVYKGIWIPDGENVKIPVAIKVLRNWTSPKANKEILDE
AYVMAGVGSPPYVSRLLGICLTSTVQLVTQIMPYGCLLDHVRENRLGSGQDLLNWCMIKAGMSYLEDVR
LVHRDLAARNVLVKSPNHVKITDFGLARLLDIDETEHADCGKVPIKMMALIESILRRRFTHQSDVWSYGV
TVWELMTFGAKPYDGI PAREIPDLLKGERLPQPPICTIDVYIMVVKCMMIDSECRFRRELVSFSSRMA
RDPQRFVVIQWEDLGPASPLDSTFYRSLLEDMDGDLVDAEEYLVPPQQFFCPDPAPGAGCMVHHRRSS
STRSCGGDLTLGLEPSEEEAPRSELPASEGACSDVEDGLGMGAAGLQSLETHDPSPLQRYSEDETVPPL
PSETDGYVAPLTCSPQPEYVNPQDVRPQPPSPREGPLPAARRACATLERPKTSLSPCKNGVVKDVFAFGGA
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FIG. 6

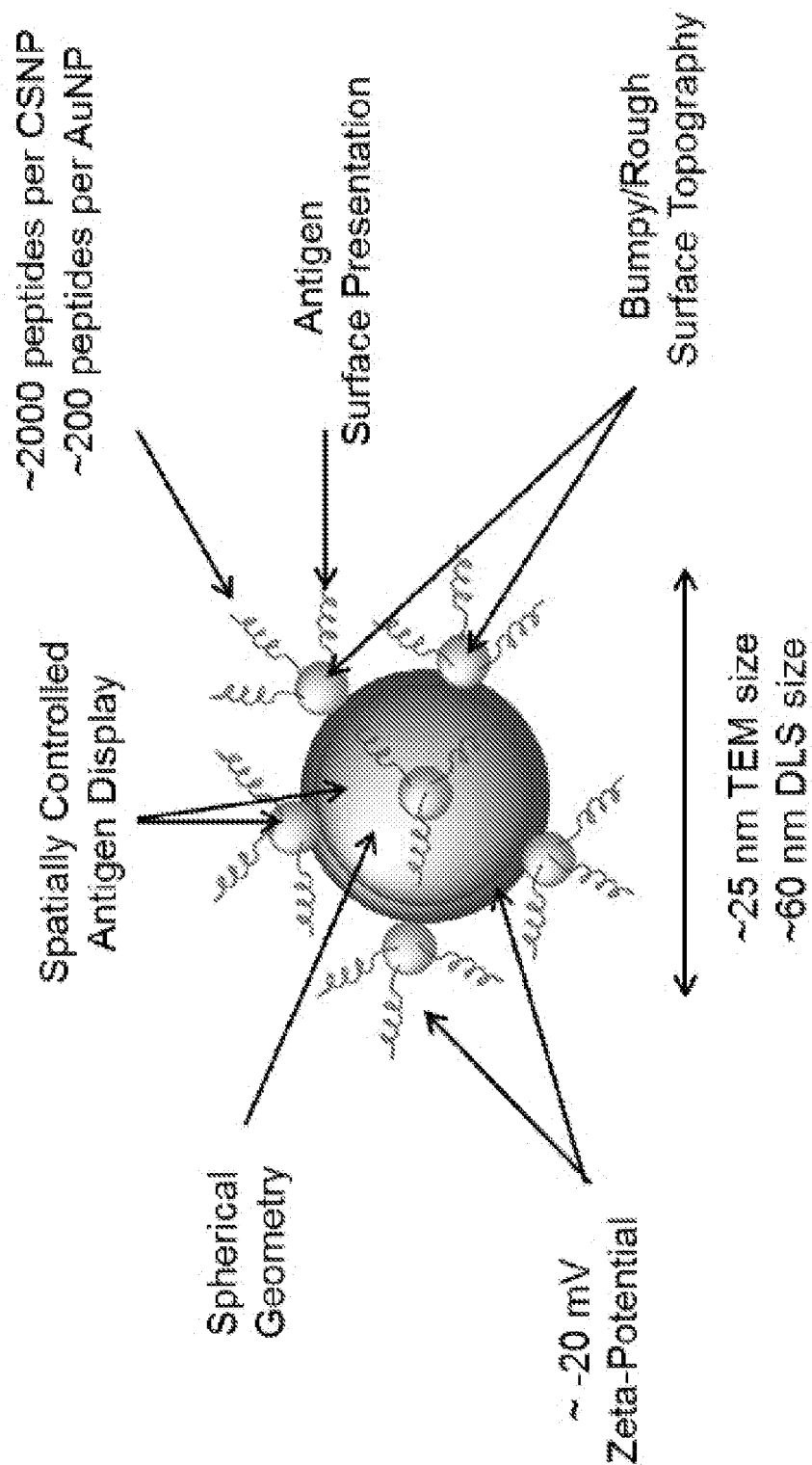


FIG. 7

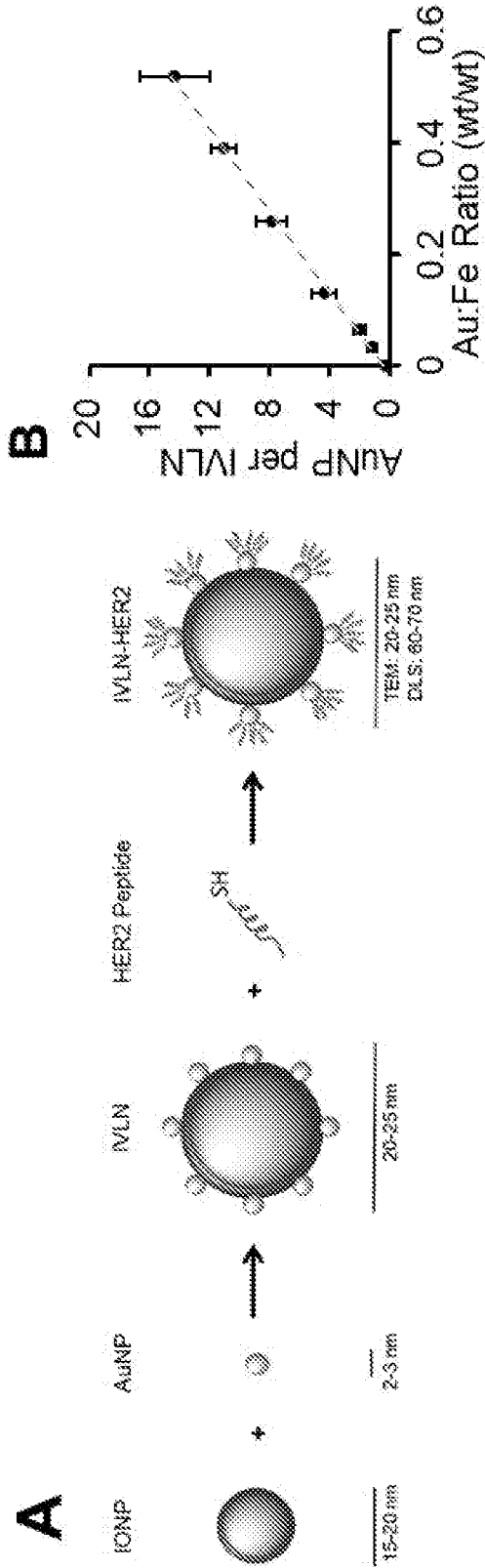


FIG. 7 (cont.)

