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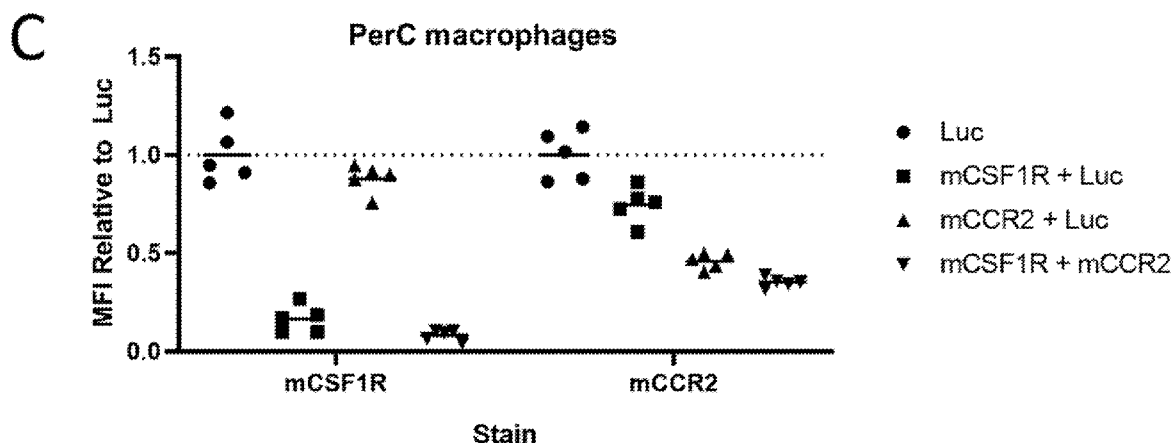
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(54) Title: OLIGONUCLEOTIDE COMPOSITIONS FOR TARGETING CCR2 AND CSF1R AND USES THEREOF

Figure 3 (cont.)



(57) **Abstract:** The present invention is based, in part, on providing oligonucleotide compositions for targeting CCR2, CSF1R, and/or both CCR2 and CSF1R, as well as methods of use thereof, such as to modulate myeloid-derive cell inflammatory phenotypes and immune responses that are mediated by such cells.

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OLIGONUCLEOTIDE COMPOSITIONS FOR TARGETING CCR2 AND CSF1R AND USES THEREOF

Cross-Reference to Related Applications

5 This application claims the benefit of U.S. Provisional Application No. 62/716,671 filed on 09 August 2018; the entire contents of said application are incorporated herein in their entirety by this reference.

Background of the Invention

10 Myeloid-derived cells, including monocytes and macrophages, are key players of the innate immune system. Circulating monocytes (*e.g.*, monocyte egressing from bone marrow) and tissue resident macrophages migrate to an area in response to environmental signals emanating from the area (*e.g.*, local growth factors, pro-inflammatory cytokines, and microbial compounds) and differentiate into mature/polarized macrophages. Under
15 non-pathological conditions, a balanced population of immune-stimulatory and immune-regulatory macrophages exist in the immune system. In some disease conditions, the balance is interrupted and the imbalance causes many clinical conditions. For example, macrophages infiltrating into a tumor tissue can be switched from being pro-inflammatory to pro-tumorigenic under the influence of tumor cells. It has been shown that certain types
20 of cancers exhibit elevated levels of anti-inflammatory macrophages within the tumor, which are often referred to as tumor associated macrophages (TAMs) or tumor infiltrating macrophages. TAMs in the tumor microenvironment are important regulators of cancer progression and metastasis in both positive and negative ways (Pollard *et al.* (2004) *Nat. Rev. Cancer* 4:71-78). The imbalanced polarization of macrophages has been recognized as
25 a key risk factor in many other inflammation related diseases, such as infection, chronic inflammation, inflammatory neurological diseases, cardiovascular diseases, allergy and system autoimmune disorders, multiple sclerosis, rheumatoid arthritis, atherosclerosis, Type I diabetes, Type II diabetes and obesity. Macrophage phenotype is dependent on activation *via* a classical or an alternative pathway (see, *e.g.*, Classen *et al.* (2009) *Methods Mol. Biol.*,
30 531:29-43). Classically activated macrophages are activated by interferon gamma (IFN γ) or lipopolysaccharide (LPS) and display an M1 phenotype. This pro-inflammatory phenotype is associated with increased inflammation and stimulation of the immune system. Alternatively activated macrophages are activated by cytokines like IL-4, IL-10,

and IL-13, and display an M2 phenotype. This anti-inflammatory phenotype is associated with decreased immune response, increased wound healing, increased tissue repair, and embryonic development.

Monocytes and macrophages express a variety of surface receptors which can be activated by their corresponding ligands, such as chemokines. The ligand binding activates signaling networks inside the cell to regulate the activation and polarization of monocytes and macrophages. Agents that block the interaction of the ligand-receptor pair in monocytes and macrophages, such as ligand-receptor antagonists, have shown promising therapeutic effects in diseases like cancer. Such agents can modulate the function of myeloid-derived cells, such as the recruitment of monocytes and/or macrophages, the development and polarization/activation of macrophages. For example, in some disease conditions, it is useful to rebalance macrophage populations and/or increase immune-stimulatory macrophage numbers and/or activity.

CCR2 and CSF1R are two surface receptors that are expressed by monocytes and macrophages in response to environmental signals. The activation of CCR2 by its ligand (CCL2) leads to the activation of intracellular signaling cascades that mediate chemotactic response, which induces the recruitment of monocytes and macrophages to the tumor microenvironment. CSF1R blockade using receptor inhibitors can reduce macrophage invasion to local disease sites and can slow disease progression in several disease conditions (Patel *et al.* (2009) *Curr, Top. Med. Chem.* 9:599-610). Signaling mediated by CSF1R activation by its ligand (CSF1L) regulates the survival, proliferation, and differentiation of myeloid cells and especially the macrophage lineage. CCR2 antagonists are being investigated as therapeutic agents in cancers and other macrophage-mediated inflammatory diseases, such as rheumatoid arthritis, multiple sclerosis, asthma, and obesity (*e.g.*, Zimmermann *et al.* (2014) *Curr, Top. Med. Chem.* 14:1539-1552).

Despite advances in the field of macrophage biology, however, there remains a need for identifying agents that are used alone and in combination to effectively target myeloid-derived cell surface receptors like CCR2 and CSF1R in order to modulate their inflammatory phenotype and use such agents to modulate immune responses.

Summary of the Invention

The present invention is drawn, in part, to oligonucleotide compositions for targeting CCR2, CSF1R, or both CCR2 and CSF1R, as well as uses thereof. The

compositions encompassed by the present invention provide siRNA molecules that specifically target CCR2 or CSF1R and modulate the activity of myeloid-derived cells. The siRNA molecules have been selected to effectively target CCR2 or CSF1R without off-target effects and to optimize a number of other factors useful for inhibiting these targets.

- 5 In addition, the present invention also provides formulations comprising such siRNA molecules for enhanced delivery to myeloid-derived cells like monocytes and macrophages. Moreover, without being bound by theory, it is believed that the use of a combination of oligonucleotide compositions described herein and formulations comprising same is particularly effective to inhibit CCR2 and CSF1R activation in order to simultaneously
- 10 inhibit the trafficking, polarization and activation of monocytes and macrophages in response to an environmental signal, such as a growth factor from tumor cells. Methods for inhibiting CCR2 and CSF1R receptor functions, modulating the recruitment, polarization, and activation of myeloid-derived cells, and treating macrophage-mediated diseases, such as cancer, are also provided.

- 15 In one aspect, a composition comprising a) at least one siRNA molecule that hybridizes to a nucleic acid molecule encoding CCR2, b) at least one siRNA molecule that hybridizes to a nucleic acid molecule encoding CSF1R, or c) a combination of a) and b), is provided.

- Numerous embodiments are further provided that can be applied to any aspect
- 20 encompassed by the present invention and/or combined with any other embodiment described herein. For example, in one embodiment, the at least one siRNA molecule that hybridizes to the nucleic acid molecule encoding CCR2 comprises a sense strand having a nucleic acid sequence selected from SEQ ID NO: 6 to SEQ ID NO: 67 and an anti-sense strand having a nucleic acid sequence selected from SEQ ID NO: 68 to SEQ ID NO: 129.

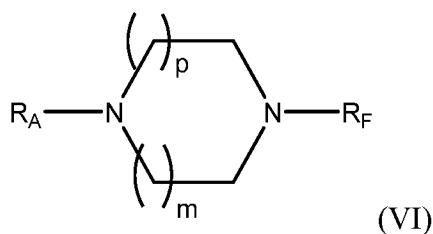
- 25 In another embodiment, the at least one siRNA molecule that hybridizes to the nucleic acid molecule encoding CSF1R comprises a sense strand having a nucleic acid sequence selected from SEQ ID NO: 130 to SEQ ID NO 248 and an anti-sense strand having a nucleic acid sequence selected from SEQ ID NO: 249 to SEQ ID NO: 367. In still another embodiment, the at least one siRNA molecule that hybridizes to the nucleic acid molecule
- 30 encoding CCR2 or CSF1R further comprise at least one modification. In yet another embodiment, the modification is a modification to the sugar moiety of the nucleic acid sequence, a nucleobase modification, an internucleoside linker modification, an artificial nucleotide, an end cap modification, or any combinations thereof. In another embodiment,

the modification locates in the sense strand of the at least one siRNA molecule. In still another embodiment, the modification locates in the anti-sense strand of the at least one siRNA molecule. In yet another embodiment, the modification locates in the sense and anti-sense strands of the at least one siRNA molecule. In another embodiment, the at least one siRNA molecule that hybridizes to the nucleic acid molecule encoding CCR2 comprises a sense strand having a modified nucleic acid sequence selected from SEQ ID NO: 368 to SEQ ID NO: 486 and SEQ ID NO: 883 to SEQ ID NO: 921, and an anti-sense strand having a modified nucleic acid sequence selected from SEQ ID NO: 487 to SEQ ID NO: 605 and SEQ ID NO: 922 to SEQ ID NO: 960. In still another embodiment, the at least one siRNA molecule that hybridizes to the nucleic acid molecule encoding CCR2 comprises a sense strand having a modified nucleic acid sequence selected from SEQ ID NO: 606 to SEQ ID NO: 743 and SEQ ID NO: 961 to SEQ ID NO: 1001, and an anti-sense strand having a modified nucleic acid sequence selected from SEQ ID NO: 744 to SEQ ID NO: 881 and SEQ ID NO: 1002 to SEQ ID NO: 1042.

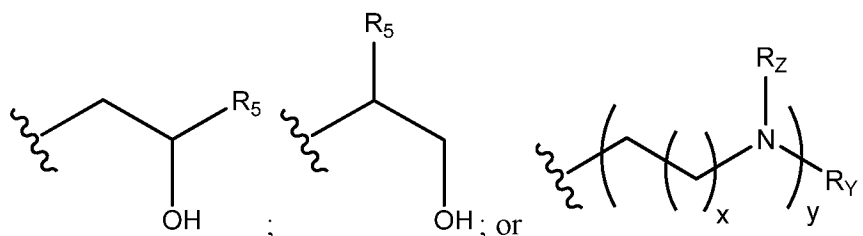
In another aspect, a composition comprising a) at least one siRNA duplex that hybridizes to a nucleic acid molecule encoding CCR2, b) at least one siRNA duplex that hybridizes to a nucleic acid molecule encoding CSF1R, or c) a combination of a) and b), wherein the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CCR2 comprises a sense strand having a nucleic acid sequence selected from SEQ ID NO: 6 to SEQ ID NO: 67, or a modified nucleic acid sequence selected from SEQ ID NO: 606 to SEQ ID NO: 743, or a modification variant selected from SEQ ID NO: 961 to SEQ ID NO: 1001, and an anti-sense strand having a nucleic acid sequence selected from SEQ ID NO: 68 to SEQ ID NO: 129, or a modified nucleic acid sequence selected from SEQ ID NO: 744 to SEQ ID NO: 881, or a modification variant selected from SEQ ID NO: 1002 to SEQ ID NO: 1042; and/or wherein the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CSF1R comprises a sense strand having a nucleic acid sequence selected from SEQ ID NO: 130 to SEQ ID NO: 248, or a modified nucleic acid sequence selected from SEQ ID NO: 368 to SEQ ID NO: 486, or a modification variant selected from SEQ ID NO: 883 to SEQ ID NO: 921, and an anti-sense strand having a nucleic acid sequence selected from SEQ ID NO: 249 to SEQ ID NO: 367, or a modified nucleic acid sequence selected from SEQ ID NO: 487 to SEQ ID NO: 605, or a modification variant selected from SEQ ID NO: 922 to SEQ ID NO: 960, is provided.

As described above, numerous embodiments are further provided that can be applied to any aspect of the present invention and/or combined with any other embodiment described herein. For example, in one embodiment, the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CCR2 is duplex XD-09048, XD-09050, XD-09098, XD-09117, XD-09127, XD-09043, XD-09045, XD-09060, XD-09062, XD-09086, XD-09094, XD-09095, XD-09107, XD-09112, XD-09113, XD-09115, XD-09121, XD-09138, XD-09143, or XD-09149, or variants thereof. In another embodiment, the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CCR2 is duplex XD-09048, XD-09050, XD-09098, XD-09117 or XD-09127, or variants thereof. In still another embodiment, the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CSF1R is duplex XD-08944, XD-08947, XD-08988, XD-08993 or XD-08916, XD-08917, XD-08922, XD-08923, XD-08936, XD-08963, XD-08969, XD-08975, XD-08982, XD-08985, XD-08986, XD-08989, XD-09003, XD-09006, XD-09015, or XD-09021, or variants thereof. In yet another embodiment, the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CSF1R is duplex XD-08944, XD-08947, XD-08988, XD-08993 or XD-08916, or variants thereof.

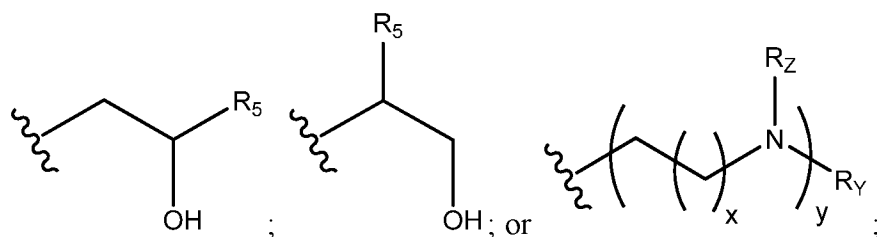
In some embodiments, the composition further comprises a lipid and/or a lipidoid. For example, in one embodiment, the lipidoid is of Formula (VI):



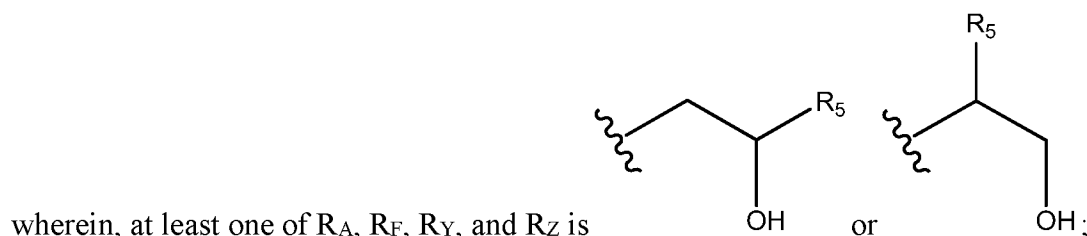
wherein p is an integer between 1 and 3, inclusive; m is an integer between 1 and 3, inclusive; R_A is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C₁₋₂₀ aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C₁₋₂₀ heteroaliphatic; substituted or unsubstituted aryl; substituted or unsubstituted heteroaryl;



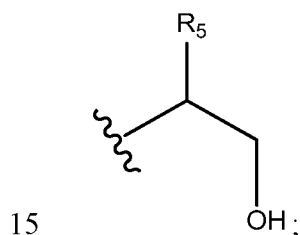
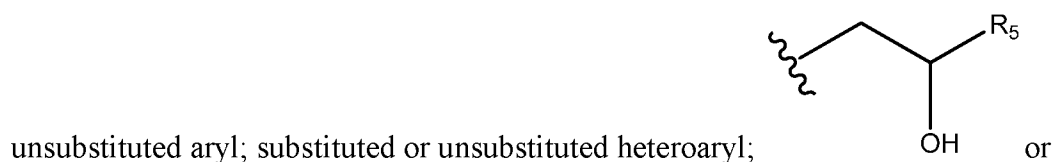
R_F is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; substituted or unsubstituted heteroaryl;



- 5 each occurrence of R_5 is independently hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; or substituted or unsubstituted heteroaryl;

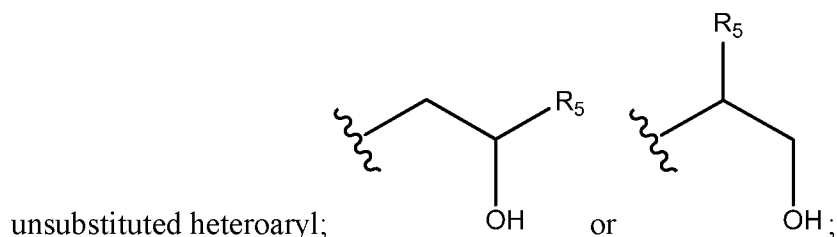


- 10 each occurrence of x is an integer between 1 and 10, inclusive; each occurrence of y is an integer between 1 and 10, inclusive; each occurrence of R_Y is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or

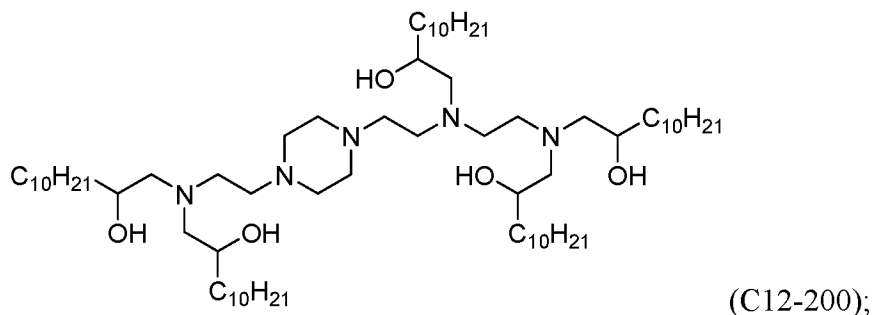
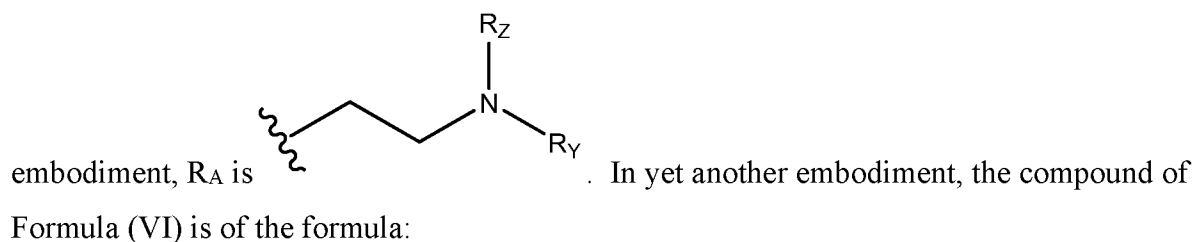
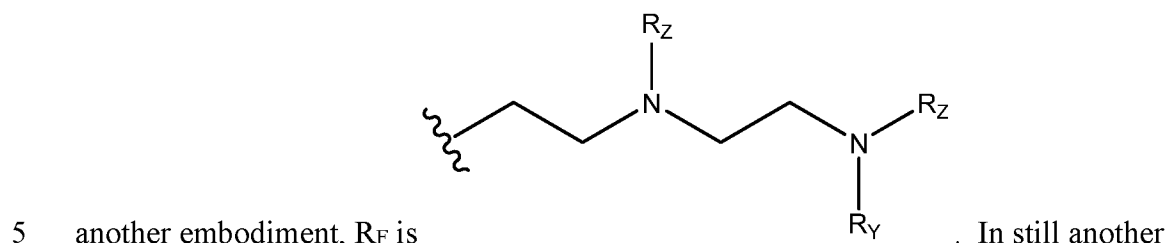


each occurrence of R_Z is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or

unbranched C₁₋₂₀ heteroaliphatic; substituted or unsubstituted aryl; substituted or



or a pharmaceutically acceptable salt thereof. In another embodiment, p is 1. In still another embodiment, wherein m is 1. In yet another embodiment, each of p and m is 1. In



or a salt thereof. In another embodiment, the composition is in the form a lipid

- 10 nanoparticle. In still another embodiment, the lipid nanoparticle comprises about 1.0% to about 60.0% by mole of C12-200. In yet another embodiment, the lipid nanoparticle further comprises one or more co-lipids. In another embodiment, each co-lipid is selected from distearylphosphatidyl choline (DSPC), cholesterol, and DMG-PEG. In still another embodiment, the concentration of DSPC is about 1.0% to about 20.0% by mole. In yet
- 15 another embodiment, the concentration of cholesterol is about 10.0% to about 50.0% by mole. In another embodiment, the concentration of DMG-PEG is about 0.1% to about 5.0% by mole. In still another embodiment, DSPC is present a concentration of about 1.0% to about 20.0% by mole; cholesterol is present at a concentration of about 10.0% to about

50.0% by mole; and DMG-PEG is present a concentration of about 0.1% to about 5.0% by mole. In yet another embodiment, C12-200, DSPC, cholesterol, and DMG-PEG are present at a ratio of 50%:10%:38.5%:1.5%, respectively. In another embodiment, the lipids and lipidoids of the LNP compared to the siRNA molecules are present at a ratio from about 20:1 to about 5:1 by weight. In still another embodiment, the lipids and lipidoids of the LNP compared to the siRNA molecules are present at a ratio of 9:1 by weight. In yet another embodiment, the composition is in a pharmaceutically acceptable formulation.

In still another aspect, a method of generating a myeloid-derived cell having an increased inflammatory phenotype after contact with at least one composition encompassed by the present invention, comprising contacting the myeloid-derived cell with an effective amount of the at least one composition, is provided.

As described above, numerous embodiments are further provided that can be applied to any aspect of the present invention and/or combined with any other embodiment described herein. For example, in one embodiment, the myeloid-derived cell having an increased inflammatory phenotype exhibits one or more of the following after contact with the at least one composition: a) increased expression of cluster of differentiation 80 (CD80), CD86, MHCII, MHCI, interleukin 1-beta (IL-1 β), IL-6, CCL3, CCL4, CXCL10, CXCL9, GM-CSF and/or tumor necrosis factor alpha (TNF- α); b) decreased expression of CD206, CD163, CD16, CD53, VSIG4, PSGL-1, TGF β and/or IL-10; c) increased secretion of at least one cytokine or chemokine selected from the group consisting of IL-1 β , TNF- α , IL-12, IL-18, GM-CSF, CCL3, CCL4, and IL-23; d) increased ratio of expression of IL-1 β , IL-6, and/or TNF- α to expression of IL-10; e) increased CD8⁺ cytotoxic T cell activation; f) increased recruitment of CD8⁺ cytotoxic T cell activation; g) increased CD4⁺ helper T cell activity; h) increased recruitment of CD4⁺ helper T cell activity; i) increased NK cell activity; j) increased recruitment of NK cell; k) increased neutrophil activity; l) increased macrophage activity; and/or m) increased spindle-shaped morphology, flatness of appearance, and/or number of dendrites, as assessed by microscopy. In another embodiment, the myeloid-derived cell contacted with the at least one composition are comprised within a population of cells and the at least one composition increases the number of Type 1 and/or M1 macrophages, and/or decreases the number of Type 2 and/or M2 macrophages, in the population of cells. In still another embodiment, the myeloid-derived cell contacted with the at least one composition is comprised within a population of cells and the at least one composition increases the ratio of i) to ii), wherein i) is Type 1

and/or M1 macrophages and ii) is Type 2 and/or M2 macrophages in the population of cells. In yet another embodiment, the myeloid-derived cell is contacted *in vitro* or *ex vivo*. In another embodiment, the myeloid-derived cell is a primary myeloid-derived cell. In still another embodiment, the myeloid-derived cell is purified and/or cultured prior to contact with the at least one composition. In yet another embodiment, the myeloid-derived cell is contacted *in vivo*. In another embodiment, the myeloid-derived cell is contacted *in vivo* by systemic, peritumoral, or intratumoral administration of the composition. In still another embodiment, the myeloid-derived cell is contacted in a subject in need thereof, optionally wherein the contact is in a tissue microenvironment. In yet another embodiment, the method further comprises contacting the myeloid-derived cell with at least one additional therapeutic agent. In another embodiment, the at least one additional therapeutic agent is an antagonist of CCL2 and/or an antagonist of CSF1. In still another embodiment, the at least one additional therapeutic agent comprises an immunotherapeutic agent that modulates the inflammatory phenotype, optionally wherein the immunotherapeutic agent comprises an immune checkpoint inhibitor, immune-stimulatory agonist, inflammatory agent, cells, a cancer vaccine, and/or a virus.

In yet another aspect, a method of increasing an inflammatory phenotype of myeloid-derived cells in a subject after contact with at least one composition encompassed by the present invention, comprising administering to the subject an effective amount of the at least one composition that contacts the myeloid-derived cells, is provided.

As described above, numerous embodiments are further provided that can be applied to any aspect of the present invention and/or combined with any other embodiment described herein. For example, in one embodiment, the myeloid-derived cells having the increased inflammatory phenotype exhibit one or more of the following after contact with the at least one composition: a) increased expression of cluster of differentiation 80 (CD80), CD86, MHCII, MHCI, interleukin 1-beta (IL-1 β), IL-6, CCL3, CCL4, CXCL10, CXCL9, GM-CSF and/or tumor necrosis factor alpha (TNF- α); b) decreased expression of CD206, CD163, CD16, CD53, VSIG4, PSGL-1 and/or IL-10; c) increased secretion of at least one cytokine selected from the group consisting of IL-1 β , TNF- α , IL-12, IL-18, and IL-23; d) increased ratio of expression of IL-1 β , IL-6, and/or TNF- α to expression of IL-10; e) increased CD8⁺ cytotoxic T cell activation; f) increased CD4⁺ helper T cell activity; g) increased NK cell activity; h) increased neutrophil activity; i) increased macrophage activity; and/or j) increased spindle-shaped morphology, flatness of appearance, and/or

number of dendrites, as assessed by microscopy. In another embodiment, the at least one composition increases the number of Type 1 and/or M1 macrophages, decreases the number of Type 2 and/or M2 macrophages, and/or increases the ratio of i) to ii), wherein i) is Type 1 and/or M1 macrophages and ii) is Type 2 and/or M2 macrophages, in the subject. In still another embodiment, the number and/or activity of cytotoxic CD8⁺ T cells in the subject is increased after administration of the at least one composition. In yet another embodiment, the at least one composition is administered systemically, peritumorally, or intratumorally. In another embodiment, the at least one composition contacts the myeloid-derived cells in a tissue microenvironment. In still another embodiment, the method further comprises contacting the myeloid-derived cells with at least one additional therapeutic agent. In yet another embodiment, the at least one additional therapeutic agent is an antagonist of CCL2 and/or an antagonist of CSF1. In another embodiment, the at least one additional therapeutic agent comprises an immunotherapeutic agent that modulates the inflammatory phenotype, optionally wherein the immunotherapeutic agent comprises an immune checkpoint inhibitor, immune-stimulatory agonist, inflammatory agent, cells, a cancer vaccine, and/or a virus. In still another embodiment, the immune checkpoint is selected from the group consisting of PD-1, PD-L1, PD-L2, and CTLA-4. In yet another embodiment, the immune checkpoint is PD-1. In another embodiment, the at least one additional therapeutic agent or regimen is administered before, concurrently with, or after the at least one composition.

In another aspect, a method of sensitizing cancer cells in a subject to cytotoxic CD8⁺ T cell-mediated killing and/or immune checkpoint therapy comprising administering to the subject a therapeutically effective amount of at least one composition encompassed by the present invention for contacting myeloid-derived cells in the subject, is provided.

As described above, numerous embodiments are further provided that can be applied to any aspect of the present invention and/or combined with any other embodiment described herein. For example, in one embodiment, the at least one composition is administered systemically, peritumorally, or intratumorally. In another embodiment, the method further comprises treating the cancer in the subject by administering to the subject an effective amount of at least one additional therapeutic agent. In still another embodiment, the at least one additional therapeutic agent is an antagonist of CCL2 and/or an antagonist of CSF1. In yet another embodiment, the at least one additional therapeutic agent comprises an immunotherapeutic agent that modulates the inflammatory phenotype of

the myeloid-derived cells, optionally wherein the immunotherapeutic agent comprises an immune checkpoint inhibitor, immune-stimulatory agonist, inflammatory agent, cells, a cancer vaccine, and/or a virus. In another embodiment, the immune checkpoint is selected from the group consisting of PD-1, PD-L1, PD-L2, and CTLA-4. In still another

5 embodiment, the immune checkpoint is PD-1. In yet another embodiment, the at least one additional therapeutic agent or regimen is administered before, concurrently with, or after the at least one composition. In another embodiment, the at least one composition reduces the number of proliferating cells in the cancer and/or reduce the volume or size of a tumor comprising the cancer cells. In still another embodiment, the at least one composition

10 increases the amount and/or activity of CD8⁺ T cells infiltrating a tumor comprising the cancer cells. In yet another embodiment, the at least one composition a) increases the amount and/or activity of M1 macrophages infiltrating a tumor comprising the cancer cells and/or b) decreases the amount and/or activity of M2 macrophages infiltrating a tumor comprising the cancer cells.

15 In some embodiments, the myeloid-derived cells contacted with the at least one composition have a modulated inflammatory phenotype exhibiting one or more of the following:: a) decreased expression of CCR2 and/or CSF1R receptors by monocytes and/or macrophages; b) increased expression of cluster of differentiation 80 (CD80), CD86, MHCII, MHCI, interleukin 1-beta (IL-1 β), IL-6, CCL3, CCL4, CXCL10, CXCL9, GM-

20 CSF and/or tumor necrosis factor alpha (TNF- α) by monocytes and/or macrophages; c) decreased expression of CD206, CD163, CD16, CD53, VSIG4, PSGL-1, TGF β and/or IL-10 by monocytes and/or macrophages; d) increased secretion of at least one cytokine or chemokine selected from the group consisting of IL-1 β , TNF- α , IL-12, IL-18, GM-CSF, CCL3, CCL4, and IL-2 by monocytes and/or macrophages; e) increased ratio of expression

25 of IL-1 β , IL-6, and/or TNF- α to expression of IL-10 by monocytes and/or macrophages; f) increased CD8⁺ cytotoxic T cell activation; g) increased recruitment of CD8⁺ cytotoxic T cell activation; h) increased CD4⁺ helper T cell activity; i) increased recruitment of CD4⁺ helper T cell activity; j) increased NK cell activity; k) increased recruitment of NK cells; l) increased neutrophil activity; m) increased macrophage activity; and/or n) increased

30 spindle-shaped morphology, flatness of appearance, and/or number of dendrites, as assessed by microscopy. In one embodiment, the myeloid-derived cell is a macrophage, a monocyte, a circulating bone marrow derived monocyte, a tissue resident macrophage, a macrophage associated with a clinical condition, a Type 1 macrophage, a M1 macrophage,

a Type 2 macrophage, a M2 macrophage, a M2c macrophage, a M2d macrophage, and/or a tumor-associated macrophages (TAM). In another embodiment, the cancer is selected from the group consisting of mesothelioma, kidney renal clear cell carcinoma, glioblastoma, lung adenocarcinoma, lung squamous cell carcinoma, pancreatic adenocarcinoma, breast
 5 invasive carcinoma, acute myeloid leukemia, adrenocortical carcinoma, bladder urothelial carcinoma, brain lower grade glioma, breast invasive carcinoma, cervical squamous cell carcinoma and endocervical adenocarcinoma, cholangiocarcinoma, colon adenocarcinoma, esophageal carcinoma, glioblastoma multiforme, head and neck squamous cell carcinoma, kidney chromophobe, kidney renal clear cell carcinoma, kidney renal papillary cell
 10 carcinoma, liver hepatocellular carcinoma, lung adenocarcinoma, lung squamous cell carcinoma, lymphoid neoplasm diffuse large B-cell lymphoma, mesothelioma, ovarian serous, cystadenocarcinoma, pancreatic adenocarcinoma, pheochromocytoma, paraganglioma, prostate adenocarcinoma, rectum adenocarcinoma, sarcoma, skin cutaneous melanoma, stomach adenocarcinoma, testicular germ cell tumors, thymoma, thyroid
 15 carcinoma, uterine carcinosarcoma, uterine corpus endometrial carcinoma, and uveal melanoma. In still another embodiment, the myeloid-derived cells are comprised within a human tumor model, an animal model of cancer, and/or a thyglycollate peritonitis model. In yet another embodiment, the subject is a mammal. In another embodiment, the mammal is a human, such as a human afflicted with a cancer.

Brief Description of the Drawings

Figure 1A – Figure 1D show dose response curves for selected oligonucleotide compositions for targeting CSF1R (Figure 1A) and CCR2 (Figure 1B), including CSF1R siRNA duplexes and variants (Figure 1C), and CCR2 siRNA duplexes and variants (Figure
 25 1D).

Figure 2 shows the results of silencing both CSF1R and CCR2 using a combination of siRNA duplexes.

Figure 3A – Figure 3C show mCSF1R and mCCR2 expression silencing in peritoneal macrophages of mice after intraperitoneal administration of LNPs formulated
 30 with mCSF1R and/or mCCR2 siRNAs. Figures 3A and 3B show flow cytometry expression plots for n = 1 representative mouse per group. Figure 3C shows normalized mCSF1R and mCCR2 MFI for n = 5 mice per group.

Figure 4A – Figure 4D show mCSF1R and mCCR2 silencing in blood monocytes of mice after intravenous administration of LNPs formulated with mCSF1R and mCCR2 siRNAs. Figures 4A – 4C show flow cytometry expression plots for n = 1 representative mouse per group. Figure 4D shows normalized mCSF1R and mCCR2 MFI for n = 3 mice per group.

Figure 5D shows the results of a single-readout *in vitro* model reporter system using a CSF1R/CCR2 psiCHECK™-2 vector. *Renilla* / firefly luminescence is plotted normalized to plasmid-transfected untreated cells in the Dual-Glo® Luciferase assay. Data are presented as mean + standard deviation (n = 4) and a four-point sigmoidal curve was fit to the data.

Detailed Description of the Invention

The present invention features compositions comprising oligonucleotide compositions that target CCR2 and CSF1R, either alone or in combination, as well as formulations comprising such compositions. Such compositions and formulations can be used in a number of methods, including for modulating myeloid-cell derived cell states, such as converting anti-inflammatory macrophages to pro-inflammatory macrophages in a disease condition or promoting immune responses, such as by increasing CD8+ T cell activity. The compositions and formulations can also be used to modulate immune responses mediated by myeloid-cell derived cells, such as treating cancer by converting pro-tumorigenic macrophages into anti-tumorigenic macrophages.

In particular, the present invention provides small interfering RNA (siRNA) molecules that hybridize to CCR2 and/or CSF1R to antagonize the function of CCR2 and/or CSF1R in myeloid-derived cells, including monocytes and macrophages. Small interfering RNA molecules (also known in the art as “short interfering RNAs”) can induce or mediate RNA interference (RNAi). RNAi is a posttranscriptional process in which small RNA molecules inhibit gene expression by neutralizing targeted mRNA molecules through chromatin remodeling, inhibition of protein translation, or direct mRNA degradation, which can bring about sequence-specific gene silencing. Upon administration, siRNA molecules are recruited to the RNA-induced silencing complex (RISC). This complex is able, via the siRNA molecule, to bind to substantially complementary structures (*i.e.*, the mRNA of a transcribed gene) and degrade them by endonuclease activity. This leads ultimately to inhibition of expression of the corresponding gene that encodes the mRNA complementary

to the siRNA molecules (*e.g.*, McManus and Sharp (2002) *Nat. Rev. Genet.* 3:737-747).

Certain siRNA molecules allow for specific on-target silencing of a target gene. Compared with conventional small therapeutic molecules, siRNA molecules offer the advantages of being highly potent and able to act on “non-druggable” targets as they can be designed to affect virtually any gene of interest. Since siRNA molecules do not integrate into the genome and they offer great safety, it is possible to deliver a cocktail of siRNA molecules targeting multiple disease-causing genes in a single delivery system to control complex diseases (*e.g.*, cancer). In accordance with the present invention, a cocktail of siRNA molecules targeting CCR2 and/or CSF1R can be delivered into myeloid-derived cells, including monocytes and macrophages.

I. Definitions

The term “about,” in some embodiments, encompasses values that are within 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, or 10%, inclusive, or any range in between (*e.g.*, plus or minus 2%-6%), of a value that is measured. In some embodiments, the term “about” refers to the inherent variation of error in a method, assay, or measured value, such as the variation that exists among experiments.

The term “activating receptor” includes immune cell receptors that bind antigen, complexed antigen (*e.g.*, in the context of major histocompatibility complex (MHC) polypeptides), or bind to antibodies. Such activating receptors include T cell receptors (TCR), B cell receptors (BCR), cytokine receptors, LPS receptors, complement receptors, Fc receptors, and other ITAM containing receptors. For example, T cell receptors are present on T cells and are associated with CD3 polypeptides. T cell receptors are stimulated by antigen in the context of MHC polypeptides (as well as by polyclonal T cell activating reagents). T cell activation via the TCR results in numerous changes, *e.g.*, protein phosphorylation, membrane lipid changes, ion fluxes, cyclic nucleotide alterations, RNA transcription changes, protein synthesis changes, and cell volume changes. Similar to T cells activation of macrophages via activation receptors such as, cytokine receptors or pattern associated molecular pattern (PAMP) receptors, results in changes such as protein phosphorylation, alteration to surface receptor phenotype, protein synthesis and release, as well as morphologic changes.

The term “administering” relates to the actual physical introduction of an agent into or onto (as appropriate) a biological target of interest, such as a host and/or subject. A

composition can be administered to the cell (*e.g.*, “contacting”) *in vitro* or *in vivo*. A composition can be administered to the subject *in vivo* via an appropriate route of administration. Any and all methods of introducing the composition into the host are contemplated according to the present invention. The method is not dependent on any

5 particular means of introduction and is not to be so construed. Means of introduction are well-known to those skilled in the art, and are also exemplified herein. The term include routes of administration which allow an agent to perform its intended function. Examples of routes of administration for treatment of a body which can be used include injection (subcutaneous, intravenous, parenterally, intraperitoneally, intrathecal, etc.), oral,

10 inhalation, and transdermal routes. The injection can be bolus injections or can be continuous infusion. Depending on the route of administration, the agent can be coated with or disposed in a selected material to protect it from natural conditions which can detrimentally affect its ability to perform its intended function. The agent can be administered alone, or in conjunction with a pharmaceutically acceptable carrier. The agent
15 also can be administered as a prodrug, which is converted to its active form *in vivo*.

The term “agent” refers to a compound, supramolecular complex, material, and/or combination or mixture thereof. A compound (*e.g.*, a molecule) can be represented by a chemical formula, chemical structure, or sequence. Representative, non-limiting examples of agents, include, *e.g.*, small molecules, polypeptides, proteins, polynucleotides (*e.g.*,
20 RNAi agents, siRNA, miRNA, piRNA, mRNA, antisense polynucleotides, aptamers, and the like), lipids, and polysaccharides. In general, agents can be obtained using any suitable method known in the art. In some embodiments, an agent can be a “therapeutic agent” for use in treating a disease or disorder (*e.g.*, cancer) in a subject (*e.g.*, a human).

The term “agonist” refers to an agent that binds to a target(s) (*e.g.*, a receptor) and
25 activates or increases the biological activity of the target(s). For example, an “agonist” antibody is an antibody that activates or increases the biological activity of the antigen(s) it binds.

The term “antagonist” or “antagonistic” refer to a molecule which is capable of, directly or indirectly, substantially counteracting, reducing or inhibiting the biological
30 activity or activation of a target protein, such as CCR2 and/or CSF1R, as well as isoforms, variants and orthologs thereof. In addition to the siRNA molecules that hybridize to CCR2 or CSF1R, the antagonists can also include monoclonal antibodies, competitive peptides, and small molecules that decrease the activity of CCR2 and/or CSF1R. For example, the

CCR2 antagonists can be compounds inhibiting CCR2 signaling and the CSF1R antagonists can be compounds inhibiting CSF1R signaling.

The terms “cancer” or “tumor” or “hyperproliferative” refer to the presence of cells possessing characteristics typical of cancer-causing cells, such as uncontrolled proliferation, 5 immortality, invasive or metastatic potential, rapid growth, and certain characteristic morphological features. In some embodiments, such cells exhibit such characteristics in part or in full due to the expression and activity of immune checkpoint proteins, such as PD-1, PD-L1, PD-L2, and/or CTLA-4.

Cancer cells are often in the form of a tumor, but such cells can exist alone within 10 an animal, or can be a non-tumorigenic cancer cell, such as a leukemia cell. As used herein, the term “cancer” includes premalignant as well as malignant cancers. Cancers include, but are not limited to, a variety of cancers, carcinoma including that of the bladder (including accelerated and metastatic bladder cancer), breast, colon (including colorectal cancer), kidney, liver, lung (including small and non-small cell lung cancer and lung 15 adenocarcinoma), ovary, prostate, testes, genitourinary tract, lymphatic system, rectum, larynx, pancreas (including exocrine pancreatic carcinoma), esophagus, stomach, gall bladder, cervix, thyroid, and skin (including squamous cell carcinoma); hematopoietic tumors of lymphoid lineage including leukemia, acute lymphocytic leukemia, acute lymphoblastic leukemia, B-cell lymphoma, T-cell lymphoma, Hodgkins lymphoma, non- 20 Hodgkins lymphoma, hairy cell lymphoma, histiocytic lymphoma, and Burketts lymphoma; hematopoietic tumors of myeloid lineage including acute and chronic myelogenous leukemias, myelodysplastic syndrome, myeloid leukemia, and promyelocytic leukemia; tumors of the central and peripheral nervous system including astrocytoma, neuroblastoma, glioma, and schwannomas; tumors of mesenchymal origin including fibrosarcoma, 25 rhabdomyosarcoma, and osteosarcoma; other tumors including melanoma, xenoderma pigmentosum, keratoactanthoma, seminoma, thyroid follicular cancer, and teratocarcinoma; melanoma, unresectable stage III or IV malignant melanoma, squamous cell carcinoma, small-cell lung cancer, non-small cell lung cancer, glioma, gastrointestinal cancer, renal cancer, ovarian cancer, liver cancer, colorectal cancer, endometrial cancer, kidney cancer, 30 prostate cancer, thyroid cancer, neuroblastoma, pancreatic cancer, glioblastoma multiforme, cervical cancer, stomach cancer, bladder cancer, hepatoma, breast cancer, colon carcinoma, and head and neck cancer, gastric cancer, germ cell tumor, bone cancer, bone tumors, adult malignant fibrous histiocytoma of bone; childhood, malignant fibrous histiocytoma of bone,

sarcoma, pediatric sarcoma, sinonasal natural killer, neoplasms, plasma cell neoplasm; myelodysplastic syndromes; neuroblastoma; testicular germ cell tumor, intraocular melanoma, myelodysplastic syndromes; myelodysplastic/myeloproliferative diseases, synovial sarcoma, chronic myeloid leukemia, acute lymphoblastic leukemia, philadelphia
5 chromosome positive acute lymphoblastic leukemia (Ph⁺ ALL), multiple myeloma, acute myelogenous leukemia, chronic lymphocytic leukemia, mastocytosis and any symptom associated with mastocytosis, and any metastasis thereof. In addition, disorders include urticaria pigmentosa, mastocytoses such as diffuse cutaneous mastocytosis, solitary mastocytoma in human, as well as dog mastocytoma and some rare subtypes like bullous,
10 erythrodermic and teleangiectatic mastocytosis, mastocytosis with an associated hematological disorder, such as a myeloproliferative or myelodysplastic syndrome, or acute leukemia, myeloproliferative disorder associated with mastocytosis, mast cell leukemia, in addition to other cancers. Other cancers are also included within the scope of disorders including, but are not limited to, the following: carcinoma, including that of the bladder,
15 urothelial carcinoma, breast, colon, kidney, liver, lung, ovary, pancreas, stomach, cervix, thyroid, testis, particularly testicular seminomas, and skin; including squamous cell carcinoma; gastrointestinal stromal tumors ("GIST"); hematopoietic tumors of lymphoid lineage, including leukemia, acute lymphocytic leukemia, acute lymphoblastic leukemia, B-cell lymphoma, T-cell lymphoma, Hodgkins lymphoma, non-Hodgkins lymphoma, hairy
20 cell lymphoma and Burketts lymphoma; hematopoietic tumors of myeloid lineage, including acute and chronic myelogenous leukemias and promyelocytic leukemia; tumors of mesenchymal origin, including fibrosarcoma and rhabdomyosarcoma; other tumors, including melanoma, seminoma, tetratocarcinoma, neuroblastoma and glioma; tumors of the central and peripheral nervous system, including astrocytoma, neuroblastoma, glioma,
25 and schwannomas; tumors of mesenchymal origin, including fibrosarcoma, rhabdomyosarcoma, and osteosarcoma; and other tumors, including melanoma, xenoderma pigmentosum, keratoactanthoma, seminoma, thyroid follicular cancer, teratocarcinoma, chemotherapy refractory non-seminomatous germ-cell tumors, and Kaposi's sarcoma, and any metastasis thereof. Other non-limiting examples of types of cancers applicable to the
30 methods encompassed by the present invention include human sarcomas and carcinomas, *e.g.*, fibrosarcoma, myxosarcoma, liposarcoma, chondrosarcoma, osteogenic sarcoma, chordoma, angiosarcoma, endotheliosarcoma, lymphangiosarcoma, lymphangioendotheliosarcoma, synovioma, mesothelioma, Ewing's tumor,

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

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

The term “complementary” refers to the broad concept of sequence complementarity between regions of two nucleic acid strands or between two regions of the same nucleic acid strand. It is known that an adenine residue of a first nucleic acid region is capable of forming specific hydrogen bonds (“base pairing”) with a residue of a second nucleic acid region which is antiparallel to the first region if the residue is thymine or uracil. Similarly, it is known that a cytosine residue of a first nucleic acid strand is capable of base pairing with a residue of a second nucleic acid strand which is antiparallel to the first strand if the residue is guanine. A first region of a nucleic acid is complementary to a

second region of the same or a different nucleic acid if, when the two regions are arranged in an antiparallel fashion, at least one nucleotide residue of the first region is capable of base pairing with a residue of the second region. Preferably, the first region comprises a first portion and the second region comprises a second portion, whereby, when the first and second portions are arranged in an antiparallel fashion, at least about 50%, and preferably at least about 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 98%, 99%, 99.5%, 99.9%, or greater of the nucleotide residues of the first portion are capable of base pairing with nucleotide residues in the second portion. More preferably, all nucleotide residues of the first portion are capable of base pairing with nucleotide residues in the second portion. In some embodiments, complementary polynucleotides can be “sufficiently complementary” or can have “sufficient complementarity,” that is, complementarity sufficient to maintain a duplex and/or have a desired activity. For example, in the case of RNAi agents, such complementarity is complementarity between the agent and a target mRNA that is sufficient to partly or completely prevent translation of the mRNA. For example, an siRNA having a “sequence sufficiently complementary to a target mRNA sequence to direct target-specific RNA interference (RNAi)” means that the siRNA has a sequence sufficient to trigger the destruction of the target mRNA by the RNAi machinery or process.