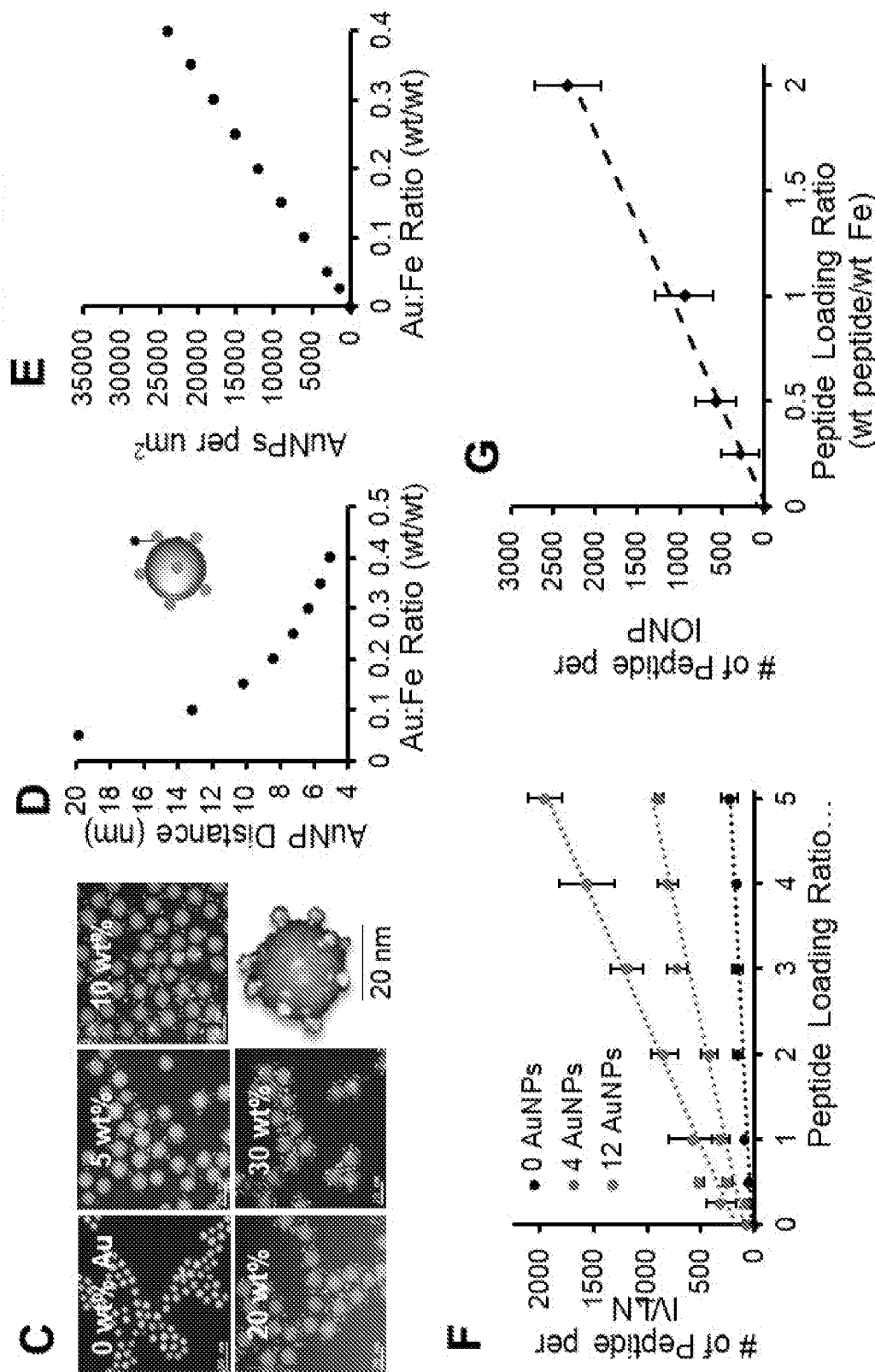


FIG. 7 (cont.)

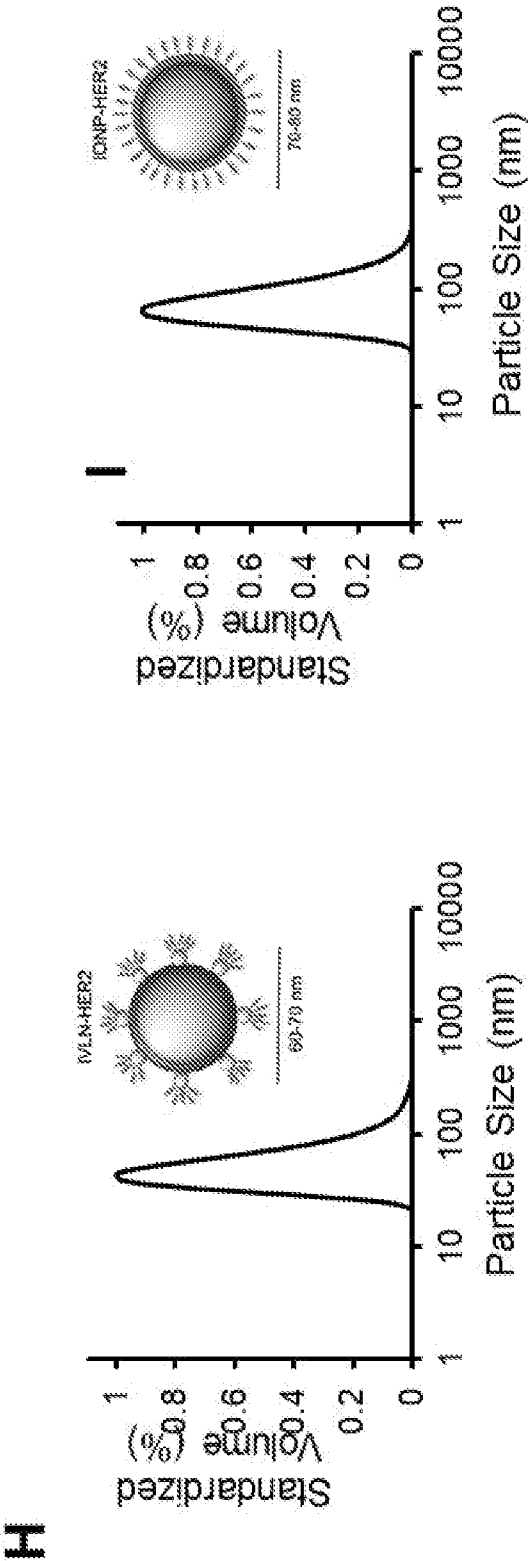


FIG. 8

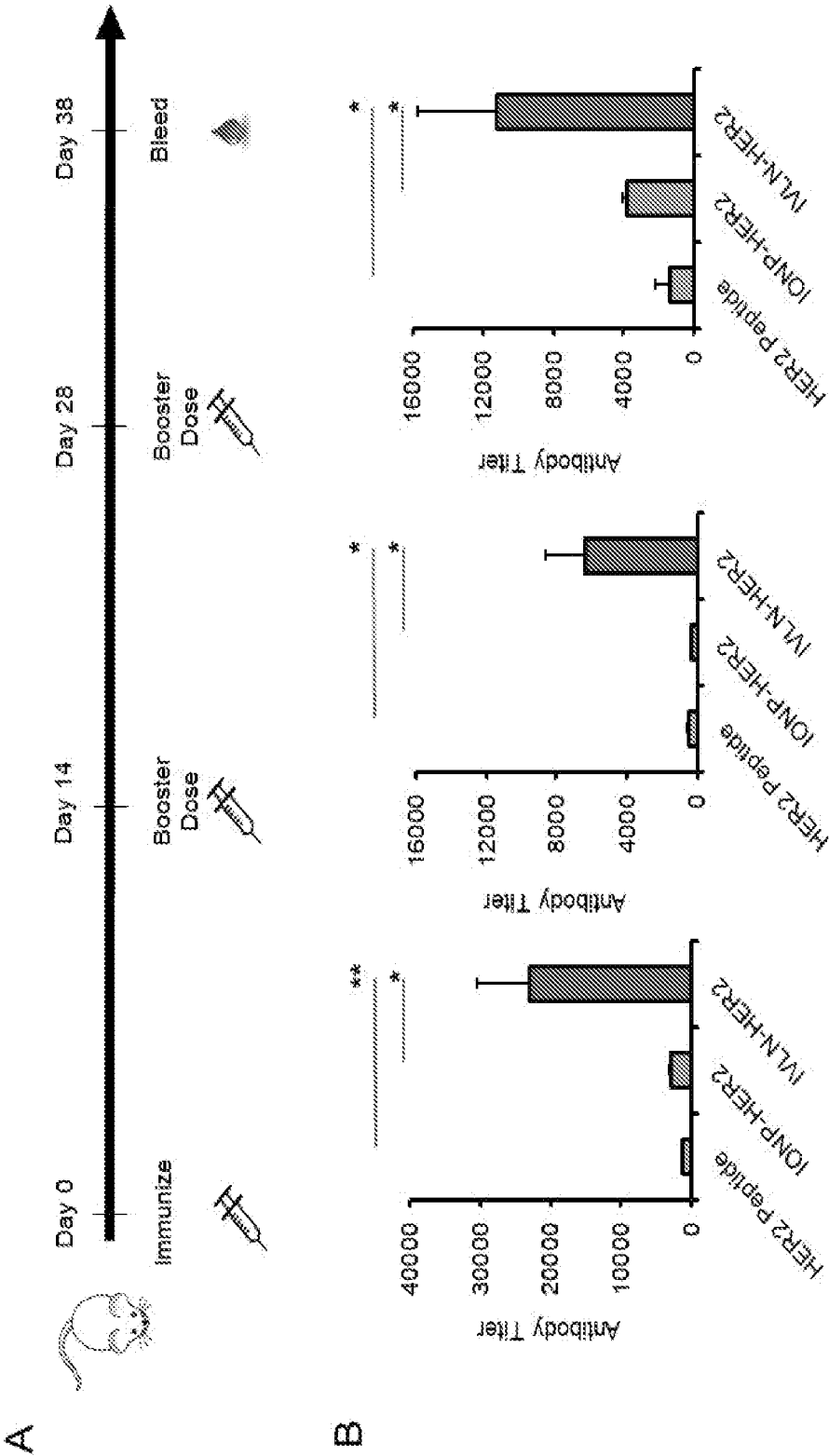


FIG. 8 (cont.)