The term “substantially complementary” refers to complementarity in a base-paired, double-stranded region between two nucleic acids and not any single-stranded region such as a terminal overhang or a gap region between two double-stranded regions. The complementarity does not need to be perfect; there can be any number of base pair mismatches. In some embodiments, when two sequences are referred to as “substantially complementary” herein, it is meant that the sequences are sufficiently complementary to each other to hybridize under the selected reaction conditions. Accordingly, substantially complementary sequences can refer to sequences with base-pair complementarity of at least 100, 99, 98, 97, 96, 95, 94, 93, 92, 91, 90, 85, 80, 75, 70, 65, 60 percent or more, or any number in between, in a double-stranded region.

The terms “conjoint therapy” and “combination therapy,” as used herein, refer to the administration of two or more therapeutic agents, *e.g.*, combination of modulators of CCR2 and CSF1R, combination of modulators of CCR2 or CSF1R with at least one additional therapeutic agent, such as an inhibitor of CCL2 or CSF1, combination of modulators of CCR2 and CSF1R further in combination with an additional agent such as an immune checkpoint therapy, and the like. The different agents comprising the combination therapy

can be administered concomitant with, prior to, or following, the administration of the other or others. The combination therapy is intended to provide a beneficial (additive or synergistic) effect from the co-action of these therapeutic agents. Administration of these therapeutic agents in combination can be carried out over a defined time period (usually
5 minutes, hours, days, or weeks depending upon the combination selected). In combination therapy, combined therapeutic agent can be applied in a sequential manner, or by substantially simultaneous application.

The term “cytokine” refers to a substance secreted by certain cells of the immune system and has a biological effect on other cells. Cytokines can be a number of different
10 substances such as interferons, interleukins, and growth factors.

The term “gene” encompasses a nucleotide (*e.g.*, DNA) sequence that encodes a molecule (*e.g.*, RNA, protein, etc.) that has a function. A gene generally comprises two complementary nucleotide strands (*i.e.*, dsDNA), a coding strand and a non-coding strand. When referring to DNA transcription, the coding strand is the DNA strand whose base
15 sequence corresponds to the base sequence of the RNA transcript produced (although with thymine replaced by uracil). The coding strand contains codons, while the non-coding strand contains anticodons. During transcription, RNA Pol II binds the non-coding strand, reads the anti-codons, and transcribes their sequence to synthesize an RNA transcript with complementary bases. In some embodiments, the gene sequence (*i.e.*, DNA sequence)
20 listed is the sequence of the coding strand.

The term “gene product” (also referred to herein as “gene expression product” or “expression product”) encompasses products resulting from expression of a gene, such as nucleic acids (*e.g.*, mRNA) transcribed from the gene, and polypeptides or proteins arising from translation of such mRNA. It will be appreciated that certain gene products can
25 undergo processing or modification, *e.g.*, in a cell. For example, mRNA transcripts can be spliced, polyadenylated, *etc.*, prior to translation, and/or polypeptides can undergo co-translational or post-translational processing, such as removal of secretion signal sequences, removal of organelle targeting sequences, or modifications such as phosphorylation, glycosylation, methylation, fatty acylation, etc. The term “gene product” encompasses such
30 processed or modified forms. Genomic mRNA and polypeptide sequences from a variety of species, including human, are known in the art and are available in publicly accessible databases such as those available at the National Center for Biotechnology Information (ncbi.nih.gov) or Universal Protein Resource (uniprot.org). Other databases include, *e.g.*,

GenBank, RefSeq, Gene, UniProtKB/SwissProt, UniProtKB/Trembl, and the like. In general, sequences in the NCBI Reference Sequence database can be used as gene product sequences for a gene of interest. It will be appreciated that multiple alleles of a gene can exist among individuals of the same species. Multiple isoforms of certain proteins can exist, *e.g.*, as a result of alternative RNA splicing or editing. In general, where aspects of this disclosure pertain to a gene or gene product, embodiments pertaining to allelic variants or isoforms are encompassed, if applicable, unless indicated otherwise. Certain embodiments can be directed to particular sequence(s), *e.g.*, particular allele(s) or isoform(s).

The term “generating” encompasses any manner in which a desired result is achieved, such as by direct or indirect action. For example, cells having modulated phenotypes described herein can be generated by direct action, such as by contact with at least one agent that modulates one or more biomarkers described herein, and/or by indirect action, such as by propagating cells having a desired physical, genetic, and/or phenotypic attributes.

The terms “high,” “low,” “intermediate,” and “negative” in connection with cellular biomarker expression refers to the amount of the biomarker expressed relative to the cellular expression of the biomarker by one or more reference cells. Biomarker expression can be determined according to any method described herein including, without limitation, an analysis of the cellular level, activity, structure, and the like, of one or more biomarker genomic nucleic acids, ribonucleic acids, and/or polypeptides. In one embodiment, the terms refer to a defined percentage of a population of cells expressing the biomarker at the highest, intermediate, or lowest levels, respectively. Such percentages can be defined as the top 0.1%, 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5%, 5.0%, 5.5%, 6.0%, 6.5%, 7.0%, 7.5%, 8.0%, 8.5%, 9.0%, 9.5%, 10%, 11%, 12%, 13%, 14%, 15% or more, or any range in between, inclusive, of a population of cells that either highly express or weakly express the biomarker. The term “low” excludes cells that do not detectably express the biomarker, since such cells are “negative” for biomarker expression. The term “intermediate” includes cells that express the biomarker, but at levels lower than the population expressing it at the “high” level. In another embodiment, the terms can also refer to, or in the alternative refer to, cell populations of biomarker expression identified by qualitative or statistical plot regions. For example, cell populations sorted using flow cytometry can be discriminated on the basis of biomarker expression level by identifying

distinct plots based on detectable moiety analysis, such as based on mean fluorescence intensities and the like, according to well-known methods in the art. Such plot regions can be refined according to number, shape, overlap, and the like based on well-known methods in the art for the biomarker of interest. In still another embodiment, the terms can also be
5 determined according to the presence or absence of expression for additional biomarkers.

The term “substantially identical” refers to a nucleic acid or amino acid sequence that, when optimally aligned, for example using the methods described below, share at least 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity with a second nucleic acid or amino acid sequence. “Substantial identity” can be
10 used to refer to various types and lengths of sequence, such as full-length sequence, functional domains, coding and/or regulatory sequences, exons, introns, promoters, and genomic sequences. Percent sequence identity between two polypeptides or nucleic acid sequences is determined in various ways that are within the skill in the art, for instance, using publicly available computer software such as BLAST program (Basic Local
15 Alignment Search Tool; (Altschul *et al.* (1995) *J. Mol. Biol.* 215:403-410), BLAST-2, BLAST-P, BLAST-N, BLAST-X, WU-BLAST-2, ALIGN, ALIGN-2, CLUSTAL, or Megalign (DNASTAR) software. In addition, those skilled in the art can determine appropriate parameters for measuring alignment, including any algorithms needed to achieve maximal alignment over the length of the sequences being compared. It is
20 understood that for the purposes of determining sequence identity when comparing a DNA sequence to an RNA sequence, a thymine nucleotide is equivalent to a uracil nucleotide. Conservative substitutions typically include substitutions within the following groups: glycine, alanine; valine, isoleucine, leucine; aspartic acid, glutamic acid, asparagine, glutamine; serine, threonine; lysine, arginine; and phenylalanine, tyrosine.

The term “immune cell” refers to a cell that is capable of participating, directly or
25 indirectly, in an immune response. Immune cells include, but are not limited to T cells, B cells, antigen presenting cells, dendritic cells, natural killer (NK) cells, natural killer T (NK) cells, lymphokine-activated killer (LAK) cells, monocytes, macrophages, eosinophils, basophils, neutrophils, granulocytes, mast cells, platelets, Langerhan's cells, stem cells,
30 peripheral blood mononuclear cells, cytotoxic T cells, tumor infiltrating lymphocytes (TIL), and the like. An “antigen presenting cell” (APC) is a cell that are capable of activating T cells, and includes, but is not limited to, monocytes/macrophages, B cells and dendritic cells (DCs). The term “dendritic cell” or “DC” refers to any member of a diverse

population of morphologically similar cell types found in lymphoid or non-lymphoid tissues. These cells are characterized by their distinctive morphology and high levels of surface MHC-class II expression. DCs can be isolated from a number of tissue sources. DCs have a high capacity for sensitizing MHC-restricted T cells and are very effective at presenting antigens to T cells *in situ*. The antigens can be self-antigens that are expressed during T cell development and tolerance, and foreign antigens that are present during normal immune processes. The term “neutrophil” generally refers to a white blood cell that makes up part of the innate immune system. Neutrophils typically have segmented nucleic containing about 2-5 lobes. Neutrophils frequently migrate to the site of an injury within minutes following trauma. Neutrophils function by releasing cytotoxic compounds, including oxidants, proteases, and cytokines, at a site of injury or infection. The term “activated DC” is a DC that has been pulsed with an antigen and capable of activating an immune cell. The term “NK cell” has its general meaning in the art and refers to a natural killer (NK) cell. One skilled in the art can easily identify NK cells by determining for instance the expression of specific phenotypic marker (*e.g.*, CD56) and identify its function based on, for example, the ability to express different kind of cytokines or the ability to induce cytotoxicity. The term “B cell” refers to an immune cell derived from the bone marrow and/or spleen. B cells can develop into plasma cells which produce antibodies. The term “T cell” refers to a thymus-derived immune cell that participates in a variety of cell-mediated immune reactions, including CD8⁺ T cell and CD4⁺ T cell. Conventional T cells, also known as Tconv or Teffs, have effector functions (*e.g.*, cytokine secretion, cytotoxic activity, anti-self-recognition, and the like) to increase immune responses by virtue of their expression of one or more T cell receptors. Tconv or Teffs are generally defined as any T cell population that is not a Treg and include, for example, naïve T cells, activated T cells, memory T cells, resting Tconv, or Tconv that have differentiated toward, for example, the Th1 or Th2 lineages. In some embodiments, Teffs are a subset of non-regulatory T cells (Tregs). In some embodiments, Teffs are CD4⁺ Teffs or CD8⁺ Teffs, such as CD4⁺ helper T lymphocytes (*e.g.*, Th0, Th1, Tfh, or Th17) and CD8⁺ cytotoxic T cells (lymphocytes). As described further herein, cytotoxic T cells are CD8⁺ T lymphocytes. “Naïve Tconv” are CD4⁺ T cells that have differentiated in bone marrow, and successfully underwent a positive and negative processes of central selection in a thymus, but have not yet been activated by exposure to an antigen. Naïve Tconv are commonly characterized by surface expression of L-selectin (CD62L), absence of activation markers

such as CD25, CD44 or CD69, and absence of memory markers such as CD45RO. Naïve T_h17 are therefore believed to be quiescent and non-dividing, requiring interleukin-7 (IL-7) and interleukin-15 (IL-15) for homeostatic survival (see, at least WO 2010/101870). The presence and activity of such cells are undesired in the context of suppressing immune responses. Unlike Tregs, T_h17 are not anergic and can proliferate in response to antigen-based T cell receptor activation (Lechler *et al.* (2001) *Philos. Trans. R. Soc. Lond. Biol. Sci.* 356:625-637). In tumors, exhausted cells can present hallmarks of anergy.

The term “immunoregulator” refers to a substance, an agent, a signaling pathway or a component thereof that regulates an immune response. The terms “regulating,” “modifying,” or “modulating” with respect to an immune response refer to any alteration in a cell of the immune system or in the activity of such cell. Such regulation includes stimulation or suppression of the immune system (or a distinct part thereof), which can be manifested by an increase or decrease in the number of various cell types, an increase or decrease in the activity of these cells, or any other changes which can occur within the immune system. Both inhibitory and stimulatory immunoregulators have been identified, some of which can have enhanced function in the cancer microenvironment.

The term “immune response” means a defensive response a body develops against “foreigner” such as bacteria, viruses and substances that appear foreign and harmful. An immune response in particular is the activation and/or action of a cell of the immune system (for example, T lymphocytes, B lymphocytes, natural killer (NK) cells, macrophages, eosinophils, mast cells, dendritic cells and neutrophils) and soluble macromolecules produced by any of these cells or the liver (including antibodies (humoral response), cytokines, and complement) that results in selective targeting, binding to, damage to, destruction of, and/or elimination from a vertebrate's body of invading pathogens, cells or tissues infected with pathogens, cancerous or other abnormal cells, or, in cases of autoimmunity or pathological inflammation, normal human cells or tissues. An anti-cancer immune response refers to an immune surveillance mechanism by which a body recognizes abnormal tumor cells and initiates both the innate and adaptive of the immune system to eliminate dangerous cancer cells.

The innate immune system is a non-specific immune system that comprises the cells (*e.g.*, natural killer cells, mast cells, eosinophils, basophils; and the phagocytic cells including macrophages, neutrophils, and dendritic cells) and mechanisms that defend the host from infection by other organisms. An innate immune response can initiate the

productions of cytokines, and active complement cascade and adaptive immune response. The adaptive immune system is specific immune system that is required and involved in highly specialized systemic cell activation and processes, such as antigen presentation by an antigen presenting cell; antigen specific T cell activation and cytotoxic effect.

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

10 The term “inhibit” or “downregulate” includes the decrease, limitation, or blockage, of, for example a particular action, function, or interaction. In some embodiments, cancer is “inhibited” if at least one symptom of the cancer is alleviated, terminated, slowed, or prevented. As used herein, cancer is also “inhibited” if recurrence or metastasis of the cancer is reduced, slowed, delayed, or prevented. Similarly, a biological function, such as the function of a protein, is inhibited if it is decreased as compared to a reference state, such as a control like a wild-type state. Such inhibition or deficiency can be induced, such as by application of an agent at a particular time and/or place, or can be constitutive, such as by a heritable mutation. Such inhibition or deficiency can also be partial or complete (*e.g.*, essentially no measurable activity in comparison to a reference state, such as a control like a wild-type state). Essentially complete inhibition or deficiency is referred to as blocked.

15 The term “promote” or “upregulate” has the opposite meaning.

20 The term “interaction,” when referring to an interaction between two molecules, refers to the physical contact (*e.g.*, binding) of the molecules with one another. Generally, such an interaction results in an activity (which produces a biological effect) of one or both of said molecules. The activity can be a direct activity of one or both of the molecules, (*e.g.*, signal transduction). Alternatively, one or both molecules in the interaction can be prevented from binding their ligand, and thus be held inactive with respect to ligand binding activity (*e.g.*, binding its ligand and triggering or inhibiting costimulation). To inhibit such an interaction results in the disruption of the activity of one or more molecules involved in the interaction. To enhance such an interaction is to prolong or increase the likelihood of said physical contact, and prolong or increase the likelihood of said activity.

25 The term “microenvironment” generally refers to the localized area in a tissue area of interest and can, for example, refer to a “tumor microenvironment.” The term “tumor microenvironment” or “TME” refers to the surrounding microenvironment that constantly

30

interacts with tumor cells which is conducive to allow cross-talk between tumor cells and its environment. The tumor microenvironment can include the cellular environment of the tumor, surrounding blood vessels, immune cells, fibroblasts, bone marrow derived inflammatory cells, lymphocytes, signaling molecules and the extracellular matrix. The tumor environment can include tumor cells or malignant cells that are aided and influenced by the tumor microenvironment to ensure growth and survival. The tumor microenvironment can also include tumor-infiltrating immune cells, such as lymphoid and myeloid cells, which can stimulate or inhibit the antitumor immune response, and stromal cells such as tumor-associated fibroblasts and endothelial cells that contribute to the tumor's structural integrity. Stromal cells can include cells that make up tumor-associated blood vessels, such as endothelial cells and pericytes, which are cells that contribute to structural integrity (fibroblasts), as well as tumor-associated macrophages (TAMs) and infiltrating immune cells, including monocytes, neutrophils (PMN), dendritic cells (DCs), T and B cells, mast cells, and natural killer (NK) cells. The stromal cells make up the bulk of tumor cellularity, while the dominating cell type in solid tumors is the macrophage.

The term “modulating” and its grammatical equivalents refer to either increasing or decreasing (*e.g.*, silencing), in other words, either up-regulating or down-regulating.

The term “peripheral blood cell subtypes” refers to cell types normally found in the peripheral blood including, but is not limited to, eosinophils, neutrophils, T cells, monocytes, macrophages, NK cells, granulocytes, and B cells.

The terms “prevent,” “preventing,” “prevention,” “prophylactic treatment,” and the like refer to reducing the probability of developing a disease, disorder, or condition in a subject, who does not have, but is at risk of or susceptible to developing a disease, disorder, or condition.

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

The term “ratio” refers to a relationship between two numbers (*e.g.*, scores, summations, and the like). Although, ratios can be expressed in a particular order (*e.g.*, a to

b or a:b), one of ordinary skill in the art will recognize that the underlying relationship between the numbers can be expressed in any order without losing the significance of the underlying relationship, although observation and correlation of trends based on the ratio can be reversed.

5 The term “receptor” refers to a naturally occurring molecule or complex of molecules that is generally present on the surface of cells of a target organ, tissue or cell type.

 The term “cancer response,” “response to immunotherapy,” or “response to modulators of T-cell mediated cytotoxicity/immunotherapy combination therapy” relates to
10 any response of the hyperproliferative disorder (*e.g.*, cancer) to an cancer agent, such as a modulator of T-cell mediated cytotoxicity, and an immunotherapy, preferably to a change in tumor mass and/or volume after initiation of neoadjuvant or adjuvant therapy.
Hyperproliferative disorder response can be assessed, for example for efficacy or in a neoadjuvant or adjuvant situation, where the size of a tumor after systemic intervention can
15 be compared to the initial size and dimensions as measured by CT, PET, mammogram, ultrasound or palpation. Responses can also be assessed by caliper measurement or pathological examination of the tumor after biopsy or surgical resection. Response can be recorded in a quantitative fashion like percentage change in tumor volume or in a qualitative fashion like “pathological complete response” (pCR), “clinical complete
20 remission” (cCR), “clinical partial remission” (cPR), “clinical stable disease” (cSD), “clinical progressive disease” (cPD) or other qualitative criteria. Assessment of hyperproliferative disorder response can be done early after the onset of neoadjuvant or adjuvant therapy, *e.g.*, after a few hours, days, weeks or preferably after a few months. A typical endpoint for response assessment is upon termination of neoadjuvant chemotherapy
25 or upon surgical removal of residual tumor cells and/or the tumor bed. This is typically three months after initiation of neoadjuvant therapy. In some embodiments, clinical efficacy of the therapeutic treatments described herein can be determined by measuring the clinical benefit rate (CBR). The clinical benefit rate is measured by determining the sum of the percentage of patients who are in complete remission (CR), the number of patients who
30 are in partial remission (PR) and the number of patients having stable disease (SD) at a time point at least 6 months out from the end of therapy. The shorthand for this formula is $CBR = CR + PR + SD$ over 6 months. In some embodiments, the CBR for a particular cancer therapeutic regimen is at least 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%,

75%, 80%, 85%, or more. Additional criteria for evaluating the response to cancer therapies are related to “survival,” which includes all of the following: survival until mortality, also known as overall survival (wherein said mortality can be either irrespective of cause or tumor related); “recurrence-free survival” (wherein the term recurrence shall
5 include both localized and distant recurrence); metastasis free survival; disease free survival (wherein the term disease shall include cancer and diseases associated therewith). The length of said survival can be calculated by reference to a defined start point (*e.g.*, time of diagnosis or start of treatment) and end point (*e.g.*, death, recurrence or metastasis). In addition, criteria for efficacy of treatment can be expanded to include response to
10 chemotherapy, probability of survival, probability of metastasis within a given time period, and probability of tumor recurrence. For example, in order to determine appropriate threshold values, a particular cancer therapeutic regimen can be administered to a population of subjects and the outcome can be correlated to biomarker measurements that were determined prior to administration of any cancer therapy. The outcome measurement
15 can be pathologic response to therapy given in the neoadjuvant setting. Alternatively, outcome measures, such as overall survival and disease-free survival can be monitored over a period of time for subjects following cancer therapy for which biomarker measurement values are known. In certain embodiments, the doses administered are standard doses known in the art for cancer therapeutic agents. The period of time for which subjects are
20 monitored can vary. For example, subjects can be monitored for at least 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 25, 30, 35, 40, 45, 50, 55, or 60 months. Biomarker measurement threshold values that correlate to outcome of a cancer therapy can be determined using well-known methods in the art, such as those described in the Examples section.

The term “resistance” refers to an acquired or natural resistance of a cancer sample
25 or a mammal to a cancer therapy (*i.e.*, being nonresponsive to or having reduced or limited response to the therapeutic treatment), such as having a reduced response to a therapeutic treatment by 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 100%, or more, such 2-fold, 3-fold, 4-fold, 5-fold, 10-
30 fold, 15-fold, 20-fold or more, or any range in between, inclusive. The reduction in response can be measured by comparing with the same cancer sample or mammal before the resistance is acquired, or by comparing with a different cancer sample or a mammal that is known to have no resistance to the therapeutic treatment. A typical acquired resistance to chemotherapy is called “multidrug resistance.” The multidrug resistance can be mediated

by P-glycoprotein or can be mediated by other mechanisms, or it can occur when a mammal is infected with a multi-drug-resistant microorganism or a combination of microorganisms. The determination of resistance to a therapeutic treatment is routine in the art and within the skill of an ordinarily skilled clinician, for example, can be measured by cell proliferative assays and cell death assays as described herein as “sensitizing.” In some embodiments, the term “reverses resistance” means that the use of a second agent in combination with a primary cancer therapy (*e.g.*, chemotherapeutic or radiation therapy) is able to produce a significant decrease in tumor volume at a level of statistical significance (*e.g.*, $p < 0.05$) when compared to tumor volume of untreated tumor in the circumstance where the primary cancer therapy (*e.g.*, chemotherapeutic or radiation therapy) alone is unable to produce a statistically significant decrease in tumor volume compared to tumor volume of untreated tumor. This generally applies to tumor volume measurements made at a time when the untreated tumor is growing log rhythmically.

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

“RNA interference (RNAi)” is an evolutionally conserved process whereby the expression or introduction of RNA of a sequence that is identical or highly similar to a target biomarker nucleic acid results in the sequence specific degradation or specific post-transcriptional gene silencing (PTGS) of messenger RNA (mRNA) transcribed from that targeted gene (*see* Coburn and Cullen (2002) *J. Virol.* 76:9225), thereby inhibiting expression of the target biomarker nucleic acid. In one embodiment, the RNA is double stranded RNA (dsRNA). This process has been described in plants, invertebrates, and mammalian cells. In nature, RNAi is initiated by the dsRNA-specific endonuclease Dicer, which promotes processive cleavage of long dsRNA into double-stranded fragments termed

siRNAs. siRNAs are incorporated into a protein complex that recognizes and cleaves target mRNAs. RNAi can also be initiated by introducing nucleic acid molecules, *e.g.*, synthetic siRNAs or RNA interfering agents, to inhibit or silence the expression of target biomarker nucleic acids. As used herein, “inhibition of target biomarker nucleic acid expression” or “inhibition of marker gene expression” includes any decrease in expression or protein activity or level of the target biomarker nucleic acid or protein encoded by the target biomarker nucleic acid. The decrease can be of at least 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95% or 99% or more as compared to the expression of a target biomarker nucleic acid or the activity or level of the protein encoded by a target biomarker nucleic acid which has not been targeted by an RNA interfering agent.

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

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

The term “sensitize” means to alter cancer cells or tumor cells in a way that allows for more effective treatment of the associated cancer with a cancer therapy (*e.g.*, anti-immune checkpoint, chemotherapeutic, and/or radiation therapy). In some embodiments, normal cells are not affected to an extent that causes the normal cells to be unduly injured by the therapies. An increased sensitivity or a reduced sensitivity to a therapeutic treatment is measured according to a known method in the art for the particular treatment and methods described herein below, including, but not limited to, cell proliferative assays (Tanigawa *et al.* (1982) *Cancer Res.* 42:2159-2164) and cell death assays (Weisenthal *et al.*

(1984) *Cancer Res.* 94:161-173; Weisenthal *et al.* (1985) *Cancer Treat Rep.* 69:615-632; Weisenthal *et al.*, In: Kaspers G J L, Pieters R, Twentyman P R, Weisenthal L M, Veerman A J P, eds. *Drug Resistance in Leukemia and Lymphoma*. Langhorne, P A: Harwood Academic Publishers, 1993:415-432; Weisenthal (1994) *Contrib. Gynecol. Obstet.* 19:82-90). The sensitivity or resistance can also be measured in animal by measuring the tumor size reduction over a period of time, for example, 6 month for human and 4-6 weeks for mouse. A composition or a method sensitizes response to a therapeutic treatment if the increase in treatment sensitivity or the reduction in resistance is 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 100%, or more, such 2-fold, 3-fold, 4-fold, 5-fold, 10-fold, 15-fold, 20-fold or more, or any range in between, inclusive, compared to treatment sensitivity or resistance in the absence of such composition or method. The determination of sensitivity or resistance to a therapeutic treatment is routine in the art and within the skill of an ordinarily skilled clinician. It is to be understood that any method described herein for enhancing the efficacy of a cancer therapy can be equally applied to methods for sensitizing hyperproliferative or otherwise cancerous cells (*e.g.*, resistant cells) to the cancer therapy.

“Short interfering RNA” (siRNA), also referred to herein as “small interfering RNA” is defined as an agent which functions to inhibit expression of a target biomarker nucleic acid, *e.g.*, by RNAi. An siRNA can be chemically synthesized, can be produced by *in vitro* transcription, or can be produced within a host cell. In one embodiment, siRNA is a double stranded RNA (dsRNA) molecule of about 15 to about 40 nucleotides in length, preferably about 15 to about 28 nucleotides, more preferably about 19 to about 25 nucleotides in length, and more preferably about 19, 20, 21, or 22 nucleotides in length, and can contain a 3' and/or 5' overhang on each strand having a length of about 0, 1, 2, 3, 4, or 5 nucleotides. The length of the overhang is independent between the two strands, *i.e.*, the length of the overhang on one strand is not dependent on the length of the overhang on the second strand. Preferably the siRNA is capable of promoting RNA interference through degradation or specific post-transcriptional gene silencing (PTGS) of the target messenger RNA (mRNA).

In another embodiment, an siRNA is a small hairpin (also called stem loop) RNA (shRNA). In one embodiment, these shRNAs are composed of a short (*e.g.*, 17-29 nucleotide, 19-25 nucleotide, etc. region) antisense strand, followed by a 4-10 nucleotide loop (*e.g.*, a 4, 5, 6, 7, 8, 9, or 10 base linker region), and the analogous sense strand.

Alternatively, the sense strand can precede the nucleotide loop structure and the antisense strand can follow. These shRNAs can be contained in plasmids, retroviruses, and lentiviruses and expressed from, for example, the pol III U6 promoter, or another promoter (*see, e.g., Stewart, et al. (2003) RNA 9:493-501*).

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

The term “selective modulator” or “selectively modulate” as applied to a biologically active agent refers to the agent's ability to modulate the target, such as a cell
 10 population, signaling activity, etc. as compared to off-target cell population, signaling activity, etc. via direct or indirect interaction with the target. For example, an agent that selectively inhibits the interaction between a protein and one natural binding partner over another interaction between the protein and another binding partner, and/or such interaction(s) on a cell population of interest, inhibits the interaction at least about 5%,
 15 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 100%, 110%, 120%, 130%, 140%, 150%, 160%, 170%, 180%, 190%, 2x (times), 3x, 4x, 5x, 6x, 7x, 8x, 9x, 10x, 15x, 20x, 25x, 30x, 35x, 40x, 45x, 50x, 55x, 60x, 65x, 70x, 75x, 80x, 85x, 90x, 95x, 100x, 105x, 110x, 120x, 125x, 150x, 200x, 250x, 300x, 350x, 400x, 450x, 500x, 600x, 700x, 800x, 900x, 1000x, 1500x, 2000x, 2500x, 3000x,
 20 3500x, 4000x, 4500x, 5000x, 5500x, 6000x, 6500x, 7000x, 7500x, 8000x, 8500x, 9000x, 9500x, 10000x, or greater, or any range in between, inclusive, against at least one other binding partner. Such metrics are typically expressed in terms of relative amounts of agent required to reduce the interaction/activity by half. Such metrics apply to any other selectivity arrangement, such as binding of a nucleic acid molecule to one or more target
 25 sequences.

More generally, the term “selective” refers to a preferential action or function. The term “selective” can be quantified in terms of the preferential effect in a particular target of interest relative to other targets. For example, a measured variable (*e.g.*, modulation of biomarker expression in desired cells versus other cells, the enrichment and/or deletion of
 30 desired cells versus other cells, etc.) can be 10%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 1-fold, 1.5-fold, 2-fold, 2.5-fold, 3-fold, 3.5-fold, 4-fold, 4.5-fold, 5-fold, 5.5-fold, 6-fold, 6.5-fold, 7-fold, 7.5-fold, 8-fold, 8.5-fold, 9-fold, 9.5-fold, 10-fold, 11-fold, 12-fold, 13-fold, 14-fold, 15-fold, 16-fold, 17-fold,

18-fold, 19-fold, 20-fold, 25-fold, 30-fold, 35-fold, 40-fold, 45-fold, 50-fold, 55-fold, 60-fold, 70-fold, 80-fold, 90-fold, 100-fold, or greater or any range in between inclusive (*e.g.*, 50% to 16-fold), different in a target of interest versus unintended or undesired targets. The same fold analysis can be used to confirm the magnitude of an effect in a given tissue, cell population, measured variable, and/or measured effect, and the like, such as cell ratios, hyperproliferative cell growth rate or volume, cell proliferation rate, etc. cell numbers, and the like.

By contrast, the term “specific” refers to an exclusionary action or function. For example, specific modulation of an interaction between a protein and one binding partner refers to the exclusive modulation of that interaction and not to any significant modulation of the interaction between the protein and another binding partner. In another example, specific binding of an antibody to a predetermined antigen refers to the ability of the antibody to bind to the antigen of interest without binding to other antigens. Typically, the antibody binds with an affinity (K_D) of approximately less than 1×10^{-7} M, such as approximately less than 10^{-8} M, 10^{-9} M, 10^{-10} M, 10^{-11} M, or even lower when determined by surface plasmon resonance (SPR) technology in a BIACORE® assay instrument using an antigen of interest as the analyte and the antibody as the ligand, and binds to the predetermined antigen with an affinity that is at least 1.1, 1.2-, 1.3-, 1.4-, 1.5-, 1.6-, 1.7-, 1.8-, 1.9-, 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 6.0-, 7.0-, 8.0-, 9.0-, or 10.0-fold or greater than its affinity for binding to a non-specific antigen (*e.g.*, BSA, casein) other than the predetermined antigen or a closely-related antigen. In addition, K_D is the inverse of K_A . The phrases “an antibody recognizing an antigen” and “an antibody specific for an antigen” are used interchangeably herein with the term “an antibody which binds specifically to an antigen.”

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

intended to encompass all stereoisomers, geometric isomers, tautomers, and isotopes of a chemical structure of interest, unless otherwise indicated.

The term “subject” refers to an animal, vertebrate, mammal, or human, especially one to whom an agent is administered, *e.g.*, for experimental, diagnostic, and/or therapeutic purposes, or from whom a sample is obtained or on whom a procedure is performed. In some embodiments, a subject is a mammal, *e.g.*, a human, non-human primate, rodent (*e.g.*, mouse or rat), domesticated animals (*e.g.*, cows, sheep, cats, dogs, and horses), or other animals, such as llamas and camels. In some embodiments, the subject is human. In some embodiments, the subject is a human subject with a cancer. The term “subject” is interchangeable with “patient.”

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

The term “synergistic effect” refers to the combined effect of two or more cancer agents (*e.g.*, a modulator of biomarkers listed in Table 1 and/or Table 2 and immunotherapy combination therapy) can be greater than the sum of the separate effects of the cancer agents/therapies alone.

The term “target” refers to a gene or gene product that is modulated, inhibited, or silenced by an agent, composition, and/or formulation described herein. A target gene or gene product includes wild-type and mutant forms. Non-limiting, representative lists of targets encompassed by the present invention are provided in Table 1 and Table 2. Similarly, the term “target”, “targets”, or “targeting” used as a verb refers to modulating the activity of a target gene or gene product. Targeting can refer to upregulating or downregulating the activity of a target gene or gene product.

The term “therapeutic effect” encompasses a local or systemic effect in animals, particularly mammals, and more particularly humans, caused by a pharmacologically active

substance. The term thus means any substance intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease or in the enhancement of desirable physical or mental development and conditions in an animal or human. A prophylactic effect encompassed by the term encompasses delaying or eliminating the appearance of a disease or condition, delaying or eliminating the onset of symptoms of a disease or condition, slowing, halting, or reversing the progression of a disease or condition, or any combination thereof.

The term “effective amount” or “effective dose” of an agent (including a composition and/or formulation comprising such an agent) refers to the amount sufficient to achieve a desired biological and/or pharmacological effect, *e.g.*, when delivered to a cell or organism according to a selected administration form, route, and/or schedule. As will be appreciated by those of ordinary skill in this art, the absolute amount of a particular agent or composition that is effective can vary depending on such factors as the desired biological or pharmacological endpoint, the agent to be delivered, the target tissue, etc. Those of ordinary skill in the art will further understand that an “effective amount” can be contacted with cells or administered to a subject in a single dose, or through use of multiple doses, in various embodiments. The term “effective amount” can be a “therapeutically effective amount.”

The terms “therapeutically effective amount” refers to that amount of an agent that is effective for producing some desired therapeutic effect in at least a sub-population of cells in an animal at a reasonable benefit/risk ratio applicable to any medical treatment. Toxicity and therapeutic efficacy of subject compounds can be determined by standard pharmaceutical procedures in cell cultures or experimental animals, *e.g.*, for determining the LD₅₀ and the ED₅₀. Compositions that exhibit large therapeutic indices are preferred. In some embodiments, the LD₅₀ (lethal dosage) can be measured and can be, for example, at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 200%, 300%, 400%, 500%, 600%, 700%, 800%, 900%, 1000% or more reduced for the agent relative to no administration of the agent. Similarly, the ED₅₀ (*i.e.*, the concentration which achieves a half-maximal inhibition of symptoms) can be measured and can be, for example, at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 200%, 300%, 400%, 500%, 600%, 700%, 800%, 900%, 1000% or more increased for the agent relative to no administration of the agent. Also, Similarly, the IC₅₀ (*i.e.*, the concentration which achieves half-maximal cytotoxic or cytostatic effect on cancer cells) can be measured and can be, for

example, at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 200%, 300%, 400%, 500%, 600%, 700%, 800%, 900%, 1000% or more increased for the agent relative to no administration of the agent. In some embodiments, cancer cell growth in an assay can be inhibited by at least about 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%,
 5 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, or even 100%. In another embodiment, at least about a 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, or even 100% decrease in a solid malignancy can be achieved.

The term “tolerance” or “unresponsiveness” includes refractivity of cells, such as immune cells, to stimulation, *e.g.*, stimulation via an activating receptor or a cytokine.
 10 Unresponsiveness can occur, *e.g.*, because of exposure to immunosuppressants or exposure to high doses of antigen. Several independent methods can induce tolerance. One mechanism is referred to as “anergy,” which is defined as a state where cells persist *in vivo* as unresponsive cells rather than differentiating into cells having effector functions. Such refractivity is generally antigen-specific and persists after exposure to the tolerizing antigen
 15 has ceased. For example, anergy in T cells is characterized by lack of cytokine production, *e.g.*, IL-2. T cell anergy occurs when T cells are exposed to antigen and receive a first signal (a T cell receptor or CD-3 mediated signal) in the absence of a second signal (a costimulatory signal). Under these conditions, reexposure of the cells to the same antigen (even if reexposure occurs in the presence of a costimulatory polypeptide) results in failure
 20 to produce cytokines and, thus, failure to proliferate. Anergic T cells can, however, proliferate if cultured with cytokines (*e.g.*, IL-2). For example, T cell anergy can also be observed by the lack of IL-2 production by T lymphocytes as measured by ELISA or by a proliferation assay using an indicator cell line. Alternatively, a reporter gene construct can be used. For example, anergic T cells fail to initiate IL-2 gene transcription induced by a
 25 heterologous promoter under the control of the 5' IL-2 gene enhancer or by a multimer of the AP1 sequence that can be found within the enhancer (Kang *et al.* (1992) *Science* 257:1134). Another mechanism is referred to as “exhaustion.” T cell exhaustion is a state of T cell dysfunction that arises during many chronic infections and cancer. It is defined by poor effector function, sustained expression of inhibitory receptors and a transcriptional
 30 state distinct from that of functional effector or memory T cells.

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

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

The term “treat” refers to the therapeutic management or improvement of a condition (*e.g.*, a disease or disorder) of interest. Treatment can include, but is not limited to, administering an agent or composition (*e.g.*, a pharmaceutical composition) to a subject. Treatment is typically undertaken in an effort to alter the course of a disease (which term is used to indicate any disease, disorder, syndrome or undesirable condition warranting or potentially warranting therapy) in a manner beneficial to the subject. The effect of treatment can include reversing, alleviating, reducing severity of, delaying the onset of, curing, inhibiting the progression of, and/or reducing the likelihood of occurrence or recurrence of the disease or one or more symptoms or manifestations of the disease. Desirable effects of treatment include, but are not limited to, preventing occurrence or recurrence of disease, alleviation of symptoms, diminishment of any direct or indirect pathological consequences of the disease, preventing metastasis, decreasing the rate of disease progression, amelioration or palliation of the disease state, and remission or improved prognosis. A therapeutic agent can be administered to a subject who has a disease or is at increased risk of developing a disease relative to a member of the general population. In some embodiments, a therapeutic agent can be administered to a subject who has had a disease but no longer shows evidence of the disease. The agent can be administered *e.g.*, to reduce the likelihood of recurrence of evident disease. A therapeutic agent can be administered prophylactically, *i.e.*, before development of any symptom or manifestation of a disease. “Prophylactic treatment” refers to providing medical and/or surgical management to a subject who has not developed a disease or does not show evidence of a disease in order, *e.g.*, to reduce the likelihood that the disease will occur or to reduce the severity of the disease should it occur. The subject can have been identified as being at risk of developing the disease (*e.g.*, at increased risk relative to the general population or as having a risk factor that increases the likelihood of developing the disease).

The term “unresponsiveness” includes refractivity of cancer cells to therapy or refractivity of therapeutic cells, such as immune cells, to stimulation, *e.g.*, stimulation via an activating receptor or a cytokine. Unresponsiveness can occur, *e.g.*, because of exposure to immunosuppressants or exposure to high doses of antigen. As used herein, the term “anergy” or “tolerance” includes refractivity to activating receptor-mediated stimulation. Such refractivity is generally antigen-specific and persists after exposure to the tolerizing

antigen has ceased. For example, anergy in T cells (as opposed to unresponsiveness) is characterized by lack of cytokine production, *e.g.*, IL-2. T cell anergy occurs when T cells are exposed to antigen and receive a first signal (a T cell receptor or CD-3 mediated signal) in the absence of a second signal (a costimulatory signal). Under these conditions,

5 reexposure of the cells to the same antigen (even if reexposure occurs in the presence of a costimulatory polypeptide) results in failure to produce cytokines and, thus, failure to proliferate. Anergic T cells can, however, proliferate if cultured with cytokines (*e.g.*, IL-2). For example, T cell anergy can also be observed by the lack of IL-2 production by T lymphocytes as measured by ELISA or by a proliferation assay using an indicator cell line.
10 Alternatively, a reporter gene construct can be used. For example, anergic T cells fail to initiate IL-2 gene transcription induced by a heterologous promoter under the control of the 5' IL-2 gene enhancer or by a multimer of the AP1 sequence that can be found within the enhancer (Kang *et al.* (1992) *Science* 257:1134).

The term "vaccine" refers to a composition for generating immunity for the
15 prophylaxis and/or treatment of diseases.

II. Myeloid-derived cells, CCR2, and CSF1R

Myeloid-derived cells

Hematopoietic stem cells (HSCs) give rise to committed lymphoid
20 or myeloid progenitor cells. Myeloid progenitor cells in turn give rise to myeloid-derived cells, which include monocytes, myeloid dendritic, myeloid erythroid, erythroid, megakaryocytes, granulocyte/macrophage, granulocyte, and macrophage cells. The term "myeloid-derived cells" can refer to a granulocyte or monocyte precursor cell in bone marrow or spinal cord, or a resemblance to
25 those found in the bone marrow or spinal cord. The myeloid cell lineage includes circulating monocytic cells in the peripheral blood and the cell populations that they become following maturation, differentiation, and/or activation. These populations include non-terminally differentiated myeloid cells, myeloid derived suppressor cells, and differentiated macrophages. Differentiated macrophages include non-polarized and
30 polarized macrophages, resting and activated macrophages. Without being limiting, the myeloid lineage can also include granulocytic precursors, polymorphonuclear derived suppressor cells, differentiated polymorphonuclear white blood cells, neutrophils,

granulocytes, basophils, eosinophils, monocytes, macrophages, microglia, myeloid derived suppressor cells, dendritic cells and erythrocytes.

The term “committed myeloid progenitor cells” refers to cell populations capable of differentiating into any of the terminally differentiated cells of the myeloid lineage.

5 Encompassed within the myeloid progenitor cells are the common myeloid progenitor cells (CMP), a cell population characterized by limited or non-self-renewal capacity but which is capable of cell division to form granulocyte/macrophage progenitor cells (GMP) and megakaryocyte/erythroid progenitor cells (MEP). The marker phenotypes useful for identifying CMPs include those commonly known in the art. For CMP cells of murine
10 origin, the cell population is characterized by the marker phenotype c-Kit^{high} (CD117) CD16^{low} CD34^{low} Sca-1^{neg} Lin^{neg} and further characterized by the marker phenotypes FcyR^{lo} IL-7R^{neg} (CD127). The murine CMP cell population is also characterized by the absence of expression of markers that include B220, CD4, CD8, CD3, Ter119, Gr-1 and Mac-1. For CMP cells of human origin, the cell population is characterized by
15 CD34⁺CD38⁺ and further characterized by the marker phenotypes CD123⁺ (IL-3R α) CD45RA^{neg}. The human CMP cell population is also characterized by the absence of cell markers CD3, CD4, CD7, CD8, CD10, CD11b, CD14, CD19, CD20, CD56, and CD234a. Descriptions of marker phenotypes for various myeloid progenitor cells are described in, for example, U.S. Pat. Nos. 6,465,247 and 6,761,883.