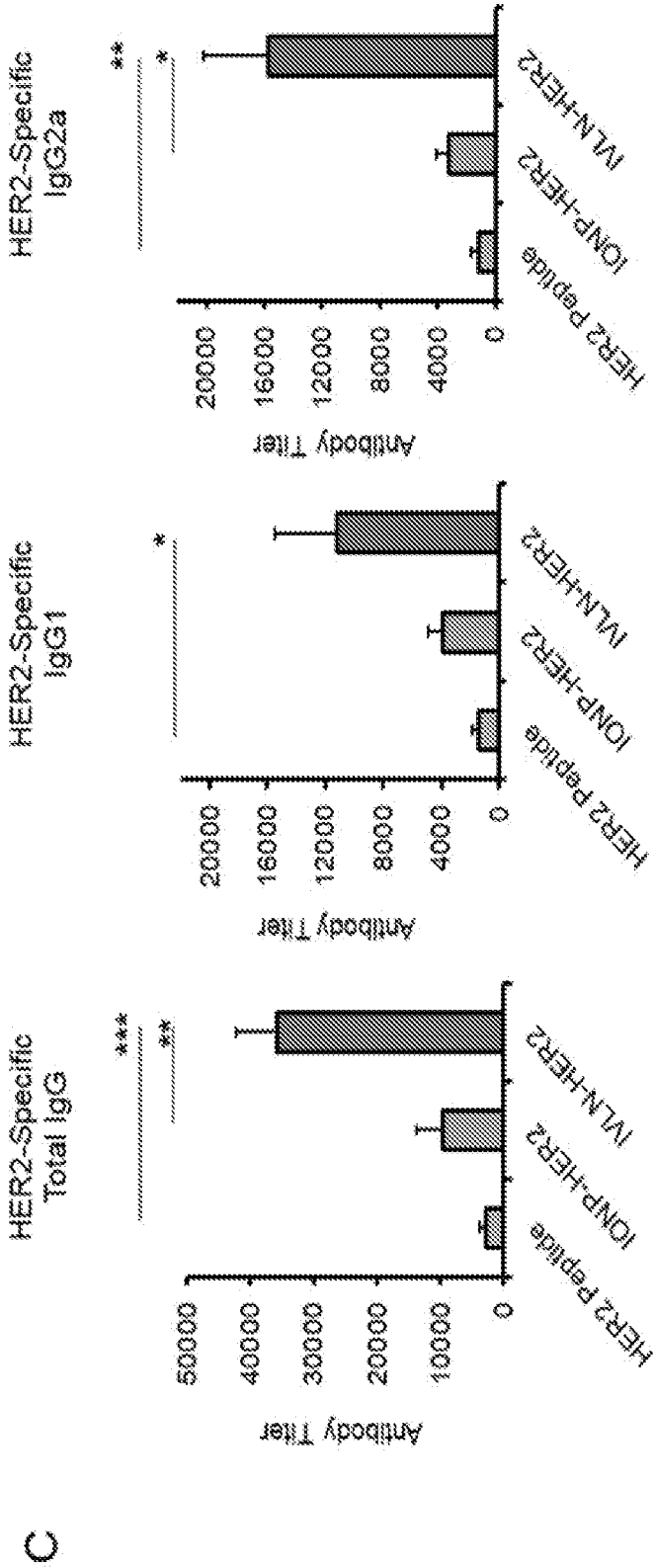


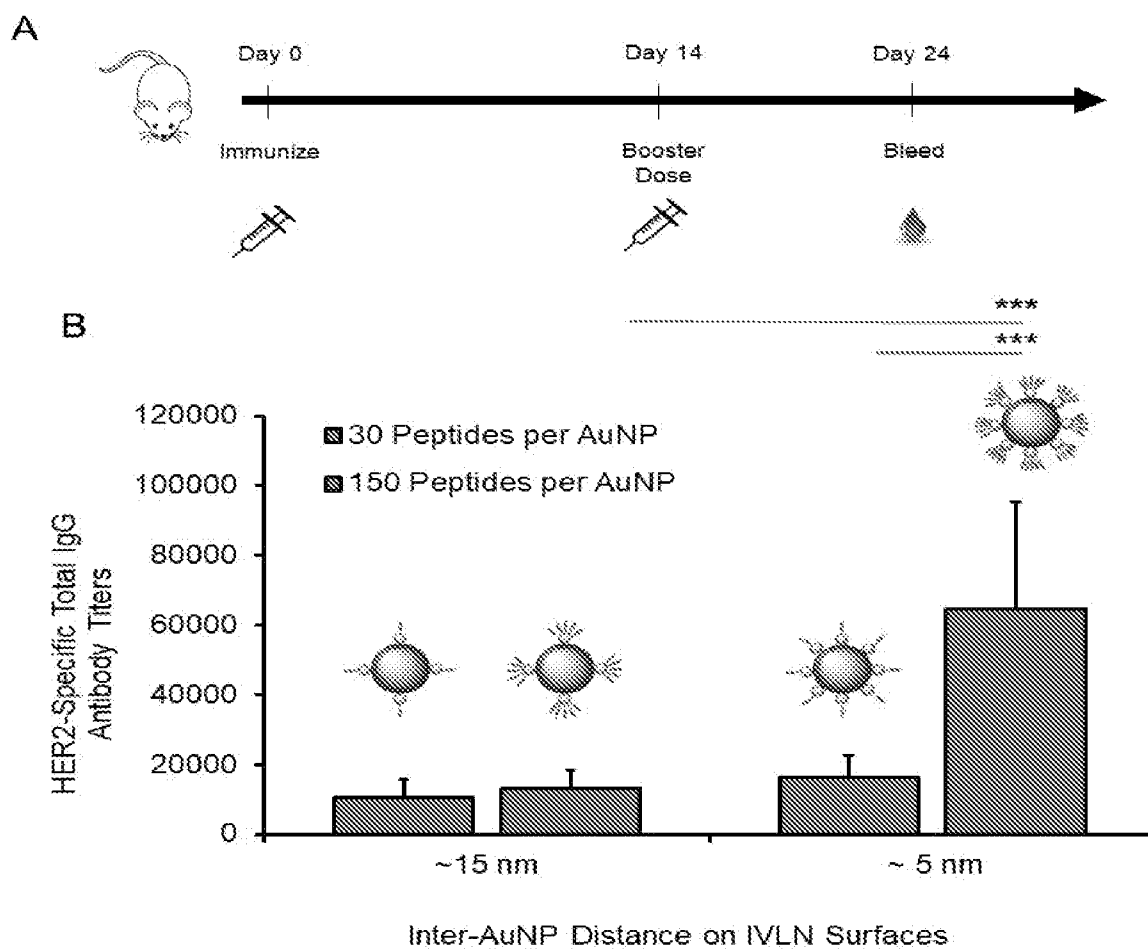
FIG. 9

FIG. 10

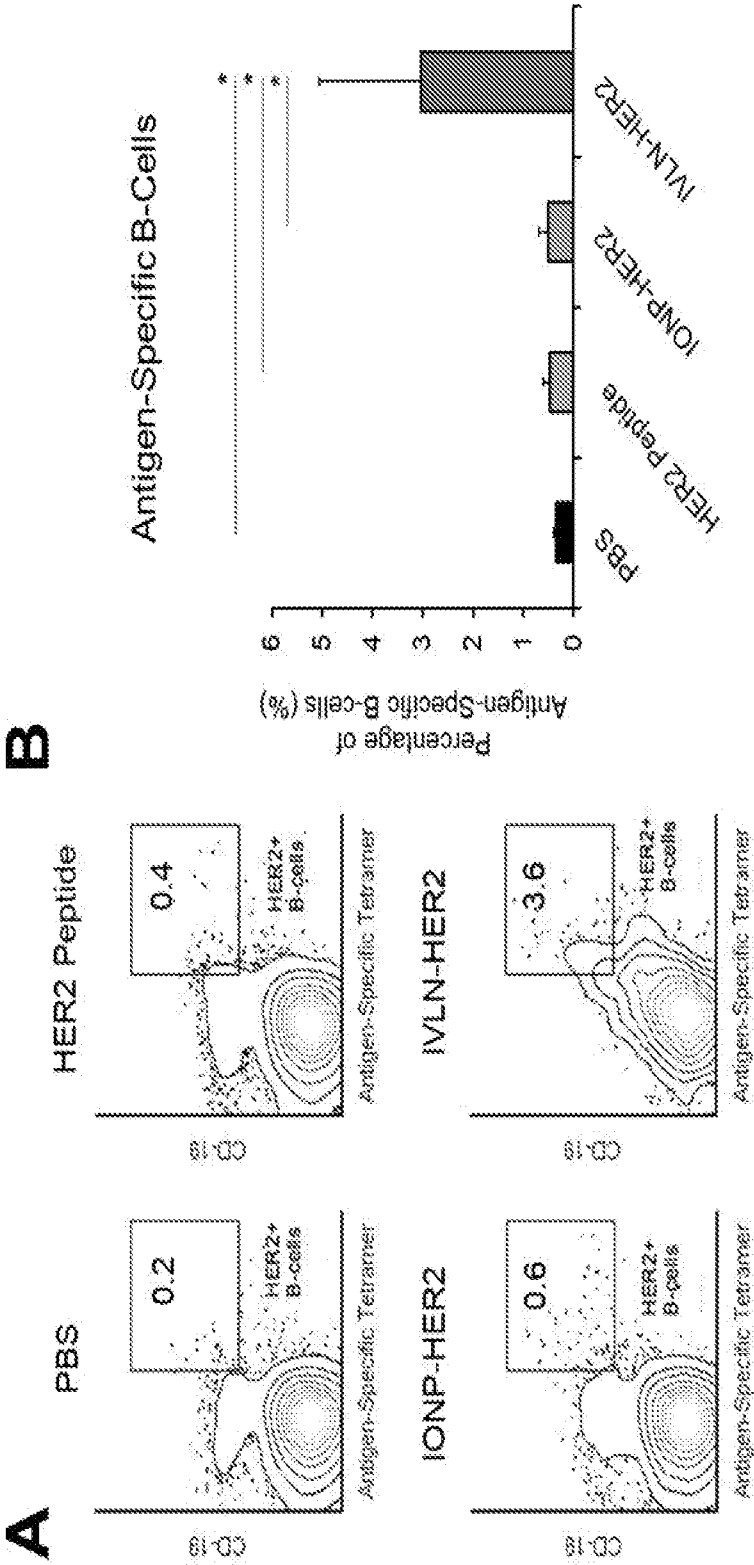


FIG. 10 (cont.)