20 Granulocyte/macrophage progenitor cell (GMP). The cells of this progenitor cell population are characterized by their capacity to give rise to granulocytes (*e.g.*, basophils, eosinophils, and neutrophils) and macrophages. Similar to other committed progenitor cells, GMPs lack self-renewal capacity. Murine GMPs are characterized by the marker phenotype c-Kit^{hi} (CD117) Sca-1^{neg} Fc γ R^{hi} (CD16) IL-7R^{neg} CD34^{pos}. Murine GMPs also
25 lack expression of markers B220, CD4, CD8, CD3, Gr-1, Mac-1, and CD90. Human GMPs are characterized by the marker phenotype CD34⁺CD38⁺CD123⁺CD45RA⁺. Human GMP cell populations are also characterized by the absence of markers CD3, CD4, CD7, CD8, CD10, CD11b, CD14, CD19, CD20, CD56, and CD235a.

30 Megakaryocyte/erythroid progenitor cells (MEP), which are derived from the CMPs, are characterized by their capability of differentiating into committed megakaryocyte progenitor and erythroid progenitor cells. Mature megakaryocytes are polyploid cells that are precursors for formation of platelets, a developmental process regulated by thrombopoietin. Erythroid cells are formed from the

committed erythroid progenitor cells through a process regulated by erythropoietin, and ultimately differentiate into mature red blood cells. Murine MEPs are characterized by cell marker phenotype c-Kit^{hi} and IL-7Ra^{neg} and further characterized by marker phenotypes FcyR^{lo} and CD34^{low}. Murine MEP cell populations are also characterized by the absence of markers B220, CD4, CD8, CD3, Gr-1, and CD90. Another exemplary marker phenotype for mouse MEPs is c-kit^{high} Sca-1^{neg} Lin^{neg/low} CD16^{low} CD34^{low}. Human MEPs are characterized by marker phenotypes CD34⁺ CD38⁺ CD123^{neg} CD45RA^{neg}. Human MEP cell populations are also characterized by the absence of markers CD3, CD4, CD7, CD8, CD10, CD11b, CD14, CD19, CD20, CD56, and CD235a.

Further restricted progenitor cells in the myeloid lineage are the granulocyte progenitor, macrophage progenitor, megakaryocyte progenitor, and erythroid progenitor. Granulocyte progenitor cells are characterized by their capability to differentiate into terminally differentiated granulocytes, including eosinophils, basophils, neutrophils. The GPs typically do not differentiate into other cells of the myeloid lineage. With regards to the megakaryocyte progenitor cell (MKP), these cells are characterized by their capability to differentiate into terminally differentiated megakaryocytes but generally not other cells of the myeloid lineage (see, e.g., PCT Publ. No. WO 2004/024875).

Monocytes and Macrophages

In some embodiments, the myeloid-derived cells of interest are monocytes and/or macrophages.

The term “monocytes” refers to a leukocyte that can differentiate into macrophages and myeloid dendritic cells. Monocytes are found among peripheral blood mononuclear cells (PBMCs), which also comprise other hematopoietic and immune cells, such as B cells, T cells, NK cells, and the like. Monocytes are produced by the bone marrow from hematopoietic stem cell precursors called monoblasts. Monocytes have two main functions in the immune system: (1) they can exit the bloodstream to replenish resident macrophages and dendritic cells (DCs) under normal states, and (2) they can quickly migrate to sites of infection in the tissues and divide/differentiate into macrophages and inflammatory dendritic cells to elicit an immune response in response to inflammation signals. Monocytes are usually identified in stained smears by their large bilobate nucleus. Monocytes also express chemokine receptors and pathogen recognition receptors that mediate migration from blood to tissues during infection. They produce inflammatory

cytokines and phagocytose cells. There are at least three types of monocytes in humans, including 1) classical monocytes, which are characterized by high level expression of CD14 cell surface receptor (CD14⁺⁺ CD16⁻ monocytes), 2) non-classical monocytes, which are characterized by low level expression of CD14 and additional co-expression of the CD16 receptor (CD14⁺CD16⁺⁺ monocyte), and 3) intermediate monocytes, which are characterized by high level expression of CD14 and low level expression of CD16 (CD14⁺⁺CD16⁺ monocytes).

Macrophages are critical immune effectors and regulators of inflammation and the innate immune response. Macrophages are heterogeneous, tissue-resident, terminally-differentiated, innate myeloid cells, which have remarkable plasticity and can change their physiology in response to local cues from the microenvironment and can assume a spectrum of functional requirements from host defense to tissue homeostasis (Ginhoux *et al.* (2016) *Nat. Immunol.* 17:34-40). Macrophages are present in virtually all tissues in the body. They are either tissue resident macrophages, for example Kupffer cells that reside in liver, or derived from circulating monocytic precursors (*i.e.*, monocytes) which mainly originate from bone marrow and spleen reservoirs and migrate into tissue in the steady state or in response to inflammation or other stimulating cues. For example, monocytes can be recruited from the blood to tissue to replenish tissue specific macrophages of the bone, alveoli (lung), central nervous system, connective tissues, gastrointestinal tract, liver, spleen and peritoneum.

The term “tissue-resident macrophages” refers to a heterogeneous populations of immune cells that fulfill tissue-specific and/or micro-anatomical niche-specific functions such as tissue immune-surveillance, response to infection and the resolution of inflammation, and dedicated homeostatic functions. Tissue resident macrophages originate in the yolk sac of the embryo and mature in one particular tissue in the developing fetus, where they acquire tissue-specific roles and change their gene expression profile. Local proliferation of tissue resident macrophages, which maintain colony-forming capacity, can directly give rise to populations of mature macrophages in the tissue. Tissue resident macrophages can also be identified and named according to the tissues they occupy. For example, adipose tissue macrophages occupy adipose tissue, Kupffer cells occupy liver tissue, sinus histiocytes occupy lymph nodes, alveolar macrophages (dust cells) occupy pulmonary alveoli, Langerhans cells occupy skin and mucosal tissue, histiocytes leading to giant cells occupy connective tissue, microglia occupy central nervous system (CNS) tissue,

Hofbauer cells occupy placental tissue, intraglomerular mesangial cells occupy kidney tissue, osteoclasts occupy bone tissue, epithelioid cells occupy granulomas, red pulp macrophages (sinusoidal lining cells) occupy the red pulp of spleen tissue, peritoneal cavity macrophages occupy peritoneal cavity tissue, lysomac cells occupy Peyer's patch tissue, and pancreatic macrophages occupy pancreatic tissue.

Macrophages, in addition to host defense against infectious agents and other inflammation reaction, can perform different homeostatic functions, including but not limited to, development, wound healing and tissue repairing, and regulation of immune response. Macrophages, first recognized as phagocytosis cells in the body which defend infections through phagocytosis, are essential components of innate immunity. In response to pathogens and other inflammation stimuli, activated macrophages can engulf infected bacteria and other microbes; stimulate inflammation and release a cocktail of pro-inflammatory molecules to these intracellular microorganisms. After engulfing the pathogens, macrophages present pathogenic antigens to T cells to further activate adaptive immune response for defense. Exemplary pro-inflammatory molecules include cytokines IL-1 β , IL-6 and TNF- α , chemokine MCP-1, CXC-5 and CXC-6, and CD40L.

In addition to their contribution to host defense against infections, macrophages play vital homeostatic roles, independent of their involvement in immune responses. Macrophages are prodigious phagocytic cells that clear erythrocytes and the released substances such as iron and hemoglobin can be recycled for the host to reuse. This clearance process is a vital metabolic contribution without which the host would not survive.

Macrophages are also involved in the removal of cellular debris that is generated during tissue remodeling, and rapidly and efficiently clear cells that have undergone apoptosis. Macrophages are believed to be involved in steady-state tissue homeostasis via the clearance of apoptotic cells. These homeostatic clearance processes are generally mediated by surface receptors on macrophages including scavenger receptors, phosphatidyl serine receptors, the thrombospondin receptor, integrins and complement receptors. These receptors that mediate phagocytosis either fail to transduce signals that induce cytokine-gene transcription or actively produce inhibitory signals and/or cytokines. The homeostatic function of macrophages is independent of other immune cells.

Macrophages can also clear cellular debris/necrotic cells that results from trauma or other damages to cells. Macrophages detect the endogenous danger signals that are present

in the debris of necrotic cells through toll-like receptors (TLRs), intracellular pattern-recognition receptors and the interleukin-1 receptor (IL-1R), most of which signal through the adaptor molecule myeloid differentiation primary-response gene 88 (MyD88). The clearance of cellular debris can markedly alter the physiology of macrophages.

5 Macrophages that clear necrosis can undergo dramatic changes in their physiology, including alterations in the expression of surface proteins and the production of cytokines and pro-inflammatory mediators. The alterations in macrophage surface-protein expression in response to these stimuli could potentially be used to identify biochemical markers that are unique to these altered cells.

10 Macrophages have important functions in maintaining homeostasis in many tissues such as white adipose tissue, brown adipose tissue, liver and pancreas. Tissue macrophages can quickly respond to changing conditions in a tissue, by releasing cell signaling molecules that trigger a cascade of changes allowing tissue cells to adapt. For instance, macrophages in adipose tissue regulate the production of new fat cells in response to
15 changes in diet (*e.g.*, macrophages in white adipose tissue) or exposure to cold temperatures (*e.g.*, macrophages in brown adipose tissue). Macrophages in the liver, known as Kupffer cells, regulate the breakdown of glucose and lipids in response to dietary changes. Macrophages in pancreas can regulate insulin production in response to high fat diet.

 Macrophages can also contribute to wound healing and tissue repair. For example,
20 macrophages, in response to signals derived from injured tissues and cells, can be activated and induce a tissue-repair response to repair damaged tissue (Minutti *et al.* (2017) *Science* 356:1076-1080).

 During embryonic development, macrophages also play a key role in tissue remodeling and organ development. For example, resident macrophages actively shape the
25 development of blood vessels in neonatal mouse hearts (Leid *et al.* (2016) *Circ. Res.* 118:1498-1511). Microglia in the brain can produce growth factors that guide neurons and blood vessels in developing brain during embryonic development. Similarly, CD95L, a macrophage-produced protein, binds to CD95 receptors on the surface of neurons and developing blood vessels in the brains of mouse embryos and increases neuron and blood
30 vessel development (Chen *et al.* (2017) *Cell Rep.* 19:1378-1393). Without the ligand, neurons branch less frequently, and the resulting adult brain exhibits less electrical activity. Monocyte-derived cells known as osteoclasts are involved in bone development, and mice that lack these cells develop dense, hardened bones—a rare condition known as

osteopetrosis. Macrophages also orchestrate development of the mammary gland and assist in retinal development in the early postnatal period (Wynn *et al.* (2013) *Nature* 496:445-455).

As described above, macrophages regulate immune systems. In addition to the presentation of antigens to T cells, macrophages can provide immunosuppressive/inhibitory signals to immune cells in some conditions. For example, in the testis, macrophages help create a protective environment for sperm from being attacked by the immune system. Tissue resident macrophages in the testis produce immunosuppressant molecules that prevent immune cell reaction against sperm (Mossadegh-Keller *et al.* (2017) *J. Exp. Med.* 214:10.1084/jem.20170829).

The plasticity of macrophages in response to different environment signals and in agreement with their functional requirements has resulted in a spectrum of macrophage activation states, including two extremes of the continuum, namely “classically activated” M1 and “alternatively activated” M2 macrophages.

The term “activation” refers to the state of a monocyte and/or macrophage that has been sufficiently stimulated to induce detectable cellular proliferation and/or has been stimulated to exert its effector function, such as induced cytokine expression and secretion, phagocytosis, cell signaling, antigen processing and presentation, target cell killing, and pro-inflammatory function.

The term “M1 macrophages” or “classically activated macrophages” refers to macrophages having a pro-inflammatory phenotype. The term “macrophage activation” (also referred to as “classical activation”) was introduced by Mackaness in the 1960s in an infection context to describe the antigen-dependent, but non-specific enhanced, microbicidal activity of macrophages toward BCG (bacillus Calmette-Guerin) and *Listeria* upon secondary exposure to the pathogens (Mackaness (1962) *J. Exp. Med.* 116:381-406). The enhancement was later linked with Th1 responses and IFN- γ production by antigen-activated immune cells (Nathan *et al.* (1983) *J. Exp. Med.* 158:670-689) and extended to cytotoxic and antitumoral properties (Pace *et al.* (1983) *Proc. Natl. Acad. Sci. U.S.A.* 80:3782-3786; Celada *et al.* (1984) *J. Exp. Med.* 160:55-74). Therefore, any macrophage functionality that enhances inflammation by cytokine secretion, antigen presentation, phagocytosis, cell-cell interactions, migration, etc. is considered pro-inflammatory. *In vitro* and *in vivo* assays can measure different endpoints: general *in vitro* measurements include pro-inflammatory cell stimulation as measured by proliferation, migration, pro-

inflammatory Th1 cytokine/chemokine secretion and/or migration, while general *in vivo* measurements further include analyzing pathogen fighting, tissue injury immediate responders, other cell activators, migration inducers, etc. For both *in vitro* and *in vivo*, pro-inflammatory antigen presentation can be assessed. Bacterial moieties, such as

5 lipopolysaccharide (LPS), certain Toll-like receptor (TLR) agonists, the Th1 cytokine interferon-gamma (IFN γ) (*e.g.*, IFN γ produced by NK cells in response to stress and infections, and T helper cells with sustained production) and TNF polarize macrophages along the M1 pathway. Activated M1 macrophages phagocytose and destroy microbes, eliminate damaged cells (*e.g.*, tumor cells and apoptotic cells), present antigen to T cells for

10 increasing adaptive immune responses, and produce high levels of pro-inflammatory cytokines (*e.g.*, IL-1, IL-6, and IL-23), reactive oxygen species (ROS), and nitric oxide (NO), as well as activate other immune and non-immune cells. Characterized by their expression of inducible nitric oxide synthase (iNOS), reactive oxygen species (ROS), and production of the Th1-associated cytokine, IL-12, M1 macrophages are well-adapted to

15 promote a strong immune response. The metabolism of M1 macrophages is characterized by enhanced aerobic glycolysis, converting glucose into lactate, increased flux through the pentose phosphate pathway (PPP), fatty acid synthesis, and a truncated tricarboxylic acid (TCA) cycle, leading to accumulation of succinate and citrate.

A “Type 1” or “M1-like” monocyte and/or macrophage is a monocyte and/or

20 macrophage capable of contributing to a pro-inflammatory response that is characterized by at least one of the following: producing inflammatory stimuli by secreting at least one pro-inflammatory cytokine, expressing at least one cell surface activating molecule/a ligand for an activating molecule on its surface, recruiting/instructing/interacting with at least one other cell (including other macrophages and/or T cells) to stimulate pro-inflammatory

25 responses, presenting antigen in a pro-inflammatory context, migrating to the site allowing for pro-inflammatory response initiation or starting to express at least one gene that is expected to lead to pro-inflammatory functionality. In some embodiments, the term includes activating cytotoxic CD8⁺ T cells, mediating increased sensitivity of cancer cells to immunotherapy, such as immune checkpoint therapy, and/or mediating reversal of cancer

30 cells to resistance. In certain embodiments, such modulation toward a pro-inflammatory state can be measured in a number of well-known manners, including, without limitation, one or more of a) increased cluster of differentiation 80 (CD80), CD86, MHCII, MHCI, interleukin 1-beta (IL-1 β , IL-6, CCL3, CCL4, CXCL10, CXCL9, GM-CSF and/or tumor

necrosis factor alpha (TNF- α); b) decreased expression of CD206, CD163, CD16, CD53, VSIG4, PSGL-1, TGF β and/or IL-10; c) increased secretion of at least one cytokine or chemokine selected from the group consisting of IL-1 β , TNF- α , IL-12, IL-18, GM-CSF, CCL3, CCL4, and IL-23; d) increased ratio of expression of IL-1 β , IL-6, and/or TNF- α to expression of IL-10; e) increased CD8⁺ cytotoxic T cell activation; f) increased recruitment of CD8⁺ cytotoxic T cell activation; g) increased CD4⁺ helper T cell activity; h) increased recruitment of CD4⁺ helper T cell activity; i) increased NK cell activity; j) increased recruitment of NK cell; k) increased neutrophil activity; l) increased macrophage activity; and/or m) increased spindle-shaped morphology, flatness of appearance, and/or number of dendrites, as assessed by microscopy.

In cells that are already pro-inflammatory, an increased inflammatory phenotype refers to an even more pro-inflammatory state.

By contrast, the term “M2 macrophages” refers to macrophages having an anti-inflammatory phenotype. Th2- and tumor-derived cytokines, such as IL-4, IL-10, IL-13, transforming growth factor beta (TGF- β), or prostaglandin E2 (PGE2) can promulgate M2 polarization. The metabolic profile of M2 macrophages is defined by OXPHOS, FAO, a decreased glycolysis, and PPP. The discovery that the mannose receptor was selectively enhanced by the Th2 IL-4 and IL-13 in murine macrophages, and induced high endocytic clearance of mannosylated ligands, increased major histocompatibility complex (MHC) class II antigen expression, and reduced pro-inflammatory cytokine secretion, led Stein, Doyle, and colleagues to propose that IL-4 and IL-13 induced an alternative activation phenotype, a state altogether different from IFN- γ activation but far from deactivation (Martinez and Gordon (2014) *F1000 Prime Reports* 6:13). *In vitro* and *in vivo* definition/assays can measure different endpoints: general *in vitro* endpoints include anti-inflammatory cell stimulation measured by proliferation, migration, anti-inflammatory Th2 cytokine/chemokine secretion and/or migration, while general *in vivo* M2 endpoints further include analyzing pathogen fighting, tissue injury delayed/pro-fibrotic response, other cell Th2 polarization, migration inducers, etc. For both *in vitro* and *in vivo*, pro-tolerogenic antigen presentation can be assessed.

A “Type 2” or “M2-like” monocyte and/or macrophage is a monocyte and/or macrophage capable of contributing to an anti-inflammatory response that is characterized by at least one of the following: producing anti-inflammatory stimuli by secreting at least one anti-inflammatory cytokine, expressing at least one cell surface inhibiting

molecule/ligand for an inhibitory molecule on its surface, recruiting/instructing/interacting at least one other cell to stimulate anti-inflammatory responses, presenting antigen in a pro-tolerogenic context, migrating to the site allowing for pro-tolerogenic response initiation or starting to express at least one gene that is expected to lead to pro-tolerogenic/anti-inflammatory functionality. In certain embodiments, such modulation toward a pro-inflammatory state can be measured in a number of well-known manners, including, without limitation, the opposite of the Type 1 pro-inflammatory state measurements described above.

A cell that has an “increased inflammatory phenotype” is one that has a more pro-inflammatory response capacity related to a) an increase in one or more of the Type 1 listed-criteria and /or b) a decrease in one or more of the Type 2-listed criteria, after modulation of at least one biomarker (*e.g.*, at least one target listed in Table 1 and/or Table 2) of the present invention, such as contact by an agent that modulates the at least one biomarker (*e.g.*, at least one target listed in Table 1 and/or Table 2) of the present invention.

A cell that has a “decreased inflammatory phenotype” is one that has a more anti-inflammatory response capacity related to a) an decrease in one or more of the Type 1 listed-criteria and /or b) an increase of one or more of the Type 2-listed criteria, after modulation of at least one biomarker (*e.g.*, at least one target listed in Table 1 and/or Table 2) of the present invention, such as contact by an agent that modulates the at least one biomarker (*e.g.*, at least one target listed in Table 1 and/or Table 2) of the present invention.

Thus, macrophages can adopt a continuum of alternatively activated states with intermediate phenotypes between the Type 1 and Type 2 states (see, *e.g.*, Biswas *et al.* (2010) *Nat. Immunol.* 11: 889–896; Mosser and Edwards (2008) *Nat. Rev. Immunol.* 8:958–969; Mantovani *et al.* (2009) *Hum. Immunol.* 70:325–330) and such increased or decreased inflammatory phenotypes can be determined as described above.

As used herein, the term “alternatively activated macrophages” or “alternatively activated states” refers to essentially all types of macrophage populations other than the classically activated M1 pro-inflammatory macrophages. Originally, the alternatively activated state was designated only to M2 type anti-inflammatory macrophages. The term has expanded to include all other alternative activation states of macrophages with dramatic difference in their biochemistry, physiology and functionality.

For example, one type of alternatively activated macrophages is those involved in wound healing. In response to innate and adaptive signals released during tissue injury

(*e.g.*, surgical wound), such as IL-4 produced by basophils and mast cells, tissue-resident macrophages can be activated to promote wound healing. The wound healing macrophages, instead of producing high levels of pro-inflammatory cytokines, secrete large amounts of extracellular matrix components, *e.g.*, chitinase and chitinase-like proteins

5 YM1/CHI3L3, YM2, AMCase and stabilin, all of which exhibit carbohydrate and matrix-binding activities and involve in tissue repair.

Another example of alternatively activated macrophages involves regulatory macrophages that can be induced by innate and adaptive immune response. Regulatory macrophages can contribute to immuno-regulatory function. For example, macrophages

10 can respond to hormones from the hypothalamic-pituitary-adrenal (HPA) axis (*e.g.*, glucocorticoids) to adopt a state with inhibited host defense and inflammatory function such as inhibition of the transcriptions of pro-inflammatory cytokines. Regulatory macrophages can produce regulatory cytokine TGF- β to dampen immune responses in certain conditions, for instance, at late stage of adaptive immune response. Many regulatory macrophages can

15 express high levels of co-stimulatory molecules (*e.g.*, CD80 and CD86) and therefore enhance antigen presentation to T cells.

Many stimuli/cues can induce polarization of regulatory macrophages. The cues can include, but are not limited to, the combination of TLR agonist and immune complexes, apoptotic cells, IL-10, prostaglandins, GPCR ligands, adenosine, dopamine, histamine,

20 sphingosine1-phosphate, melanocortin, vasoactive intestinal peptides and Siglec-9. Some pathogens, such as parasites, viruses, and bacteria, can specifically induce the differentiation of regulatory macrophages, resulting in defective pathogen killing and enhanced survival and spread of the infected microorganisms.

Regulatory macrophages share some common features. For example, regulatory

25 macrophages need two stimuli to induce their anti-inflammatory activity. Differences among the regulatory macrophage subpopulations that are induced by different cues/stimuli are also observed, reflecting their heterogeneity.

Regulatory macrophages also are a heterogeneous population of macrophages, including a variety of subpopulations found in metabolism, during development, in the

30 maintenance of homeostasis. In one example, a subpopulation of alternatively activated macrophages are immunoregulatory macrophages with unique immunoregulatory properties which can be induced in the presence of M-CSF/GM-CSF, a CD16 ligand (such as an immunoglobulin), and IFN- γ (PCT Publ. No. WO 2017/153607).

Macrophages in a tissue can change their activation states *in vivo* over time. This dynamic reflects constant influx of migrating macrophages to the tissue, dynamic changes of activated macrophages, and macrophages that switch back the rest state. In some conditions, different signals in an environment can induce macrophages to a mix of different activation states. For example, in a condition with chronic wound, macrophages over time, can include pro-inflammatory activation subpopulation, macrophages that are pro-wound healing, and macrophages that exhibit some pro-resolving activities. Under non-pathological conditions, a balanced population of immune-stimulatory and immune-regulatory macrophages exist in the immune system. In some disease conditions, the balance is interrupted and the imbalance causes many clinical conditions.

The apparent plasticity of macrophages also make them vulnerably responsive to environmental cues they receive in a disease condition. Macrophages can be repolarized in response to a variety of disease conditions, demonstrating distinct characteristics. One example is macrophages that are attracted and filtrate into tumor tissues from peripheral blood monocytes, which are often called “tumor associated macrophages” (“TAMs”) or “tumor infiltrating macrophages” (“TIMs”). Tumor-associated macrophages are amongst the most abundant inflammatory cells in tumors and a significant correlation was found between high TAM density and a worse prognosis for most cancers (Zhang *et al.* (2012) *PloS One* 7:e50946.10.1371/journal.pone.0050946).

TAMs are a mixed population of both M1-like pro-inflammatory and M2-like anti-inflammatory subpopulations. In the earliest stage of neoplasia, classically activated macrophages that have a pro-inflammatory phenotype are present in the normoxic tumor regions, are believed to contribute to early eradication of transformed tumor cells. However, as a tumor grows and progresses, the majority of TAMs in late stage tumors is M2-like regulatory macrophages that reside in the hypoxic regions of the tumor. This phenotypic change of macrophages is markedly influenced by the tumor microenvironmental stimuli, such as tumor extracellular matrix, anoxic environment and cytokines secreted by tumor cells. The M2-like TAMs demonstrate a hybrid activation state of wound healing macrophages and regulatory macrophages, demonstrating various unique characteristics, including the production of high levels of IL-10 but little or no IL-12, defective TNF production, suppression of antigen presenting cells, and contribution to tumor angiogenesis.

Generally, TAMs are characterized by a M2 phenotype and suppress M1 macrophage-mediated inflammation through IL-10 and IL-1 β production. Thus, TAMs promote tumor growth and metastasis through activation of wound-healing (*i.e.*, anti-inflammatory) pathways that provide nutrients and growth signals for proliferation and invasion and promote the creation of new blood vessels (*i.e.*, angiogenesis). In addition, TAMs contribute to the immune-suppressive tumor microenvironment by secreting anti-inflammatory signals that prevent other components of the immune system from recognizing and attacking the tumor. It has been reported that TAMs are key players in promoting cancer growth, proliferation, and metastasis in many types of cancers (*e.g.*, breast cancer, astrocytoma, head and neck squamous cell cancer, papillary renal cell carcinoma Type II, lung cancer, pancreatic cancer, gall bladder cancer, rectal cancer, glioma, classical Hodgkin's lymphoma, ovarian cancer, and colorectal cancer). In general, a cancer characterized by a large population of TAMs is associated with poor disease prognosis.

The diversified functions and activation states can have dangerous consequences if not appropriately regulated. For example, classically activated macrophages can cause damage to host tissue, predispose surrounding tissue and influence glucose metabolism if over activated.

In many disease conditions, the balanced dynamics of macrophage activation states is interrupted and the imbalance causes diseases. For example, tumors are abundantly populated with macrophages. Macrophages can be found in 75 percent of cancers. The aggressive types of cancer are often associated with higher infiltration of macrophages and other immune cells. In most malignant tumors, TAM exert several tumor-promoting functions, including promotion of cancer cell survival, proliferation, invasion, extravasation and metastasis, stimulation of angiogenesis, remodeling of the extracellular matrix, and suppression of antitumor immunity (Qian and Pollard, 2010, *Cell*, 141(1): 39-51). They also could produce growth-promoting molecules such as ornithine, VEGF, EGF and TGF- β .

TAMs stimulate tumor growth and survival in response to CSF1 and IL4/IL13 encountered in the tumor microenvironment. TAMs also can remodel the tumor microenvironment through the expression of proteases, such as MMPs, cathepsins and uPA and matrix remodeling enzymes (*e.g.*, lysyl oxidase and SPARC).

TAMs play an important role in tumor angiogenesis regulating the dramatic increase of blood vessel in tumor tissues which is required for the transition of the malignant state of tumor. These angiogenic TAMs express angiopoietin receptor, TIE2 and secrete many angiogenic molecules including VEGF family members, TNF α , IL1 β , IL8, PDGF and FGF.

5 A diversity of subpopulations of macrophages perform these individual pro-tumoral functions. These TAMs are different in the extent of macrophage infiltrate as well as phenotype in different tumor types. For example, detailed profiling in human hepatocellular carcinoma shows various macrophage sub-types defined in terms of their anatomic location, and pro-tumoral and anti-tumoral properties. It has been shown that
10 M2-like macrophages are a major resource of pro-tumoral functions of TAMs. M2-like TAMs have been shown to affect the efficacy of anti-cancer treatments, contribute to therapy resistance, and mediate tumor relapse following conventional cancer therapy.

Dysregulated monocytes and/or macrophages have been found in a variety of disorders such as autoimmune diseases, chronic inflammation, multiple sclerosis,
15 rheumatoid arthritis, atherosclerosis, Type I diabetes, Type II diabetes, obesity, allergy, asthma, hemophagocytic lymphohistiocytosis, sarcoidosis, periodontitis, pulmonary alveolar proteinosis, macrophage-related pulmonary disease, cardiovascular diseases, microbial infection, transplant-related complications, metabolic syndrome, hypertension, and inflammatory neurological diseases. Monocytes and macrophages are potential
20 therapeutic targets for those macrophage mediated diseases.

CCR2 and CSF1R as myeloid-derived cell targets

CCR2 (C-C chemokine receptor 2; also known as CCR2A, CCR2B, CD192, CMKBR2 and CKR2) is a G protein-coupled receptor expressed on cell surface that can be
25 activated by multiple chemokines known as macrophage chemoattractant proteins including CCL2 (MCP-1), CCL8 (MCP-2), CCL7 (MCP-3), CCL13 (MCP-4) and CCL16 in human (Charo *et al.* (1994) *Proc. Natl. Acad. Sci. U.S.A.* 91:2752-2756). Activation of CCR2 results in directional migration of receptor-bearing cell types such as monocytes, dendritic cells and macrophages. CCR2 plays an important role in immune cell trafficking,
30 especially for recruiting circulating bone marrow derived monocytes to inflammatory sites and subsequent transformation to macrophages or dendritic cells. For example, CCR2 activation is deeply involved in cancer metastatic process by increasing the migration and invasion of monocytes from the bone marrow to cancer tissues). It has been shown that

tumor cells can express CCL2, which attracts CCR2-positive monocytes and macrophages to the tumor area. The infiltrated macrophages, under the influence of tumor microenvironments, are adapted to tumor-promoting functions. CCR2 signaling cascades are also involved in numerous inflammatory diseases and neurodegenerative disorders, as well as cardiovascular disorders such as atherosclerosis and myocardial infarction (see Franca *et al.* (2017) *Clin. Sci.* 131:1215-1224). CCR2 is also a co-receptor for HIV (Conner *et al.* (1997) *J. Exp. Med.* 185:621-628).

Due to the involvement of CCR2 and its ligand CCL2/MCP-1 in undesirable immune responses in various diseases, it has been recognized that CCR2 antagonists are promising therapeutic agents in preventing, treating, or ameliorating a macrophage-mediated inflammatory disease, such as cancer. For example, a CCR antagonist can suppress the proliferation, migration and invasion of human lung adenocarcinoma cells (An *et al.* (2017) *Oncotarget* 8:39230-39240). Blocking CCL2/CCR2 axis can suppress TAMs and activate anti-tumor immune response in cancers such as hepatocellular carcinoma (Li *et al.* (2017) *Gut* 66:157-167).

CSF1R (colony stimulating factor 1 receptor; also known as macrophage colony-stimulating factor receptor (M-CSFR), FMS, FIM2, C-FMS, and CD115 in the art) is a single-pass transmembrane receptor with an N-terminal extracellular domain (ECD) and a C-terminal intracellular domain with tyrosine kinase activity. Activation of CSF1R by the ligand CSF1 (also known as M-CSF) or IL-34 can stimulate the trafficking, survival, proliferation, and differentiation of monocytes and macrophages. Dysregulation of CSF1R activity can result in an imbalance in the levels and/or activities of macrophage cell populations, which can lead to several diseases. Expression and activity of CSF1R has been shown to be important for sustaining tumor infiltrating macrophages (TAMs) in a variety of solid tumor types and hematologic malignancies (*e.g.*, chronic lymphocytic leukemia (CLL)).

Both CSF1R and its ligand CSF1 have been identified as potential therapeutic targets for many macrophage-mediated diseases, including cancer, autoimmune diseases, and inflammation. It has been reported that CSF1R inhibition can deplete the suppressive tumor micro-environmental signal from CD4⁺ monocytes in AML (Edwards *et al.* (2015) *Blood* 126:3824). Several studies also showed that CSF1 and/or CSF1R inhibitors, such as siRNAs, antagonist antibodies, and small molecule inhibitors (*e.g.*, GW2580) can reverse immune-inhibitory TAMs in pancreatic cancer (Zhu *et al.* (2014) *Cancer Res.* 74:5057-

5069), diffuse-type giant cell tumor (Dt-GCT) (Ries *et al.* (2014) *Cancer Cell* 25:846-859), and acute myeloid leukemia (AML) (Moughon *et al.* (2015) *Cancer Res.* 75:4742-4752). The blockage of TAMs by inhibiting CSF1R activation can effectively improve cancer treatment in tested tumor models. CSF1R and CSF1 antagonists such as antibodies directed
5 against CSF1R and CSF1 interaction, RNAi mediated silencing of CSF1R or CSF1 expression (*e.g.*, PCT Publ. No. WO 2007/081879), soluble forms of the CSF1R extracellular domain (ECD) (see *e.g.*, WO 2007/081879), and small molecule inhibitors of CSF1R tyrosine kinase activity, and inhibitors of CSF1 have been investigated for treatment of macrophage mediated diseases (see, *e.g.*, PCT Publ. No. WO 2007/081879;
10 Irvine *et al.* (2006) *FASEB J.* 20:1315-1326; Ohno *et al.* (2008) *Clin. Immunol.* 38: 283-291).

Without being bound by theory, it is believed that the use of a combination of oligonucleotide compositions described herein and formulations comprising same is particularly effective to inhibit CCR2 and CSF1R activation in order to simultaneously
15 inhibit the trafficking, polarization and activation of monocytes and macrophages in response to an environmental signal, such as a growth factor from tumor cells.

III. Compositions of the Invention

Antagonists of CCR2 and CSF1R have been investigated for their effects on
20 modulating macrophage content in a disease condition, for example the content of pro-tumorigenic macrophages (*e.g.*, TAMs) and pro-inflammatory macrophages that inhibit tumorigenesis. The present invention provides compositions comprising particularly effective antagonists of CCR2 and/or CSF1R that block CCR2 and CSF1R signaling and that can functions synergistically to block CCR2 and CSF1R simultaneously.

25 In accordance with the present invention, antagonists can be small molecules, peptidomimetics, polypeptides, peptides, antibodies, nucleic acid molecules in either sense or anti-sense orientation, either single or double stranded nucleic acids specifically targeted to CCR2 and/or CSF1R. In some embodiments, a nucleic acid-based agent can be a single molecule that targets both CCR2 and CSF1R by comprising complementary sequences
30 (*e.g.*, anti-sense) against CCR2 and CSF1R, such as by separation using an oligonucleotide linker. In some embodiments, nucleic acid-based agents individually target either CCR2 or CSF1R. In some embodiments, the combined antagonists of CCR2 and CSF1R comprise double stranded siRNA molecule cocktail.

One aspect encompassed by the present invention involves the use of nucleic acid molecules. Nucleic acid molecules can be deoxyribonucleic acid (DNA) molecules (*e.g.*, cDNA, genomic DNA, and the like), ribonucleic acid (RNA) molecules (*e.g.*, mRNA, long non-coding RNA, small RNA species, and the like), DNA/RNA hybrids, and analogs of the DNA or RNA generated using nucleotide analogs. RNA agents can include RNAi (RNA interfering) agents (*e.g.*, small interfering RNA (siRNA)), single-strand RNA (ssRNA) molecules (*e.g.*, antisense oligonucleotides) or double-stranded RNA (dsRNA) molecules. A dsRNA molecule comprises a first strand and a second strand, wherein the second strand is substantially complementary to the first strand, and the first strand and the second strand form at least one double-stranded duplex region. The dsRNA molecule can be blunt-ended or have at least one terminal overhang. When used as agents that bind target nucleic acid sequences, nucleic acid agents encompassed by the present invention can hybridize to any region of a target sequence, such as genomic sequence and/or mRNA sequence, including, but not limited to, the enhancer region, the promoter region, the transcriptional start and/or stop region, splice sites, the coding region, the 3'-untranslated region (3'-UTR), the 5'-untranslated region (5'-UTR), the 5' cap, the 3' poly adenyl tail, or any combination thereof.

An "isolated" nucleic acid molecule is one which is separated from other nucleic acid molecules which are present in the natural source of the nucleic acid molecule.

Preferably, an "isolated" nucleic acid molecule is free of sequences (preferably protein-encoding sequences) which naturally flank the nucleic acid (*i.e.*, sequences located at the 5' and 3' ends of the nucleic acid) in the genomic DNA of the organism from which the nucleic acid is derived. For example, in various embodiments, the isolated nucleic acid molecule can contain less than about 5 kB, 4 kB, 3 kB, 2 kB, 1 kB, 0.5 kB or 0.1 kB of nucleotide sequences which naturally flank the nucleic acid molecule in genomic DNA of the cell from which the nucleic acid is derived. Moreover, an "isolated" nucleic acid molecule, such as a cDNA molecule, can be substantially free of other cellular material or culture medium when produced by recombinant techniques, or substantially free of chemical precursors or other chemicals when chemically synthesized.

A nucleic acid molecule encompassed by the present invention can be isolated using standard molecular biology techniques and the sequence information in the database records described herein. Using all or a portion of such nucleic acid sequences, nucleic acid molecules encompassed by the present invention can be isolated using standard

hybridization and cloning techniques (*e.g.*, as described in Sambrook *et al.*, ed., *Molecular Cloning: A Laboratory Manual*, 4th ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 2012).

A nucleic acid molecule encompassed by the present invention can be amplified
5 using cDNA, mRNA, or genomic DNA as a template and appropriate oligonucleotide
primers according to standard PCR amplification techniques. The nucleic acid molecules
so amplified can be cloned into an appropriate vector and characterized by DNA sequence
analysis. Furthermore, nucleic acid molecules corresponding to all or a portion of a nucleic
acid molecule encompassed by the present invention can be prepared by standard synthetic
10 techniques, *e.g.*, using an automated nucleic acid synthesizer. Alternatively, the nucleic
acid molecules can be produced biologically using an expression vector into which a
nucleic acid has been sub-cloned. For example, antisense nucleic acid molecules can be
cloned in an antisense orientation (*i.e.*, RNA transcribed from the inserted nucleic acid will
be of an antisense orientation to a target nucleic acid of interest as described further below).

Moreover, a nucleic acid molecule encompassed by the present invention can
15 comprise only a portion of a nucleic acid sequence, wherein the full length nucleic acid
sequence comprises a marker encompassed by the present invention or which encodes a
polypeptide corresponding to a marker encompassed by the present invention. Such nucleic
acid molecules can be used, for example, as a probe or primer. The probe/primer typically
20 is used as one or more substantially purified oligonucleotides. The oligonucleotide
typically comprises a region of nucleotide sequence that hybridizes under stringent
conditions to at least about 7, preferably about 15, more preferably about 25, 50, 75, 100,
125, 150, 175, 200, 250, 300, 350, or 400 or more consecutive nucleotides of a biomarker
nucleic acid sequence. Probes based on the sequence of a biomarker nucleic acid molecule
25 can be used to detect transcripts or genomic sequences corresponding to one or more
markers encompassed by the present invention. The probe comprises a label group attached
thereto, *e.g.*, a radioisotope, a fluorescent compound, an enzyme, or an enzyme co-factor.

Biomarker nucleic acid molecules that differ, due to degeneracy of the genetic code,
from the nucleotide sequence of nucleic acid molecules encoding a protein which
30 corresponds to the biomarker, and thus encode the same protein, are also contemplated.

In addition, it will be appreciated by those skilled in the art that DNA sequence
polymorphisms that lead to changes in the amino acid sequence can exist within a
population (*e.g.*, the human population). Such genetic polymorphisms can exist among

individuals within a population due to natural allelic variation. An allele is one of a group of genes which occur alternatively at a given genetic locus. In addition, it will be appreciated that DNA polymorphisms that affect RNA expression levels can also exist that can affect the overall expression level of that gene (*e.g.*, by affecting regulation or degradation).

The term “allele,” which is used interchangeably herein with “allelic variant,” refers to alternative forms of a gene or portions thereof. Alleles occupy the same locus or position on homologous chromosomes. When a subject has two identical alleles of a gene, the subject is said to be homozygous for the gene or allele. When a subject has two different alleles of a gene, the subject is said to be heterozygous for the gene or allele. For example, biomarker alleles can differ from each other in a single nucleotide, or several nucleotides, and can include substitutions, deletions, and insertions of nucleotides. An allele of a gene can also be a form of a gene containing one or more mutations.

The term “allelic variant of a polymorphic region of gene” or “allelic variant”, used interchangeably herein, refers to an alternative form of a gene having one of several possible nucleotide sequences found in that region of the gene in the population. As used herein, allelic variant is meant to encompass functional allelic variants, non-functional allelic variants, SNPs, mutations and polymorphisms.

The term “single nucleotide polymorphism” (SNP) refers to a polymorphic site occupied by a single nucleotide, which is the site of variation between allelic sequences. The site is usually preceded by and followed by highly conserved sequences of the allele (*e.g.*, sequences that vary in less than 1/100 or 1/1000 members of a population). A SNP usually arises due to substitution of one nucleotide for another at the polymorphic site. SNPs can also arise from a deletion of a nucleotide or an insertion of a nucleotide relative to a reference allele. Typically the polymorphic site is occupied by a base other than the reference base. For example, where the reference allele contains the base “T” (thymidine) at the polymorphic site, the altered allele can contain a “C” (cytidine), “G” (guanine), or “A” (adenine) at the polymorphic site. SNP’s can occur in protein-coding nucleic acid sequences, in which case they can give rise to a defective or otherwise variant protein, or genetic disease. Such a SNP can alter the coding sequence of the gene and therefore specify another amino acid (a “missense” SNP) or a SNP can introduce a stop codon (a “nonsense” SNP). When a SNP does not alter the amino acid sequence of a protein, the SNP is called “silent.” SNP’s can also occur in noncoding regions of the nucleotide

sequence. This can result in defective protein expression, *e.g.*, as a result of alternative splicing, or it can have no effect on the function of the protein.

As used herein, the terms “gene” and “recombinant gene” refer to nucleic acid molecules comprising an open reading frame encoding a polypeptide corresponding to a marker encompassed by the present invention. Such natural allelic variations can typically result in 1-5% variance in the nucleotide sequence of a given gene. Alternative alleles can be identified by sequencing the gene of interest in a number of different individuals. This can be readily carried out by using hybridization probes to identify the same genetic locus in a variety of individuals. Any and all such nucleotide variations and resulting amino acid polymorphisms or variations that are the result of natural allelic variation and that do not alter the functional activity are intended to be within the scope encompassed by the present invention.

In another embodiment, a biomarker nucleic acid molecule can be at least 7, 15, 20, 25, 30, 40, 60, 80, 100, 150, 200, 250, 300, 350, 400, 450, 550, 650, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2200, 2400, 2600, 2800, 3000, 3500, 4000, 4500, or more nucleotides in length and hybridizes under stringent conditions to a nucleic acid molecule corresponding to a marker encompassed by the present invention or to a nucleic acid molecule encoding a protein corresponding to a marker encompassed by the present invention. The term “hybridizes under stringent conditions” is intended to describe conditions for hybridization and washing under which nucleotide sequences at least 60% (65%, 70%, 75%, 80%, preferably 85%) identical to each other typically remain hybridized to each other. Such stringent conditions are known to those skilled in the art and can be found in sections 6.3.1-6.3.6 of *Current Protocols in Molecular Biology*, John Wiley & Sons, N.Y. (1989). A preferred, non-limiting example of stringent hybridization conditions are hybridization in 6X sodium chloride/sodium citrate (SSC) at about 45°C, followed by one or more washes in 0.2X SSC, 0.1% SDS at 50-65°C.

In addition to naturally-occurring allelic variants of a nucleic acid molecule encompassed by the present invention that can exist in the population, the skilled artisan will further appreciate that sequence changes can be introduced by mutation thereby leading to changes in the amino acid sequence of the encoded protein, without altering the biological activity of the protein encoded thereby. For example, one can make nucleotide substitutions leading to amino acid substitutions at “non-essential” amino acid residues. A “non-essential” amino acid residue is a residue that can be altered from the wild-type

sequence without altering the biological activity, whereas an “essential” amino acid residue is required for biological activity. For example, amino acid residues that are not conserved or only semi-conserved among homologs of various species can be non-essential for activity and thus would be likely targets for alteration. Alternatively, amino acid residues
5 that are conserved among the homologs of various species (*e.g.*, murine and human) can be essential for activity and thus would not be likely targets for alteration.

Accordingly, another aspect encompassed by the present invention encompasses nucleic acid molecules encoding a polypeptide encompassed by the present invention that contain changes in amino acid residues that are not essential for activity. Such polypeptides
10 differ in amino acid sequence from the naturally-occurring proteins which correspond to the markers encompassed by the present invention, yet retain biological activity. In one embodiment, a biomarker protein has an amino acid sequence that is at least about 40% identical, 50%, 60%, 70%, 75%, 80%, 83%, 85%, 87.5%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or identical to the amino acid sequence of a biomarker protein
15 described herein.

An isolated nucleic acid molecule encoding a variant protein can be created by introducing one or more nucleotide substitutions, additions or deletions into the nucleotide sequence of nucleic acids encompassed by the present invention, such that one or more amino acid residue substitutions, additions, or deletions are introduced into the encoded
20 protein. Mutations can be introduced by standard techniques, such as site-directed mutagenesis and PCR-mediated mutagenesis. Preferably, conservative amino acid substitutions are made at one or more predicted non-essential amino acid residues. A “conservative amino acid substitution” is one in which the amino acid residue is replaced with an amino acid residue having a similar side chain. Families of amino acid residues
25 having similar side chains have been defined in the art. These families include amino acids with basic side chains (*e.g.*, lysine, arginine, histidine), acidic side chains (*e.g.*, aspartic acid, glutamic acid), uncharged polar side chains (*e.g.*, glycine, asparagine, glutamine, serine, threonine, tyrosine, cysteine), non-polar side chains (*e.g.*, alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan), beta-branched side chains (*e.g.*,
30 threonine, valine, isoleucine) and aromatic side chains (*e.g.*, tyrosine, phenylalanine, tryptophan, histidine). Alternatively, mutations can be introduced randomly along all or part of the coding sequence, such as by saturation mutagenesis, and the resultant mutants can be screened for biological activity to identify mutants that retain activity. Following

mutagenesis, the encoded protein can be expressed recombinantly and the activity of the protein can be determined.

As described further below, some forms of nucleic acids useful according to the present invention can act as inhibitors, which refers to an agent that inhibits the function of a biological target. In some embodiments, the inhibitor is a gene silencing agent that prevents the expression of a gene or gene product. “Gene silencing” is often referred to as “gene knockdown.” Gene silencing can occur on the transcriptional level, *i.e.*, prevent the transcription of DNA to RNA, or on the translational level, *i.e.*, post-transcriptional silencing *i.e.*, prevent the translation of mRNA to protein. Types of transcriptional gene silencing include genomic imprinting, paramutation, transposon silencing, histone modification, transgene silencing, position effect, and RNA-directed DNA methylation, for example. Examples of post-transcriptional gene silencing include RNA interference (RNAi), RNA silencing, and nonsense mediated decay. A gene silencing agent can be designed to silence (*e.g.*, inhibit the expression of) a specific gene or to silence multiple genes simultaneously. A gene silencing agent can reduce the expression of a gene and/or gene product by at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 95%, at least about 98%, at least about 99%, or at least about 100%. In some embodiments, a gene silencing agent reduces expression of a gene and/or gene product by at least about 70%.

In some embodiments, nucleic acids in genomes are useful and can be used as targets and/or agents. For example, target DNA in the genome can be manipulated using well-known methods in the art. Target DNA in the genome can be manipulated by deletion, insertion, and/or mutation are retroviral insertion, artificial chromosome techniques, gene insertion, random insertion with tissue specific promoters, gene targeting, transposable elements and/or any other method for introducing foreign DNA or producing modified DNA/modified nuclear DNA. Other modification techniques include deleting DNA sequences from a genome and/or altering nuclear DNA sequences. Nuclear DNA sequences, for example, can be altered by site-directed mutagenesis.

siRNA molecules

In some embodiments, the antagonists of CCR2 and CSF1R are small interfering RNA (siRNA) molecules that hybridize to CCR2 or CSF1R. In other embodiments, the antagonists of CCR2 and CSF1R can be shRNA (short hairpin RNA) molecules in which

the two strands of the siRNA molecule can be connected by a linker region (*e.g.*, a nucleotide linker or a non-nucleotide linker).

The siRNA molecules specific to CCR2 can hybridize to human CCR2 mRNA, including the coding region, the untranslated regions and UTRs (Gene Bank Ref. Sequence NM_001123041.2; SEQ ID NO: 1). The siRNA molecules specific to CCR2 can target all protein coding transcripts of CCR2 (*e.g.*, CCR2 isoforms CCR2A (NM_001123041.2; SEQ ID NO: 1) and CCR2B (NM_001123396.1; SEQ ID NO: 3)) and its orthologs, such as in cynomolgus and rhesus monkey.

The siRNA molecules specific to CSF1R can hybridize to human CSF1R mRNA including the coding region, the untranslated regions and UTRs (Gene Bank Ref. Sequence NM_005211.3; SEQ ID NO: 2). The siRNA molecules specific to CSF1R2 can target all protein coding transcripts of CSF1R2 (*e.g.*, CSF1R isoform 1 (NM_005211.3; SEQ ID NO: 2) and CSF1R isoform 2 (NM_001288705.2; SEQ ID NO: 4) and CSF1R isoform 4 (NM_001349736.1; SEQ ID NO: 5) and its orthologs, such as in cynomolgus and rhesus monkey.

Table 1: Representative CCR2 and CSF1R cDNA sequences

Description	Sequence (5'-3')	SEQ ID NO:
Human CCR2 mRNA NM_001123041.2	TTTATTCTCTGGAACATGAAACATTCTGTTGTGCTCATATCATGCAAATT ATCACTAGTAGGAGAGCAGAGAGTGGAATGTTCCAGGTATAAAGACCC ACAAGATAAAGAAGCTCAGAGTCGTTAGAAACAGGAGCAGATGTACAG GGTTTGCCTGACTCACACTCAAGGTTGCATAAGCAAGATTTCAAAATTAA TCCTATTCTGGAGACCTCAACCCAATGTACAATGTTCCCTGACTGGAAAAG AAGAACTATATTTTTCTGATTTTTTTTTTCAAATCTTTACCATTAGTTGCC CTGTATCTCCGCCTTCACTTTCTGCAGGAACTTTATTTCTACTTCTGCA TGCCAAGTTTCTACCTCTAGATCTGTTTGGTTCAGTTGCTGAGAAGCCTG ACATACCAGGACTGCCTGAGACAAGCCACAAGCTGAACAGAGAAAAGTG GATTGAACAAGGACGCATTTCCCCAGTACATCCACAACATGCTGTCCAC ATCTCGTTCTCGGTTTATCAGAAATACCAACGAGAGCGGTGAAGAAGTC ACCACCTTTTTTGATTATGATTACGGTGCTCCCTGTCATAAATTTGACGTG AAGCAAATTGGGGCCCAACTCCTGCCTCCGCTCTACTCGCTGGTGTTCAT CTTTGGTTTTGTGGGCAACATGCTGGTCGTCCTCATCTTAATAAACTGCA AAAAGCTGAAGTGCTTGACTGACATTTACCTGCTCAACCTGGCCATCTCT GATCTGCTTTTTCTTATTACTCTCCCATTTGTGGGCTCACTCTGCTGCAAT GAGTGGGTCTTTGGGAATGCAATGTGCAAATTATTCACAGGGCTGTATC ACATCGGTTATTTGGCGGAATCTTCTTCATCATCCTCCTGACAATCGAT AGATACCTGGCTATTGTCCATGCTGTGTTTGCTTTAAAAGCCAGGACGGT CACCTTTGGGGTGGTGACAAGTGTGATCACCTGGTTGGTGGCTGTGTTTG	1

	CTTCTGTCCCAGGAATCATCTTTACTAAATGCCAGAAAGAAGATTCTGTT TATGTCTGTGGCCCTTATTTTCCACGAGGATGGAATAATTTCCACACAAT AATGAGGAACATTTTGGGGCTGGTCCTGCCGCTGCTCATCATGGTCATCT GCTACTCGGGAATCCTGAAAACCTGCTTCGGTGTGCGAACGAGAAGAA GAGGCATAGGGCAGTGAGAGTCATCTTCACCATCATGATTGTTTACTTTC TCTTCTGGACTCCCTATAATATTGTCATTCTCCTGAACACCTTCCAGGAAT TCTTCGGCCTGAGTAACTGTGAAAGCACCAGTCAACTGGACCAAGCCAC GCAGGTGACAGAGACTCTTGGGATGACTCACTGCTGCATCAATCCCATC ATCTATGCCTTCGTTGGGGAGAAGTTCAGAAGCCTTTTTACATAGCTCT TGGCTGTAGGATTGCCCCACTCCAAAAACCAGTGTGTGGAGGTCCAGGA GTGAGACCAGGAAAGAATGTGAAAGTGACTACACAAGGACTCCTCGATG GTCGTGGAAAAGGAAAGTCAATTGGCAGAGCCCCTGAAGCCAGTCTTCA GGACAAAGAAGGAGCCTAGAGACAGAAATGACAGATCTCTGCTTTGGA AATCACACGTCTGGCTTCACAGATGTGTGATTACAGTGTGAATCTTGGT GTCTACGTTACCAGGCAGGAAGGCTGAGAGGAGAGAGACTCCAGCTGG GTTGGAAAACAGTATTTTCCAAACTACCTTCCAGTTCCTCATTITTTGAAT ACAGGCATAGAGTTCAGACTTTTTTTTAAATAGT AAAAATAAAATTAAAGCTGAAAACCTGCAACTTGTAATGTGGTAAAGAG TTAGTTTGAGTTACTATCATGTCAAACGTGAAAATGCTGTATTAGTCACA GAGATAATTCTAGCTTTGAGCTTAAGAATTTTGAGCAGGTGGTATGTTTG GGAGACTGCTGAGTCAACCCAATAGTTGTTGATTGGCAGGAGTTGGAAG TGTGTGATCTGTGGGCACATTAGCCTATGTGCATGCAGCATCTAAGTAAT GATGTGCTTTGAATCACAGTATAACGCTCCATCGCTGTCATCTCAGCTGGA TCTCCATTCTCTCAGGCTTGCTGCCAAAAGCCTTTTGTTGTTTTGTTTGT TCATTATGAAGTCATGCGTTAATCACATTGAGTGTTTCAGTGCTTCGC AGATGTCCTTGATGCTCATATTGTTCCCTATTTTGCCAGTGGGAACTCCT AAATCAAGTTGGCTTCTAATCAAAGCTTTTAAACCCTATTGGTAAAGAAT GGAAGGTGGAGAAGCTCCCTGAAGTAAGCAAAGACTTTTCTCTTAGTCCG AGCCAAGTTAAGAATGTTCTTATGTTGCCAGTGTGTTTCTGATCTGATG CAAGCAAGAAACACTGGGCTTCTAGAACCAGGCAACTTGGGAACTAGAC TCCAAGCTGGACTATGGCTCTACTTTCAGGCCACATGGCTAAAGAAGG TTTCAGAAAGAAGTGGGGACAGAGCAGAACTTTCACCTTCATATATTTGT ATGATCCTAATGAATGCATAAAATGTTAAGTTGATGGTGATGAAATGTA AATACTGTTTTTAACAACATGATTTGGAAAATAAATCAATGCTATAACT ATGTTGAAAAAAAAAAAAAAAAAAAA	
Human CSF1R (NM_005211 .3)	GAAGGGCAGACAGAGTGTCCAAAAGCGTGAGAGCACGAAGTGAGGAGA AGGTGGAGAAGAGAGAAGAGGAAGAGGAAGAGGAAGAGAGGAAGCGG AGGGAAGTGCAGCCAGGCTAAAAGGGGAAGAAGAGGATCAGCCCAAGG AGGAGGAAGAGGAAAACAAGACAAACAGCCAGTGCAGAGGAGAGGAA CGTGTGTCCAGTGTCCCGATCCCTGCGGAGCTAGTAGCTGAGAGCTCTGT GCCCTGGGCACCTTGACGCCCTGCACCTGCCTGCCACTTCCCCACCGAGG CCATGGGCCCAGGAGTTCTGCTGCTCCTGCTGGTGGCCACAGCTTGGCAT GGTCAGGGAATCCCAGTGATAGAGCCCAGTGTCCCTGAGCTGGTCGTGA AGCCAGGAGCAACGGTGACCTTGCGATGTGTGGGCAATGGCAGCGTGGA	2

ATGGGATGGCCCCCATCACCTCACTGGACCCTGTACTCTGATGGCTCCA GCAGCATCCTCAGCACCAACAACGCTACCTTCCAAAACACGGGGACCTA TCGCTGCACTGAGCCTGGAGACCCCCTGGGAGGCAGCGCCGCCATCCAC CTCTATGTCAAAGACCCTGCCCGGCCCTGGAAACGTGCTAGCACAGGAGG TGGTCGTGTTGAGGACCAGGACGCACTACTGCCCTGTCTGCTCACAGAC CCGGTGCTGGAAGCAGGCGTCTCGCTGGTGCCTGTGCTGGCCGGCCCC TCATGCGCCACACCAACTACTCCTTCTCGCCCTGGCATGGCTTCACCATC CACAGGGCCAAGTTCATTGAGAGCCAGGACTATCAATGCAGTGCCCTGA TGGGTGGCAGGAAGGTGATGTCCATCAGCATCCGGCTGAAAGTGCAGAA AGTCATCCCAGGGCCCCCAGCCTTGACACTGGTGCCTGCAGAGCTGGTG CGGATTCGAGGGGAGGCTGCCCAGATCGTGTGCTCAGCCAGCAGCGTTG ATGTTAACTTTGATGTCTTCTCCAACAACAACAACCAAGCTCGCAATC CCTCAACAATCTGACTTTCATAATAACCGTTACCAAAAAGTCCTGACCCT CAACCTCGATCAAGTAGATTTCCAACATGCCGGCAACTACTCCTGCGTGG CCAGCAACGTGCAGGGCAAGCACTCCACCTCCATGTTCTTCCGGGTGGT AGAGAGTGCCTACTTGAACCTGAGCTCTGAGCAGAACCTCATCCAGGAG GTGACCGTGGGGGAGGGGCTCAACCTCAAAGTCATGGTGGAGGCCTACC CAGGCCTGCAAGGTTTTAACTGGACCTACCTGGGACCCTTTCTGACCAC CAGCCTGAGCCCAAGCTTGCTAATGCTACCACCAAGGACACATACAGGC ACACCTTCACCCCTCTCTGCCCCGCCTGAAGCCCTCTGAGGCTGGCCGC TACTCCTTCCTGGCCAGAAACCCAGGAGGCTGGAGAGCTCTGACGTTTG AGCTCACCCCTTCGATACCCCCAGAGGTAAGCGTCATATGGACATTTCATC AACGGCTCTGGCACCCCTTTTGTGTGCTGCCTCTGGGTACCCCCAGCCAA CGTGACATGGCTGCAGTGCAGTGGCCACACTGATAGGTGTGATGAGGCC CAAGTGCTGCAGGTCTGGGATGACCCATACCCTGAGGTCCTGAGCCAGG AGCCCTTCCACAAGGTGACGGTGCAGAGCCTGCTGACTGTTGAGACCTT AGAGCACAACCAAACCTACGAGTGCAGGGCCCACAACAGCGTGGGGAG TGGCTCCTGGGCCTTCATACCCATCTCTGCAGGAGCCCACACGCATCCCC CGGATGAGTTCCTCTTACACCAAGTGGTGGTGCCTGCATGTCCATCATG GCCTTGCTGCTGCTGCTGCTCCTGCTGCTATTGTACAAGTATAAGCAGAA GCCCAAGTACCAGGTCCGCTGGAAGATCATCGAGAGCTATGAGGGCAAC AGTTATACTTTTCATCGACCCACGCAGCTGCCTTACAACGAGAAGTGGG AGTTCCCCCGGAACAACCTGCAGTTTGGTAAGACCCTCGGAGCTGGAGC CTTTGGGAAGGTGGTGGAGGCCACGGCCTTTGGTCTGGGCAAGGAGGAT GCTGTCCTGAAGGTGGCTGTGAAGATGCTGAAGTCCACGGCCCATGCTG ATGAGAAGGAGGCCCTCATGTCCGAGCTGAAGATCATGAGCCACCTGGG CCAGCACGAGAACATCGTCAACCTTCTGGGAGCCTGTACCCATGGAGGC CCTGTACTGGTCATCACGGAGTACTGTTGCTATGGCGACCTGCTCAACTT TCTGCGAAGGAAGGCTGAGGCCATGCTGGGACCCAGCCTGAGCCCCGGC CAGGACCCCGAGGGAGGCGTCGACTATAAGAACATCCACCTCGAGAAG AAATATGTCCGCAGGGACAGTGGCTTCTCCAGCCAGGGTGTGGACACCT ATGTGGAGATGAGGCCTGTCTCCACTTCTTCAAATGACTCCTTCTCTGAG CAAGACCTGGACAAGGAGGATGGACGGCCCCCTGGAGCTCCGGGACCTGC TTCCTTCTCCAGCCAAGTAGCCCAGGGCATGGCCTTCTCGCTTCCAAG
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	AATTGCATCCACCGGGACGTGGCAGCGCGTAACGTGCTGTTGACCAATG GTCATGTGGCCAAGATTGGGGACTTCGGGCTGGCTAGGGACATCATGAA TGA CTCCA ACTACATTGTCAAGGGCAATGCCCCGCTGCCTGTGAAGTGG ATGGCCCCAGAGAGCATCTTTGACTGTGTCTACACGGTTCAGAGCGACG TCTGGTCCTATGGCATCCTCCTCTGGGAGATCTTCTCACTTGGGCTGAAT CCCTACCCTGGCATCCTGGTGAACAGCAAGTTCTATAAACTGGTGAAGG ATGGATACCAAATGGCCCAGCCTGCATTTGCCCCAAAGAATATATACAG CATCATGCAGGCCTGCTGGGCCTTGAGAGCCACCCACAGACCCACCTTCC AGCAGATCTGCTCCTTCCTTCAGGAGCAGGCCCAAGAGGACAGGAGAGA GCGGGACTATACCAATCTGCCGAGCAGCAGCAGAAGCGGTGGCAGCGG CAGCAGCAGCAGTGAGCTGGAGGAGGAGAGCTCTAGTGAGCACCTGAC CTGCTGCGAGCAAGGGGATATCGCCCAGCCCTTGCTGCAGCCCCAACAAC TATCAGTTCTGCTGAGGAGTTGACGACAGGGAGTACCACTCTCCCCCTCCC ACAACTTCAACTCCTCCATGGATGGGGCGACACGGGGAGAACATACAA ACTCTGCCTTCGGTCATTTCACTCAACAGCTCGGCCAGCTCTGAAACTT GGGAAGGTGAGGGATTGAGGGGAGGTCAGAGGATCCCACCTTCCTGAGCA TGGGCCATCACTGCCAGTCAGGGGCTGGGGGCTGAGCCCTCACCCCCC CTCCCCTACTGTTCTCATGGTGTGGCCTCGTGTTTGCTATGCCAACTAGT AGAACCTTCTTTCTAATCCCCTTATCTTCATGGAAATGGACTGACTTTAT GCCTATGAAGTCCCCAGGAGCTACACTGATACTGAGAAAACCAGGCTCT TTGGGGCTAGACAGACTGGCAGAGAGTGAGATCTCCCTCTCTGAGAGGA GCAGCAGATGCTCACAGACCACACTCAGCTCAGGCCCTTGAGCAGGA TGGCTCCTCTAAGAATCTCACAGGACCTCTTAGTCTCTGCCCTATACGCC GCCTTCACTCCACAGCCTCACCCCTCCCACCCCATACTGGTACTGCTGT AATGAGCCAAGTGGCAGCTAAAAGTTGGGGGTGTTCTGCCAGTCCCGT CATTCTGGGCTAGAAGGCAGGGGACCTTGGCATGTGGCTGGCCACACCA AGCAGGAAGCACAACTCCCCCAAGCTGACTCATCCTAACTAACAGTCA CGCCGTGGGATGTCTCTGTCCACATTAACTAACAGCATTAAATGCAGTCA AAAAAAAAAAAAAAAAAAAA	
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* The nucleic acid sequences encompassed by the present invention listed in Table 1 have been submitted at GenBank under the unique identifier provided herein and each such uniquely identified sequence submitted at GenBank is hereby incorporated in its entirety by reference.

* Included in Table 1 are RNA nucleic acid molecules (*e.g.*, thymidines replaced with uridines), nucleic acid molecules encoding orthologs of the encoded proteins, as well as DNA or RNA nucleic acid sequences comprising a nucleic acid sequence having at least 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.5%, or more identity across their full length with the nucleic acid sequence of any publicly available sequence listed in Table 1, or a portion

thereof. Such nucleic acid molecules can have a function of the full-length nucleic acid as described further herein.

* Included in Table 1 are orthologs of the proteins encoded by the nucleic acid sequences, as well as polypeptide molecules comprising an amino acid sequence having at least 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.5%, or more identity across their full length with an amino acid sequence of any publicly available sequence listed in Table 2, or a portion thereof. Such polypeptides can have a function of the full-length polypeptide as described further herein.

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* Included in Table 1 are additional known nucleic acid and amino acid sequences for the listed CCR2 and CSF1R biomarkers.

In some embodiments, the siRNA molecules encompassed by the present invention can comprise about 10 to 50 nucleotides or nucleotide analogs. The siRNA molecules encompassed by the present invention include a duplex region wherein the duplex region comprises (or consists of) a sense region and an antisense region that together form the duplex region. The antisense strand having sufficient complementarity to a target mRNA (*e.g.*, CCR2 mRNA or CSF1R mRNA) to mediate RNAi. The siRNA molecule encompassed by the present invention can have a length from about 10-50 or more nucleotides, *i.e.*, each strand comprises 10-50 nucleotides. Preferably, the sense and antisense strand of the siRNA molecule each has a length from about 15-45 nucleotides. Further preferably, the antisense and the sense strand of the siRNA molecule each has a length from 18 to 30 nucleotides, for example, about 18 nucleotides, about 19 nucleotides, about 20 nucleotides, about 21 nucleotides, about 22 nucleotides, about 23 nucleotides, about 24 nucleotides, about 25 nucleotides, about 26 nucleotides, about 27 nucleotides, about 28 nucleotides, about 29 nucleotides, or about 30 nucleotides, and the antisense region comprises (or alternatively, consists essentially of, or consists of) a nucleotide sequence that is substantially complementary to the target mRNA. As used herein, the term “substantially complementary” refers to complementarity in a based-paired and double stranded region of the siRNA molecule. The complementarity does not need to be perfect; there can be any number of base pair mismatches that do not impact hybridization under even the least stringent hybridization conditions. For example, the antisense region of the siRNA molecule encompassed by the present invention can comprise at least about 80% or

greater complementary, or at least about 85% or greater complementary, or at least about 90% or greater complementary, or at least about 91% or greater complementary, or at least about 92% or greater complementary, or at least about 93% or greater complementary, or at least about 94% or greater complementary, or at least about 95% or greater complementary, or at least about 96% or greater complementary, or at least about 97% or greater complementary, or at least about 98% or greater complementary, or at least about 99% or greater complementary, to the nucleic acid sequence of the target mRNA molecule, for example the nucleic acid sequence of CCR2 mRNA (SEQ ID NO:1), or the nucleic acid sequence of CSF1R mRNA (SEQ ID NO: 2), to direct target specific RNA interference (RNAi).

In some embodiments, the siRNA molecules encompassed by the present invention can further include at least one overhang region, wherein each overhang region has six or fewer nucleotides. That is to say, when the antisense and sense strands of a siRNA molecule are aligned, there are at least one, two, three, four, five or six nucleotides at the end of the strands which do not align (*i.e.*, no complementary bases in the opposing strand). In some examples, an overhang can occur at one or both ends of the duplex when the sense and antisense strands are annealed.

In some examples, the antisense region and the sense region of the siRNA molecule encompassed by the present invention can vary in lengths, sequences and the nature of chemical modifications thereto.

The siRNA molecule that hybridizes to CCR2 mRNA (SEQ ID NO: 1) can comprise a sense strand nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 6 to 67; and an antisense strand nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 68 to 129 (Table 2).

In some embodiments, the siRNA molecule that hybridizes to CCR2 mRNA (SEQ ID NO: 1) can comprise a sense strand nucleic acid sequence of SEQ ID NO: 6 and an antisense strand nucleic acid sequence of SEQ ID NO: 68; or a sense strand nucleic acid sequence of SEQ ID NO: 7 and an antisense strand nucleic acid sequence of SEQ ID NO: 69; or a sense strand nucleic acid sequence of SEQ ID NO: 8 and an antisense strand nucleic acid sequence of SEQ ID NO: 70; or a sense strand nucleic acid sequence of SEQ ID NO: 9 and an antisense strand nucleic acid sequence of SEQ ID NO: 71; or a sense strand nucleic acid sequence of SEQ ID NO: 10 and an antisense strand nucleic acid

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NO: 119; or a sense strand nucleic acid sequence of SEQ ID NO: 58 and an antisense strand nucleic acid sequence of SEQ ID NO: 120; or a sense strand nucleic acid sequence of SEQ ID NO: 59 and an antisense strand nucleic acid sequence of SEQ ID NO: 121; or a sense strand nucleic acid sequence of SEQ ID NO: 60 and an antisense strand nucleic acid sequence of SEQ ID NO: 122; or a sense strand nucleic acid sequence of SEQ ID NO: 61 and an antisense strand nucleic acid sequence of SEQ ID NO: 123; or a sense strand nucleic acid sequence of SEQ ID NO: 62 and an antisense strand nucleic acid sequence of SEQ ID NO: 124; or a sense strand nucleic acid sequence of SEQ ID NO: 63 and an antisense strand nucleic acid sequence of SEQ ID NO: 125; or a sense strand nucleic acid sequence of SEQ ID NO: 64 and an antisense strand nucleic acid sequence of SEQ ID NO: 126; or a sense strand nucleic acid sequence of SEQ ID NO: 65 and an antisense strand nucleic acid sequence of SEQ ID NO: 127; or a sense strand nucleic acid sequence of SEQ ID NO: 66 and an antisense strand nucleic acid sequence of SEQ ID NO: 128; or a sense strand nucleic acid sequence of SEQ ID NO: 67 and an antisense strand nucleic acid sequence of SEQ ID NO: 129.

Table 2: Sense and anti-sense sequences of siRNA molecules specific to CCR2

ID (position in CCR2 NM_0011230 41.2)	sense strand sequence (5'-3')	SEQ ID NO:	antisense strand sequence (5'-3')	SEQ ID NO:
463	CAUUUCCCCAGUACAUCCA	6	UGGAUGUACUGGGGAAAUG	68
464	AUUUCCCCAGUACAUCCAC	7	GUGGAUGUACUGGGGAAAU	69
486	AUGCUGUCCACAUCUCGUU	8	AACGAGAUGUGGACAGCAU	70
487	UGCUGUCCACAUCUCGUUC	9	GAACGAGAUGUGGACAGCA	71
488	GCUGUCCACAUCUCGUUCU	10	AGAACGAGAUGUGGACAGC	72
489	CUGUCCACAUCUCGUUCUC	11	GAGAACGAGAUGUGGACAG	73
491	GUCCACAUCUCGUUCUCGG	12	CCGAGAACGAGAUGUGGAC	74
529	AGAGCGGUGAAGAAGUCAC	13	GUGACUUCUUCACCGCUCU	75
533	CGGUGAAGAAGUACACCACC	14	GGUGGUGACUUCUUCACCG	76
541	AAGUACACCACCUUUUUUGA	15	UCAAAAAAGGUGGUGACUU	77
544	UCACCACCUUUUUUGAUUA	16	UAAUCAAAAAAGGUGGUGA	78
545	CACCACCUUUUUUGAUUAU	17	AUAAUCAAAAAAGGUGGUG	79
546	ACCACCUUUUUUGAUUAUG	18	CAUAAUCAAAAAAGGUGGU	80
571	GUGCUCUCCUGUCAUAAAUU	19	AAUUUAUGACAGGGAGCAC	81
572	UGCUCUCCUGUCAUAAAUU	20	AAUUUAUGACAGGGAGCA	82
574	CUCCUCCUGUCAUAAAUUUGA	21	UCAAAUUUAUGACAGGGAG	83
577	CCUGUCAUAAAUUUGACGU	22	ACGUCAAAUUUAUGACAGG	84
579	UGUCAUAAAUUUGACGUGA	23	UCACGUCAAAUUUAUGACA	85
580	GUCAUAAAUUUGACGUGAA	24	UUCACGUCAAAUUUAUGAC	86
581	UCAUAAAUUUGACGUGAAG	25	CUUCACGUCAAAUUUAUGA	87
583	AUAAAUUUGACGUGAAGCA	26	UGCUUCACGUCAAAUUUAU	88
586	AAUUUGACGUGAAGCAAAU	27	AUUUGCUUCACGUCAAAU	89
587	AUUUGACGUGAAGCAAAU	28	AAUUUGCUUCACGUCAAAU	90

783	CACUCUGCUGCAAAUGAGU	29	ACUCAUUUGCAGCAGAGUG	91
799	AGUGGGUCUUUGGGAAUGC	30	GCAUUCCTCAAAGACCCACU	92
800	GUGGGUCUUUGGGAAUGCA	31	UGCAUUCCTCAAAGACCCAC	93
802	GGGUCUUUGGGAAUGCAAU	32	AUUGCAUUCCTCAAAGACCC	94
808	UUGGGAAUGCAAUGUGCAA	33	UUGCACAUUGCAUUCCTCAA	95
821	GUGCAAAUUAUUCACAGGG	34	CCCUGUGAAUAAUUGCAC	96
833	CACAGGGCUGUAUCACAUC	35	GAUGUGAUACAGCCCUGUG	97
851	CGGUUAUUUUGGCGGAAUC	36	GAUUCCTGCTCAAUAAACCG	98
853	GUUAUUUUGGCGGAAUCUU	37	AAGAUAUUCCTGCTCAAUAA	99
854	UUUUUUUGGCGGAAUCUUC	38	GAAGAUAUUCCTGCTCAAUA	100
855	UAUUUUUGGCGGAAUCUUCU	39	AGAAGAUAUUCCTGCTCAAUA	101
856	AUUUUUGGCGGAAUCUUCUU	40	AAGAAGAUAUUCCTGCTCAAU	102
857	UUUUUGGCGGAAUCUUCUUC	41	GAAGAAGAUAUUCCTGCTCAA	103
858	UUUGGCGGAAUCUUCUUCU	42	UGAAGAAGAUAUUCCTGCTCAA	104
965	AAGUGUGAUCACCGGUUG	43	CAACCAGGUGAUCACACUU	105
968	UGUGAUCACCGGUUGGUG	44	CACCAACCAGGUGAUCACA	106
969	GUGAUCACCGGUUGGUGG	45	CCACCAACCAGGUGAUCAC	107
970	UGAUCACCGGUUGGUGGC	46	GCCACCAACCAGGUGAUCAC	108
974	CACCGGUUGGUGGUGGUG	47	CACAGCCACCAACCAGGUG	109
1007	AGGAAUCAUCUUUACUAAA	48	UUUAGUAAAGAUAUUCU	110
1055	UGGCCCUAUUUUUCCACGA	49	UCGUGGAAAAUAAGGGCCA	111
1056	GGCCCUAUUUUUCCACGAG	50	CUCGUGGAAAAUAAGGGCC	112
1057	GCCCUAUUUUUCCACGAGG	51	CCUCGUGGAAAAUAAGGGC	113
1060	CUUAUUUUUCCACGAGGAUG	52	CAUCCUCGUGGAAAAUAAG	114
1061	UUUUUUUCCACGAGGAUGG	53	CCAUCCUCGUGGAAAAUA	115
1062	UAUUUUUCCACGAGGAUGGA	54	UCCAUCCUCGUGGAAAAUA	116
1065	UUUCCACGAGGAUGGAAUA	55	UAUCCAUCCUCGUGGAAA	117
1066	UUCACGAGGAUGGAAUAA	56	UUAUCCAUCCUCGUGGAA	118
1067	UCCACGAGGAUGGAAUAAU	57	AUAUCCAUCCUCGUGGA	119
1069	CACGAGGAUGGAAUAAUUU	58	AAAUUAUCCAUCCUCGUG	120
1083	AAUUUCCACACAAUAAUGA	59	UCAUUAUUGUGUGGAAUU	121
1085	UUUCCACACAAUAAUGAGG	60	CCUCAUUAUUGUGUGGAAA	122
1089	CACACAAUAAUGAGGAACA	61	UGUCCUCAUUAUUGUGUG	123
1104	AACAUUUUGGGGUGGUCC	62	GGACCAGCCCCAAAUGUU	124
1294	AAUUCUUCGGCCUGAGUAA	63	UUACUCAGGCCGAAGAAU	125
1295	AUUCUUCGGCCUGAGUAAC	64	GUUACUCAGGCCGAAGAAU	126
1296	UUCUUCGGCCUGAGUAACU	65	AGUUACUCAGGCCGAAGAA	127
1299	UUCGGCCUGAGUAACUGUG	66	CACAGUUACUCAGGCCGAA	128
1306	UGAGUAACUGUGAAAGCAC	67	GUGCUUUCACAGUUACUCA	129

The siRNA molecule that hybridizes to CSF1R mRNA (SEQ ID NO: 2) can comprise a sense strand nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 130 to 248; and an antisense strand nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 249 to 367 (Table 3).

In some embodiments, the siRNA molecule that hybridizes to CSF1R mRNA (SEQ ID NO: 2) can comprise a sense strand nucleic acid sequence of SEQ ID NO: 130 and an antisense strand nucleic acid sequence of SEQ ID NO: 249; or a sense strand nucleic acid sequence of SEQ ID NO: 131 and an antisense strand nucleic acid sequence of SEQ ID NO:

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acid sequence of SEQ ID NO: 226 and an antisense strand nucleic acid sequence of SEQ ID NO: 345; or a sense strand nucleic acid sequence of SEQ ID NO: 227 and an antisense strand nucleic acid sequence of SEQ ID NO: 346; or a sense strand nucleic acid sequence of SEQ ID NO: 228 and an antisense strand nucleic acid sequence of SEQ ID NO: 347; or a
5 sense strand nucleic acid sequence of SEQ ID NO: 229 and an antisense strand nucleic acid sequence of SEQ ID NO: 348; or a sense strand nucleic acid sequence of SEQ ID NO: 230 and an antisense strand nucleic acid sequence of SEQ ID NO: 349; or a sense strand nucleic acid sequence of SEQ ID NO: 231 and an antisense strand nucleic acid sequence of SEQ ID NO: 350; or a sense strand nucleic acid sequence of SEQ ID NO: 232 and an antisense
10 strand nucleic acid sequence of SEQ ID NO: 351; or a sense strand nucleic acid sequence of SEQ ID NO: 233 and an antisense strand nucleic acid sequence of SEQ ID NO: 352; or a sense strand nucleic acid sequence of SEQ ID NO: 234 and an antisense strand nucleic acid sequence of SEQ ID NO: 353; or a sense strand nucleic acid sequence of SEQ ID NO: 235 and an antisense strand nucleic acid sequence of SEQ ID NO: 354; or a sense strand nucleic
15 acid sequence of SEQ ID NO: 236 and an antisense strand nucleic acid sequence of SEQ ID NO: 355; or a sense strand nucleic acid sequence of SEQ ID NO: 237 and an antisense strand nucleic acid sequence of SEQ ID NO: 356; or a sense strand nucleic acid sequence of SEQ ID NO: 238 and an antisense strand nucleic acid sequence of SEQ ID NO: 357; or a sense strand nucleic acid sequence of SEQ ID NO: 239 and an antisense strand nucleic acid
20 sequence of SEQ ID NO: 358; or a sense strand nucleic acid sequence of SEQ ID NO: 240 and an antisense strand nucleic acid sequence of SEQ ID NO: 359; or a sense strand nucleic acid sequence of SEQ ID NO: 241 and an antisense strand nucleic acid sequence of SEQ ID NO: 360; or a sense strand nucleic acid sequence of SEQ ID NO: 242 and an antisense strand nucleic acid sequence of SEQ ID NO: 361; or a sense strand nucleic acid sequence of
25 SEQ ID NO: 243 and an antisense strand nucleic acid sequence of SEQ ID NO: 362; or a sense strand nucleic acid sequence of SEQ ID NO: 244 and an antisense strand nucleic acid sequence of SEQ ID NO: 363; or a sense strand nucleic acid sequence of SEQ ID NO: 245 and an antisense strand nucleic acid sequence of SEQ ID NO: 364; or a sense strand nucleic acid sequence of SEQ ID NO: 246 and an antisense strand nucleic acid sequence of SEQ ID
30 NO: 365; or a sense strand nucleic acid sequence of SEQ ID NO: 247 and an antisense strand nucleic acid sequence of SEQ ID NO: 366; or a sense strand nucleic acid sequence of SEQ ID NO: 248 and an antisense strand nucleic acid sequence of SEQ ID NO: 367.

Table 3: Sense and anti-sense sequences of siRNA specific to CSF1R

ID (Position in CSF1R NM_005211.3)	core sense strand sequence (5'-3')	SEQ ID NO:	core antisense strand sequence (5'-3')	SEQ ID NO:
346	GGGAAUCCCAGUGAUAGAG	130	CUCUAUCACUGGGAUUCCC	249
410	UUGCGAUGUGUGGGCAAUG	131	CAUUGCCCACACAUCGCAA	250
412	GCGAUGUGUGGGCAAUGGC	132	GCCAUUGCCCACACAUCGC	251
508	CAACGCUACCUUCCAAAAC	133	GUUUUGGAAGGUAGCGUUG	252
510	ACGCUACCUUCCAAAACAC	134	GUGUUUUGGAAGGUAGCGU	253
511	CGCUACCUUCCAAAACACG	135	CGUGUUUUGGAAGGUAGCG	254
604	UGCCCGGCCUGGAACGUG	136	CACGUUCCAGGGCCGGGCA	255
675	UGCUCACAGACCCGGUGCU	137	AGCACCGGGUCUGUGAGCA	256
700	AGGCGUCUCGUGGUGCGU	138	ACGACCAGCGAGACGCCU	257
817	UCAAUGCAGUGCCCUGAUG	139	CAUCAGGGCACUGCAUUGA	258
859	CAGCAUCCGGCUGAAAGUG	140	CACUUUCAGCCGGAUGCUG	259
921	CAGAGCUGGUGCGGAUUCG	141	CGAAUCCGCACCAGCUCUG	260
923	GAGCUGGUGCGGAUUCGAG	142	CUCGAAUCCGCACCAGCUC	261
930	UGCUGAUUCGAGGGGAGGC	143	GCCUCCCCUCGAAUCCGCA	262
948	CUGCCCAGAUCGUGUGCUC	144	GAGCACACGAUCUGGGCAG	263
950	GCCCAGAUCGUGUGCUCAG	145	CUGAGCACACGAUCUGGGC	264
953	CAGAUCGUGUGCUCAGCCA	146	UGGCUGAGCACACGAUCUG	265
1053	AUAACCGUUACCAAAAAGU	147	ACUUUUUGGUAACGGUUAU	266
1055	AACCGUUACCAAAAAGUCC	148	GGACUUUUUGGUAACGGUU	267
1056	ACCGUUACCAAAAAGUCCU	149	AGGACUUUUUGGUAACGGU	268
1060	UUACCAAAAAGUCCUGACC	150	GGUCAGGACUUUUUGGUA	269
1288	AGGUUUUAACUGGACCUAC	151	GUAGGUCCAGUUAAAACCU	270
1289	GGUUUUUAACUGGACCUACC	152	GGUAGGUCCAGUUAAAACC	271
1292	UUUAACUGGACCUACCUGG	153	CCAGGUAGGUCCAGUUAAA	272
1293	UUAACUGGACCUACCUGGG	154	CCCAGGUAGGUCCAGUUAA	273
1300	GACCUACCUGGGACCCUUU	155	AAAGGGUCCCAGGUAGGUC	274
1467	UGACGUUUGAGCUCACCCU	156	AGGGUGAGCUCAAACGUCA	275
1468	GACGUUUGAGCUCACCCU	157	AAGGGUGAGCUCAAACGUC	276
1473	UUGAGCUCACCCUUCGAUA	158	UAUCGAAGGGUGAGCUCAA	277
1476	AGCUCACCCUUCGAUACCC	159	GGGUAUCGAAGGGUGAGCU	278
1485	UUCGAUACCCCCAGAGGU	160	ACCUCUGGGGGGUAUCGAA	279
1488	GAUACCCCCCAGAGGUAAG	161	CUUACCUCUGGGGGGUAUC	280
1715	GAGACCUUAGAGCACAACC	162	GGUUGUGCUCUAAGGUCUC	281
1717	GACCUUAGAGCACAACCAA	163	UUGGUUGUGCUCUAAGGUC	282
1759	CAGCGUGGGGAGUGGCUC	164	GGAGCCACUCCCCACGCUG	283
1815	AUCCCCCGGAUGAGUCCU	165	AGGAACUCAUCCGGGGGAU	284
1819	CCCGGAUGAGUUCUCUUC	166	GAAGAGGAACUCAUCCGGG	285
1847	GUGGUCGCCUGCAUGUCCA	167	UGGACAUGCAGGCGACCAC	286
1896	UGCUAUUGUACAAGUAUAA	168	UUAUACUUGUACAAUAGCA	287
1931	CAGGUCCGUGGAAGAUAUC	169	UGAUCUCCAGCGGACCUG	288
1933	GGUCCGUGGAAGAUAUC	170	GAUGAUCUCCAGCGGACC	289
1935	UCCGUGGAAGAUAUCGA	171	UCGAUGAUCUCCAGCGGA	290
1936	CCGUGGAAGAUAUCGAG	172	CUCGAUGAUCUCCAGCGG	291

1946	AUCAUCGAGAGCUAUGAGG	173	CCUCAUAGCUCUCGAUGAU	292
1948	CAUCGAGAGCUAUGAGGGG	174	GCCCUCUAUAGCUCUCGAUG	293
1958	UAUGAGGGCAACAGUUAUA	175	UAUAACUGUUGCCCUCAUA	294
1962	AGGGCAACAGUUAUCUUU	176	AAAGUAUAACUGUUGCCCU	295
1964	GGCAACAGUUAUCUUUCA	177	UGAAAGUAUAACUGUUGCC	296
1990	CACGCAGCUGCCUUAACAAC	178	GUUGUAAGGCAGCUGCGUG	297
2021	UUCCCCCGGAACAACCUGC	179	GCAGGUUGUUCGGGGGAA	298
2026	CCGGAACAACCUGCAGUUU	180	AAACUGCAGGUUGUUCGG	299
2042	UUUGGUAAGACCCUCGGAG	181	CUCCGAGGGUCUUACCAAA	300
2044	UGGUAAGACCCUCGGAGCU	182	AGCUCCGAGGGUCUUACCA	301
2145	UGAAGUCCACGGCCCAUGC	183	GCAUGGGCCGUGGACUUCA	302
2146	GAAGUCCACGGCCCAUGCU	184	AGCAUGGGCCGUGGACUUC	303
2264	CCUGUACUGGUCAUCACGG	185	CCGUGAUGACCAGUACAGG	304
2265	CUGUACUGGUCAUCACGGA	186	UCCGUGAUGACCAGUACAG	305
2266	UGUACUGGUCAUCACGGAG	187	CUCCGUGAUGACCAGUACA	306
2268	UACUGGUCAUCACGGAGUA	188	UACUCCGUGAUGACCAGUA	307
2272	GGUCAUCACGGAGUACUGU	189	ACAGUACUCCGUGAUGACC	308
2276	AUCACGGAGUACUGUUGCU	190	AGCAACAGUACUCCGUGAU	309
2277	UCACGGAGUACUGUUGCUA	191	UAGCAACAGUACUCCGUGA	310
2279	ACGGAGUACUGUUGCUAUG	192	CAUAGCAACAGUACUCCGU	311
2283	AGUACUGUUGCUAUGGCGA	193	UCGCCAUAGCAACAGUACU	312
2288	UGUUGCUAUGGCGACCUGC	194	GCAGGUCGCCAUAGCAACA	313
2292	GCUAUGGCGACCUGCUCAA	195	UUGAGCAGGUCGCCAUAGC	314
2295	AUGGCGACCUGCUC AACUU	196	AAGUUGAGCAGGUCGCCAU	315
2305	GCUCAACUUUCUGCGAAGG	197	CCUUCGCAGAAAGUUGAGC	316
2308	CAACUUUCUGCGAAGGAAG	198	CUUCCUUCGCAGAAAGUUG	317
2313	UUCUGCGAAGGAAGGCUGA	199	UCAGCCUUCUUCGCAGAA	318
2444	CAGGGUGUGGACACCUAUG	200	CAUAGGUGUCCACACCCUG	319
2518	GGACAAGGAGGAUGGACGG	201	CCGUCCAUCCUCCUUGUCC	320
2600	GCUUCCAAGAAUUGCAUCC	202	GGAUGCAAUUCUUGGAAGC	321
2679	ACUUCGGGCUGGCUAGGGA	203	UCCCUAGCCAGCCCGAAGU	322
2687	CUGGCUAGGGACAUCAUGA	204	UCAUGAUGUCCCUAGCCAG	323
2689	GGCUAGGGACAUCAUGAAU	205	AUUCAUGAUGUCCCUAGCC	324
2774	UUUGACUGUGUCUACACGG	206	CCGUGUAGACACAGUCAA	325
2776	UGACUGUGUCUACACGGUU	207	AACCGUGUAGACACAGUCA	326
2778	ACUGUGUCUACACGGUUCA	208	UGAACCGUGUAGACACAGU	327
2781	GUGUCUACACGGUUCAGAG	209	CUCUGAACCGUGUAGACAC	328
2785	CUACACGGUUCAGAGCGAC	210	GU CGCUCUGAACCGUGUAG	329
2788	CACGGUUCAGAGCGACGUC	211	GACGUCGCUCUGAACCGUG	330
2791	GGUUCAGAGCGACGUCUGG	212	CCAGACGUCGCUCUGAACC	331
2793	UUCAGAGCGACGUCUGGUC	213	GACCAGACGUCGCUCUGAA	332
2843	CUUGGGCUGAAUCCCUACC	214	GGUAGGGAUUCAGCCCAAG	333
2874	UGAACAGCAAGUUCUAUAA	215	UUAUAGAACUUGCUGUUA	334
2880	GCAAGUUCUAUAAACUGGU	216	ACCAGUUUAUAGAACUUGC	335
2940	AGAAUAUAUACAGCAUCAU	217	AUGAUGCUGUAUAUAUUCU	336
3047	AGAGAGCGGGACUAUACCA	218	UGGUAUAGUCCCGCUCUCU	337
3048	GAGAGCGGGACUAUACCAA	219	UUGGUAUAGUCCCGCUCUC	338
3049	AGAGCGGGACUAUACCAAU	220	AUUGGUAUAGUCCCGCUCU	339
3052	GCGGGACUAUACCAAUCUG	221	CAGAUUGGUAUAGUCCCGC	340

3055	GGACUAUACCAAUCUGCCG	222	CGGCAGAUUGGUAUAGUCC	341
3149	UGCUGCGAGCAAGGGGAUA	223	UAUCCCCUUGCUCGCAGCA	342
3153	GCGAGCAAGGGGAUAUCGC	224	GCGAUAUCCCCUUGCUCGC	343
3154	CGAGCAAGGGGAUAUCGCC	225	GGCGAUAUCCCCUUGCUCG	344
3164	GAUAUCGCCCAGCCCUUGC	226	GCAAGGGCUGGGCGAUUUC	345
3186	AGCCCAACAACUAUCAGUU	227	AACUGAUAGUUGUUGGGCU	346
3187	GCCCAACAACUAUCAGUUC	228	GAACUGAUAGUUGUUGGGC	347
3188	CCCAACAACUAUCAGUUCU	229	AGAACUGAUAGUUGUUGGG	348
3292	ACAAACUCUGCCUUCGGUC	230	GACCGAAGGCAGAGUUUGU	349
3298	UCUGCCUUCGGUCAUUUCA	231	UGAAAUGACCGAAGGCAGA	350
3301	GCCUUCGGUCAUUUCACUC	232	GAGUGAAAUGACCGAAGGC	351
3305	UCGGUCAUUUCACUCAACA	233	UGUUGAGUGAAAUGACCGA	352
3457	CUCAUGGUGUUGGCCUCGU	234	ACGAGGCCAACACCAUGAG	353
3458	UCAUGGUGUUGGCCUCGUG	235	CACGAGGCCAACACCAUGA	354
3459	CAUGGUGUUGGCCUCGUGU	236	ACACGAGGCCAACACCAUG	355
3462	GGUGUUGGCCUCGUGUUUG	237	CAAACACGAGGCCAACACC	356
3473	CGUGUUUGCUAUGCCAACU	238	AGUUGGCAUAGCAAACACG	357
3808	AGCUAAAAGUUGGGGGUGU	239	ACACCCCCAACUUUUAGCU	358
3911	CCAAGCUGACUCAUCCUAA	240	UUAGGAUGAGUCAGCUUGG	359
3914	AGCUGACUCAUCCUAAACUA	241	UAGUUAGGAUGAGUCAGCU	360
3916	CUGACUCAUCCUAAACUAC	242	GUUAGUUAGGAUGAGUCAG	361
3917	UGACUCAUCCUAAACUACA	243	UGUUAGUUAGGAUGAGUCA	362
3918	GACUCAUCCUAAACUACAG	244	CUGUUAGUUAGGAUGAGUC	363
3924	UCCUAAACUAAACAGUCACGC	245	GCGUGACUGUUAGUUAGGA	364
3925	CCUAAACUAAACAGUCACGCC	246	GGCGUGACUGUUAGUUAGG	365
3958	UCCACAUUAAACUAAACAGC	247	GCUGUUAGUUUAAUGUGGA	366
3959	CCACAUUAAACUAAACAGCA	248	UGCUGUUAGUUUAAUGUGG	367

Chemical modifications of siRNA molecules

In some embodiments, nucleic acid molecules encompassed by the present invention can contain one or more chemical modifications. The modifications will not compromise the activity of the nucleic acid molecules. Chemical modifications well-known in the art are capable of increasing stability, availability, and/or cell uptake of the nucleic acid molecules. In one embodiment, modifications can be used to provide improved resistance to degradation (by nucleases) or improved uptake of nucleic acid molecules by cells. In some embodiments, modified nucleic acid molecules encompassed by the present invention can have an enhanced target efficiency as compared to corresponding non-modified nucleic acid molecules.