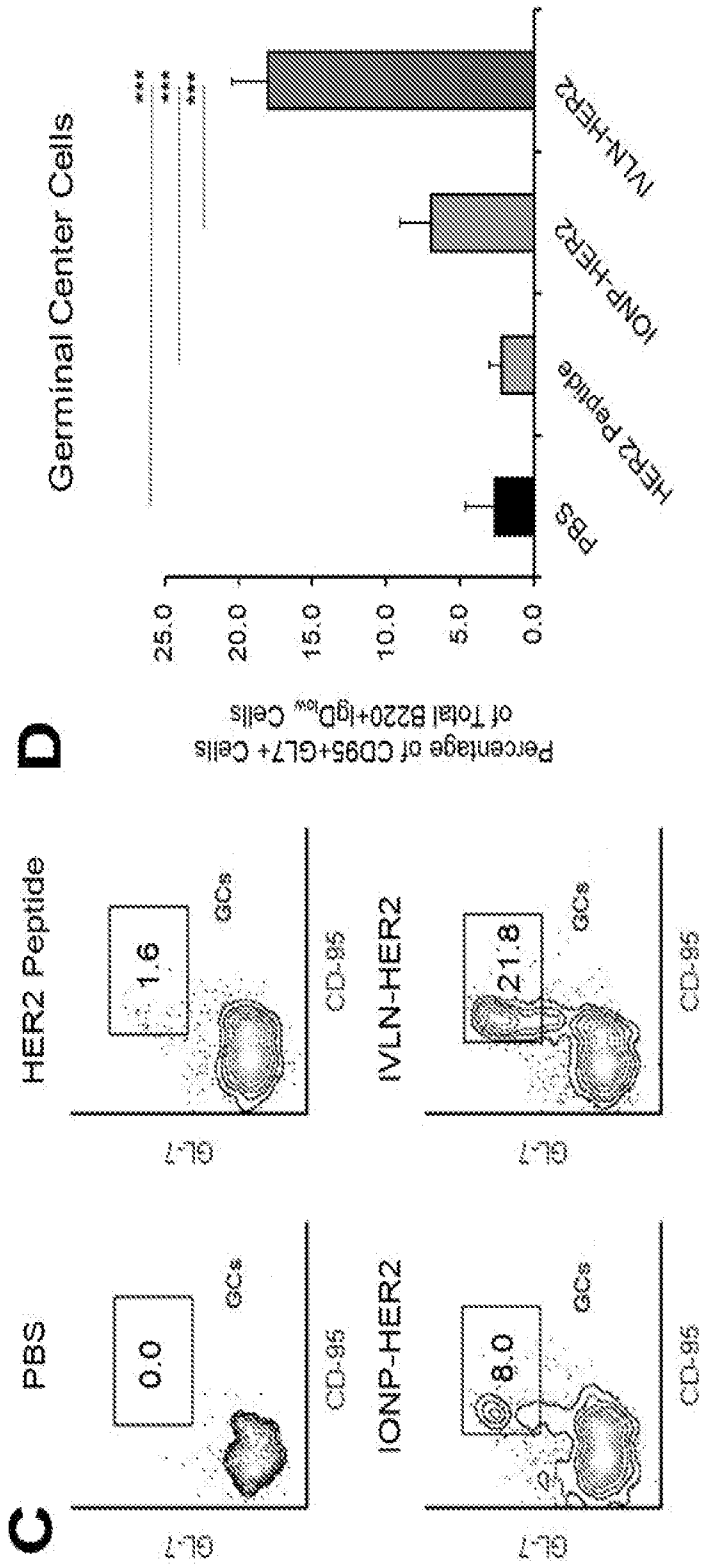
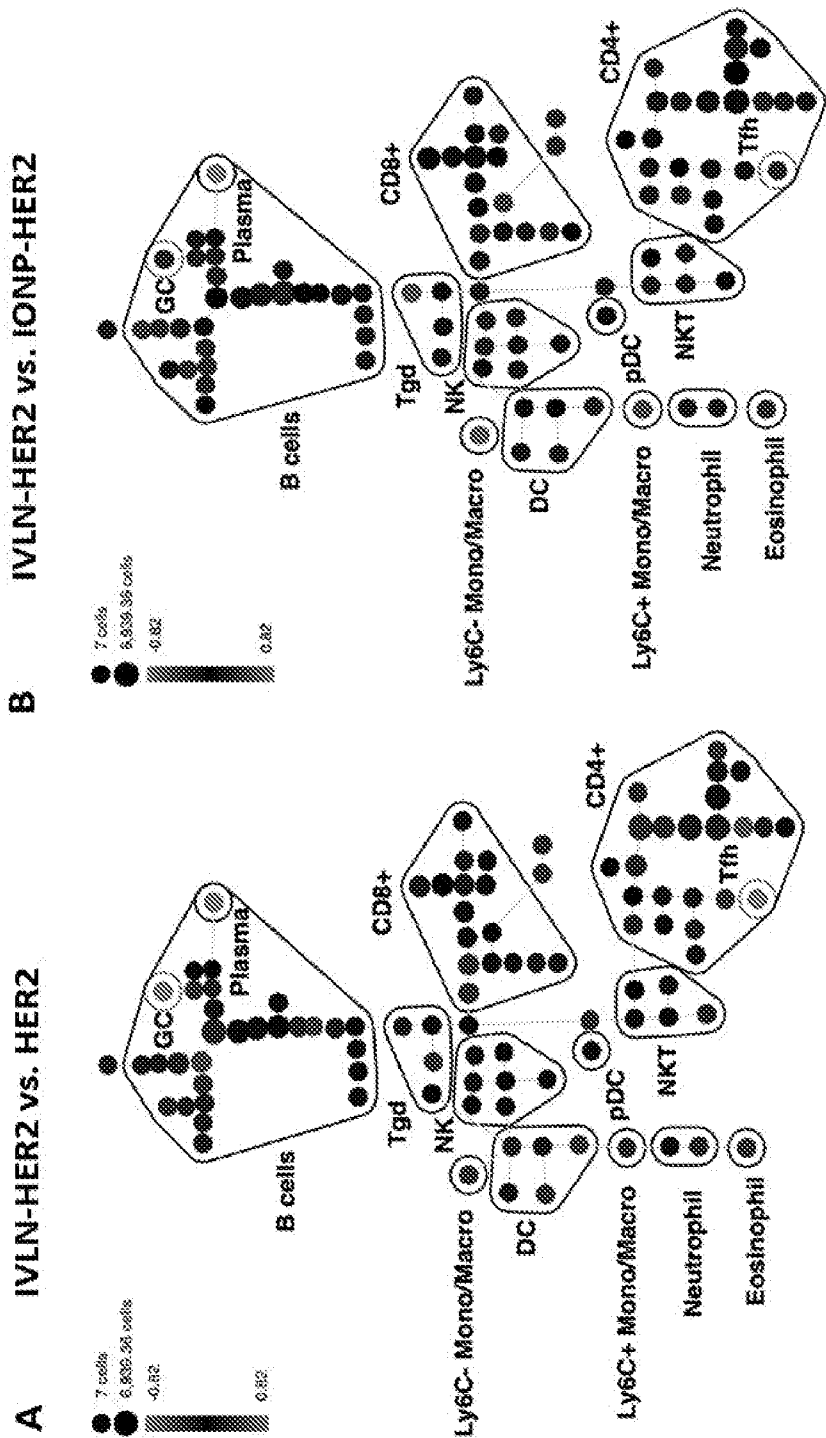


FIG. 11



Log10 (percent of total in HER2, or IONP-HER2 /percent of total in IVLN-HER2)
Blue = more in IVLN-HER2 and red = less in IVLN-HER2

FIG. 11 (cont.)