In some embodiments, nucleic acid molecules encompassed by the present invention can be optimized, such as to increase expression, improve the effectiveness of gene silencing for use to silence a target gene, and the like. In another embodiment, modifications can be used to increase or decrease affinity for the complementary

nucleotides in the target mRNA and/or in the complementary siRNA strand. In some embodiments, siRNAs encompassed by the present invention can be modified to increase the ability to avoid or modulate an immune response in a cell, tissue or organism.

In some embodiments, nucleic acid molecules encompassed by the present invention can be further modified to increase the membrane penetrance and/or delivery to a target organ, tissue and cell. In one example, the nucleic acid molecule can be modified to increase its delivery to myeloid cells, monocytes and macrophages. For example, nucleic acid molecules can be modified such that they specifically bind to receptors or antigens expressed on a selected cell surface, *e.g.*, by linking the antisense nucleic acid molecules to peptides or antibodies which bind to cell surface receptors or antigens. The nucleic acid molecules can also be modified as part of vectors that target cells of interest and/or selectively express within cells of interest.

Duplex molecules encompassed by the present invention, such as siRNA molecules, can comprise a modified sense strand, a modified anti-sense strand, or modified sense and antisense strands.

In some embodiments, a nucleic acid molecule encompassed by the present invention can be an α -anomeric nucleic acid molecule. An α -anomeric nucleic acid molecule forms specific double-stranded hybrids with complementary RNA in which, contrary to the usual α -units, the strands run parallel to each other (Gaultier *et al.* (1987) *Nucleic Acids Res.* 15:6625-6641). The antisense nucleic acid molecule can also comprise a 2'-o-methylribonucleotide (Inoue *et al.* (1987) *Nucleic Acids Res.* 15:6131-6148) or a chimeric RNA-DNA analogue (Inoue *et al.* (1987) *FEBS Lett.* 215:327-330).

Nucleic acid molecules encompassed by the present invention can be modified at the 5' end, 3' end, 5' and 3' end, and/or at internal residues, or any combination thereof. As described herein, a naturally occurring nucleic acid with repeating nucleotide residues has a backbone consisting of sugars and phosphodiester, and nitrogenous bases (often called nucleobases or simply bases). Accordingly chemically modified nucleotides can include modified nucleobases, modified sugars and/or non-phosphodiester linkages (*i.e.*, backbone modifications). In some embodiments, the modification is a mixture of different kinds of modifications described herein, such as a combination of unlocked nucleomonomer agents (UNAs), modified cap structures, modified inter-nucleoside linkages and or nucleobase modifications.

End/cap modifications

In some embodiments, nucleic acid molecules encompassed by the present invention can further comprise at least one terminal modification or “cap.”

For example, the cap can be a 5' and/or a 3'-cap structure. The terms “cap” and “end-cap” include chemical modifications at either terminus of each strand of the nucleic acid molecule (with respect to terminal ribonucleotides), and /or modifications at the linkage between the last two nucleotides at the 5' end and/or the last two nucleotides at the 3' end. The cap structure can increase resistance of the nucleic acid molecule to exonucleases without compromising molecular interactions with target mRNAs or cellular machinery. Such modifications can be selected on the basis of their increased potency *in vitro* or *in vivo*.

The cap can be present at the 5'-terminus (5'-cap) or at the 3'-terminus (3'-cap) or can be present at both ends. In certain embodiments, the 5'- and/or 3'-cap is independently selected from phosphorothioate monophosphate, abasic residue (moiety), phosphorothioate linkage, 4'-thio nucleotide, carbocyclic nucleotide, phosphorodithioate linkage, inverted nucleotide or inverted abasic moiety (2'-3' or 3'-3') (*e.g.*, Invabasic X, Abasic II, rSpacer/RNA abasic), and dSpacer), phosphorodithioate monophosphate, and methylphosphonate moiety. The phosphorothioate or phosphorodithioate linkage(s), when part of a cap structure, are generally positioned between the two terminal nucleotides at the 5' end and the two terminal nucleotides at the 3' end.

In some embodiments, nucleic acid molecules encompassed by the present invention have at least one terminal phosphorothioate monophosphate. The phosphorothioate monophosphate can be at the 5' and/or 3' end of each strand of the nucleic acid molecule. In other embodiments, the nucleic acid molecule has terminal phosphorothioate monophosphate at both 5' and 3' terminus of the sense and/or antisense strand. The phosphorothioate monophosphate can support a higher potency by inhibiting the action of exonucleases.

In some embodiments, modifications at the 5' end is preferred in the sense strand, and comprises, for example, a 5'-propylamine group. Modifications to the 3' OH terminus are in the sense strand, antisense strand, or in the sense and antisense strands. A 3' end modification comprises, for example, 3'-puromycin, 3'-biotin and the like.

Terminal modifications can also be useful for monitoring distribution, and in such cases the preferred groups to be added include fluorophores, *e.g.*, fluorescein or an Alexa dye, *e.g.*, Alexa 488. Terminal modifications can also be useful for enhancing uptake,

useful modifications for this include targeting ligands. Terminal modifications can also be useful for cross-linking an oligonucleotide to another moiety; modifications useful for this include mitomycin C, psoralen, and derivatives thereof. Exemplary 5'-modifications include, but are not limited to, 5'-monophosphate ((HO)₂(O)P—O-5'); 5'-diphosphate ((HO)₂(O)P—O—P(HO)(O)—O-5'); 5'-triphosphate ((HO)₂(O)P—O—(HO)(O)P—O—P(HO)(O)—O-5'); 5'-monothiophosphate (phosphorothioate; (HO)₂(S)P—O-5'); 5'-monodithiophosphate (phosphorodithioate; (HO)(HS)(S)P—O-5'); 5'-phosphorothiolate ((HO)₂(O)P—S-5'); 5'-alpha-thiotriphosphate; 5'-beta-thiotriphosphate; 5'-gamma-thiotriphosphate; 5'-phosphoramidates ((HO)₂(O)P—NH-5', (HO)(NH₂)(O)P—O-5'). Other 5'-modification include 5'-alkylphosphonates (R(OH)(O)P—O-5', R=alkyl, *e.g.*, methyl, ethyl, isopropyl, propyl, etc.), 5'-alkyletherphosphonates (R(OH)(O)P—O-5', R=alkylether, *e.g.*, methoxymethyl (CH₂OMe), ethoxymethyl, etc.).

In some embodiments, the cap at the terminus of the nucleic acid molecule can be a conjugate, for example, a 5' conjugate. The 5' end conjugates can inhibit 5' to 3' exonucleolytic cleavage (*e.g.*, naproxen; ibuprofen; small alkyl chains; aryl groups; heterocyclic conjugates; modified sugars (D-ribose, deoxyribose, glucose etc.)).

Modified nucleobases (bases)

In some embodiments, nucleic acid molecules encompassed by the present invention can include base modifications and/or substitutions of natural nucleobases.

The term “unmodified” or “natural” nucleobases include the purine bases adenine (A) and guanine (G), and the pyrimidine bases thymine (T), cytosine (C) and uracil (U). In some embodiments, nucleic acid molecules can comprise one or more nucleobase-modified nucleotides. It can comprise about 1, about 2, about 3, about 4, about 5, about 6, about 7, about 8, about 9, about 10, about 11, about 12, about 13, about 14, about 15, about 16, about 17, about 18, about 19, about 20, about 21, about 22, about 23, about 24, about 25, about 26, about 27, about 28, about 29, or more nucleobase-modified nucleotides. In some examples, nucleic acid molecules can comprise about 1% to 10% modified nucleotides, or about 10% to 50% modified nucleotides. Modified bases refer to nucleotide bases such as, for example, adenine (A), guanine (G), cytosine (C), thymine (T), uracil (U), xanthine, inosine, and queuosine that have been modified by the replacement or addition of one or more atoms or groups. Some examples of types of modifications that can comprise nucleotides that are modified with respect to the base moieties include but are not limited

to, alkylated, halogenated, thiolated, aminated, amidated, or acetylated bases, individually or in combination. More specific examples include, for example, 5-fluorouracil, 5-bromouracil, 5-chlorouracil, 5-iodouracil, hypoxanthine, xanthine, 4-acetylcytosine, 5-(carboxyhydroxymethyl) uracil, 5-carboxymethylaminomethyl-2-thiouridine, 5-carboxymethylaminomethyluracil, dihydrouracil, beta-D-galactosylqueosine, inosine, N6-isopentenyladenine, 1-methylguanine, 1-methylinosine, 2,2-dimethylguanine, 2-methyladenine, 2-methylguanine, 3-methylcytosine, 5-methylcytosine, N6-adenine, 7-methylguanine, 5-methylaminomethyluracil, 5-methoxyaminomethyl-2-thiouracil, beta-D-mannosylqueosine, 5'-methoxycarboxymethyluracil, 5-methoxyuracil, 2-methylthio-N6-isopentenyladenine, uracil-5-oxyacetic acid (v), wybutoxosine, pseudouracil, queosine, 2-thiocytosine, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-methyluracil, uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid (v), 5-methyl-2-thiouracil, 3-(3-amino-3-N-2-carboxypropyl) uracil, (acp3)w, and 2,6-diaminopurine, 5-propynyluridine, 5-propynylcytidine, 6-methyladenine, 6-methylguanine, N,N,-dimethyladenine, 2-propyladenine, 2-propylguanine, 2-aminoadenine, 3-methyluridine, 5-methylcytidine, 5-methyluridine and other nucleotides having a modification at the 5 position, 5-(2-amino)propyl uridine, 5-halocytidine, 5-halouridine, 4-acetylcytidine, 1-methyladenosine, 2-methyladenosine, 3-methylcytidine, 6-methyluridine, 2-methylguanosine, 7-methylguanosine, 2,2-dimethylguanosine, 5-methylaminoethyluridine, 5-methoxyuridine, deazanucleotides such as 7-deaza-adenosine, 6-azouridine, 6-azocytidine, 6-azothymidine, 5-methyl-2-thiouridine, other thio bases such as 2-thiouridine and 4-thiouridine and 2-thiocytidine, dihydrouridine, pseudouridine, queuosine, archaeosine, naphthyl and substituted naphthyl groups, any O- and N-alkylated purines and pyrimidines such as N6-methyladenosine, 5-methylcarbonylmethyluridine, uridine 5-oxyacetic acid, pyridine-4-one, pyridine-2-one, phenyl and modified phenyl groups such as aminophenol or 2,4,6-trimethoxy benzene, modified cytosines that act as G-clamp nucleotides, 8-substituted adenines and guanines, 5-substituted uracils and thymines, azapyrimidines, carboxyhydroxyalkyl nucleotides, carboxyalkylaminoalkyl nucleotides, and alkylcarbonylalkylated nucleotides. Modified nucleotides also include those nucleotides that are modified with respect to the sugar moiety, as well as nucleotides having sugars or analogs thereof that are not ribosyl. For example, the sugar moieties can be, or be based on, mannoses, arabinoses, glucopyranoses, galactopyranoses, 4'-thioribose, and other sugars, heterocycles, or carbocycles.

Exemplary modified nucleobases include, but are not limited to, other synthetic and naturally modified nucleobases such as 5-methylcytosine (5-me-C), 5-hydroxymethyl cytosine, xanthine, hypoxanthine, 2-aminoadenine, 6-methyl and other alkyl derivatives of adenine and guanine, 2-propyl and other alkyl derivatives of adenine and guanine, 2-thiouracil, 2-thiothymine and 2-thiocytosine, 5-halouracil and cytosine, 5-propynyl uracil and cytosine, 6-azo uracil, cytosine and thymine, 5-uracil (pseudouracil), 4-thiouracil, 8-halo, 8-amino, 8-thiol, 8-thioalkyl, 8-hydroxyl and other 8-substituted adenines and guanines, 5-halo, particularly 5-bromo, 5-trifluoromethyl and other 5-substituted uracils and cytosines, 7-methylguanine and 7-methyladenine, 8-azaguanine and 8-azaadenine, 7-deazaguanine and 7-daazaadenine and 3-deazaguanine and 3-deazaadenine. In some particular embodiments, nucleobase-modified nucleotides useful in the invention include, but are not limited to: 5-bromo-uridine, 5-iodo-uridine, 5-methyl-cytidine, ribo-thymidine, 2-aminopurine, 5-fluoro-cytidine, and 5-fluoro-uridine, 2,6-diaminopurine, 4-thio-uridine; and 5-amino-allyl-uridine and the like.

In some embodiments, nucleic acid molecules encompassed by the present invention can also contain nucleotides with base analogues.

The nucleobase can be naturally occurring non canon bases such as CpG islands, inosine which can base pair with C, U or A, thiouridine, dihydrouridine, queuosine, xanthine, hypoxanthine, nubularine, isoguanisine, tubercidine and wyosine. Other analogues can include fluorophores (*e.g.*, rhodamine, fluorescein) and other fluorescent base analogues such as 2-AP (2-aminopurine), 3-MI, 6-MI, 6-MAP, pyrrolo-dC, modified and improved derivatives of pyrrolo-dC, furan-modified bases, and tricyclic cytosine family (*e.g.*, 1,3-Diaza-2-oxophenothiazine, tC; oxo-homologue of tC, tC^O; 1,3-diaza-2-oxophenoxazine). Nucleobase modified nucleotides can also include universal bases. By way of example, universal bases include but are not limited to 3-nitropyrrole, 5-nitroindole, or nebularine. The term “nucleotide” is also meant to include the N3' to P5' phosphoramidate, resulting from the substitution of a ribosyl 3' oxygen with an amine group. As used herein, a universal nucleobase is any modified nucleobase that can base pair with all of the four naturally occurring nucleobases without substantially affecting the melting behavior, recognition by intracellular enzymes or activity of the oligonucleotide duplex. Some exemplary universal nucleobases include, but are not limited to, 2,4-difluorotoluene, nitropyrrolyl, nitroindolyl, 8-aza-7-deazaadenine, 4-fluoro-6-methylbenzimidazole, 4-methylbenzimidazole, 3-methyl isocarbostyrylyl, 5-methyl

isocarbostyrylyl, 3-methyl-7-propynyl isocarbostyrylyl, 7-azaindolyl, 6-methyl-7-azaindolyl, imidizopyridinyl, 9-methyl-imidizopyridinyl, pyrrolopyrizinyl, isocarbostyrylyl, 7-propynyl isocarbostyrylyl, propynyl-7-azaindolyl, 2,4,5-trimethylphenyl, 4-methylindolyl, 4,6-dimethylindolyl, phenyl, naphthalenyl, anthracenyl, phenanthracenyl, pyrenyl, stilbenzyl, tetracenyl, pentacenyl, and structural derivatives thereof. In some embodiments, the nucleotides of the nucleic acid molecules can incorporate base analogues and modified bases that are described in U.S. Pat. Numbers 6,008,334; 6,107,039; 6,664,058; 7,678,894; 7,786,292; and 7,956,171; U.S. Pat. Publ. Nos. 2013/122,506 and 2013/0296402; carboxamido-modified bases as described in PCT Pat. Publ. No. WO 2012/061810).

Artificial nucleic acid analogues (or nucleotide analogues)

In some embodiments, modified nucleic acid molecules encompassed by the present invention can comprise artificial nucleic acid analogues.

The term “nucleoside” refers to a molecule having a purine or pyrimidine base covalently linked to a ribose or deoxyribose sugar. Exemplary nucleosides include adenosine, guanosine, cytidine, uridine and thymidine.

The term “nucleotide” refers to a nucleoside having one or more phosphate groups joined in ester linkages to the sugar moiety. A nucleotide can be a ribonucleotide or a deoxyribonucleotide or modified form thereof, as well as an analog thereof. Nucleotides include species that comprise purines, *e.g.*, adenine, hypoxanthine, guanine, and their derivatives and analogs, as well as pyrimidines, *e.g.*, cytosine, uracil, thymine, and their derivatives and analogs.

The term “nucleotide analog”, also referred to herein as an “altered nucleotide” or “modified nucleotide” refers to a non-standard nucleotide, including non-naturally occurring ribonucleotides or deoxyribonucleotides. Preferred nucleotide analogs are modified at any position so as to alter certain chemical properties of the nucleotide yet retain the ability of the nucleotide analog to perform its intended function. Nucleotide analogs include nucleotides having modifications in the chemical structure of the base, sugar and/or phosphate, including, but not limited to, 5-position pyrimidine modifications, 8-position purine modifications, modifications at cytosine exocyclic amines, and substitution of 5-bromo-uracil; and 2'-position sugar modifications, including but not limited to, sugar-modified ribonucleotides in which the 2'-OH is replaced by a group such as an H, OR, R, halo, SH, SR, NH₂, NHR, NR₂, or CN, wherein R is an alkyl moiety. Nucleotide analogs are also meant to include nucleotides with bases such as inosine,

queuosine, xanthine, sugars such as 2'-methyl ribose, non-natural phosphodiester linkages such as methylphosphonates, phosphorothioates and peptides.

An analog can have any of the phosphate backbone, sugar, or the nucleobase (*i.e.*, G, C, T, U, and A) altered. In some embodiments, the modified nucleotide can be an
5 unlocked nucleomonomer agent (UNA). UNAs include any monomer unit suitable for inclusion in an oligomeric or polymeric composition such as an oligonucleotide or polynucleotide and which have, in reference to nucleosides or nucleotides, an unlocked or acyclic sugar moiety. Where such UNAs are included in a larger oligomer or polymer, such larger oligomer or polymer, *e.g.*, oligonucleotide, can also be referred to as a UNA
10 oligomer or UNA polymer, or UNA oligonucleotide. Where a UNA is included in a standard nucleotide, such variant nucleotide is referred to as a UNA nucleotide. Where a UNA is included in a standard nucleoside, such variant nucleoside is referred to as a UNA nucleoside. UNAs can be used as substitutes for nucleosides or nucleotides in oligonucleotides. In this case, UNAs, whether the monomer or oligomer containing the
15 monomer, have often been referred to as "unlocked nucleic acids" in the art. When referred to as an unlocked nucleic acid herein, one of skill will understand that the inventors are referring to UNAs. According to the present invention, UNAs are not naturally occurring nucleomonomer agents. In one embodiment, one or more nucleotides in the nucleic acid molecule can be replaced with one or more unlocked nucleic acid/nucleomonomer agent
20 (UNA) moieties, including those described in, *e.g.*, PCT Publ. WO 2015/148580. A UNA oligomer can be a chain composed of UNA monomers, as well as various nucleotides that can be based on naturally-occurring nucleosides or modified nucleotides. UNA oligomers have been reported to have reduced off-target effects as compared to counterpart oligonucleotides lacking the modifications. Other UNA modifications and uses which can
25 be utilized in accordance with the present invention include any of those disclosed in U.S. Pat. Publ. 2015/0232851, 2015/0232849, 2015/0239926, 2015/0239834, and 2015/0141678; U.S. Pat. No. 9,051,570; EP Publ. Nos. 2162538 and 2370577; and PCT Publ. No. WO 2015/074085.

In some embodiments, artificial nucleic acid analogs with backbone analogues
30 include, but are not limited to, a bicyclic nucleotide analog such as locked nucleic acid (LNA), bridged nucleic acid (BNA), glycol nucleic acid (GNA), threose nucleic acid (TNA), and morpholino. The modified oligonucleotides that comprise these backbone analogs, although having a different backbone sugar, or in case of PNA, an amino acid

residue in place of the ribose phosphate, still bind to RNA or DNA according to Watson and Crick pairing, but are immune to nuclease activity. LNAs are described, for example, in U.S. Pat. Nos. 6,268,490; 6,316,198; 6,403,566; 6,770,748; 6,998,484; 6,670,461; and 7,034,133; and PCT Publ. No. 1999/014226. Other suitable locked nucleotides that can be
5 incorporated in the nucleic acid molecules encompassed by the present invention include those described in U.S. Pat. Nos. 6,403,566; 6,833,361; and 7,060,809. Other locked nucleic acid derivatives, such as D-oxy-LNA, α -L-oxy-LNA, β -D-amino-LNA, α -L-amino-LNA, thio-LNA, α -L-thio-LNA, seleno-LNA, methylene-LNA and β -D-ENA, can be incorporated into nucleic acid molecules encompassed by the present invention. Those
10 LNA derivatives described in U.S. Pat. Nos. 7,569, 575; 8,084,458; and 8,429,390, can also be incorporated into the nucleic acid molecules.

Modified sugars

In some embodiments, nucleic acid molecules encompassed by the present
15 invention can comprise one or more sugar-modified nucleotides.

It can comprise about 1, about 2, about 3, about 4, about 5, about 6, about 7, about 8, about 9, about 10, or more sugar-modified nucleotides. Sugar-modified nucleotides useful in the invention include, but are not limited to: 2'-fluoro modified ribonucleotide, 2'-OMe modified ribonucleotide, 2'-deoxy ribonucleotide, 2'-amino modified ribonucleotide
20 and 2'-thio modified ribonucleotide. The sugar-modified nucleotide can be, for example, 2'-fluoro-cytidine, 2'-fluoro-uridine, 2'-fluoro-adenosine, 2'-fluoro-guanosine, 2'-amino-cytidine, 2'-amino-uridine, 2'-amino-adenosine, 2'-amino-guanosine or 2'-amino-butyryl-pyrene-uridine. In addition to 2' modification of the backbone sugar, the sugar group can be modified at other positions. The sugar group can comprise two different modifications
25 at the same carbon of the sugar. The sugar group can also contain one or more carbons that possess the opposite stereochemical configuration than that of the corresponding carbon in ribose. Thus, a nucleic acid molecule can include nucleotides containing, *e.g.*, arabinose, as the sugar. The nucleotide can have an alpha linkage at the 1' position on the sugar, *e.g.*, alpha-nucleosides. The nucleotide can also have the opposite configuration at the 4'-
30 position, *e.g.*, C5' and H4' or substituents replacing them are interchanged with each other. When the C5' and H4' or substituents replacing them are interchanged with each other, the sugar is said to be modified at the 4' position.

The nucleic acid molecules encompassed by the present invention can also include abasic sugars, which lack a nucleobase at C-1' or have other chemical groups in place of a

nucleobase at C1' (see, *e.g.*, U.S. Pat. No. 5,998,203). These abasic sugars can also be further containing modifications at one or more of the constituent sugar atoms. In other embodiments, nucleic acid molecules can also contain one or more sugars that are the L isomers. In one aspect, modification to the sugar group can also include replacement of the 4'-O with a sulfur, optionally substituted nitrogen or CH₂ group. In another aspect, modifications to the sugar group can also include acyclic nucleotides, wherein a C-C bond between ribose carbons is absent and/or at least one of ribose carbons or oxygen are independently or in combination absent from the nucleotide. Such acyclic nucleotides have been disclosed in U.S. Pat. Numbers 5, 047,533 and 7,737,273, and U.S. Pat. Publ. No. 20130130378. It is to be understood that when a particular nucleotide is linked through its 2'-position to the next nucleotide, the sugar modifications described herein can be placed at the 3'-position of the sugar for that particular nucleotide, *e.g.*, the nucleotide that is linked through its 2'-position. A modification at the 3' position can be present in the xylose configuration. The term "xylose configuration", as used herein, refers to the placement of a substituent on the C3' of ribose in the same configuration as the 3'-OH is in the xylose sugar. The hydrogen attached to C4' and/or C1' of the sugar group can be replaced by substitutes as described for 2' modification. In one example, nucleic acid molecules encompassed by the present invention can comprise 2'-fluoro modified ribonucleotide. Preferably, the 2'-fluoro ribonucleotides are in the sense and antisense strands. More preferably, the 2'-fluoro ribonucleotides are every uridine and cytidine.

In some embodiments, the internucleoside linkage groups of the nucleic acid molecules encompassed by the present invention are modified.

The internucleoside linkage modification can be within the sense strand, antisense strand, or within the sense and antisense strands. The term "internucleoside linkage group" is intended to mean a group capable of covalently coupling together two nucleobases, such as between DNA residues, between RNA residues, between DNA and RNA residues and nucleotide analogues, between two non-LNA residues, between a non-LNA residue and a LNA residue, and between two LNA residues, etc. The naturally standard linkage is the phosphodiester linkage (PO linkage), consisting of -O-P(O)₂-O- (from 5' to 3' end), wherein the deoxyribose/ribose sugars are joined at both the 3'-hydroxyl and 5'-hydroxyl groups to phosphate groups in ester links, also known as "phosphodiester" bonds/linker. The linker can be modified by the replacement of one or both linking oxygens (*i.e.*, oxygens that link the phosphate to the nucleoside), with nitrogen (bridged phosphoroamidates),

sulfur (bridged phosphorothioates) and carbon (bridged methylenephosphonates). In some embodiments, the phosphate linker moiety can be replaced by non-phosphorus containing linkers, *e.g.*, dephospho-linkers. While not wishing to be bound by theory, it is believed that since the charged phosphodiester group is the reaction center in nucleolytic

5 degradation, its replacement with neutral structural mimics should impart enhanced nuclease stability. Examples of moieties which can replace the phosphate linker include, but are not limited to, amides (for example amide-3 (3'-CH₂—C(=O)—N(H)-5') and amide-4 (3'-CH₂—N(H)—C(=O)-5')), hydroxylamino, siloxane (dialkylsiloxane), carboxamide, carbonate, carboxymethyl, carbamate, carboxylate ester, thioether, ethylene
10 oxide linker, sulfide, sulfonate, sulfonamide, sulfonate ester, thioformacetal (3'-S—CH₂—O-5'), formacetal (3'-O—CH₂—O-5'), oxime, methyleneimino, methylenecarbonylamino, methylenemethylimino (MMI, 3'-CH₂—N(CH₃)—O-5'), methylenehydrazo, methylenedimethylhydrazo, methyleneoxymethylimino, ethers (C3'-O—C5'), thioethers (C3'-S—C5'), thioacetamido (C3'-N(H)—C(=O)—CH₂—S—C5', C3'-O—P(O)—O—
15 SS—C5', C3'-CH₂—NH—NH—C5', 3'—NHP(O)(OCH₃)—O-5' and 3'—NHP(O)(OCH₃)—O-5' and nonionic linkages containing mixed N, O, S and CH₂ component parts.

In some embodiments, the modification of the linkage further comprises at least one of the oxygen atoms of one phosphate which is replaced or modified. In some aspects, one
20 or both of the non-linking phosphate oxygens on the phosphate linker can be modified or replaced. The modified phosphates can include, but are not limited to, phosphonocarboxylate (in which one of the non-linking oxygen atoms has been replaced/modified with a carboxylic acid) (*e.g.*, phosphoacetate, phosphonoformic acid, phosphoramidate); phosphorothioate (—O—P(O,S)—O—, —O—P(S)₂—O—);
25 methylphosphonate (—O—P(OCH₃)—O—), and alkyl or aryl phosphonates. As discussed herein, one or more atoms of the linkage between two successive monomers in the siRNA molecules encompassed by the present invention are modified. Illustrative examples of such linkages are —CH₂—CH₂—CH₂—, —CH₂—CO—CH₂—, —CH₂—CHOH—CH₂—, —
O—CH₂—O—, —O—CH₂—CH₂—, —O—CH₂—CH=, —CH₂—CH₂—O—, —NR^H—
30 CH₂—CH₂—, —CH₂—CH₂—NR^H—, —CH₂—NR^H—CH₂—, —O—CH₂—CH₂—NR^H—, —NR^H—CO—O—, —NR^H—CO—NR^H—, —NR^H—CS—NR^H—, —NR^H—C(=NR^H)—NR^H—, —NR^H—CO—CH₂—NR^H—, —O—CO—O—, —O—CO—CH₂—O—, —O—CH₂—CO—O—, —CH₂—CO—NR^H—, —O—CO—NR^H—, —NR^H—CO—CH₂—, —

$\text{O}-\text{CH}_2-\text{CO}-\text{NR}^{\text{H}}-$, $-\text{O}-\text{CH}_2-\text{CH}_2-\text{NR}^{\text{H}}-$, $-\text{CH}=\text{N}-\text{O}-$, $-\text{CH}_2-\text{NR}^{\text{H}}\text{O}-$,
 $-\text{CH}_2-\text{O}-\text{N}=\text{O}-$, $-\text{S}-\text{P}(\text{O})_2-\text{O}-$, $-\text{S}-\text{P}(\text{O},\text{S})-\text{O}-$, $-\text{S}-\text{P}(\text{S})_2-\text{O}-$, $-\text{O}-$
 $\text{P}(\text{O})_2-\text{S}-$, $-\text{O}-\text{P}(\text{O},\text{S})-\text{S}-$, $-\text{S}-\text{P}(\text{O})_2-\text{S}-$, $-\text{O}-\text{PO}(\text{R}^{\text{H}})-\text{O}-$, $-\text{O}-$
 $\text{PO}(\text{NR}^{\text{H}})-\text{O}-$, $-\text{O}-\text{PO}(\text{OCH}_2\text{CH}_2\text{S}-\text{R})-\text{O}-$, $-\text{O}-\text{PO}(\text{BH}_3)-\text{O}-$, $-\text{O}-$
5 $\text{PO}(\text{NHR}^{\text{H}})-\text{O}-$, $-\text{O}-\text{P}(\text{O})_2-\text{NR}^{\text{H}}-$, $-\text{NR}^{\text{H}}-\text{P}(\text{O})_2-\text{O}-$, $-\text{NR}^{\text{H}}-\text{CO}-\text{O}-$, $-\text{NR}^{\text{H}}-\text{CO}-\text{NR}^{\text{H}}-$, $-\text{O}-\text{CO}-\text{O}-$, $-\text{O}-\text{CO}-\text{NR}^{\text{H}}-$, $-\text{NR}^{\text{H}}-\text{CO}-\text{CH}_2-$, $-\text{O}-$
 $\text{CH}_2-\text{CO}-\text{NR}^{\text{H}}-$, $-\text{O}-\text{CH}_2-\text{CH}_2-\text{NR}^{\text{H}}-$, $-\text{CO}-\text{NR}^{\text{H}}-\text{CH}_2-$, $-\text{CH}_2-\text{NR}^{\text{H}}-$
 $\text{CO}-$, $-\text{O}-\text{CH}_2-\text{CH}_2-\text{S}-$, $-\text{S}-\text{CH}_2-\text{CH}_2-\text{O}-$, $-\text{S}-\text{CH}_2-\text{CH}_2-\text{S}-$, $-\text{CH}_2-\text{SO}_2-\text{CH}_2-$, $-\text{CH}_2-\text{CO}-\text{NR}^{\text{H}}-$, $-\text{O}-\text{CH}_2-\text{CH}_2-\text{NR}^{\text{H}}-\text{CO}-$, $-\text{CH}_2-$
10 $\text{NCH}_3-\text{O}-\text{CH}_2-$, $-\text{S}-\text{CH}_2-\text{CH}=\text{O}-$, $-\text{O}-\text{PO}(\text{OCH}_2\text{CH}_3)-\text{O}-$, $-\text{O}-$
 $\text{PO}(\text{OCH}_2\text{CH}_2\text{S}-\text{R})-\text{O}-$, $-\text{O}-\text{PO}(\text{BH}_3)-\text{O}-$, $-\text{CH}_2-\text{S}-\text{CH}_2-$, $-\text{CH}_2-\text{SO}-$
 CH_2- , $-\text{CH}_2-\text{SO}_2-\text{CH}_2-$, $-\text{O}-\text{SO}-\text{O}-$, $-\text{O}-\text{S}(\text{O})_2-\text{O}-$, $-\text{O}-\text{S}(\text{O})_2-$
 CH_2- , $-\text{O}-\text{S}(\text{O})_2-\text{NR}^{\text{H}}-$, $-\text{NR}^{\text{H}}-\text{S}(\text{O})_2-\text{CH}_2-$, $-\text{O}-\text{S}(\text{O})_2-\text{CH}_2-$, $-\text{O}-$
 $\text{P}(\text{O})_2-\text{O}-$, $-\text{O}-\text{P}(\text{O},\text{S})-\text{O}-$, $-\text{O}-\text{P}(\text{S})_2-\text{O}-$, $-\text{O}-\text{P}(\text{O},\text{NR}^{\text{H}})-\text{O}-$, $-\text{O}-$
15 $\text{PO}(\text{R}'')-\text{O}-$, $-\text{O}-\text{PO}(\text{CH}_3)-\text{O}-$, and $-\text{O}-\text{PO}(\text{NHR}^{\text{N}})-\text{O}-$, wherein R^{H} is
selected from hydrogen and C_{1-4} -alkyl.

In the context encompassed by the present invention, preferred examples include
 phosphate, phosphodiester (PO) linkages and phosphorothioate (PS) linkages.
 Phosphorodithioates have both non-bridging oxygens replaced by sulfur. The phosphorus
20 center in the phosphorodithioates is achiral which precludes the formation of
 oligonucleotide diastereomers. Thus, while not wishing to be bound by theory,
 modifications to both non-linking oxygens, which eliminate the chiral center, *e.g.*,
 phosphorodithioate formation, can be desirable in that they cannot produce diastereomer
 mixtures. Thus, the non-linking oxygens can be independently any one of O, S, Se, B, C,
25 H, N, or OR (R is alkyl or aryl). In some embodiments, nucleic acid molecules
 encompassed by the present invention can contain one or more phosphorothioate linkages.
 For example, the polynucleotide can be partially phosphorothioate-linked, for example,
 phosphorothioate linkages can alternate with phosphodiester linkages. In certain
 embodiments, the oligonucleotide is fully phosphorothioate-linked. In other embodiments,
30 the oligonucleotide has from one to seven, one to five or one to three phosphodiester
 linkages. Phosphorothioate linkages have been used to render oligonucleotides more
 resistant to nuclease cleavage. In addition to normal 5'-3' linkage, modified
 oligonucleotide can have 5'-2' linkage and those having inverted polarity wherein the

adjacent pairs of nucleoside units are linked 3'-5' to 5'-3' or 2'-5' to 5'-2'. Representative U.S. patents that teach modifications of internucleoside linkage groups include U.S. Pat. Numbers 5,519,126; 5,536,821; 5,541,306; 5,550,111; 5,563,253; 5,571,799; 5,587,361; 5,625,050; 5,378,825; 5,697,248 and 7,368,439. Other references that teach internucleoside

5 linkage modifications include Mesmaeker *et al.* (1995) *Curr. Opin. Struct. Biol.* 5:343-355; Freier and Altmann (1997) *Nucl. Acids Res.* 25:4429-4443; and Micklefield (2001) *Curr. Med. Chem.* 8:1157-1179.

In some embodiments, nucleic acid molecules encompassed by the present invention can comprise one or more backbone-modified nucleotides.

10 The backbone-modified nucleotide is within the sense strand, antisense strand, or within the sense and antisense strands. A normal "backbone", as used herein, refers to the repeating alternating sugar-phosphate sequences in a DNA or RNA molecule. In naturally occurring DNA and RNA molecules, the backbone of a nucleic acid molecule includes deoxyribose/ribose sugars joined at both the 3'-hydroxyl and 5'-hydroxyl groups to

15 phosphate groups in ester links (*i.e.* PO linkage). The natural phosphodiester bonds can be replaced by amide bonds but the four atoms between two sugar units are kept. Such amide modifications can increase the thermodynamic stability of duplex formed with miRNA complement (see, *e.g.*, Mesmaeker *et al.* (1997) *Pure Appl. Chem.* 3:437-440). In some embodiments, nucleic acid molecules encompassed by the present invention can contain

20 chemical modifications with respect to non-locked nucleotides in the sequence, such as 2' modification with respect to 2' hydroxyl. For example, incorporation of 2'-position modified nucleotides in an siRNA molecule can increase both resistance of the oligonucleotides to nucleases and their thermal stability with complementary targets. Various modifications at the 2' positions can be independently selected from those that

25 provide increased nuclease resistance, without compromising molecular interactions with the target or cellular machinery. Such modifications can be selected on the basis of their increased potency *in vitro* or *in vivo*. In some embodiments, the 2' modification can be independently selected from a number of different "oxy" or "deoxy" substituents. Examples of "oxy"-2' hydroxyl group modifications include alkoxy or aryloxy (*e.g.*,

30 Omethyl, R=H, alkyl, cycloalkyl, aryl, aralkyl, heteroaryl or sugar; polyethyleneglycols (PEG), O(CH₂CH₂O)_nCH₂CH₂OR (n=1-50); O-AMINE or O—(CH₂)_nAMINE (n=1-10), AMINE=NH₂; alkylamino, dialkylamino, heterocyclyl, arylamino, diaryl amino, heteroaryl amino, diheteroaryl amino, ethylene diamine or polyamino; and O—

CH₂CH₂(NCH₂CH₂NMe₂)₂). “Deoxy” modifications include hydrogen (*i.e.*, deoxyribose sugars, which are of particular relevance to the single-strand overhangs); halo (*e.g.*, fluoro); amino (*e.g.*, NH₂; alkylamino, dialkylamino, heterocyclyl, arylamino, diaryl amino, heteroaryl amino, diheteroaryl amino, or amino acid; NH(CH₂CH₂NH)_nCH₂CH₂-AMINE (AMINE=NH₂; alkylamino, dialkylamino, heterocyclyl, arylamino, diaryl amino, heteroaryl amino, or diheteroaryl amino; —NHC(O)R(R=alkyl, cycloalkyl, aryl, aralkyl, heteroaryl or sugar); cyano; mercapto; alkyl-thio-alkyl; thioalkoxy; thioalkyl; alkyl; cycloalkyl; aryl; alkenyl and alkynyl.

Substantially all, or all, nucleotide 2' positions of the non-locked nucleotides can be modified in certain embodiments. For example, the 2' modifications can each be independently selected from O-methyl and fluoro. In exemplary embodiments, purine nucleotides each have a 2' O-methyl and pyrrolidine nucleotides each have a 2'-F. In accordance with the present invention, 2' position modifications can also include small hydrocarbon substituents. The hydrocarbon substituents include alkyl, alkenyl, alkynyl, and alkoxyalkyl, where the alkyl (including the alkyl portion of alkoxy), alkyl and alkyl can be substituted or unsubstituted. The alkyl, alkenyl, and alkynyl can be C1 to C10 alkyl, alkenyl or alkynyl, such as C1, C2, or C3. The hydrocarbon substituents can include one or two or three non-carbon atoms, which can be independently selected from N, O, and/or S. The 2' modifications can further include the alkyl, alkenyl, and alkynyl as O-alkyl, O-alkenyl, and O-alkynyl. Exemplary 2' modifications in accordance with the invention include 2'-H, 2'-O-alkyl (C1-3alkyl, such as 2'-O-Methyl or 2'-OEt), 2'-O-methoxyethyl (2'-O-MOE), 2'-O-aminopropyl (2'-O-AP), 2'-O-dimethylaminoethyl (2'-O-DMAOE), 2'-O-dimethylaminopropyl (2'-O-DMAP), 2'-O-dimethylaminoethoxyethyl (2'-O-DMAEOE), 2'-O-N-methylacetamido (2'-O-NMA) or gem 2'-OMe/2'F substitutions. In some embodiments, nucleic acid molecules encompassed by the present invention contains at least one 2' position modified as 2'-O-Methoxy (2'-OMe) in non-locked nucleotides. The oligonucleotide can contain from 1 to about 5 2'-O-Methoxy (2'-OMe) modified nucleotides, or from 1 to about 3 2'-O-Methoxy (2'-OMe) modified nucleotides. In some embodiments, all the nucleotides of the miR-124 mimic contain 2'-O-Methoxy (2'-OMe) modification. Other exemplary combinations of different types of 2' position modifications can contain at least one 2'-halo modification (*e.g.*, in place of a 2' hydroxyl), such as 2'-fluoro, 2'-chloro, 2'-bromo, and 2'-iodo.