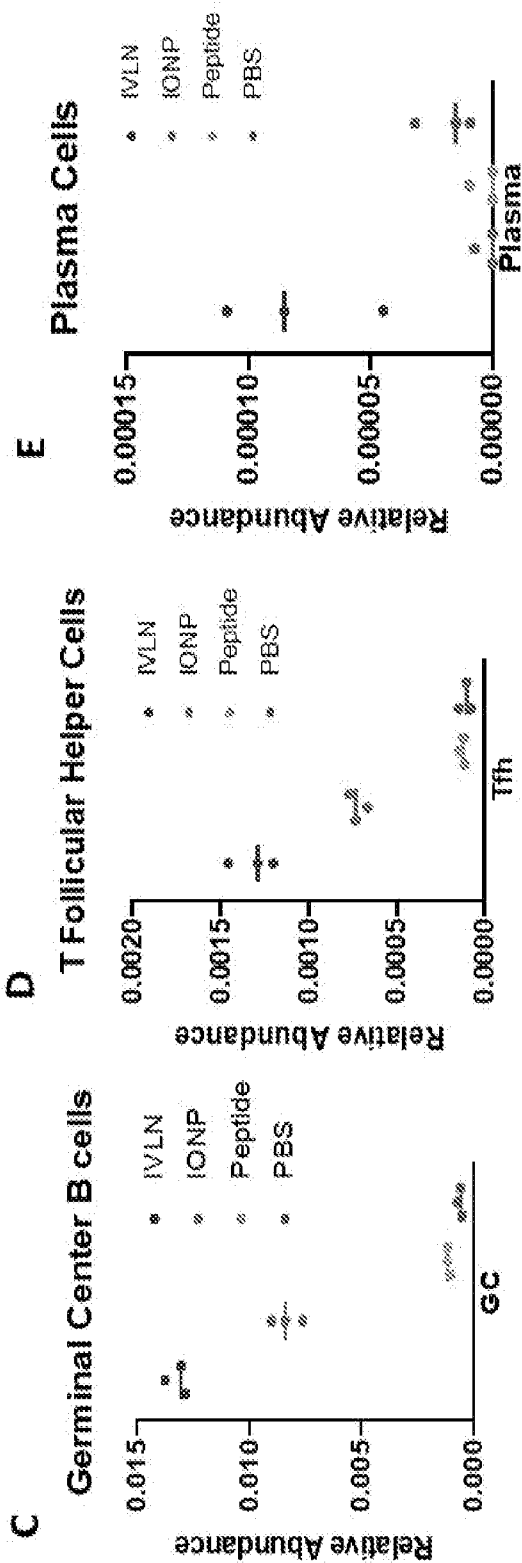


FIG. 12

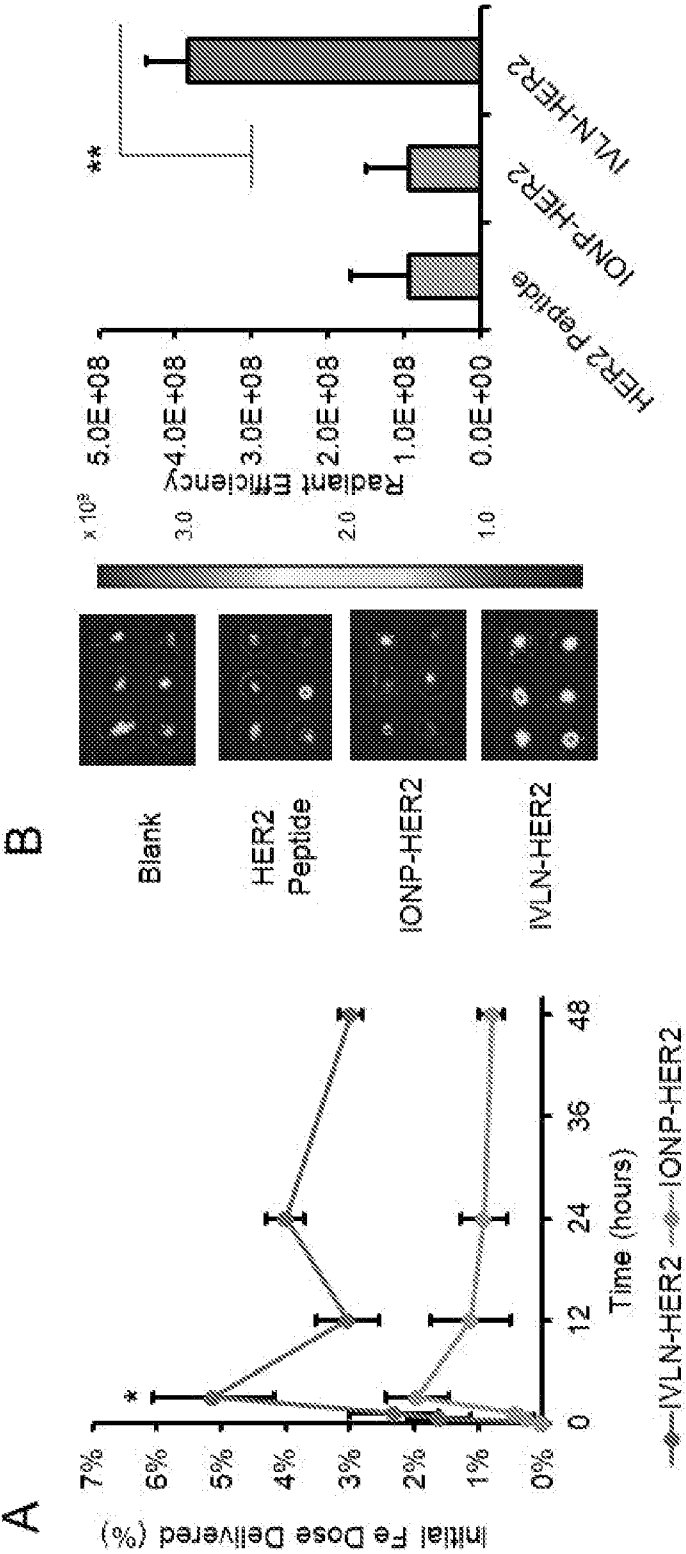


FIG. 12 (cont.)