In some embodiments, the backbone of a strand or the strand of the nucleic acid molecule can be constructed wherein the phosphate linker and ribose sugar are replaced by nuclease resistant nucleosides or nucleotide surrogates. While not wishing to be bound by theory, it is believed that the absence of a repetitively charged backbone diminishes binding to proteins that recognize polyanions (*e.g.*, nucleases). As non-limiting examples, such nucleotide surrogates include morpholino, cyclobutyl, pyrrolidine, peptide nucleic acid (PNA), aminoethylglycyl PNA (Aegina) and backbone-extended pyrimidine PNA (bepPNA) nucleoside surrogates (*e.g.*, U.S. Pat. Numbers 5,359,044; 5,519,134; 5,142,047 and 5,235,033; Bioorganic & Medicinal Chemistry (1996), 4:5-23). A surrogate for the replacement of the sugar-phosphate backbone involves a PNA surrogate (peptide nucleic acid). The term "peptide nucleic acid (PNA)" is chemically synthesized polymer similar to DNA and RNA, wherein the backbone is composed of repeating N-(2-aminoethyl)-glycine (AEG) units linked by peptide bonds (Nielsen *et al.* (1991) *Science* 254:1497-1500). Synthetic oligonucleotides with PNAs have higher binding strength and greater specificity in binding to complementary DNAs or RNAs, with a PNA/DNA base mismatch being more desirable than a similar DNA/RNA duplex. PNAs are not easily recognized by either nucleases or proteases, making them resistant to enzyme degradation. PNAs are also stable over a wide pH range. PNA has been suggested for use in antisense and anti-gene therapy in a number of studies. PNA is resistant to DNases and proteases and can be further modified for increased cell penetration, etc.

Other modifications

Nucleic acid molecules encompassed by the present invention can also contain additional modifications, such as mismatches, bulges, or crosslinks. Similarly, they can also include other conjugates, such as linkers, heterofunctional cross linkers, dendrimer, nano-particle, peptides, organic compounds (*e.g.*, fluorescent dyes), and/or photocleavable compounds. In some embodiments, nucleic acid molecules encompassed by the present invention can comprise any combination of two or more modifications as described herein. The nucleic acid sequences can comprise, independently, one or more modifications to one or more sugar moieties, to one or more internucleoside linkages, and/or to one or more nucleobases. As disclosed herein, these sequences can be modified with any combinations of chemical modifications.

In some embodiments, the nucleic acid molecule is a siRNA which comprises a nucleic acid sequence wherein the sense strand and anti-sense strand comprise one or more mismatches, for example, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, or more mismatches. The term “mismatch” refers to a basepair consisting of non-complementary bases, *e.g.*, not normal complementary G:C, A:T or A:U base pairs. In some embodiments, the antisense strand of the siRNA molecule encompassed by the present invention and the target mRNA sequence can comprise one or more mismatches, for example, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, or more mismatches. In some instances, the mismatch can be downstream of the cleavage site referencing the antisense strand. More preferably, the mismatch can be present within 1-6 nucleotides from the 3' end of the antisense strand. In another embodiment, the siRNA molecule encompassed by the present invention comprises a bulge, *e.g.*, one or more, *e.g.*, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, or more, unpaired bases in the duplex siRNA. Preferably, the bulge can be in the sense strand.

In some embodiments, the siRNA molecule encompassed by the present invention comprises one or more (*e.g.*, about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, or more) crosslinks, *e.g.*, a crosslink wherein the sense strand is crosslinked to the antisense strand of the siRNA duplex. Crosslinkers useful in the invention are those commonly known in the art, including, but not limited to, psoralen, mitomycin C, cisplatin, chloroethylnitrosoureas and the like. Preferably, the crosslink is present downstream of the cleavage site referencing the antisense strand, and more preferably, the crosslink is present at the 5' end of the sense strand. In accordance with the present invention, siRNA derivatives are also included, such as a siRNA derivative having a single crosslink (*e.g.*, a psoralen crosslink), a siRNA having a photocleavable biotin (*e.g.*, photocleavable biotin), a peptide (*e.g.*, a Tat peptide), a nanoparticle, a peptidomimetic, organic compounds (*e.g.*, a dye such as a fluorescent dye), or dendrimer.

In some embodiments, nucleic acid molecules encompassed by the present invention can include other appended groups, such as peptides (*e.g.*, for targeting host cell receptors *in vivo*), or agents facilitating transport across the cell membrane (see, *e.g.*, Letsinger *et al.* (1989) *Proc. Natl. Acad. Sci. U.S.A.* 86:6553-6556; Lemaitre *et al.* (1987) *Proc. Natl. Acad. Sci. U.S.A.* 84:648-652; PCT Pat. Publ. No. WO 88/09810) or the blood-brain barrier (see, *e.g.*, PCT Publ. No. WO 89/10134). In addition, nucleic acid molecules can be modified with hybridization-triggered cleavage agents (see, *e.g.*, Krol *et al.* (1988)

BioTechniques 6:958-976) or intercalating agents (see, *e.g.*, Zon (1988) *Pharm. Res.* 5:539-549).

In some embodiments, the siRNA molecules encompassed by the present invention can comprise any combinations of two or more modifications as described herein. The nucleic acid sequences set forth herein are independent of any modification to the nucleic acid. As such, nucleic acids defined by a SEQ ID NO can comprise, independently, one or more modifications to one or more sugar moieties, to one or more internucleoside linkages, and/or to one or more nucleobases. As disclosed herein, these sequences can be modified with any combinations of chemical modifications.

In some embodiments, the siRNA molecules encompassed by the present invention can include a sense strand and an antisense strand, wherein the antisense strand has a sequence sufficiently complementary to CCR2 mRNA sequence (SEQ ID NO: 1), or to CSF1R mRNA sequence (SEQ ID NO: 2), to direct target-specific RNA interference (RNAi) and wherein the sense strand and/or antisense strand is modified by the substitution of nucleotides with modified nucleotides. In one embodiment, the sense strand and/or antisense strand is modified by the substitution of at least one nucleotide. In another embodiment, the sense strand and/or antisense strand is modified by the substitution of at least 2 nucleotides, 3 nucleotides, 4 nucleotides, 5 nucleotides, 6 nucleotides, 7 nucleotides, 8 nucleotides, 9 nucleotides, 10 nucleotides, 11 nucleotides, 12 nucleotides, 13 nucleotides, 14 nucleotides, 15 nucleotides, 16 nucleotides, 17 nucleotides, 18 nucleotides, 19 nucleotides, 20 nucleotides, 21 nucleotides, 22 nucleotides, 23 nucleotides, 24 nucleotides, 25 nucleotides, 26 nucleotides, 27 nucleotides, 28 nucleotides, 29 nucleotides, 30 nucleotides, or more nucleotides. In another embodiment, the sense strand and/or antisense strand is modified by the substitution of at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or more of the internal nucleotides. In yet another embodiment, the sense strand and/or antisense strand is modified by the substitution of all of the nucleotides.

In some embodiments, the siRNA molecule that hybridize to CSF1R can comprise a modified sense nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 368 to 486 and a modified antisense nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 487 to 605 (Table 4). The target position of the sense and antisense duplex is indicated in the first column in Table 4. In other embodiments, a modified siRNA molecule that can result in a

significant reduction of CSF1R mRNA in macrophages can be further modified to generate one or more variants. As non-limiting examples, some variants derived from siRNA molecules that hybridize to CSF1R can comprise a modified sense nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 883 to 921 and a modified antisense nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 922 and 960. These modifications can increase the efficiency, specificity and stability of the siRNA molecule.

Table 4: Modified sense and anti-sense sequences of siRNA specific to CSF1R

Duplex Position	duplex ID	SS ID	sense strand sequence (5'-3')	SEQ ID NO	AS ID	antisense strand sequence (5'-3')	SEQ ID NO:
346	XD-08903	X28754	ggGAUucccAGuGauAGAGdTsdT	368	X28755	CUCuAUcACUGGGAUUCcCdTsdT	487
410	XD-08904	X28756	uuGcGAuGuGuGGgcAAuGdTsdT	369	X28757	cAUUGCCcAcAcAUCGcAAdTsdT	488
412	XD-08905	X28758	gcGAuGuGuGGGcaAuGGcdTsdT	370	X28759	GCcAUUGCCcAcAcAUCGcCdTsdT	489
508	XD-08906	X28760	caAcGcuAccuuccAAAcdTsdT	371	X28761	GUUUUGGAAGGuAGCGUUGdTsdT	490
510	XD-08907	X28762	acGcuAccuuccAAAcAcdTsdT	372	X28763	GUGUUUUGGAAGGuAGCGUdTsdT	491
511	XD-08908	X28764	cgcGcuAccuuccAAAcAcGdTsdT	373	X28765	CGUGUUUUGGAAGGuAGCGdTsdT	492
604	XD-08909	X28766	ugcccGGcccuGGaAcGuGdTsdT	374	X28767	cACGUUCcAGGGCCGGGcAdTsdT	493
675	XD-08910	X28768	ugcucAcAGAcccgGuGcudTsdT	375	X28769	AGcACCGGGUCUGUGAGcAdTsdT	494
700	XD-08911	X28770	agGcGucucGcuGguGcGudTsdT	376	X28771	ACGcACcAGCGAGACGCCUdTsdT	495
817	XD-08912	X28772	ucAAuGcAGuGccuGAuGdTsdT	377	X28773	cAUcAGGGcACUGcAUUGAdTsdT	496
859	XD-08913	X28774	caGcAuccGGcuGaAGuGdTsdT	378	X28775	cACUUUcAGCCGGAUGCUGdTsdT	497
921	XD-08914	X28776	caGAGcuGGuGcGgAuucGdTsdT	379	X28777	CGAAUCCGcACcAGCUCUGdTsdT	498
923	XD-08915	X28778	gaGcuGGuGcGGAuuGAGdTsdT	380	X28779	CUCGAAUCCGcACcAGCUCdTsdT	499
930	XD-08916	X28780	ugcGGAuucGAGGgGAGGcdTsdT	381	X28781	GCCUCCCCUCGAUCCGcAdTsdT	500
948	XD-08917	X28782	cuGcccAGAuGuguGcudTsdT	382	X28783	GAGcAcACGAUCUGGGcAGdTsdT	501
950	XD-08918	X28784	gcccAGAuGuguGcuGcAdTsdT	383	X28785	CUGAGcAcACGAUCUGGGCdTsdT	502
953	XD-08919	X28786	caGAuGcuGcuGcucAGccAdTsdT	384	X28787	UGGCUGAGcAcACGAUCUGdTsdT	503
1053	XD-08920	X28788	auAAccGuuAccAaAAGudTsdT	385	X28789	ACUUUUUGGuAACCGUuAuDtTsdT	504
1055	XD-08921	X28790	aaccGuuAccAAAaAGuccdTsdT	386	X28791	GGACUUUUUGGuAACGGUuDtTsdT	505
1056	XD-08922	X28792	accGuuAccAAAaGuccdTsdT	387	X28793	AGGACUUUUUGGuAACGGUdTsdT	506

1060	XD-08923	X28794	uuAccAAAAAGuccu GaccdTsdT	388	X28795	GGUcAGGACUUU UUGGuAAdTsdT	507
1288	XD-08924	X28796	agGuuuuAAcuGGacc uAcdTsdT	389	X28797	GuAGGUCcAGUu AAAACCUdTsdT	508
1289	XD-08925	X28798	gguuuuAAcuGGAccu AccdTsdT	390	X28799	GGuAGGUcAGU uAAAACcdTsdT	509
1292	XD-08926	X28800	uuuAAcuGGAccuacc uGGdTsdT	391	X28801	CcAGGuAGGUCc AGUuAAAdTsdT	510
1293	XD-08927	X28802	uuAAcuGGAccuAcc uGGdTsdT	392	X28803	CCcAGGuAGGUC cAGUuAAdTsdT	511
1300	XD-08928	X28804	gaccuAccuGGGAccc uuudTsdT	393	X28805	AAAGGGUCCcAG GuAGGUCdTsdT	512
1467	XD-08929	X28806	ugAcGuuuGAGcucA cccdTsdT	394	X28807	AGGGUGAGCUcA AACGUcAdTsdT	513
1468	XD-08930	X28808	gacGuuuGAGcucacc uudTsdT	395	X28809	AAGGGUGAGCUc AAACGUCdTsdT	514
1473	XD-08931	X28810	uuGAGcucAcccuucG AuAdTsdT	396	X28811	uAUCGAAGGGUG AGCUcAAdTsdT	515
1476	XD-08932	X28812	agcucAcccuucGauAc ccdTsdT	397	X28813	GGGuAUCGAAGG GUGAGCUdTsdT	516
1485	XD-08933	X28814	uucGAuAccccccGA GGuAdTsdT	398	X28815	ACCUCUGGGGG GuAUCGAAdTsdT	517
1488	XD-08934	X28816	gauAccccccAGAgGu AAGdTsdT	399	X28817	CUuACCUCUGGG GGGuAUCdTsdT	518
1715	XD-08935	X28818	gaGAccuuAGAGcac AAccdTsdT	400	X28819	GGUUGUGCUCuA AGGUCUCdTsdT	519
1717	XD-08936	X28820	gaccuuAGAGcAcaAc cAAdTsdT	401	X28821	UUGGUUGUGCU CuAAGGUCdTsdT	520
1759	XD-08937	X28822	caGcGuGGGAGug GcuccdTsdT	402	X28823	GGAGCcACUCCC cACGCUGdTsdT	521
1815	XD-08938	X28824	aucccccGGAuGAGuu ccudTsdT	403	X28825	AGGAACUcAUCC GGGGGAUdTsdT	522
1819	XD-08939	X28826	cccGGAuGAGuuccuc uucdTsdT	404	X28827	GAAGAGGAACUc AUCCGGGdTsdT	523
1847	XD-08940	X28828	guGGucGccuGcAuG uccAdTsdT	405	X28829	UGGAcAUGcAGG CGAcAcAdTsdT	524
1896	XD-08941	X28830	ugcuAuuGuAcAAgu AuAAdTsdT	406	X28831	UuAuACUUGuAcA AuAGcAdTsdT	525
1931	XD-08942	X28832	caGGuccGcuGGAaG AucAdTsdT	407	X28833	UGAUCUUCcAGC GGACCUGdTsdT	526
1933	XD-08943	X28834	gguccGcuGGAAGau cAucdTsdT	408	X28835	GAUGAUCUUCcA GCGGACCdTsdT	527
1935	XD-08944	X28836	uccGcuGGAAGAu AucGAdTsdT	409	X28837	UCGAUGAUCU CcAGCGGAdTsdT	528
1936	XD-08945	X28838	ccGcuGGAAGAucau cGAGdTsdT	410	X28839	CUCGAUGAUCU UCcAGCGGdTsdT	529
1946	XD-08946	X28840	aucAucGAGAGcuau GAGGdTsdT	411	X28841	CCUcAuAGCUCU CGAUGAUdTsdT	530
1948	XD-08947	X28842	caucGAGAGcuAugA GGGcdTsdT	412	X28843	GCCCUcAuAGCU CUCGAUGdTsdT	531
1958	XD-08948	X28844	uauGAGGGcAAcAg uuAuAdTsdT	413	X28845	uAuAACUGUUGC CCUcAuAdTsdT	532
1962	XD-08718	X28192	agGGcAAcAGuuAu AcuuudTsdT	414	X28193	AAAGuAuAACUG UUGCCCUdTsdT	533
1964	XD-08950	X28846	ggcAAcAGuuAuAcu uucAdTsdT	415	X28847	UGAAAGuAuAAC UGUUGCCdTsdT	534
1990	XD-08951	X28848	cacGcAGcuGccuuAc AAcdTsdT	416	X28849	GUUGuAAGGcAG CUGCGUGdTsdT	535

2021	XD-08952	X28850	uucccccGGAACaacc uGcdTsdT	417	X28851	GcAGGUUGUUCG GGGGGAAdTsdT	536
2026	XD-08953	X28852	ccGGAACaAccuGcA GuudTsdT	418	X28853	AAACUGcAGGUU GUUCCGdTsdT	537
2042	XD-08954	X28854	uuuGGuAAGAccuc GGAGdTsdT	419	X28855	CUCCGAGGGUC UuACcAAAdTsdT	538
2044	XD-08955	X28856	ugGuAAGAccucgG AGcdTsdT	420	X28857	AGCUCCGAGGG UCUuACcAdTsdT	539
2145	XD-08956	X28858	ugAAGuccAcGGccc AuGcdTsdT	421	X28859	GcAUGGGCCGUG GACUUCAdTsdT	540
2146	XD-08957	X28860	gaAGuccAcGGcccAu GcdTsdT	422	X28861	AGcAUGGGCCGU GGACUUCdTsdT	541
2264	XD-08958	X28862	ccuGuAcuGGucAuc AcGGdTsdT	423	X28863	CCGUGAUGACcA GuAcAGGdTsdT	542
2265	XD-08959	X28864	cuGuAcuGGucAucA cGGAdTsdT	424	X28865	UCCGUGAUGACc AGuAcAGdTsdT	543
2266	XD-08960	X28866	uguAcuGGucAucacG GAGdTsdT	425	X28867	CUCCGUGAUGA CcAGuAcAdTsdT	544
2268	XD-08961	X28868	uacuGGucAucAcgG AGuAdTsdT	426	X28869	uACUCCGUGAUG ACcAGuAdTsdT	545
2272	XD-08962	X28870	ggucAucAcGGAGuA cuGudTsdT	427	X28871	AcAGuACUCCGU GAUGACCdTsdT	546
2276	XD-08963	X28872	aucAcGGAGuAcugu uGcdTsdT	428	X28873	AGcAAcAGuACU CCGUGAUdTsdT	547
2277	XD-08964	X28874	ucAcGGAGuAcuGuu GcuAdTsdT	429	X28875	uAGcAAcAGuACU CCGUGAdTsdT	548
2279	XD-08965	X28876	acGGAGuAcuGuugc uAuGdTsdT	430	X28877	cAuAGcAAcAGuA CUCCGUdTsdT	549
2283	XD-08966	X28878	aguAcuGuuGcuAuG GcGAdTsdT	431	X28879	UCGCcAuAGcAAc AGuACUdTsdT	550
2288	XD-08967	X28880	uguuGcuAuGGcGacc uGcdTsdT	432	X28881	GcAGGUCCGcAu AGcAAcAdTsdT	551
2292	XD-08968	X28882	gcuAuGGcGAccugcu cAAAdTsdT	433	X28883	UUGAGcAGGUCC CcAuAGCdTsdT	552
2295	XD-08969	X28884	auGGcGAccuGcucA AcuudTsdT	434	X28885	AAGUUGAGcAGG UCGCcAUdTsdT	553
2305	XD-08970	X28886	gcucAAcuuucuGcGA AGGdTsdT	435	X28887	CCUUCGcAGAAA GUUGAGCdTsdT	554
2308	XD-08971	X28888	caAcuuucuGcGAaGG AAGdTsdT	436	X28889	CUUCCUUCGcAG AAAGUUGdTsdT	555
2313	XD-08972	X28890	uucuGcGAAGGAAG GcuGAdTsdT	437	X28891	UcAGCCUCCUU CGcAGAdTsdT	556
2444	XD-08973	X28892	caGGGuGuGGAcAcc uAuGdTsdT	438	X28893	cAuAGGUGUCcAc ACCCUGdTsdT	557
2518	XD-08974	X28894	ggAcAAGGAGGAUG GAcGGdTsdT	439	X28895	CCGUCcAUCCUC CUUGUCCdTsdT	558
2600	XD-08975	X28896	gcuuccAAGAAuugc AuccdTsdT	440	X28897	GGAUGcAAUUCU UGGAAGCdTsdT	559
2679	XD-08976	X28898	acuucGGGcuGGcuA GGGAdTsdT	441	X28899	UCCCuAGCcAGC CCGAAGUdTsdT	560
2687	XD-08977	X28900	cuGGcuAGGGAcAu cAuGAdTsdT	442	X28901	UcAUGAUGUCCC uAGCcAGdTsdT	561
2689	XD-08978	X28902	ggcuAGGGAcAucAu GAAdTsdT	443	X28903	AUUCaUGAUGUC CCuAGCCdTsdT	562
2774	XD-08979	X28904	uuuGAcuGuGucuacA cGGdTsdT	444	X28905	CCGUGuAGAcAc AGUcAAAdTsdT	563
2776	XD-08980	X28906	ugAcuGuGucuAcacG GuudTsdT	445	X28907	AACCGUGuAGAc AcAGUcAdTsdT	564

2778	XD-08981	X28908	acuGuGucuAcAcgGuucAdTsdT	446	X28909	UGAACCGUGuAGAcAcAGUdTsdT	565
2781	XD-08982	X28910	guGucuAcAcGGuucAGAGdTsdT	447	X28911	CUCUGAACCGUGuAGAcACdTsdT	566
2785	XD-08983	X28912	cuAcAcGGuucAGaGcGAcdTsdT	448	X28913	GUCGCUCUGAACCGUGuAGdTsdT	567
2788	XD-08984	X28914	cacGGuucAGAGcgAcGucdTsdT	449	X28915	GACGUCGCUCUGAACCGUGdTsdT	568
2791	XD-08985	X28916	gguucAGAGcGAcguGcGdTsdT	450	X28917	CcAGACGUCGUCUGAACCGdTsdT	569
2793	XD-08986	X28918	uucAGAGcGAcGucuGGucdTsdT	451	X28919	GACcAGACGUCGCUCUGAAAdTsdT	570
2843	XD-08987	X28920	cuuGGGcuGAuuccuAccdTsdT	452	X28921	GGuAGGGAUUCaGCCcAAGdTsdT	571
2874	XD-08988	X28922	ugAAcAGcAAGuucuAuAAdTsdT	453	X28923	UuAuAGAACUUGCUGUUCAdTsdT	572
2880	XD-08989	X28924	gcAAGuucuAuAAacuGGdTsdT	454	X28925	ACcAGUuAuAGAACUUGCdTsdT	573
2940	XD-08990	X28926	agAAuAuAuAcAGcAucAudTsdT	455	X28927	AUGAUGCUGuAuAuAUUCUdTsdT	574
3047	XD-08991	X28928	agAGAGcGGGAcuaAccAdTsdT	456	X28929	UGGuAuAGUCCCGCUCUCUdTsdT	575
3048	XD-08992	X28930	gaGAGcGGGAcuAuAccAAdTsdT	457	X28931	UUGGuAuAGUCCCGCUCUCUdTsdT	576
3049	XD-08993	X28932	agAGcGGGAcuAuaccAAudTsdT	458	X28933	AUUGGuAuAGUCCCGCUCUCUdTsdT	577
3052	XD-08994	X28934	gcGGGAcuAuAccaAucuGdTsdT	459	X28935	cAGAUUGGuAuAGUCCCGCdTsdT	578
3055	XD-08995	X28936	ggAcuAuAccAAucGccGdTsdT	460	X28937	CGGcAGAUUGGuAuAGUCCdTsdT	579
3149	XD-08996	X28938	ugcuGcGAGcAAGgGGAuAdTsdT	461	X28939	uAUCCCCUUGCUCGcGAdTsdT	580
3153	XD-08997	X28940	gcGAGcAAGGGGAuAucGcdTsdT	462	X28941	GCGAuAUCCCCUUGCUCGcdTsdT	581
3154	XD-08998	X28942	cgAGcAAGGGGAuaucGccdTsdT	463	X28943	GGCGAuAUCCCCUUGCUCGdTsdT	582
3164	XD-08999	X28944	gauAucGcccAGcccuGcdTsdT	464	X28945	GcAAGGGCUGGGCGAuAUCdTsdT	583
3186	XD-09000	X28946	agcccAAcAAcuAucAGuudTsdT	465	X28947	AACUGAuAGUUGUUGGGCUdTsdT	584
3187	XD-09001	X28948	gcccAAcAAcuAucAGuucdTsdT	466	X28949	GAACUGAuAGUUGUUGGGCdTsdT	585
3188	XD-09002	X28950	cccAAcAAcuAucaGuucdTsdT	467	X28951	AGAACUGAuAGUUGUUGGGdTsdT	586
3292	XD-09003	X28952	acAAAcucuGccuucGucdTsdT	468	X28953	GACCGAAGGcAGAGUUGUdTsdT	587
3298	XD-09004	X28954	ucuGccuucGGucauuucAdTsdT	469	X28955	UGAAAUGACCGAAGGcAGAdTsdT	588
3301	XD-09005	X28956	gccuucGucAuucAcucdTsdT	470	X28957	GAGUGAAAUGACCGAAGGCdTsdT	589
3305	XD-09006	X28958	ucGGuAuucAcucAcAdTsdT	471	X28959	UGUUGAGUGAAUGACCGAdTsdT	590
3457	XD-09007	X28960	cucAuGGuGuuGGccucGdTsdT	472	X28961	ACGAGGCcAAcAcAUGAGdTsdT	591
3458	XD-09008	X28962	ucAuGGuGuuGGccucGuGdTsdT	473	X28963	cACGAGGCcAAcAcAUGAdTsdT	592
3459	XD-09009	X28964	cauGGuGuuGGccucGuGdTsdT	474	X28965	AcACGAGGCcAAcAcAUGdTsdT	593

3462	XD-09010	X28966	gguGuuGGccucGuGuuuGdTsdT	475	X28967	cAAAcACGAGGCcAAcACcGdTsdT	594
3473	XD-09011	X28968	cguGuuuGcuAuGccAAcudTsdT	476	X28969	AGUUGGcAuAGcAAAcACGdTsdT	595
3808	XD-09012	X28970	agcuAAAAGuuGGGGGuGdTsdT	477	X28971	AcACCCcAACUUuAGCUdTsdT	596
3911	XD-09013	X28972	ccAAGcuGAcucAuccuAAdTsdT	478	X28973	UuAGGAUGAGUcAGCUUGGdTsdT	597
3914	XD-09014	X28974	agcuGAcucAuccuAAcuAdTsdT	479	X28975	uAGUuAGGAUGAGUcAGCUdTsdT	598
3916	XD-09015	X28976	cuGAcucAuccuAacuAAcTsdT	480	X28977	GUuAGUuAGGAUGAGUcAGdTsdT	599
3917	XD-09016	X28978	ugAcucAuccuAAcuAAcAdTsdT	481	X28979	UGUuAGUuAGGAUGAGUcAdTsdT	600
3918	XD-09017	X28980	gacucAuccuAAcuAAcAGdTsdT	482	X28981	CUGUuAGUuAGGAUGAGUCdTsdT	601
3924	XD-09018	X28982	uccuAAcuAAcAGucAcGdTsdT	483	X28983	GCGUGACUGUuAGUuAGGAdTsdT	602
3925	XD-09019	X28984	ccuAAcuAAcAGucAcGcdTsdT	484	X28985	GGCGUGACUGUuAGUuAGGdTsdT	603
3958	XD-09020	X28986	uccAcAuuAAAcuaAcAGdTsdT	485	X28987	GCUGUuAGUuAUGUGGAdTsdT	604
3959	XD-09021	X28988	ccAcAuuAAAcuAacAGcAdTsdT	486	X28989	UGCUGUuAGUuAAUGUGGdTsdT	605

In some embodiments, the siRNA molecule that hybridize to CCR2 can comprise a modified sense nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 606 to 743 and a modified antisense nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 744 to 881 (Table 5). The identifier of the sense and antisense duplex is indicated in the first column in Table 5. In other embodiments, a modified siRNA molecule that can result in a significant reduction of CCR2 mRNA in macrophages can be further modified to generate one or more variants. As non-limiting examples, some variants derived from siRNA molecules that hybridize to CCR2 can comprise a modified sense nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 961 to 1001 and a modified antisense nucleic acid sequence selected from the group consisting of nucleic acid sequences of SEQ ID NOs: 1002 and 1042. These modifications can increase the efficiency, specificity and stability of the siRNA molecule.

Table 5: Modified sense and anti-sense sequences of siRNA specific to CCR2

Duplex ID	SS ID	Sense Sequence (5'-3')	SEQ ID NO	AS ID	Antisense Sequence (5'-3')	SEQ ID NO
XD-09027	X29012	caAGGAcGcAuuuucccAGdTsdT	606	X29013	CUGGGGAAAUGCGUCCUUGdTsdT	744
XD-09028	X29014	aaGGAcGcAuuuucccAGuTsdT	607	X29015	ACUGGGGAAAUGCGUCCUUdTsdT	745

XD-09029	X29016	ggAcGcAuuuccccAGu AcdTsdT	608	X29017	GuACUGGGGAAAUGCG UCCdTsdT	746
XD-09030	X29018	gacGcAuuuccccaGuAc AdTsdT	609	X29019	UGuACUGGGGAAAUGC GUCdTsdT	747
XD-09031	X29020	acGcAuuuccccAguAcA udTsdT	610	X29021	AUGuACUGGGGAAAUG CGuTdTsdT	748
XD-09032	X29022	cgcAuuuccccAGuAcAu cdTsdT	611	X29023	GAUGuACUGGGGAAAU GCGdTsdT	749
XD-09033	X29024	cauuuccccAGuAcAucc AdTsdT	612	X29025	UGGAUGuACUGGGGAA AUGdTsdT	750
XD-09034	X29026	auuuccccAGuAcauccA cdTsdT	613	X29027	GUGGAUGuACUGGGGA AAuTdTsdT	751
XD-09035	X29028	uuuccccAGuAcAuccAc AdTsdT	614	X29029	UGUGGAUGuACUGGGG AAAdTsdT	752
XD-09036	X29030	uccccAGuAcAuccAcA AcdTsdT	615	X29031	GUUGUGGAUGuACUGG GGAdTsdT	753
XD-09037	X29032	caGuAcAuccAcAacAu GcdTsdT	616	X29033	GcAUGUUGUGGAUGuA CUGdTsdT	754
XD-09038	X29034	guAcAuccAcAAcauGc uGdTsdT	617	X29035	cAGcAUGUUGUGGAUGu ACdTsdT	755
XD-09039	X29036	acAuccAcAAcAugcuG ucdTsdT	618	X29037	GAcAGcAUGUUGUGGA UGuTdTsdT	756
XD-09040	X29038	auGcuGuccAcAucucGu udTsdT	619	X29039	AACGAGAUGUGGAcAG cAUdTsdT	757
XD-09041	X29040	ugcuGuccAcAucucGuu cdTsdT	620	X29041	GAACGAGAUGUGGAcA GcAdTsdT	758
XD-09042	X29042	gcuGuccAcAucucGuuc udTsdT	621	X29043	AGAACGAGAUGUGGAc AGCdTsdT	759
XD-09043	X29044	cuGuccAcAucucguucuc dTsdT	622	X29045	GAGAACGAGAUGUGGA cAGdTsdT	760
XD-09044	X29046	guccAcAucucGuucucG GdTsdT	623	X29047	CCGAGAACGAGAUGUG GACdTsdT	761
XD-09045	X29048	uccAcAucucGuucucGG udTsdT	624	X29049	ACCGAGAACGAGAUGU GGAdTsdT	762
XD-09046	X29050	ccAcAucucGuucucGGu udTsdT	625	X29051	AACCGAGAACGAGAUG UGGdTsdT	763
XD-09047	X29052	cacAucucGuucucGGuu udTsdT	626	X29053	AAACCGAGAACGAGAU GUGdTsdT	764
XD-09048	X29054	acAucucGuucucgGuuu AdTsdT	627	X29055	uAAACCGAGAACGAGA UGuTdTsdT	765
XD-09049	X29056	caucucGuucucGguuuA udTsdT	628	X29057	AuAAACCGAGAACGAG AUGdTsdT	766
XD-09050	X29058	ucucGuucucGGuuuAuc AdTsdT	629	X29059	UGAuAAACCGAGAACG AGAdTsdT	767
XD-09051	X29060	cucGuucucGGuuuAuc AGdTsdT	630	X29061	CUGAuAAACCGAGAAC GAGdTsdT	768
XD-09052	X29062	ucGuucucGGuuuauca GAdTsdT	631	X29063	UCUGAuAAACCGAGAA CGAdTsdT	769
XD-09053	X29064	cguucucGGuuuAucAG AAdTsdT	632	X29065	UUCUGAuAAACCGAGA ACGdTsdT	770
XD-09054	X29066	uucucGGuuuAucaGAA AudTsdT	633	X29067	AUUUCUGAuAAACCGA GAAdTsdT	771
XD-09055	X29068	ucucGGuuuAucAgAA AuAdTsdT	634	X29069	uAUUUCUGAuAAACCG AGAdTsdT	772
XD-09056	X29070	cucGGuuuAucAGaAA uAcdTsdT	635	X29071	GuAUUUCUGAuAAACC GAGdTsdT	773
XD-09057	X29072	ucGGuuuAucAGaAu AccdTsdT	636	X29073	GGuAUUUCUGAuAAAC CGAdTsdT	774

XD-09058	X29074	uuuAucAGAAuAccA AcGdTsdT	637	X29075	CGUUGGuAUUUCUGAu AAAdTsdT	775
XD-09059	X29076	agAGcGGuGAAGaG ucAdTsdT	638	X29077	GUGACUUCUuACCGC UCUdTsdT	776
XD-09060	X29078	cgGuGAAGAGucacc AccdTsdT	639	X29079	GGUGGUGACUUCUuA CCGdTsdT	777
XD-09061	X29080	aaGucAccAccuuuuuG AdTsdT	640	X29081	UcAAAAAAGGUGGUGA CUUdTsdT	778
XD-09062	X29082	ucAccAccuuuuuGAuu AdTsdT	641	X29083	uAAUcAAAAAAGGUGG UGAdTsdT	779
XD-09063	X29084	caccAccuuuuuugAuA udTsdT	642	X29085	AuAAUcAAAAAAGGUG GUGdTsdT	780
XD-09064	X29086	accAccuuuuuGAuuAu GdTsdT	643	X29087	cAuAAUcAAAAAAGGUG GUDdTsdT	781
XD-09065	X29088	uuuuGAuuAuGAuuAc GGudTsdT	644	X29089	ACCGuAAUcAuAAUcAA AAdTsdT	782
XD-09066	X29090	ugAuAuGAuuAcgGu GcudTsdT	645	X29091	AGcACCGuAAUcAuAAU cAdTsdT	783
XD-09067	X29092	uuAuGAuuAcGGuguc ccdTsdT	646	X29093	GGGAGcACCGuAAUcAu AAdTsdT	784
XD-09068	X29094	uuuGAuuAcGGuGcucc cudTsdT	647	X29095	AGGGAGcACCGuAAUcA uAdTsdT	785
XD-09069	X29096	ugAuAcGGuGcucccu GudTsdT	648	X29097	AcAGGGAGcACCGuAAU cAdTsdT	786
XD-09070	X29098	gauuAcGGuGcucccuG ucdTsdT	649	X29099	GAcAGGGAGcACCGuAA UCdTsdT	787
XD-09071	X29100	auuAcGGuGcucccuGuc AdTsdT	650	X29101	UGAcAGGGAGcACCGuA AUdTsdT	788
XD-09072	X29102	uuAcGGuGcucccuGuc AudTsdT	651	X29103	AUGAcAGGGAGcACCGu AAdTsdT	789
XD-09073	X29104	acGGuGcucccuGucAu AAdTsdT	652	X29105	UuAUGAcAGGGAGcACC GUdTsdT	790
XD-09074	X29106	guGcucccuGucAuAAA uudTsdT	653	X29107	AAUuUuAUGAcAGGGAGc ACdTsdT	791
XD-09075	X29108	ugcucccuGucAuAAuu udTsdT	654	X29109	AAAUuUuAUGAcAGGGA GcAdTsdT	792
XD-09076	X29110	cucccuGucAuAAuuu GAdTsdT	655	X29111	UcAAAUuUuAUGAcAGGG AGdTsdT	793
XD-09077	X29112	ccuGucAuAAuuuGA cGudTsdT	656	X29113	ACGUcAAAUuUuAUGAcA GGdTsdT	794
XD-09078	X29114	ugucAuAAuuuGacGu GAdTsdT	657	X29115	UcACGUcAAAUuUuAUGA cAdTsdT	795
XD-09079	X29116	gucAuAAuuuGacGu GAAdTsdT	658	X29117	UUcACGUcAAAUuUuAUG ACdTsdT	796
XD-09080	X29118	ucAuAAuuuGacguG AAGdTsdT	659	X29119	CUUcACGUcAAAUuUuAU GAdTsdT	797
XD-09081	X29120	auAAuuuGacGugAA GcAdTsdT	660	X29121	UGCUUcACGUcAAAUuUu AUdTsdT	798
XD-09082	X29122	aauuuGacGuGAAGcA AAudTsdT	661	X29123	AUUUGCUUcACGUcAA AUdTsdT	799
XD-09083	X29124	auuuGacGuGAAGcA AAudTsdT	662	X29125	AAUUUGCUUcACGUcA AAudTsdT	800
XD-09084	X29126	uuuGacGuGAAGcA AuuGdTsdT	663	X29127	cAAUUUGCUUcACGUcA AAdTsdT	801
XD-09085	X29128	uuGacGuGAAGcAaA uuGGdTsdT	664	X29129	CcAAUUUGCUUcACGUc AAdTsdT	802
XD-09086	X29130	ugAcGuGAAGcAAuu GGGdTsdT	665	X29131	CCcAAUUUGCUUcACGU cAdTsdT	803

XD-09087	X29132	gacGuGAAGcAAAu GGGdTsdt	666	X29133	CCCcAAUUUGCUUcACG UCdTsdt	804
XD-09088	X29134	acGuGAAGcAAAuG GGGdTsdt	667	X29135	GCCCCAAUUUGCUUcAC GUdTsdt	805
XD-09089	X29136	cguGAAGcAAAuG GGccdTsdT	668	X29137	GGCCCCAAUUUGCUUcA CGdTsdt	806
XD-09090	X29138	gaAGcAAAuGGGgcc cAdTsdt	669	X29139	UUGGGCCCCAAUUUGC UUCdTsdt	807
XD-09091	X29140	aaGcAAAuGGGGccc AAcdTsdt	670	X29141	GUUGGGCCCCAAUUUG CUUdTsdt	808
XD-09092	X29142	agcAAAuGGGGcccA AcudTsdt	671	X29143	AGUUGGGCCCCAAUUU GCudTsdt	809
XD-09093	X29144	gcAAAuGGGGcccA AcudTsdt	672	X29145	GAGUUGGGCCCCAAUU UGCdTsdt	810
XD-09094	X29146	ugcAAAAAGcUGaG uGcudTsdt	673	X29147	AGcACUUCAGCUUUUU GcAdTsdt	811
XD-09095	X29148	aaAGcUGaAGUGcuG AcudTsdt	674	X29149	AGUcAAGcACUUCAGCU UUDTsdt	812
XD-09096	X29150	ugcuUGAcUGAcuuuA ccdTsdt	675	X29151	GGuAAAUGUGcAGUcAAG cAdTsdt	813
XD-09097	X29152	cuUGAcUGAcuuuAcc uGdTsdt	676	X29153	cAGGuAAAUGUGcAGUcA AGdTsdt	814
XD-09098	X29154	ugcuuuuucuuAuAcucu dTsdT	677	X29155	AGAGuAAuAAGAAAAA GcAdTsdt	815
XD-09099	X29156	uuuuuAuAcucucccAu udTsdt	678	X29157	AAUGGGAGAGuAAuAA GAAdTsdt	816
XD-09100	X29158	cucccAuUGGGGcucA cudTsdt	679	X29159	AGUGAGCCcAcAAUGG GAGdTsdt	817
XD-09101	X29160	cccAuUGGGGcucAcu cudTsdt	680	X29161	AGAGUGAGCCcAcAAU GGGdTsdt	818
XD-09102	X29162	cacucuGcuGcAAuGA GudTsdt	681	X29163	ACUcAUUUGcAGcAGAG UGdTsdt	819
XD-09103	X29164	acucuGcuGcAAuGA GuGdTsdt	682	X29165	cACUcAUUUGcAGcAGA GUdTsdt	820
XD-09104	X29166	aguGGGucuuuGGgAA uGcdTsdt	683	X29167	GcAUUCCcAAAGACCcA CUdTsdt	821
XD-09105	X29168	guGGGucuuuGGGAu GcAdTsdt	684	X29169	UGcAUUCCcAAAGACCc ACdTsdt	822
XD-09106	X29170	ggGucuuuGGGAuGc AAudTsdt	685	X29171	AUUGcAUUCCcAAAGA CCCdTsdt	823
XD-09107	X29172	uuGGGAuGcAAuGu GcAAAdTsdt	686	X29173	UUGcAcAUUGcAUUCCc AAAdTsdt	824
XD-09108	X29174	guGcAAAuAuucacA GGGdTsdt	687	X29175	CCCUGUGAAuAAUUUG cACdTsdt	825
XD-09109	X29176	cacAGGGcuGuAucAc AucdTsdT	688	X29177	GAUGUGAuAcAGCCCU GUGdTsdt	826
XD-09110	X29178	acAGGGcuGuAucAcu cGdTsdT	689	X29179	CGAUGUGAuAcAGCCC UGdTsdt	827
XD-09111	X29180	caGGGcuGuAucAcAuc GGdTsdT	690	X29181	CCGAUGUGAuAcAGCCC UGdTsdt	828
XD-09112	X29182	agGGcuGuAucAcaucG GudTsdt	691	X29183	ACCGAUGUGAuAcAGC CCUdTsdt	829
XD-09113	X29184	ggcuGuAucAcAucGGu uAdTsdt	692	X29185	uAACCGAUGUGAuAcAG CCdTsdt	830
XD-09114	X29186	gcuGuAucAcAucgGuu AudTsdt	693	X29187	AuAACCGAUGUGAuAcA GCdTsdt	831
XD-09115	X29188	cuGuAucAcAucGguuA uudTsdt	694	X29189	AAuAACCGAUGUGAuAc AGdTsdt	832

XD-09116	X29190	uguAucAcAucGGuuAu uudTsdT	695	X29191	AAAuAACCGAUGUGAu AcAdTsdT	833
XD-09117	X29192	guAucAcAucGGuuAu uudTsdT	696	X29193	AAAAuAACCGAUGUGA uACdTsdT	834
XD-09118	X29194	uaucaAucGGuuuuu GdTsdT	697	X29195	cAAAAuAACCGAUGUG AuAdTsdT	835
XD-09119	X29196	ucAcAucGGuuuuuG GcdTsdT	698	X29197	GCcAAAAuAACCGAUG UGAdTsdT	836
XD-09120	X29198	acAucGGuuuuuGGc GGdTsdT	699	X29199	CCGCcAAAAuAACCGAU GUdTsdT	837
XD-09121	X29200	caucGGuuuuuugGcG GAdTsdT	700	X29201	UCCGCcAAAAuAACCGA UGdTsdT	838
XD-09122	X29202	aucGGuuuuuGgcGG AAdTsdT	701	X29203	UUCCGCcAAAAuAACCG AUdTsdT	839
XD-09123	X29204	ucGGuuuuuGGcGG AAudTsdT	702	X29205	AUCCGCcAAAAuAACC GAdTsdT	840
XD-09124	X29206	cgGuuuuuuGGcgGA AucdTsdT	703	X29207	GAUCCGCcAAAAuAA CCGdTsdT	841
XD-09125	X29208	guuuuuuGGcGGaAuc uudTsdT	704	X29209	AAGAUCCGCcAAAAu AACdTsdT	842
XD-09126	X29210	uuuuuuuGGcGGAaucu ucdTsdT	705	X29211	GAAGAUCCGCcAAAA uAAdTsdT	843
XD-09127	X29212	uuuuuuuGGcGGAaucu cudTsdT	706	X29213	AGAAGAUCCGCcAAA AuAdTsdT	844
XD-09128	X29214	uuuuuGGcGGAaucuuc uudTsdT	707	X29215	AAGAAGAUCCGCcAA AAudTsdT	845
XD-09129	X29216	uuuuGGcGGAaucuuc ucdTsdT	708	X29217	GAAGAAGAUCCGCcA AAAdTsdT	846
XD-09130	X29218	uuuGGcGGAaucuucuu cAdTsdT	709	X29219	UGAAGAAGAUCCGCc AAAdTsdT	847
XD-09131	X29220	aaGuGuGAucAccuGG uuGdTsdT	710	X29221	cAACcAGGUGAUcAcAC UUDTsdT	848
XD-09132	X29222	uguGAucAccuGGuuG GuGdTsdT	711	X29223	cACcAACcAGGUGAUcAc AdTsdT	849
XD-09133	X29224	guGAucAccuGGuuGG uGGdTsdT	712	X29225	CcACcAACcAGGUGAUc ACdTsdT	850
XD-09134	X29226	ugAucAccuGGuugGuG GcdTsdT	713	X29227	GCcACcAACcAGGUGAU cAdTsdT	851
XD-09135	X29228	ucAccuGGuuGGuGcu GudTsdT	714	X29229	AcAGCcACcAACcAGGU GAdTsdT	852
XD-09136	X29230	caccuGGuuGGuGcuG uGdTsdT	715	X29231	cAcAGCcACcAACcAGGU GdTsdT	853
XD-09137	X29232	agGAucAucuuuacuA AAdTsdT	716	X29233	UUuAGuAAAGAUGAUU CCUdTsdT	854
XD-09138	X29234	ucAucuuuAcuAAauGc cAdTsdT	717	X29235	UGGcAUUuAGuAAAGA UGAdTsdT	855
XD-09139	X29236	gaAGAuucGuuuauGu cudTsdT	718	X29237	AGAcAuAAAcAGAAUCU UCdTsdT	856
XD-09140	X29238	cuGuGgccuuuuuucc AdTsdT	719	X29239	UGGAAAAuAAGGGCcAc AGdTsdT	857
XD-09141	X29240	ugGccuuuuuuccAcG AdTsdT	720	X29241	UCGUGGAAAAuAAGGG CcAdTsdT	858
XD-09142	X29242	ggccuuuuuuccAcGA GdTsdT	721	X29243	CUCGUGGAAAAuAAGG GCCdTsdT	859
XD-09143	X29244	gcccuuuuuuccacGAG GdTsdT	722	X29245	CCUCGUGGAAAAuAAG GGCdTsdT	860
XD-09144	X29246	cuuuuuuuccAcGaGGA uGdTsdT	723	X29247	cAUCCUCGUGGAAAAu AAGdTsdT	861

XD-09145	X29248	uuAuuuuccAcGAgGAuGGdTsdT	724	X29249	CcAUCCUCGUGGAAAAuAAdTsdT	862
XD-09146	X29250	uaauuuuccAcGAGgAuGGAdTsdT	725	X29251	UCcAUCCUCGUGGAAAuAAdTsdT	863
XD-09147	X29252	uuuccAcGAGGAuGGAuAAdTsdT	726	X29253	uAUUCcAUCCUCGUGGAAAdTsdT	864
XD-09148	X29254	uuccAcGAGGAuGGAuAAdTsdT	727	X29255	UuAUUCcAUCCUCGUGGAAdTsdT	865
XD-09149	X29256	uccAcGAGGAuGGaAuAAdTsdT	728	X29257	AUuAUUCcAUCCUCGUGGAdTsdT	866
XD-09150	X29258	cacGAGGAuGGAAuAAuudTsdT	729	X29259	AAAUuAUUCcAUCCUCGUGdTsdT	867
XD-09151	X29260	aaauuccAcAcAAuAAuGAdTsdT	730	X29261	UcAUuAUUGUGUGGAAAUUdTsdT	868
XD-09152	X29262	uuuccAcAcAAuAAuGAGGdTsdT	731	X29263	CCUcAUuAUUGUGUGGAAAdTsdT	869
XD-09153	X29264	cacAcAAuAAuGAGGAAdTsdT	732	X29265	UGUUCcAUuAUUGUGUGdTsdT	870
XD-09154	X29266	uaAuGAGGAACauuuGGGdTsdT	733	X29267	CCcAAAAUGUCCUcAUuAdTsdT	871
XD-09155	X29268	aacAuuuuGGGGcuGUccdTsdT	734	X29269	GGACcAGCCcAAAAUGUUDTsdT	872
XD-09156	X29270	gccGcuGcuAucAuGGucdTsdT	735	X29271	GACcAUGAUGAGcAGCGGcTdTsdT	873
XD-09157	X29272	aaucucGcGccuGAGuAAdTsdT	736	X29273	UuACUcAGGCCGAAGA AUUdTsdT	874
XD-09158	X29274	auucucGcGccuGAGuAAdTsdT	737	X29275	GUuACUcAGGCCGAAGAAUdTsdT	875
XD-09159	X29276	uucucGcGccuGAGuAAcudTsdT	738	X29277	AGUuACUcAGGCCGAAGAAAdTsdT	876
XD-09160	X29278	uucGcGccuGAGuAAcuGuGdTsdT	739	X29279	cAcAGUuACUcAGGCCGAAdTsdT	877
XD-09161	X29280	ugAGuAAcuGAGuAAcGcAdTsdT	740	X29281	GUGCUUUcAcAGUuACUcAdTsdT	878
XD-09162	X29282	caccAGucAAcuGgAccAAdTsdT	741	X29283	UUGGUCcAGUUGACUGGUGdTsdT	879
XD-09163	X29284	caAcuGGAccAAGccAcGcdTsdT	742	X29285	GCGUGGCUUGGUCcAGUUGdTsdT	880
XD-09164	X29286	aacuGGAccAAGccAcGcAdTsdT	743	X29287	UGCGUGGCUUGGUCcAGUUDTsdT	881

Other antagonists of CCR2 and CSF1R

In some embodiments, the antagonists of CCR2 and CSF1R can be inhibitory oligonucleotides, antibody antagonists of CCR2 and CSF1R, small molecules, peptide antagonists, and combinations thereof for CCR2, CSF1R, or both CCR, and CSF1R.

As used herein, the term "antibody" refers to an immunoglobulin molecule with a specific amino acid sequence evoked by an antigen, *e.g.* CCR2 or CSF1R, and characterized by reacting specifically with the antigen. The term "antibody" encompasses polyclonal and monoclonal antibodies, CDR-grafted antibodies, hybrid antibodies, VHH antibodies, altered antibodies, F(ab)₂ fragments, F(ab) molecules, Fab' fragments, Fv fragments, single domain antibodies, ScFvs, chimeric antibodies, humanized antibodies,

nanobodies, diabodies, tandem antibodies and functional fragments thereof which exhibit immunological binding properties of the parent antibody molecule.

In some embodiments, CCR2 antagonist antibodies can be the humanized CCR2 antibodies of U.S. Pat. Nos. 6,696,550 and 6,084,075; human antibodies in U.S. Pat. Nos. 9,315,579 and 9,238,691; antibodies in U.S. Pat. Publ. No. 2009/0297502; anti-CCR2 antibodies in PCT Publ. Nos. WO 2016/08180 and WO 2010/021697. The antibodies or functional fragments thereof which bind to CCR2 can also include, for example, an anti-CCR2 antibody and its fragments as described in U.S. Publ. Nos. 2002/0042370; 2004/0132980; 2004/0126851; 2005/0048052; 2008/0241923; 2009/0191192, 2011/0274696; 2013/0344070; and 2015/0086546; PCT Publ. Nos. WO 2005/060368 and WO2007/147026.

In one embodiment, the antagonist of CCR2 is an antagonist peptide such as a blocking peptide that blocks the binding of its ligand and inhibits activation of the receptor, for example, a CCR non-competitive antagonist peptide that consists of LGTFLKC (SEQ ID NO: 882) disclosed in U.S. Pat. No. 9,434,766.

In other embodiments, CCR2 antagonists can be a modified chemokine ligand, for example, a modified MCP-1 chemokine and a modified MCP-5 chemokine.

The antagonists of CCR2 can also include a range of small molecule antagonists of CCR2, including, but not limited to compounds, for example, described in U.S. Pat. Nos. 8,546,408; 8,575,173 and 9,394,307; U.S. Pat. Publ. Nos. 2010/0056509 and 2011/0118248; PCT Publ. Nos. WO2004/069809, WO2005/118578, WO2006/012135, WO2007/130712, WO2007/014008, WO 2008/008374, WO2008/109238, WO2008/008375, WO2010/008761, WO2011/156554, WO2011/159854, WO2011/042399, WO2012/125661, WO2012/125662, WO2012/125663, WO2013/111129, WO2013/152269, WO2014/014901, and WO2016/187393.

In some embodiments, the antagonists of CSF1R can be antibodies and their functional fragments and variants; other inhibitory nucleic acid molecules such as oligonucleotides and aptamers; small molecules; and competitive ligands such as CSF1R extracellular domain (ECD) fusion molecules.

In some embodiments, CSF1R antagonist antibodies can include, but are not limited to, anti-CSF1R antibodies in U.S. Pat. Nos. 8,747,845 and 9,200,075; antibodies that bind CSF1R in PCT Publ. Nos. WO 2011/140294, WO 2016/168149, and WO 2016/106180; anti-CSF1R antibodies in U.S. Pat. Publ. Nos 2017/0081415 and 2017/0152320.

CSF1R inhibitors can include, but are not limited to, CSF1R inhibitors, such as GW2580, KI20227, HY-13075, cFMS Receptor Inhibitor II, cFMS Receptor Inhibitor III, cFMS Receptor Inhibitor IV or ARRY-382 (*e.g.*, U.S. Pat. Publ. No. 2016/0032248). The CSF1R inhibitors can also comprise the compounds discussed in U.S. Pat. Nos. 8,648,086 and 9,452,167; inhibitors screened in PCT Publ. No. WO 2009/075344.

In some embodiments, CSF1R antagonist can be a CSF1R ECD-Fc fusion protein as described in U.S. Pat. No. 8,080,246.

In some embodiments, the siRNA molecules encompassed by the present invention can be combined with other antagonists of CCR2 and CSF1R. In one embodiment, the siRNA molecules specific to CCR2 can be combined with another antagonist of CSF1R to form combined antagonists. In another embodiment, the siRNA molecules specific to CCR2 can be combined with another antagonist of CCR2 (*e.g.*, an anti-CCR2 antibody) to achieve a dual inhibition of CCR2.

Cell-based compositions

In some embodiments, cell-based agents are used. For example, myeloid-derived cells contacted with agents described herein can be administered.

Cell-based agents have an immunocompatibility relationship to a subject host and any such relationship is contemplated for use according to the present invention. For example, the cells, such as adoptive monocytes and/or macrophages, T cells, and the like, can be syngeneic. The term “syngeneic” can refer to the state of deriving from, originating in, or being members of the same species that are genetically identical, particularly with respect to antigens or immunological reactions. These include identical twins having matching MHC types. Thus, a “syngeneic transplant” refers to transfer of cells from a donor to a recipient who is genetically identical to the donor or is sufficiently immunologically compatible as to allow for transplantation without an undesired adverse immunogenic response (*e.g.*, such as one that would work against interpretation of immunological screen results described herein).

A syngeneic transplant can be “autologous” if the transferred cells are obtained from and transplanted to the same subject. An “autologous transplant” refers to the harvesting and reinfusion or transplant of a subject's own cells or organs. Exclusive or supplemental use of autologous cells can eliminate or reduce many adverse effects of administration of the cells back to the host, particular graft versus host reaction.

A syngeneic transplant can be “matched allogeneic” if the transferred cells are obtained from and transplanted to different members of the same species yet have sufficiently matched major histocompatibility complex (MHC) antigens to avoid an adverse immunogenic response. Determining the degree of MHC mismatch can be accomplished according to standard tests known and used in the art. For instance, there are at least six major categories of MHC genes in humans, identified as being important in transplant biology. HLA-A, HLA-B, HLA-C encode the HLA class I proteins while HLA-DR, HLA-DQ, and HLA-DP encode the HLA class II proteins. Genes within each of these groups are highly polymorphic, as reflected in the numerous HLA alleles or variants found in the human population, and differences in these groups between individuals is associated with the strength of the immune response against transplanted cells. Standard methods for determining the degree of MHC match examine alleles within HLA-B and HLA-DR, or HLA-A, HLA-B and HLA-DR groups. Thus, tests can be made of at least 4, and even 5 or 6 MHC antigens within the two or three HLA groups, respectively. In serological MHC tests, antibodies directed against each HLA antigen type are reacted with cells from one subject (*e.g.*, donor) to determine the presence or absence of certain MHC antigens that react with the antibodies. This is compared to the reactivity profile of the other subject (*e.g.*, recipient). Reaction of the antibody with an MHC antigen is typically determined by incubating the antibody with cells, and then adding complement to induce cell lysis (*i.e.*, lymphocytotoxicity testing). The reaction is examined and graded according to the amount of cells lysed in the reaction (see, for example, Mickelson and Petersdorf (1999) *Hematopoietic Cell Transplantation*, Thomas, E. D. *et al.* eds., pg 28-37, Blackwell Scientific, Malden, Mass.). Other cell-based assays include flow cytometry using labeled antibodies or enzyme linked immunoassays (ELISA). Molecular methods for determining MHC type are well-known and generally employ synthetic probes and/or primers to detect specific gene sequences that encode the HLA protein. Synthetic oligonucleotides can be used as hybridization probes to detect restriction fragment length polymorphisms associated with particular HLA types (Vaughn (2002) *Method. Mol. Biol. MHC Protocol.* 210:45-60). Alternatively, primers can be used for amplifying the HLA sequences (*e.g.*, by polymerase chain reaction or ligation chain reaction), the products of which can be further examined by direct DNA sequencing, restriction fragment polymorphism analysis (RFLP), or hybridization with a series of sequence specific oligonucleotide primers (SSOP) (Petersdorf

et al. (1998) *Blood* 92:3515-3520; Morishima *et al.* (2002) *Blood* 99:4200-4206; and Middleton and Williams (2002) *Method. Mol. Biol. MHC Protocol*. 210:67-112).

A syngeneic transplant can be “congenic” if the transferred cells and cells of the subject differ in defined loci, such as a single locus, typically by inbreeding. The term
5 “congenic” refers to deriving from, originating in, or being members of the same species, where the members are genetically identical except for a small genetic region, typically a single genetic locus (*i.e.*, a single gene). A “congenic transplant” refers to transfer of cells or organs from a donor to a recipient, where the recipient is genetically identical to the donor except for a single genetic locus. For example, CD45 exists in several allelic forms
10 and congenic mouse lines exist in which the mouse lines differ with respect to whether the CD45.1 or CD45.2 allelic versions are expressed.

By contrast, “mismatched allogeneic” refers to deriving from, originating in, or being members of the same species having non-identical major histocompatibility complex (MHC) antigens (*i.e.*, proteins) as typically determined by standard assays used in the art,
15 such as serological or molecular analysis of a defined number of MHC antigens, sufficient to elicit adverse immunogenic responses. A “partial mismatch” refers to partial match of the MHC antigens tested between members, typically between a donor and recipient. For instance, a “half mismatch” refers to 50% of the MHC antigens tested as showing different MHC antigen type between two members. A “full” or “complete” mismatch refers to all
20 MHC antigens tested as being different between two members.

Similarly, in contrast, “xenogeneic” refers to deriving from, originating in, or being members of different species, *e.g.*, human and rodent, human and swine, human and chimpanzee, etc. A “xenogeneic transplant” refers to transfer of cells or organs from a donor to a recipient where the recipient is a species different from that of the donor.

25 In addition, cells can be obtained from a single source or a plurality of sources (*e.g.*, a single subject or a plurality of subjects). A plurality refers to at least two (*e.g.*, more than one). In still another embodiment, the non-human mammal is a mouse. The animals from which cell types of interest are obtained can be adult, newborn (*e.g.*, less than 48 hours old), immature, or *in utero*. Cell types of interest can be primary cancer cells, cancer stem cells,
30 established cancer cell lines, immortalized primary cancer cells, and the like. In certain embodiments, the immune systems of host subjects can be engineered or otherwise elected to be immunological compatible with transplanted cancer cells. For example, in one embodiment, the subject can be “humanized” in order to be compatible with human cancer

cells. The term “immune-system humanized” refers to an animal, such as a mouse, comprising human HSC lineage cells and human acquired and innate immune cells, survive without being rejected from the host animal, thereby allowing human hematopoiesis and both acquired and innate immunity to be reconstituted in the host animal. Acquired

5 immune cells include T cells and B cells. Innate immune cells include macrophages, granulocytes (basophils, eosinophils, neutrophils), DCs, NK cells and mast cells. Representative, non-limiting examples include SCID-hu, Hu-PBL-SCID, Hu-SRC-SCID, NSG (NOD-SCID IL2r-gamma(null) lack an innate immune system, B cells, T cells, and cytokine signaling), NOG (NOD-SCID IL2r-gamma(truncated)), BRG (BALB/c-

10 Rag2(null)IL2r-gamma(null)), and H2dRG (Stock-H2d-Rag2(null)IL2r-gamma(null)) mice (see, for example, Shultz *et al.* (2007) *Nat. Rev. Immunol.* 7:118; Pearson *et al.* (2008) *Curr. Protocol. Immunol.* 15:21; Brehm *et al.* (2010) *Clin. Immunol.* 135:84-98; McCune *et al.* (1988) *Science* 241:1632-1639, U.S. Pat. 7,960,175, and U.S. Pat. Publ. No. 2006/0161996), as well as related null mutants of immune-related genes like Rag1 (lack B

15 and T cells), Rag2 (lack B and T cells), TCR alpha (lack T cells), perforin (CD8⁺ T cells lack cytotoxic function), FoxP3 (lack functional CD4⁺ T regulatory cells), IL2rg, or Prfl, as well as mutants or knockouts of PD-1, PD-L1, Tim3, and/or 2B4, allow for efficient engraftment of human immune cells in and/or provide compartment-specific models of immunocompromised animals like mice (see, for example, PCT Publ. No. WO

20 2013/062134). In addition, NSG-CD34⁺ (NOD-SCID IL2r-gamma(null) CD34⁺) humanized mice are useful for studying human gene and tumor activity in animal models like mice.

As used herein, “obtained” from a biological material source means any conventional method of harvesting or partitioning a source of biological material from a

25 donor. For example, biological material can be obtained from a solid tumor, a blood sample, such as a peripheral or cord blood sample, or harvested from another body fluid, such as bone marrow or amniotic fluid. Methods for obtaining such samples are well-known to the artisan. In the present invention, the samples can be fresh (*i.e.*, obtained from a donor without freezing). Moreover, the samples can be further manipulated to remove extraneous

30 or unwanted components prior to expansion. The samples can also be obtained from a preserved stock. For example, in the case of cell lines or fluids, such as peripheral or cord blood, the samples can be withdrawn from a cryogenically or otherwise preserved bank of such cell lines or fluid. Such samples can be obtained from any suitable donor.

The obtained populations of cells can be used directly or frozen for use at a later date. A variety of mediums and protocols for cryopreservation are known in the art. Generally, the freezing medium will comprise DMSO from about 5-10%, 10-90% serum albumin, and 50-90% culture medium. Other additives useful for preserving cells include, by way of example and not limitation, disaccharides such as trehalose (Scheinkonig *et al.* (2004) *Bone Marrow Transplant.* 34:531-536), or a plasma volume expander, such as hetastarch (*i.e.*, hydroxyethyl starch). In some embodiments, isotonic buffer solutions, such as phosphate-buffered saline, can be used. An exemplary cryopreservative composition has cell-culture medium with 4% HSA, 7.5% dimethyl sulfoxide (DMSO), and 2% hetastarch. Other compositions and methods for cryopreservation are well-known and described in the art (see, *e.g.*, Broxmeyer *et al.* (2003) *Proc. Natl. Acad. Sci. U.S.A.* 100:645-650). Cells are preserved at a final temperature of less than about -135°C.

In some embodiments, useful agents can be CAR (chimeric antigen receptor)-T therapy, where T cells engineered to express CARs comprising an antigen-binding domain specific to an antigen on tumor cells of interest. The term “chimeric antigen receptor” or “CAR” refers to receptors having a desired antigen specificity and signaling domains to propagate intracellular signals upon antigen binding. For example, T lymphocytes recognize specific antigens through interaction of the T cell receptor (TCR) with short peptides presented by major histocompatibility complex (MHC) class I or II molecules. For initial activation and clonal expansion, naive T cells are dependent on professional antigen-presenting cells (APCs) that provide additional co-stimulatory signals. TCR activation in the absence of co-stimulation can result in unresponsiveness and clonal anergy. To bypass immunization, different approaches for the derivation of cytotoxic effector cells with grafted recognition specificity have been developed. CARs have been constructed that consist of binding domains derived from natural ligands or antibodies specific for cell-surface components of the TCR-associated CD3 complex. Upon antigen binding, such chimeric antigen receptors link to endogenous signaling pathways in the effector cell and generate activating signals similar to those initiated by the TCR complex. Since the first reports on chimeric antigen receptors, this concept has steadily been refined and the molecular design of chimeric receptors has been optimized and routinely use any number of well-known binding domains, such as scFV, Fav, and another protein binding fragments described herein.

In some embodiments, monocytes and macrophages can be engineered to, for example, express a chimeric antigen receptor (CAR). The modified cell can be recruited to the tumor microenvironment where it acts as a potent immune effector by infiltrating the tumor and killing target cancer cells. The CAR includes an antigen binding domain, a transmembrane domain and an intracellular domain. The antigen binding domain binds to an antigen on a target cell. Examples of cell surface markers that can act as an antigen that binds to the antigen binding domain of the CAR include those associated with viral, bacterial, parasitic infections, autoimmune disease and cancer cells (*e.g.*, tumor antigens).

In one embodiment, the antigen binding domain binds to a tumor antigen, such as an antigen that is specific for a tumor or cancer of interest. Non-limiting examples of tumor associated antigens include BCMA, CD19, CD24, CD33, CD38; CD44v6, CD123, CD22, CD30, CD117, CD171, CEA, CS-1, CLL-1, EGFR, ERBB2, EGFRvIII, FLT3, GD2, NY-BR-1, NY-ESO-1, p53, PRSS21, PSMA, ROR1, TAG72, Tn Ag, VEGFR2.

In one embodiment, the transmembrane domain is naturally associated with one or more of the domains in the CAR. The transmembrane domain can be derived either from a natural or from a synthetic source. Transmembrane regions of particular use in this invention can be derived from (*i.e.* comprise at least the transmembrane region(s) of) the alpha, beta or zeta chain of the T-cell receptor, CD28, CD3 epsilon, CD45, CD4, CD5, CD8, CD9, CD 16, CD22, CD33, CD37, CD64, CD80, CD86, CD134, CD137, CD154, Toll-like receptor 1 (TLR1), TLR2, TLR3, TLR4, TLR5, TLR6, TLR7, TLR8, and TLR9. In some instances, a variety of human hinges can be employed as well including the human Ig (immunoglobulin) hinge.

In one embodiment, the intracellular domain of the CAR includes a domain responsible for signal activation and/or transduction. Examples of the intracellular domain include a fragment or domain from one or more molecules or receptors including, but are not limited to, TCR, CD3 zeta, CD3 gamma, CD3 delta, CD3 epsilon, CD86, common FcR gamma, FcR beta (Fc Epsilon Rib), CD79a, CD79b, Fc gamma RIIa, DAP10, DAP 12, T cell receptor (TCR), CD27, CD28, 4-1BB (CD137), OX40, CD30, CD40, PD-1, ICOS, lymphocyte function-associated antigen-1 (LFA-1), CD2, CD7, LIGHT, NKG2C, B7-H3, a ligand that specifically binds with CD83, CDS, ICAM-1, GITR, BAFFR, HVEM (LIGHTR), SLAMF7, NKp80 (KLRF1), CD127, CD160, CD19, CD4, CD8alpha, CD8beta, IL2R beta, IL2R gamma, IL7R alpha, ITGA4, VLA1, CD49a, ITGA4, IA4, CD49D, ITGA6, VLA-6, CD49f, ITGAD, CD11d, ITGAE, CD103, ITGAL, CD11a, LFA-

1, ITGAM, CD11b, ITGAX, CD11c, ITGB1, CD29, ITGB2, CD18, LFA-1, ITGB7, TNFR2, TRANCE/RANKL, DNAM1 (CD226), SLAMF4 (CD244, 2B4), CD84, CD96 (Tactile), CEACAM1, CRTAM, Ly9 (CD229), CD160 (BY55), PSGL1, CD100 (SEMA4D), CD69, SLAMF6 (NTB-A, Ly108), SLAM (SLAMF1, CD150, IPO-3),

5 BLAME (SLAMF8), SELPLG (CD 162), LTBR, LAT, GADS, SLP-76, PAG/Cbp, NKp44, NKp30, NKp46, NKG2D, Toll-like receptor 1 (TLR1), TLR2, TLR3, TLR4, TLR5, TLR6, TLR7, TLR8, TLR9, other co-stimulatory molecules described herein, any derivative, variant, or fragment thereof, any synthetic sequence of a co-stimulatory molecule that has the same functional capability, and any combination thereof.

10 In some embodiments, agents, compositions and methods encompassed by the present invention can be used to re-engineer monocytes and macrophages to increase their ability to present antigens to other immune effector cells, for example, T cells. Engineered monocytes and macrophages as antigen presenting cells (APCs) will process tumor antigens and present antigenic epitopes to T cells to stimulate adaptive immune responses to attack

15 tumor cells.

IV. Formulations

In some embodiments, the oligonucleotide compositions encompassed by the present invention comprising siRNA molecules specific to CCR2 are used alone as

20 therapeutic agents. In other embodiments, the oligonucleotide compositions encompassed by the present invention comprising siRNA molecules specific to CSF1R can be used alone as therapeutic agents.

In still other embodiments, the oligonucleotide compositions encompassed by the present invention comprising siRNA molecules specific to CCR2 and CSF1R are used in

25 combination. In some examples, the siRNA molecules specific to CCR2 and CSF1R can form a siRNA molecule cocktail. The siRNA molecules specific to CCR2 and the siRNA molecules specific to CSF1R can be present in the siRNA molecule cocktail composition at a ratio from 1:1 to 1:10. Alternatively, the siRNA molecules specific to CSF1R and the siRNA molecules specific to CCR2 can be present in the siRNA molecule cocktail

30 composition at a ratio from 1:1 to 1:10. In other embodiments, the siRNA molecules specific to CCR2 and CSF1R can be incorporated with a complex of macromolecular assemblies or pharmaceutical compositions. The siRNA molecules encompassed by the present invention can be formulated as a variety of pharmaceutical compositions.

The pharmaceutical compositions will be prepared in a form appropriate for the desired use, such as *in vitro*, *ex vivo*, or *in vivo* administration and include an effective amount of pharmacologically active compound encompassed by the present invention, alone or in combination with one or more pharmaceutically acceptable carriers.

5 The siRNA molecule cocktail composition comprising the siRNA molecules specific to CCR2 and the siRNA molecules specific to CSF1R encompassed by the present invention can be used to suppress the expression of CCR2 and CSF1R receptors, and/or to inhibit the activity of CCR2 and CSF1R.

10 In some embodiments, the siRNA composition encompassed by the present invention can further comprise an antagonist against the ligands of CCR2 and CSF1R, such as CCL2 and CSF1, respectively. In one example, the composition encompassed by the present invention can comprise siRNA molecules specific to CCR2 in combination with a CCL2 antagonist; the CCL2 antagonist can be a siRNA molecule specific to CCL2, an anti-CCL2 antibody and/or a small molecule. In another example, the composition
15 encompassed by the present invention can comprise siRNA molecules specific to CSF1R in combination with a CSF1 antagonist; the CSF1 antagonist can be a siRNA molecule specific to CSF1, an anti-CSF1 antibody and/or a small molecule.

20 In some embodiments, the siRNA cocktail composition comprising the siRNA molecules specific to CCR2 and the siRNA molecules specific to CSF1R encompassed by the present invention can further comprise one or more agents, such as those that target monocytes and macrophages, those that stimulate immune responses, and the like. Such monocyte/macrophage targeting drugs can include, but are not limited to, rovelizumab which targets CD11b, small molecules MNRP1685A that targets Neurophilin-1, nesvcumab targeting ANG2, pascolizumab specific to IL-4, dupilumab specific to IL4R α , tocilizumab
25 and sarilumab specific to IL-6R, adalimumab, certolizumab, tanercept, golimumab, and infliximab specific to TNF- α , and CP-870 and CP-893 targeting CD40.

30 In some embodiments, the oligonucleotide compositions comprising siRNA molecules specific to CCR2 and/or siRNA molecules specific to CSF1R encompassed by the present invention can be used as naked compositions. In other embodiments, the oligonucleotide compositions encompassed by the present invention can be formulated as combined agents.

 In some embodiments, the pharmaceutical compositions comprising the oligonucleotide compositions encompassed by the present invention can be formulated with

one or more agents that can enhance the uptake of oligonucleotides at the cellular level, such as for the transport of oligomers across a cell membrane.

A composition in accordance with the invention can be prepared, packaged, and/or sold in bulk, as a single unit dose, and/or as a plurality of single unit doses. As used herein, a “unit dose” is discrete amount of the pharmaceutical composition comprising a pre-determined amount of the active ingredient. The amount of the active ingredient is generally equal to the dosage of the active ingredient which would be administered to a subject and/or a convenient fraction of such a dosage such as, for example, one-half or one-third of such a dosage.

Lipid-based formulations

In some embodiments, lipid-based formulations are used. Accordingly, provided herein are lipid-based formulations comprising a composition as described herein and one or more lipids. In some embodiments, the lipid is a lipid particle or amphiphilic compound.

The lipid can be neutral, anionic, or cationic at physiologic pH.

Suitable solid lipids include, but are not limited to, higher saturated alcohols, higher fatty acids, sphingolipids, synthetic esters, and mono-, di-, and triglycerides of higher saturated fatty acids. Solid lipids can include aliphatic alcohols having 10-40, preferably 12-30 carbon atoms, such as cetostearyl alcohol. Solid lipids can include higher fatty acids of 10-40, preferably 12-30 carbon atoms, such as stearic acid, palmitic acid, decanoic acid, and behenic acid. Solid lipids can include glycerides, including monoglycerides, diglycerides, and triglycerides, of higher saturated fatty acids having 10-40, preferably 12-30 carbon atoms, such as glyceryl monostearate, glycerol behenate, glycerol palmitostearate, glycerol trilaurate, tricaprins, trilaurins, trimyristins, tripalmitins, tristearins, and hydrogenated castor oil. Suitable solid lipids can include cetyl palmitate, beeswax, or cyclodextrin.

Amphiphilic compounds include, but are not limited to, phospholipids, such as 1,2 distearoyl-sn-glycero-3-phosphoethanolamine (DSPE), dipalmitoylphosphatidylcholine (DPPC), distearoylphosphatidylcholine (DSPC), diarachidoylphosphatidylcholine (DAPC), dibehenoylphosphatidylcholine (DBPC), ditricosanoylphosphatidylcholine (DTPC), and dilignoceroylphosphatidylcholine (DLPC), incorporated at a ratio of between 0.01-60 (weight lipid/w polymer), for example, between 0.1-30 (weight lipid/w polymer). Phospholipids which can be used include, but are not limited to, phosphatidic acids, phosphatidyl choline

with both saturated and unsaturated lipids, phosphatidyl ethanolamines, phosphatidylglycerols, phosphatidylserines, phosphatidylinositols, lysophosphatidyl derivatives, cardiolipin, and β -acyl- γ -alkyl phospholipids. Examples of phospholipids include, but are not limited to, phosphatidylcholines such as dioleoylphosphatidylcholine, dimyristoylphosphatidylcholine, dipentadecanoylphosphatidylcholine, dilauroylphosphatidylcholine, dipalmitoylphosphatidylcholine (DPPC), distearoylphosphatidylcholine (DSPC), diarachidoylphosphatidylcholine (DAPC), dibehenoylphosphatidylcho- line (DBPC), ditricosanoylphosphatidylcholine (DTPC), dilignoceroylphatidylcholine (DLPC); and phosphatidylethanolamines such as dioleoylphosphatidylethanolamine or 1-hexadecyl-2-palmitoylglycerophos- phoethanolamine. Synthetic phospholipids with asymmetric acyl chains (*e.g.*, with one acyl chain of 6 carbons and another acyl chain of 12 carbons) can also be used.

In some embodiments, lipid-based particles are used. The term “lipid particles” refers to liposomes, lipid micelles, solid lipid particles, lipoplexes, lipid nanoparticles (LNPs), or lipid-stabilized polymeric particles, composed of one or a mixture of different biocompatible lipids, *e.g.*, at least one or more cationic lipids and/or one or more neutral lipids and/or polyethylene glycol (PEG)-lipids.

The particle can be a lipid micelle. Lipid micelles can be formed, for instance, as a water-in-oil emulsion with a lipid surfactant. An emulsion is a blend of two immiscible phases wherein a surfactant is added to stabilize the dispersed droplets. In some embodiments the lipid micelle is a microemulsion. A microemulsion is a thermodynamically stable system composed of at least water, oil and a lipid surfactant producing a transparent and thermodynamically stable system whose droplet size is less than 1 micron, from about 10 nm to about 500 nm, or from about 10 nm to about 250 nm. Lipid micelles are generally useful for encapsulating hydrophobic active agents, including hydrophobic therapeutic agents, hydrophobic prophylactic agents, or hydrophobic diagnostic agents.

The particle can be a solid lipid particle. Solid lipid particles present an alternative to the colloidal micelles and liposomes. Solid lipid particles are typically submicron in size, *i.e.* from about 10 nm to about 1 micron, from 10 nm to about 500 nm, or from 10 nm to about 250 nm. Solid lipid particles are formed of lipids that are solids at room temperature. They are derived from oil-in-water emulsions, by replacing the liquid oil by a solid lipid.

The particle can be a liposome. Liposomes are small vesicles composed of an aqueous medium surrounded by lipids arranged in spherical bilayers. Liposomes can be classified as small unilamellar vesicles, large unilamellar vesicles, or multi-lamellar vesicles. Multi-lamellar liposomes contain multiple concentric lipid bilayers. Liposomes
5 can be used to encapsulate agents, by trapping hydrophilic agents in the aqueous interior or between bilayers, or by trapping hydrophobic agents within the bilayer.

The lipid micelles and liposomes typically have an aqueous center. The aqueous center can contain water or a mixture of water and alcohol. Suitable alcohols include, but are not limited to, methanol, ethanol, propanol, (such as isopropanol), butanol (such as *n*-
10 butanol, isobutanol, *sec*-butanol, *tert*-butanol, pentanol (such as amyl alcohol, isobutyl carbinol), hexanol (such as 1-hexanol, 2-hexanol, 3-hexanol), heptanol (such as 1-heptanol, 2-heptanol, 3-heptanol and 4-heptanol) or octanol (such as 1-octanol) or a combination thereof.

Liposomes are artificially-prepared vesicles which can primarily be composed of a
15 lipid bilayer and can be used as a delivery vehicle for the administration of nutrients and pharmaceutical formulations. Liposomes can be of different sizes such as, but not limited to, a multilamellar vesicle (MLV) which can be hundreds of nanometers in diameter and can contain a series of concentric bilayers separated by narrow aqueous compartments, a small unicellular vesicle (SUV) which can be smaller than 50 nm in diameter, and a large
20 unilamellar vesicle (LUV) which can be between 50 and 500 nm in diameter. Liposome design can include, but is not limited to, opsonins or ligands in order to improve the attachment of liposomes to unhealthy tissue or to activate events such as, but not limited to, endocytosis. Liposomes can contain a low or a high pH in order to improve the delivery of the pharmaceutical formulations.

25 The formation of liposomes can depend on the physicochemical characteristics such as, but not limited to, the pharmaceutical formulation entrapped and the liposomal ingredients, the nature of the medium in which the lipid vesicles are dispersed, the effective concentration of the entrapped substance and its potential toxicity, any additional processes involved during the application and/or delivery of the vesicles, the optimization size,
30 polydispersity and the shelf-life of the vesicles for the intended application, and the batch-to-batch reproducibility and possibility of large-scale production of safe and efficient liposomal products.

In one embodiment, pharmaceutical compositions described herein can include, without limitation, liposomes such as those formed from 1,2-dioleoyloxy-*N,N*-dimethylaminopropane (DODMA) liposomes, DiLa2 liposomes from Marina Biotech (Bothell, WA), 1,2-dilinoleyloxy-3-dimethylaminopropane (DLin-DMA), 2,2-dilinoleyloxy-4-(2-dimethylaminoethyl)-[1,3]-dioxolane (DLin-KC2-DMA), and MC3 (*e.g.*, as described in U.S. Pat. Publ. No. 2010/0324120).

In one embodiment, the compositions encompassed by the present invention can be formulated in a lipid-polycation complex. The formation of the lipid-polycation complex can be accomplished by methods known in the art and/or as described in U.S. Pat. Publ. No. 2012/0178702. As a non-limiting example, the polycation can include a cationic peptide or a polypeptide such as, but not limited to, polylysine, polyornithine and/or polyarginine and the cationic peptides described in PCT Publ. No. WO 2012/013326. In another embodiment, the compositions encompassed by the present invention can be formulated in a lipid-polycation complex which can further include a neutral lipid such as, but not limited to, cholesterol or dioleoyl phosphatidylethanolamine (DOPE). The liposome formulation can be influenced by, but not limited to, the selection of the cationic lipid component, the degree of cationic lipid saturation, the nature of the PEGylation, ratio of all components and biophysical parameters such as size.

In some embodiments, the lipid particle is a lipid nanoparticle (LNP). The term “lipid nanoparticle (LNP)” refers to lipid-based particles in the submicron range which include one or more lipid components as described herein. LNPs can have structural characteristics of liposomes and/or have alternative non-bilayer types of structures, which can be used to systemically deliver nucleic acid based drugs, including, for example, siRNA molecules complementary to the nucleic acid sequence of mRNA transcribed from at least one biomarker (*e.g.*, at least one target listed in Table 1 and/or Table 2) described herein. In some embodiments, the LNP formulation comprises one or more cationic lipids. Cationic lipids are lipids that carry a net positive charge at any physiological pH. In certain particular embodiments, the LNP comprises a lipidoid as described herein. The positive charge is useful for association with negatively charged therapeutic agents, such as siRNA molecules.

In certain embodiments, a lipid nanoparticle comprises one or more lipids and a composition as described herein. In certain particular embodiments, a composition as described herein is encapsulated within a lipid nanoparticle.

In some embodiments, the sizes and charge ratios and other physical properties (*e.g.*, membrane fluidity) of LNPs are optimized for increased cell transfection and delivery.

Lipid or lipidoid particles can comprise, for example, cationic lipids, neutral lipids, amino acid- or peptide-based lipids, polyethylene glycol (PEG)-lipids, *e.g.*, lipids with PEG chains such as hydrogenated soybean phosphatidylcholine (HSPC), cholesterol (CHE), 1, 2-distearoyl-glycero-3-phosphoethanolamine-N-[methoxy (PEG)-2000] (DSPE-PEG2000), 1, 2-distearoyl-sn-glycero-3-phosphoethanolamine-N-[methoxy (PEG)-2000] modified with a maleimidic group in the distal end of the chain 1, 2-distearoyl-sn-glycero-3-phosphoethanolamine-N-[maleimide (PEG)-2000], DSPE-PEG2000-MAL, 1,2-dimyristoyl-sn-glycero-3-phosphoethanolamine-N-[methoxy(polyethylene glycol)-550] (DMPE-PEG550), 1, 2-dioleoyl-1-3-trimethylammonium propane (DOTAP), and those with a glycerol backbone *e.g.*, DMG-PEG, DSG-PEG (DMG-PEG2000) etc. As used herein, a liposome is a structure comprising lipid-containing membranes enclosing an aqueous interior. For example, lipid-based formulations can be used to deliver nucleic acid agents of the present invention, *e.g.*, siRNAs, miRNAs, oligonucleotides, modified mRNAs and other types of nucleic acid molecules.

Suitable neutral and anionic lipids include, but are not limited to, sterols and lipids such as cholesterol, phospholipids, lysolipids, lysophospholipids, sphingolipids or pegylated lipids. Neutral and anionic lipids include, but are not limited to, phosphatidylcholine (PC) (such as egg PC, soy PC), including 1,2-diacyl-glycero-3-phosphocholines; phosphatidylserine (PS), phosphatidylglycerol, phosphatidylinositol (PI); glycolipids; sphingophospholipids such as sphingomyelin and sphingoglycolipids (also known as 1-ceramidyl glucosides) such as ceramide galactopyranoside, gangliosides and cerebroside; fatty acids, sterols, containing a carboxylic acid group for example, cholesterol; 1,2-diacyl-sn-glycero-3-phosphoethanolamine, including, but not limited to, 1,2-dioleoylphosphoethanolamine (DOPE), 1,2-dihexadecylphosphoethanolamine (DHPE), 1,2-distearoylphosphatidylcholine (DSPC), 1,2-dipalmitoyl phosphatidylcholine (DPPC), and 1,2-dimyristoylphosphatidylcholine (DMPC). The lipids can also include various natural (*e.g.*, tissue derived L- α -phosphatidyl: egg yolk, heart, brain, liver, soybean) and/or synthetic (*e.g.*, saturated and unsaturated 1,2-diacyl-*sn*-glycero-3-phosphocholines, 1-acyl-2-acyl-*sn*-glycero-3-phosphocholines, 1,2-diheptanoyl-SN-glycero-3-phosphocholine) derivatives of the lipids.

A number of cationic lipids, and methods for making them, are described in, for example, U.S. Pat. Numbers 5,830,430; 6,056,938; 7,893,302; 7,404,969; 8,034,376; 8,283,333; and 8,642,076, as well as PCT Publ. Numbers WO 2010/054406, WO 2010/054401, WO 2010/054405, WO 2010/054384, WO 2012/040184, WO 2011/153120, 5 WO 2011/149733, WO 2011/090965, WO 2011/043913, WO 2011/022460, WO 2012/061259, WO 2012/054365, WO 2012/044638, WO 2010/080724, WO 2010/21865, and WO 2008/103276.

The term “cationic lipid” is meant to include those lipids having one or two fatty acid or fatty aliphatic chains and an amino head group (including an alkylamino or 10 dialkylamino group) that can be protonated to form a cationic lipid at physiological pH, which consist of a positively charged headgroup and a hydrophobic tail. The positively charged headgroup can serve to electrostatically bind the negatively charged siRNA molecule, while the hydrophobic tail leads to self-assembly into lipophilic particles. Examples of cationic lipids can include, but are not limited to: DLin-K-DMA, DLinDMA, 15 DLinDAP, DLin-K-C2-DMA, DLin-K2-DMA, DOTAP, DMRIE, DORIE, DOTMA, DDAB, Ethyl PC, multivalent cationic lipid and DC-cholesterol, DODA, DODMA, DSDMA, DOTMA, DDAB, DODAP, DOTAP, DOTAP-Cl, DC-Chol, DMRIE, DOSPA, DOGS, DOPE, CLinDMA, CpLinDMA, DMOBA, DOcarbDAP, DLincarbDAP, DLinCDAP. A number of these lipids and related analogs have been described in U.S. Pat. 20 Publ. Numbers 2006/0083780 and 2006/0240554; and U.S. Pat. Numbers 5,208,036; 5,264,618; 5,279,833; 5,283,185; 5,753,613 and 5,785,992. Cationic lipids can also be a lipofectin (see, *e.g.*, U.S. Pat. No. 5,705,188), such as Lipofectamine[®], Lipofectamine 2000[®], Lipofectamine 3000[®], RNAiMAX[®], and the like.

Other cationic lipids, which carry a net positive charge at about physiological pH, 25 can be used in the lipid particles of the present invention, including, but not limited to, N,N-dioleoyl-N,N-dimethylammonium chloride (DODAC), dioctadecyldimethylammonium (DODMA), distearyldimethylammonium (DSDMA), N-(1-(2,3-dioleoyloxy)propyl)-N,N,N-trimethylammonium chloride (DOTMA), N,N-distearyl-N,N-dimethylammonium bromide (DDAB), 1,2-dioleoyl-3-dimethylammonium propane (DODAP), N-(1-(2,3- 30 dioleoyloxy)propyl)-N,N,N-trimethylammonium chloride (DOTAP), 1,2-Dioleoyloxy-3-trimethylaminopropane chloride salt (DOTAP.Cl), 3-(N—(N',N'-dimethylaminoethane)-carbamoyl)cholesterol (DC-Chol), N-(1,2-dimyristyloxyprop-3-yl)-N,N-dimethyl-N-hydroxyethyl ammonium bromide (DMRIE), 2,3-dioleoyloxy-N-[2(spermine-

carboxamido)ethyl]-N,N-dimethyl-1-propanaminiumtrifluoroacetate (DOSPA), dioctadecylamidoglycyl spermine (DOGS), 1,2-dioleoyl-sn-3-phosphoethanolamine (DOPE, which carries a positive charge at physiological pH but at acidic pH), 3-dimethylamino-2-(cholest-5-en-3-beta-oxybutan-4-oxy)-1-(cis,cis-9,12-octadecadienoxy)propane (CLinDMA), 2-[5'-(cholest-5-en-3 β -oxy)-3'-oxapentoxo]-3-dimethyl-1-(cis,cis-9',1'-octadecadienoxy)propane (CpLinDMA), N,N-dimethyl-3,4-dioleoyloxybenzylamine (DMOBA), 1,2-N,N'-dioleoylcarbaryl-3-dimethylaminopropane (DOcarbDAP), 1,2-N,N'-Dilinoleoylcarbaryl-3-dimethylaminopropane (DLincarbDAP), 1,2-Dilinoleoylcarbaryl-3-dimethylaminopropane (DLinCDAP), and mixtures thereof. A number of these lipids and related analogs have been described in U.S. Pat. Publ. Nos. 2006/0083780 and 2006/0240554; U.S. Pat. Nos. 5,208,036; 5,264,618; 5,279,833; 5,283,185; 5,753,613; and 5,785,992.