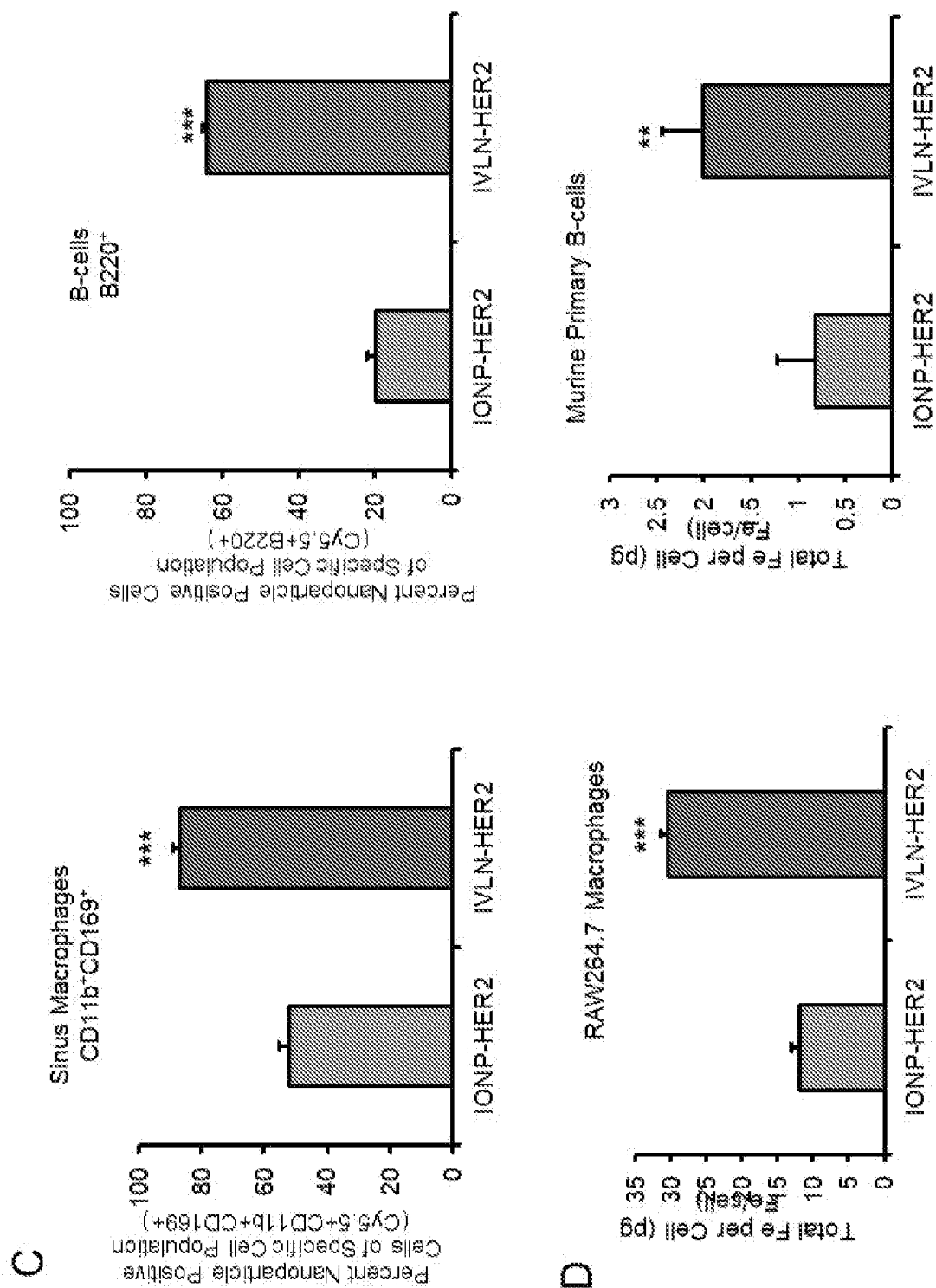
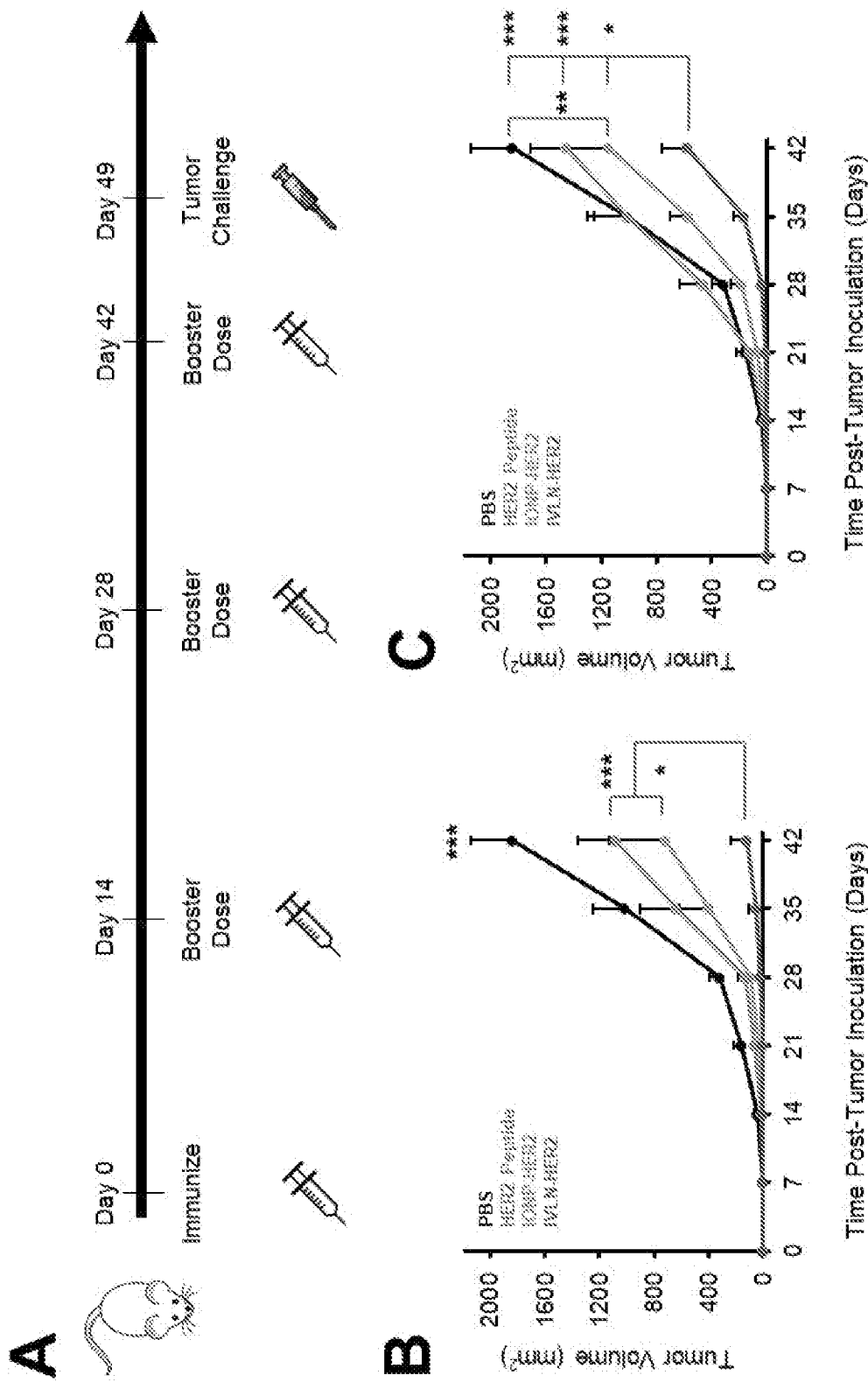


FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/56765

A. CLASSIFICATION OF SUBJECT MATTER

IPC - A61K 39/385; A61K 47/64; A61K 47/69; A61K 39/00; B82Y 5/00; A61K 33/24 (2019)

CPC - A61K 39/0011; C61K 39/385; A61K 47/646; A61K 47/6923; A61K 2039/60; A61K 2036/622; A61K 33/242; A61K 33/26; B82Y 5/00

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.
Y	US 2015/0065858 A1 (THE REGENTS OF THE UNIVERSITY OF MICHIGAN) 5 March 2015 (05.03.2015). Especially para [0014], [0016], [0044], [0049], [0055], [0077], sheet 1 fig 1.	1, 2, 6
Y	US 2014/0086828 A1 (FOSTER et al.) 27 March 2014 (27.03.2014). Especially para [0014], [0016], [0027].	1, 2, 6

☐ 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

"D" document cited by the applicant in the international application

"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

21 December 2019

Date of mailing of the international search report

03 MAR 2020

Name and mailing address of the ISA/US

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Facsimile No. 571-273-8300

Authorized officer

Lee Young

Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/56765

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.: 3-5, 7-9, 21-49
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:
-----Go to Extra Sheet for continuation-----

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.:
Claims 1, 2, 6 limited to the weight-to-weight ratio of all of said satellite particles to the nanoparticle core is 10-40%

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.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/US 19/56765

Continuation of Box III: Observations where Unity of Invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I+: Claims 1, 2, 6, 10-20, drawn to a nano-satellite complex composition.

The nano-satellite complex will be searched to the extent that the specific property is the first named, the weight-to-weight ratio of all of said satellite particles to said nanoparticle core is 10-40% (claim 1d i) and claim 2d i)). It is believed that claims 1, 2, 6 read on this first named invention and thus these claims will be searched without fee to the extent that they encompass the weight-to-weight ratio of all of said satellite particles to said nanoparticle core is 10-40%. Additional properties of the nano-satellite complex will be searched upon payment of additional fees. Applicant must specify the claims that encompass any additional elected property. Applicants must further indicate, if applicable, the claims which read on the first named invention if different than what was indicated above for this group. Failure to clearly identify how any paid additional invention fees are to be applied to the "+" group(s) will result in only the first claimed invention to be searched/examined. An exemplary election would be: the diameter of each of said satellite particles is 2-20 nm (claims 1, 2, 10-12).

The inventions listed as Group I+ do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features:

Among the inventions listed as Groups I+ are the specific properties of the nano-satellite complexes recited therein (listed in claim 1d) or claim 2d). Each invention requires a specific property not required by any other inventions

Common Technical Feature:

Group I+ inventions comprise independent claims 1 and 2 [note claim 1 comprises claim 2 with the exception of claim 2d) iii)].

However, said common technical features do not represent a contribution over the prior art, and is disclosed by US 2015/0065858 A1 to The Regents of the University of Michigan (hereinafter "UMichigan"), in view of US 2014/0086828 A1 to Foster et al. (hereinafter "Foster").

As to claim 1, UMichigan discloses composition comprising: a nano-satellite complex, wherein said nano-satellite complex comprises: a) a core nanoparticle complex (para [0049]; "the design of core-satellite hybrid nanocomposites with highly crystallized iron oxide nanoparticles (IONPs) as the core and multiple gold sulfide (Au₂S) nanoparticles as satellites attached on the surface polymer coated IONP") comprising a biocompatible coating surrounding a nanoparticle core (para [0044]; "i) a core nanoparticle complex comprising a biocompatible coating surrounding a nanoparticle core, and ii) at least one satellite component attached to, or absorbed to, the biocompatible coating");

b) 3-25 satellite particles attached to, or absorbed to (sheet 1 fig 1 depicts six gold sulfite satellite nanoparticles attached or absorbed to biocompatible coating surrounding an iron oxide magnetic core) , said biocompatible coating (para [0044]; "at least one satellite component attached to, or absorbed to, the biocompatible coating"; para [0016]; "FIG. 1 shows a TEM image of IONP-Au₂S core-satellite nanocomposite, where the magnetic core is 15 nm in diameter and is further attached with multiple Au₂S nanoparticles");

d) wherein said nano-satellite complex comprises at least one of the following properties:

ii) wherein the diameter of each of said satellite particles is 2-20 nm (para [0014]; "the at least one satellite component has a size between 2 nm and 7 nm in diameter (e.g., about 5 nm)").

UMichigan fails to disclose claim limitation c) a plurality of antigenic peptides conjugated to, or absorbed to, said satellite particles.

However, antigen peptides conjugated to, or absorbed to gold nanoparticles used as an anti-cancer vaccine was well-known in the art, as disclosed by Foster (para [0016]; "one or more compositions comprising one or more gold nanoparticles and a biological moiety selected from the group consisting of a peptide"; para [0014]; "In some aspects, the composition further comprises one or more peptides, and in some cases the peptide is conjugated to the nanoparticle. In specific aspects, the conjugation of the peptide to the nanoparticle is pH-sensitive. In specific embodiments, the peptide is from 15-40 amino acids in length. The peptide may be further defined as an antigenic peptide. The one or more peptides may be all the same peptides, or the one or more peptides may include different peptides"; para [0027]; "In certain embodiments, a peptide-loaded nanoparticle is employed as a vaccine composition").

An artisan of ordinary skill in the art would have recognized the value of conjugating antigenic peptides disclosed by Foster to the gold satellite particles of UMichigan as a means of exploiting the system as a cancer vaccine.

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INTERNATIONAL SEARCH REPORT

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As to claim 2d iii), UMichigan discloses wherein said satellite particles are present at density of 15,00-30,000 per square micron (para [0024]; FIG. 9 shows absorption spectrum of IR820 only and IONP-IR820 conjugate. By measuring the free IR820 concentration in the supernatant, it was estimated that the IR820 [optical dye] density on each IONP is 2.times.10.exp.4 IR820 on average. In IONP-IR820 sample, the IR820 concentration: 32.6 uM"; abstract: "the satellite component is additionally or alternatively composed of near-infrared optical dye material").

As the common technical features were known in the art at the time of the invention, they cannot be considered common special technical features that would otherwise unify the groups. The inventions lack unity with one another.

Therefore, Group I+ inventions lack unity of invention under PCT Rule 13 because they do not share a same or corresponding special technical feature.

Item 4 (cont.): Claims 3-5, 7-9, 21-49 are improper dependent claims and are not drafted according to the second and third sentences of PCT Rule 6.4(a).

Note: This application does not have a claim 44 in the claim set.