Suitable additional cationic lipids can also include, but are not limited to, N-[1-(2,3-dioleoyloxy)propyl]-N,N,N-trimethyl ammonium salts, also referenced as TAP lipids, for example methylsulfate salt. Suitable TAP lipids include, but are not limited to, DOTAP (dioleoyl-), DMTAP (dimyristoyl-), DPTAP (dipalmitoyl-), and DSTAP (distearoyl-). Suitable cationic lipids in the liposomes include, but are not limited to, dimethyldioctadecyl ammonium bromide (DDAB), 1,2-diacyloxy-3-trimethylammonium propanes, N-[1-(2,3-dioloxyloxy)propyl]-N,N-dimethyl amine (DODAP), 1,2-diacyloxy-3-dimethylammonium propanes, N-[1-(2,3-dioleoyloxy)propyl]-N,N,N-trimethylammonium chloride (DOTMA), 1,2-dialkyloxy-3-dimethylammonium propanes, dioctadecylamidoglycylspermine (DOGS), 3-[N-(N',N'-dimethylamino-ethane)carbonyl]cholesterol (DC-Chol); 2,3-dioleoyloxy-N-(2-(spermincarboxamido)-ethyl)-N,N-dimethyl-1-propanaminium trifluoroacetate (DOSPA), β -alanyl cholesterol, cetyl trimethyl ammonium bromide (CTAB), diC₁₄-amidine, N-ferf-butyl-N'-tetradecyl-3-tetradecylamino-propionamidine, N-(alpha-trimethylammonioacetyl)didodecyl-D-glutamate chloride (TMAG), ditetradecanoyl-N-(trimethylammonio-acetyl)diethanolamine chloride, 1,3-dioleoyloxy-2-(6-carboxy-spermyl)-propylamide (DOSPER), and N, N, N', N'-tetramethyl-, N'-bis(2-hydroxyethyl)-2,3-dioleoyloxy-1,4-butanediammonium iodide. In one embodiment, the cationic lipids can be 1-[2-(acyloxy)ethyl]2-alkyl(alkenyl)-3-(2-hydroxyethyl)-imidazolinium chloride derivatives, for example, 1-[2-(9(Z)-octadecenoyloxy)ethyl]-2-(8(Z)-heptadecenyl-3-(2-hydroxyethyl)imidazolinium chloride (DOTIM), and 1-[2-(hexadecanoyloxy)ethyl]-2-pentadecyl-3-(2-hydroxyethyl)imidazolinium chloride

(DPTIM). In one embodiment, the cationic lipids can be 2,3-dialkyloxypropyl quaternary ammonium compound derivatives containing a hydroxyalkyl moiety on the quaternary amine, for example, 1,2-dioleoyl-3-dimethyl-hydroxyethyl ammonium bromide (DORI), 1,2-dioleoyloxypropyl-3-dimethyl-hydroxyethyl ammonium bromide (DORIE), 1,2-dioleoyloxypropyl-3-dimethyl-hydroxypropyl ammonium bromide (DORIE-HP), 1,2-dioleoyloxypropyl-3-dimethyl-hydroxybutyl ammonium bromide (DORIE-HB), 1,2-dioleoyloxypropyl-3-dimethyl-hydroxypentyl ammonium bromide (DORIE-Hpe), 1,2-dimyristyloxypropyl-3-dimethyl-hydroxyethyl ammonium bromide (DMRIE), 1,2-dipalmitoyloxypropyl-3-dimethyl-hydroxyethyl ammonium bromide (DPRIE), and 1,2-disteryloxypropyl-3-dimethyl-hydroxyethyl ammonium bromide (DSRIE).

Cationic lipids can also be ionizable cationic lipids. Suitable ionizable cationic lipids for use in formulating a composition described herein include lipids described in WO2015/074805. Other suitable ionizable cationic lipids suitable for formulating a composition of the present invention can include those described in US 2015/0239834.

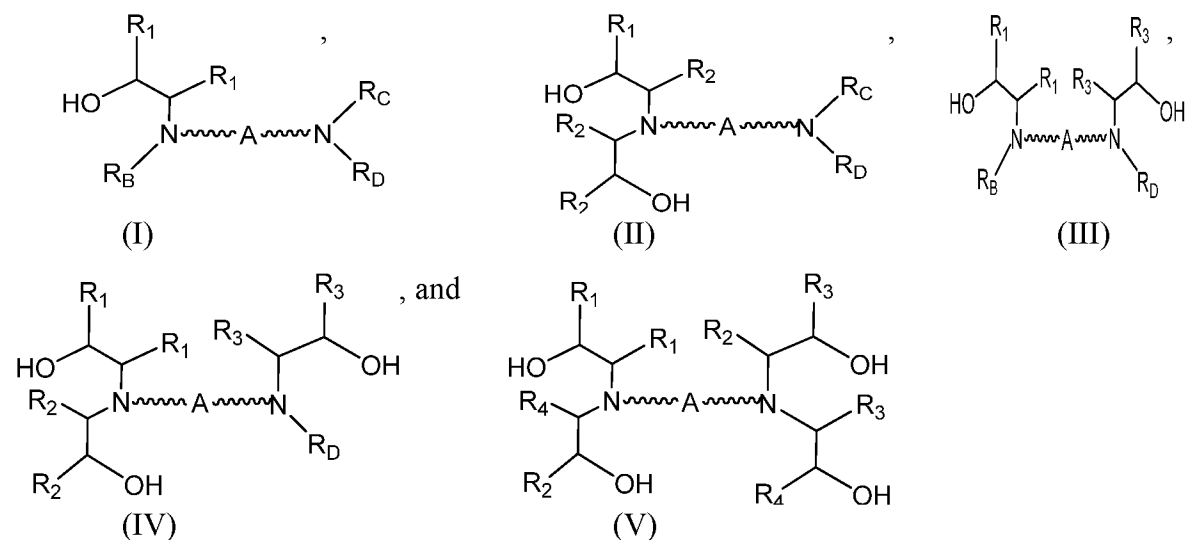
In some embodiments, symmetric or asymmetric or ionizable cationic lipids can be used in a nanoparticle or lipid formulation. Such lipids are disclosed in, for example, U.S. Pat. Publ. Nos. 2015/0239926, 2015/0239834, and 2015/0141678, and PCT Publ. No. WO 2015/074805.

Additionally, a number of commercial preparations of cationic lipids can be used, such as LIPOFECTIN[®] (including DOTMA and DOPE, available from GIBCO/BRL), LIPOFECTAMINE[®] (comprising DOSPA and DOPE, available from GIBCO/BRL), TRANSFECTIN[®] (from Bio-Rad Laboratories, Inc.) and siPORT NEOFX[®] (from Applied Biosystems).

Cationic lipids can also be modified cationic lipids suitable for cellular delivery of compositions comprising agents described herein, such as siRNA molecules (see, for example, those described in U.S. Pat. Publ. No. 2013/0323269); cationic glycerol derivatives, and polycationic molecules, such as polylysine (PCT Publ. No. WO 97/30731), cationic group including one or more biodegradable groups (U.S. Pat. Publ. No. 2013/0195920).

In some embodiments, the ionizable lipid can be ionizable amino lipids described in WO 2015/074805 or US 2015/0239834.

In certain embodiments, a composition described herein further comprises an aminoalcohol lipidoid as described in WO 2010/053572. In certain embodiments, the lipidoid compound is selected from Formulae (I)-(V):



; and pharmaceutically acceptable salts thereof, wherein:

- 5 A is a substituted or unsubstituted, branched or unbranched, cyclic or acyclic C_{2-20} alkylene, optionally interrupted by 1 or more heteroatoms independently selected from O, S and N, or A is a substituted or unsubstituted, saturated or unsaturated 4-6-membered ring;

R_1 is hydrogen, a substituted, unsubstituted, branched or unbranched C_{1-20} -aliphatic or a substituted, unsubstituted, branched or unbranched C_{1-20} heteroaliphatic, wherein at least
 10 one occurrence of R_1 is hydrogen;

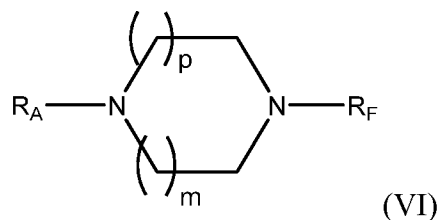
R_B , R_C , and R_D are, independently, hydrogen, a substituted, unsubstituted, branched or unbranched C_{1-20} -aliphatic, or a substituted, unsubstituted, branched or unbranched C_{1-20} -heteroaliphatic or $-\text{CH}_2\text{CH}(\text{OH})\text{R}_E$;

R_B and R_D together can optionally form a cyclic structure;

- 15 R_C and R_D together can optionally form a cyclic structure; and

R_E is a substituted, unsubstituted, branched or unbranched C_{1-20} aliphatic or a substituted, unsubstituted, branched or unbranched C_{1-20} heteroaliphatic.

In certain particular embodiments, the lipidoid is of Formula (VI):

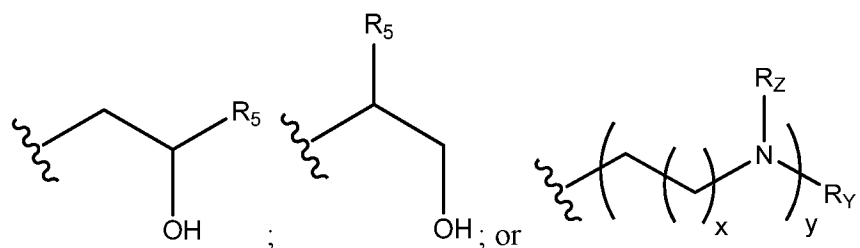


or a pharmaceutically acceptable salt thereof, wherein:

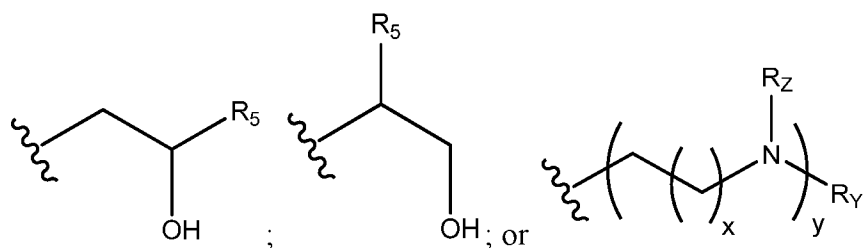
p is an integer between 1 and 3, inclusive;

m is an integer between 1 and 3, inclusive;

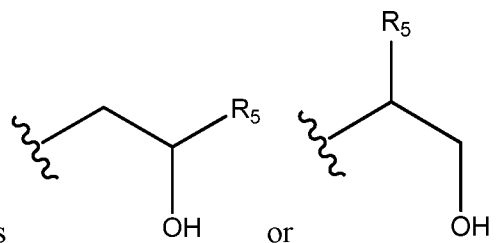
- 5 R_A is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; substituted or unsubstituted heteroaryl;



- 10 R_F is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; substituted or unsubstituted heteroaryl;



- 15 each occurrence of R_5 is independently hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; or substituted or unsubstituted heteroaryl;

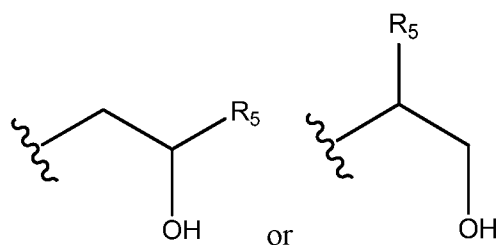


wherein, at least one of R_A , R_F , R_Y , and R_Z is

each occurrence of x is an integer between 1 and 10, inclusive;

each occurrence of y is an integer between 1 and 10, inclusive;

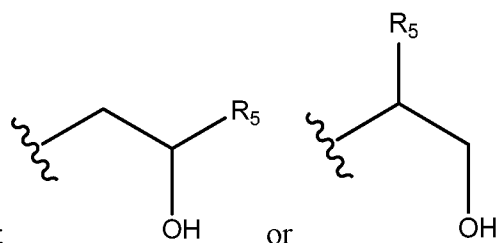
- each occurrence of R_Y is hydrogen; substituted or unsubstituted, cyclic or acyclic,
 5 branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic,
 branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; substituted



or unsubstituted heteroaryl;

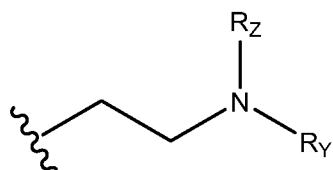
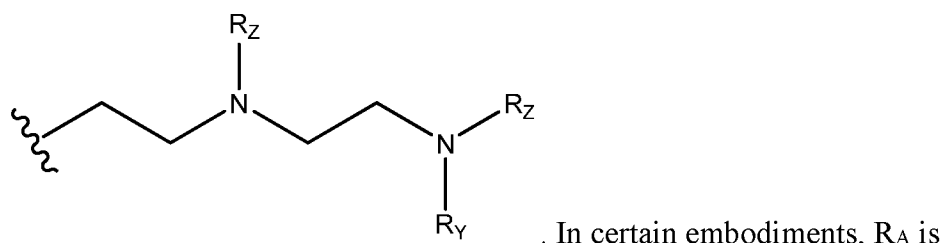
each occurrence of R_Z is hydrogen; substituted or unsubstituted, cyclic or acyclic,
 branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic,

- 10 branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; substituted



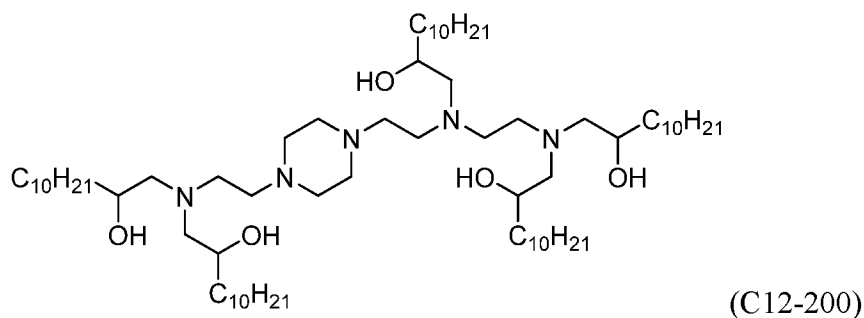
or unsubstituted heteroaryl;

In certain embodiments of Formula (VI), p is 1. In certain embodiments, m is 1. In
 certain embodiments, p and m are both 1. In certain embodiments, R_F is

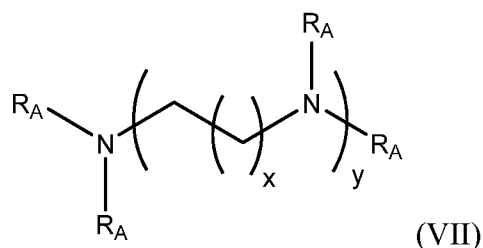


In certain embodiments, the composition comprises an aminoalcohol lipidoid selected from C14-120, C16-120, C14-98, C14-113, C14-96, C12-200, C12-205, C16-96, C12-111, and C12-210 (see U.S. Pat. No. 8,450,298 and PCT Publ. No. WO 2010/053572, referenced above).

In certain particular embodiments, the aminoalcohol lipidoid is C12-200:

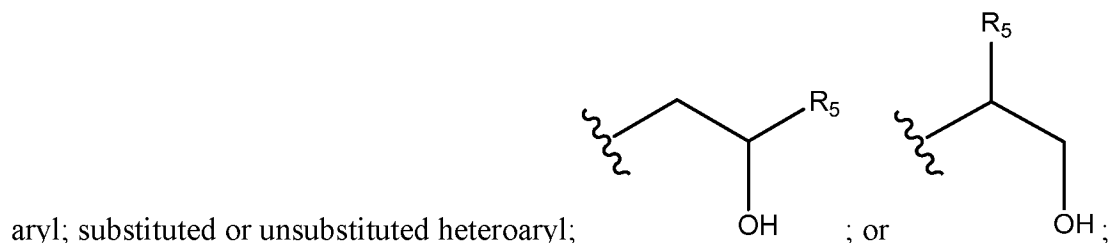


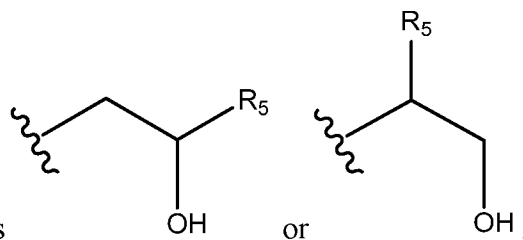
In certain particular embodiments, the lipidoid is of Formula (VII):



or a pharmaceutically acceptable salt thereof, wherein:

each occurrence of R_A is independently hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C₁₋₂₀ aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C₁₋₂₀ heteroaliphatic; substituted or unsubstituted





wherein at least one R_A is

or

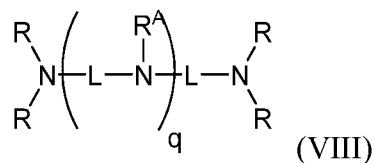
each occurrence of R_5 is independently hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; or substituted or unsubstituted heteroaryl;

each occurrence of x is an integer between 1 and 10, inclusive; and

each occurrence of y is an integer between 1 and 10, inclusive.

In certain embodiments, a composition described herein further comprises an amine-containing lipidoid as described in WO 2014/028847.

In certain embodiments, the amine-containing lipidoid is of Formula (VIII):



or a pharmaceutically acceptable salt thereof, wherein:

each L is, independently, branched or unbranched C_{1-6} alkylene, wherein L is optionally substituted with one or more fluorine radicals;

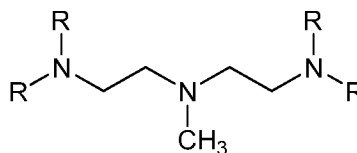
each R^A is, independently, branched or unbranched C_{1-6} alkyl, C_{3-7} cycloalkyl, or branched or unbranched C_{4-12} cycloalkylalkyl, wherein R^A is optionally substituted with one or more fluorine radicals;

each R is, independently, hydrogen or $-\text{CH}_2\text{CH}_2\text{C}(=\text{O})\text{OR}^B$;

each R^B is, independently, C_{10-14} alkyl, wherein R^B is optionally substituted with one or more fluorine radicals; and

q is 1, 2, or 3;

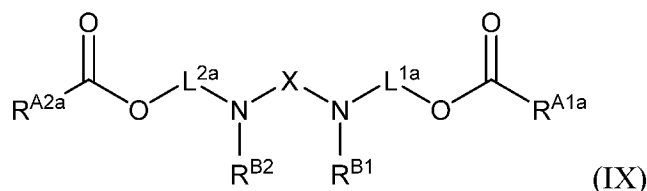
provided that at least three R groups are $-\text{CH}_2\text{CH}_2\text{C}(=\text{O})\text{OR}^B$;



provided that the compound is not

In certain embodiments, a composition described herein further comprises a polyamine-fatty acid derived lipidoid as described in WO 2016/004202.

In certain embodiments, the amine-containing lipidoid is of Formula (IX):



or a pharmaceutically acceptable salt, wherein:

X is substituted or unsubstituted alkylene, substituted or unsubstituted alkenylene, substituted or unsubstituted alkynylene, substituted or unsubstituted heteroalkylene, substituted or unsubstituted heteroalkenylene, substituted or unsubstituted heteroalkynylene, substituted or unsubstituted carbocyclylene, substituted or unsubstituted heterocyclylene, substituted or unsubstituted arylene, substituted or unsubstituted

heteroarylene, a divalent moiety of the formula: , or a combination thereof,

wherein each instance of R^X is independently hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted alkenyl, substituted or unsubstituted alkynyl, substituted or unsubstituted carbocyclyl, substituted or unsubstituted heterocyclyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, a nitrogen protecting group, or a

moiety of the formula: , or R^{B1} and an instance of R^X are joined to form a substituted or unsubstituted, heterocyclic ring or a substituted or unsubstituted, heteroaryl ring, or R^{B2} and an instance of R^X are joined to form a substituted or unsubstituted, heterocyclic ring or a substituted or unsubstituted, heteroaryl ring, wherein:

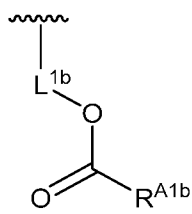
each instance of L^X is independently substituted or unsubstituted alkylene or substituted or unsubstituted heteroalkylene; and

each instance of R^{X1} is independently substituted or unsubstituted, C_{4-30} alkyl, substituted or unsubstituted, C_{4-30} alkenyl, or substituted or unsubstituted, C_{4-30} alkynyl;

L^{1a} is substituted or unsubstituted alkylene or substituted or unsubstituted heteroalkylene;

5 R^{A1a} is substituted or unsubstituted, C_{4-30} alkyl, substituted or unsubstituted, C_{4-30} alkenyl, or substituted or unsubstituted, C_{4-30} alkynyl;

R^{B1} is hydrogen, substituted or unsubstituted acyl, substituted or unsubstituted alkyl, substituted or unsubstituted alkenyl, substituted or unsubstituted alkynyl, substituted or unsubstituted carbocyclyl, substituted or unsubstituted heterocyclyl, substituted or
10 unsubstituted aryl, substituted or unsubstituted heteroaryl, a nitrogen protecting group, or a

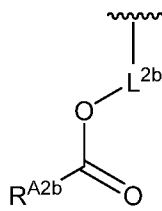


moiety of the formula: $L^{1b}-O-C(=O)-R^{A1b}$, wherein L^{1b} is substituted or unsubstituted alkylene or substituted or unsubstituted heteroalkylene, and R^{A1b} is substituted or unsubstituted, C_{4-30} alkyl, substituted or unsubstituted, C_{4-30} alkenyl, or substituted or unsubstituted, C_{4-30} alkynyl;

15 L^{2a} is substituted or unsubstituted alkylene or substituted or unsubstituted heteroalkylene;

R^{A2a} is substituted or unsubstituted, C_{4-30} alkyl, substituted or unsubstituted, C_{4-30} alkenyl, or substituted or unsubstituted, C_{4-30} alkynyl; and

R^{B2} is hydrogen, substituted or unsubstituted acyl, substituted or unsubstituted alkyl, substituted or unsubstituted alkenyl, substituted or unsubstituted alkynyl, substituted or unsubstituted carbocyclyl, substituted or unsubstituted heterocyclyl, substituted or
20 unsubstituted aryl, substituted or unsubstituted heteroaryl, a nitrogen protecting group, or a

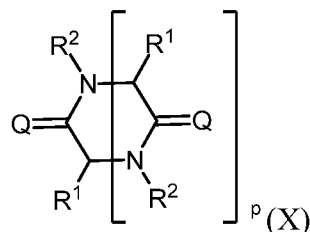


moiety of the formula: $R^{A2b}-C(=O)-O-L^{2b}$, wherein L^{2b} is substituted or unsubstituted alkylene or substituted or unsubstituted heteroalkylene, and R^{A2b} is substituted or unsubstituted, C_{4-30}

alkyl, substituted or unsubstituted, C₄₋₃₀ alkenyl, or substituted or unsubstituted, C₄₋₃₀ alkynyl; or

R^{B1} and R^{B2} are joined to form a substituted or unsubstituted, heterocyclic ring or a substituted or unsubstituted, heteroaryl ring.

- 5 In certain embodiments, a composition described herein further comprises an amino acid-, peptide- or polypeptide-lipid as described in WO 2013/063468. In certain embodiments, the amine-containing lipidoid is of Formula (X):



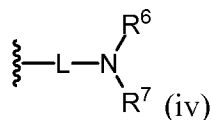
or a pharmaceutically acceptable salt, wherein:

- 10 p is an integer of between 1 and 9, inclusive;

each instance of Q is independently O, S, or NR^Q, wherein R^Q is hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, a nitrogen protecting group, or a group of
15 the formula (i), (ii), (iii);

- each instance of R¹ is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, halogen, -OR^{A1}, -N(R^{A1})₂, -SR^{A1}; wherein each occurrence of R^{A1} is
20 independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, an oxygen protecting group when attached to an oxygen atom, a sulfur protecting group when attached to an sulfur atom, a nitrogen protecting group when attached to a nitrogen atom, or two R^{A1}
25 groups are joined to form an optionally substituted heterocyclic or optionally substituted heteroaryl ring;

or at least one instance of R¹ is a group of formula:

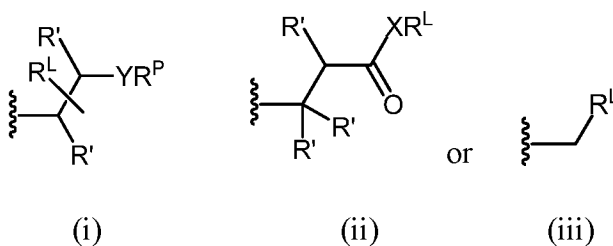


wherein L is an optionally substituted alkylene, optionally substituted alkenylene, optionally substituted alkynylene, optionally substituted heteroalkylene, optionally substituted heteroalkenylene, optionally substituted heteroalkynylene, optionally substituted carbocyclylene, optionally substituted heterocyclylene, optionally substituted arylene, or optionally substituted heteroarylene, and

R^6 and R^7 are each independently selected from the group consisting of hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, and a nitrogen protecting group;

each instance of R^2 is independently hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, a nitrogen protecting group, or a group of the formula (i), (ii), or (iii); and

Formulae (i), (ii), and (iii) are:



wherein:

each instance of R' is independently hydrogen or optionally substituted alkyl;

X is O, S, NR^{X} , wherein R^{X} is hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, or a nitrogen protecting group;

Y is O, S, NR^{Y} , wherein R^{Y} is hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl,

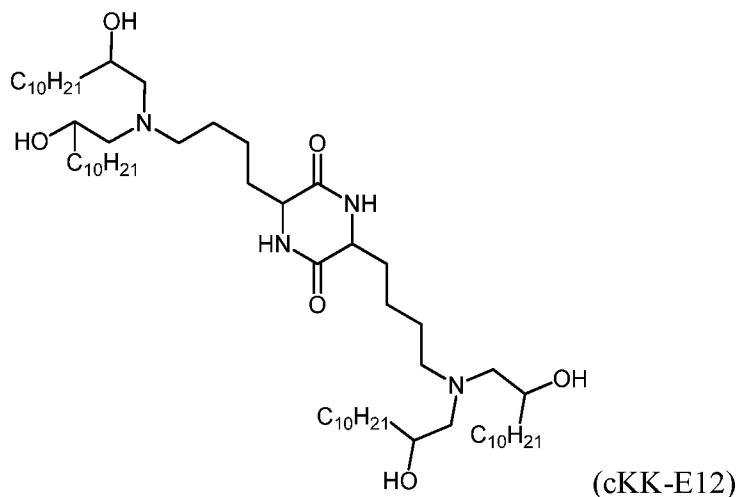
optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, or a nitrogen protecting group;

R^P is hydrogen, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted carbocyclyl, optionally substituted heterocyclyl, optionally substituted aryl, optionally substituted heteroaryl, an oxygen protecting group when attached to an oxygen atom, a sulfur protecting group when attached to a sulfur atom, or a nitrogen protecting group when attached to a nitrogen atom; and

R^L is optionally substituted C_{1-50} alkyl, optionally substituted C_{2-50} alkenyl, optionally substituted C_{2-50} alkynyl, optionally substituted hetero C_{1-50} alkyl, optionally substituted hetero C_{2-50} alkenyl, optionally substituted hetero C_{2-50} alkynyl, or a polymer;

provided that at least one instance of R^Q , R^2 , R^6 , or R^7 is a group of the formula (i), (ii), or (iii).

In certain particular embodiments, the amino acid-, peptide- or polypeptide-lipid has the formula:



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In certain particular embodiments, a composition as described herein can be formulated with C12-200 containing lipid nanoparticles. In some embodiments, the C12-200 is present in a molar percentage of about 1.0% to about 60.0%, about 10.0% to 40.0%, or about 20.0% to about 50.0% of the total composition. In some embodiments, the composition comprises C12-200 in a concentration of about 5.0%, about 7.5%, about 10.0%, about 12.5%, about 15.0%, about 17.5%, about 20.0%, about 20.5%, about 21.0%, about 21.5%, about 22.0%, about 22.5%, about 23.0%, about 23.5%, about 24.0%, about 24.5%, about 25.0%, about 25.5%, about 26.0%, about 26.5%, about 27.0%, about 27.5%, about 28.0%, about 28.5%, about 29.0%, about 29.5%, about 30.0%, about 30.5%, about

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31.0%, about 31.5%, about 32.0%, about 32.5%, about 33.0%, about 33.5 %, about 34.0%, about 34.5%, about 35.0%, about 35.5%, about 36.0%, about 36.5%, about 37.0%, about 37.5%, about 38.0%, about 38.5%, about 39.0%, about 39.5%, about 40.0%, about 40.5%, about 41.0%, about 41.5%, about 42.0%, about 42.5%, about 43.0%, about 43.5%, about 44.0%, about 44.5%, about 45.0%, about 45.5%, about 46.0%, about 46.5%, about 47.0%, about 47.5%, about 48.0%, about 48.5%, about 49.0%, about 49.5%, about 50.0%, about 50.5%, about 51.0%, about 52.0%, about 53.0%, about 54.0%, about 55.0%, about 56.0%, about 57.0%, about 58.0%, about 59.0% or about 60.0% by mole of the total composition. In certain embodiments, the composition comprises about 50.0% by mole C12-200.

In some embodiments, the lipid nanoparticles can also include one or more auxiliary lipids (also referred to herein as “co-lipids”) including, but not limited to, neutral lipids, amphipathic lipids, PEG-containing lipids, anionic lipids, and sterols.

In some embodiments, the lipid nanoparticles further comprise one or more neutral lipids. Neutral lipids, when present, can be any of a number of lipid species, which exist either in an uncharged or neutral zwitterionic form at physiological pH. Such lipids include, for example, diacylphosphatidylcholine, diacylphosphatidylethanolamine, ceramide, sphingomyelin, dihydrosphingomyelin, cephalin, and cerebroside. In some embodiments, the neutral lipid component is a lipid having two acyl groups (*e.g.*, diacylphosphatidylcholine and diacylphosphatidylethanolamine). In some embodiments, the neutral lipid comprises saturated fatty acids with carbon chain lengths in the range of C₁₀ to C₂₀, inclusive. In some embodiments, the neutral lipid includes mono- or di-unsaturated fatty acids with carbon chain lengths in the range of C₁₀ to C₂₀, inclusive. Suitable neutral lipids include, but are not limited to, DPPC (Dipalmitoyl phosphatidylcholine), POPC (*Palmitoyl-Oleoyl Phosphatidyl Cholin*), DOPE (1,2-dioleoyl-sn-glycero-3-phosphoethanolamine), DSPC (disteroylphosphatidyl choline), egg L-alpha-phosphatidylcholine (EPC); 1,2-dipalmitoyl-sn-glycero-3-phosphoethanolamine (DPPE); and SM (Sphingomyelin). In some embodiments, the neutral lipid is DSPC (disteroylphosphatidyl choline). In some embodiments, the composition comprises DSPC at about 1.0% to about 20.0%, or from about 5.0% to about 10.0% by mole of the total composition. In some embodiments, the composition comprises DSPC at about 1.0%, about 1.5%, about 2.0%, about 2.5%, about 3.0%, about 3.5%, about 4.0%, about 4.5%, about 5.0%, about 5.5%, about 6.0%, about 6.5%, about 7.0%, about 7.5%, about 8.0%, about 8.5%, about 9.0%, about 9.5%, about 10.0%, about 10.5%, about 11.0%, about

11.5%, about 12.0%, about 12.5%, about 13.0%, about 13.5%, about 14.0%, about 14.5%, about 15.0%, about 15.5%, about 16.0%, about 16.5%, about 17.0%, about 17.5%, about 18.0%, about 18.5%, about 19.0% about 19.5% or about 20.0% by mole of the total composition. In some embodiments, composition comprises about 10% DSPC by mole.

5 In some embodiments, the lipid nanoparticles further comprise one or more anionic lipids. Anionic lipids are lipids that carry a net negative charge at physiological pH. Anionic lipids, when used in combination with cationic lipids, can reduce the overall surface charge of lipid particles, and/or introduce pH-dependent disruption of lipid structures, facilitating the release of therapeutic agents formulated in the lipid particles
 10 (*e.g.*, siRNA molecules). Anionic lipids can include, but are not limited to, fatty acids (*e.g.*, oleic, linoleic, linolenic acids); cholesteryl hemisuccinate (CHEMS); 1,2-di-O-tetradecyl-sn-glycero-3-phospho-(1'-rac-glycerol) (Diether PG); 1,2-dimyristoyl-sn-glycero-3-phospho-(1'-rac-glycerol) (sodium salt); 1,2-dimyristoyl-sn-glycero-3-phospho-L-serine (sodium salt); 1-hexadecanoyl,2-(9Z,12Z)-octadecadienoyl-sn-glycero-3-phosphate; 1,2-dioleoyl-sn-glycero-3-[phospho-rac-(1'-glycerol)] (DOPG); dioleoylphosphatidic acid (DOPA); 1,2-dioleoyl-sn-glycero-3-phospho-L-serine (DOPS); and derivatives thereof. Other examples of suitable anionic lipids include, but are not limited to: fatty acids, such as oleic, linoleic, and linolenic acids; and cholesteryl hemisuccinate. Such lipids can be used alone or in combination, for a variety of purposes, such as to attach ligands to the liposome surface.

20 The lipid nanoparticle can also include one or more lipids capable of reducing aggregation. Examples of lipids that reduce aggregation of particles during formulation include PEG lipids (*e.g.*, DMG-PEG (1,2-Dimyristoyl-sn-glycerol, methoxypolyethylene glycol-PEG), DMA-PEG (poly(ethylene glycol)-dimethacrylate-PEG) and DMPE-PEG550 (1,2-dimyristoyl-sn-glycero-3-phosphoethanolamine-N-[methoxy(polyethylene glycol)-
 25 550]), PEG), monosialoganglioside Gml, and polyamide oligomers (PAO), such as those described in U.S. Pat. No. 6,320,017. The lipid nanoparticles can include DMPE-PEG2000 or DMG-PEG which could be substituted with DMPE-PEG2000 in any of the formulations taught herein. Other suitable PEG lipids include, but are not limited to, PEG-modified phosphatidylethanolamine and phosphatidic acid, PEG-ceramide conjugates (*e.g.*, PEG-CerC₁₄ or PEG-CerC₂₀) (such as those described in U.S. Pat. No. 5,820,873), PEG-modified
 30 dialkylamines and PEG-modified 1,2-diacyloxypropan-3-amines, PEG-modified diacylglycerols and dialkylglycerols, mPEG (mw2000)-diastearoylphosphatidylethanolamine (PEG-DSPE).

In some embodiments, a lipid capable of reducing aggregation is DMPE-PEG2000 or DMG-PEG (1,2-Dimyristoyl-sn-glycerol, methoxypolyethylene glycol, PEG). In some embodiments, the compositions comprises about 0.1% to about 5.0% DMPE-PEG2000 or DMG-PEG by mole (*i.e.*, about 0.1% to about 5.0% DMPE-PEG2000 or 0.1% to about 5.0% DMG-PEG) or from about 0.5% to 2.0% DMPE-PEG2000 or DMG-PEG by mole. In some embodiments, the composition comprises about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1.0%, about 1.1%, about 1.2%, about 1.3%, about 1.4%, about 1.5%, about 1.6%, about 1.7%, about 1.8%, about 1.9%, about 2.0%, about 2.1%, about 2.2%, about 2.3%, about 2.4%, about 2.5%, about 2.6%, about 2.7%, about 2.8%, about 2.9%, about 3.0%, about 3.1%, about 3.2%, about 3.3%, about 3.4%, about 3.5%, about 3.6%, about 3.7%, about 3.8%, about 3.9%, about 4.0%, about 4.1%, about 4.2%, about 4.3%, about 4.4%, about 4.5%, about 4.6%, about 4.7%, about 4.8%, about 4.9%, or about 5.0% DMPE-PEG2000 or DMG-PEG by mole in the total composition. In some embodiments, the composition comprises about 1.5% DMPE-PEG2000 or DMG-PEG by mole.

In some embodiments, the lipid nanoparticle further comprises a sterol. In some embodiments, the sterol is cholesterol. In some embodiments, the composition comprises from about 10.0% to about 50.0% cholesterol by mole, or about 15.0% to about 40.0% cholesterol by mole. In some embodiments, the composition comprises about 10.0%, about 11.0%, about 11.5%, about 12.0%, about 12.5%, about 13.0%, about 13.5%, about 14.0%, about 14.5%, about 15.0 %, about 15.5%, about 16.0%, about 16.5 %, about 17.0%, about 17.5%, about 18.0%, about 18.5%, about 19.0%, about 19.5%, about 20.0%, about 20.5%, about 21.0%, about 21.5%, about 22.0%, about 22.5%, about 23.0%, about 23.5%, about 24.0%, about 24.5%, about 25.0%, about 25.5%, about 26.0%, about 26.5%, about 27.0%, about 27.5%, about 28.0%, about 28.5%, about 29.0%, about 29.5%, about 30.0%, about 30.5%, about 31.0%, about 31.5%, about 32.0%, about 32.5%, about 33.0%, about 33.5 %, about 34.0%, about 34.5%, about 35.0%, about 35.5%, about 36.0%, about 36.5%, about 37.0%, about 37.5%, about 38.0%, about 38.5%, about 39.0%, about 39.5% or about 40.0% cholesterol by mole. In some embodiments, the composition comprises about 38.5% cholesterol by mole.

The ratio of PEG in the LNP formulations can be increased or decreased and/or the carbon chain length of the PEG lipid can be modified from C14 to C18 to alter the pharmacokinetics and/or biodistribution of the LNP formulations.

In some embodiments, the lipid nanoparticles described herein further comprise one or more compounds that are capable of enhancing the cellular uptake or cytosolic distribution of the lipid nanoparticle and/or its encapsulated composition (*e.g.*, gene silencing agent, siRNA molecule, peptide, etc.). Compounds that can enhance the cellular uptake can include levodopa, naphazoline hydrochloride, acetohexamide, niclosamide, diprophylline, and isoxicam, or a combination thereof. Compounds that can enhance the cytosolic distribution can include azaguanine-8, isoflupredone acetate, chloroquine, trimethobenzamide, hydrochloride, isoxsuprine hydrochloride, and diphemanil methylsulfate, or a combination thereof.

In some embodiments, the lipid nanoparticles comprise lipid bilayers encapsulating one or more agents encompassed by the present invention, such as siRNA molecules sufficiently complementary to the mRNA transcription product of at least one biomarker described herein. In some embodiments, the lipid nanoparticles are formulated to facilitate an uptake into cells. In some embodiments, the lipid nanoparticles are formulated to facilitate uptake into monocytes, dendritic cells, and/or macrophages.

The lipid nanoparticle can, in some aspects, further comprise additional agents. In some embodiments, the lipid nanoparticle further comprises one or more antioxidants. Without wishing to be bound by any particular theory, the antioxidant can help stabilize the lipid nanoparticle and prevent, decrease, and/or inhibit degradation of the cationic lipids and/or active agents encapsulated in the lipid nanoparticle. In some embodiments, the antioxidant is a hydrophilic antioxidant, a lipophilic antioxidant, a metal chelator, a primary antioxidant, a secondary antioxidant, or salts or mixtures thereof. In some embodiments, the antioxidant comprises EDTA, or a salt thereof. In some embodiments, the lipid nanoparticle further comprises EDTA in combination with one, two, three, four, five, six, seven, eight, or more additional antioxidants (*e.g.*, primary antioxidants, secondary antioxidants, or other metal chelators). Examples of antioxidants include, but are not limited to, hydrophilic antioxidants, lipophilic antioxidants, and mixtures thereof. Non-limiting examples of hydrophilic antioxidants include chelating agents (*e.g.*, metal chelators) such as ethylenediaminetetraacetic acid (EDTA), citrate, ethylene glycol tetraacetic acid (EGTA), 1,2-bis(o-aminophenoxy)ethane-N,N',N'-tetraacetic acid (BAPTA), diethylene triamine pentaacetic acid (DTPA), 2,3-dimercapto-1-propanesulfonic acid (DMPS), dimercaptosuccinic acid (DMSA), cc-lipoic acid, salicylaldehyde isonicotinoyl hydrazone (SIR), hexyl thioethylamine hydrochloride (HTA),

desferrioxamine, salts thereof, and mixtures thereof. Additional hydrophilic antioxidants include ascorbic acid, cysteine, glutathione, dihydrolipoic acid, 2-mercaptoethane sulfonic acid, 2-mercaptobenzimidazole sulfonic acid, 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid, sodium metabisulfite, salts thereof, and mixtures thereof. Non-limiting
 5 examples of lipophilic antioxidants include vitamin E isomers such as α -, β -, γ -, and δ -tocopherols and α -, β -, γ -, and δ -tocotrienols; polyphenols such as 2-tert-butyl-4-methyl phenol, 2-tert-butyl-5-methyl phenol, and 2-tert-butyl-6-methyl phenol; butylated hydroxyanisole (BHA) (*e.g.*, 2-terti-butyl-4-hydroxyanisole and 3-tert-butyl-4-hydroxyanisole); butylhydroxytoluene (BHT); tert-butylhydroquinone (TBHQ); ascorbyl
 10 palmitate; *rac*-propyl gallate; salts thereof; and mixtures thereof.

In some embodiments, the lipid-based particles formulated for delivery of one or more agents (*e.g.*, gene silencing agents, siRNA molecules, peptides) are selected from lipid vectors, liposomes, lipoplexes, lipid nanoparticles, and micelles. In some
 15 embodiments, the lipid-based particle is a pH-sensitive nanoparticle. Such pH-sensitive nanoparticles (PNSDS), which are positive-charge-free nanocarriers comprising siRNA chemically cross-linked with multi-armed poly(ethylene glycol) carriers via acid-labile acetal linkers, can be beneficial for the delivery of siRNA molecules (*Tang et al.*, SiRNA Crosslinked Nanoparticles for the Treatment of Inflammation-induced Liver Injury, *Advanced Science*, 2016, 4(2), e1600228).

20 In some embodiments, the lipid nanoparticle further comprises one or more C12-200 aminoalcohol lipids. In some embodiments, the lipid nanoparticle comprises from about 40.0% to about 50.0% C12-200 by mole. In some embodiments, the lipid nanoparticle comprises from about 5.0% to about 10.0% DSPC by mole. In some
 25 embodiments, the lipid nanoparticle comprises from about 1.0% to about 2.0% DMG-PEG by mole. In some embodiments, the lipid nanoparticle comprises from about 20.0% to about 40.0% cholesterol by mole. In some embodiments, the lipid nanoparticle comprises 50% C12-200, 10.0% DSPC, 1.5% DMG-PEG, and 38.5% cholesterol by mole.

In some embodiments, the total siRNA molecule moles with respect to the total lipid
 30 moles within the formulation ranges from about 1:5 to about 1:20. In some embodiments, the total siRNA molecule moles with respect to the total lipid moles is about 1:5, about 1:6, about 1:7, about 1:8, about 1:9, about 1:10, about 1:11, about 1:12, about 1:13, about 1:14, about 1:15, about 1:16, about 1:17, about 1:18, about 1:18, about 1:19, or about 1:20. In

some embodiments, the total siRNA molecule moles with respect to the total lipid moles is about 1:9.

In some embodiments, the lipid nanoparticle (LNP) is formulated to encapsulate an agent, such as an siRNA, using a spontaneous vesicle formation formulation procedure as previously described in Semple *et al.* (2010) *Nat. Biotechnol.* 28172–28176.

In some embodiments, the total concentration of one or more agents encompassed by the present invention, such as siRNA molecules that are sufficiently complementary to the mRNA transcription product of at least one biomarker described herein in the formulation is about 0.001mg/ml to about 100 mg/ml, about 0.01 mg/ml to about 10 mg/ml, or about 0.1 mg/ml to about 20mg/ml. In some embodiments, the total concentration of two or more, three or more, four or more, five or more, or all six siRNA molecules is about 0.001 mg/ml to about 100 mg/ml, about 0.01 mg/ml to about 10 mg/ml, or about 0.1 mg/ml to about 20 mg/ml.

In some embodiments, the lipid nanoparticles (LNPs) ranging in size from about 40 to about 200 nm, or from about 50 nm to about 100nm. In some embodiments, the lipid nanoparticle is about 40 nm, about 45 nm, about 50 nm, about 55 nm, about 60 nm, about 65 nm, about 70 nm, about 75 nm, about 80 nm, about 85 nm, about 90 nm, about 95 nm, about 100 nm, about 110 nm, about 120 nm, about 130 nm, about 140 nm, about 150 nm, about 160 nm, about 170 nm, about 180 nm, or about 200 nm in size. In some embodiments, the lipid nanoparticle is about 80 nm in size.

In accordance with the present invention, the formulations as described herein are stable. The term “stable,” as used herein, means remaining in a state or condition that is suitable for administration to a patient. In some embodiments, the formulations are substantially pure. As used herein, “substantially pure” means that the active ingredient (*e.g.*, the siRNA molecules sufficiently complementary to the mRNA transcription product of at least one biomarker described herein) is the predominant species present in the formulation. In some embodiments, a substantially pure composition comprises a composition that is more than 80% comprised of macromolecular species (*e.g.*, active agents, gene silencing agents, siRNA molecules, additional agents (*e.g.*, antioxidants)). In some embodiments, the substantially pure composition comprises a composition that is more than 85%, 90%, 95%, 96%, 97%, 98%, or 99% comprised of macromolecular species. In some embodiments, the one or more active agents are purified to essential homogeneity

(i.e., contaminant species cannot be detected in the composition by conventional detection methods), wherein the composition consists essentially of a single macromolecular species.

Other nanoparticles can be used as delivery vehicles of the agents and compositions described herein. In some embodiments, the nanoparticles comprises chemically and/or enzymatically modified lipoproteins (e.g., apolipoproteins as described in U.S. Pat. Publ. No. 2011/0256224). In some embodiments, the nanoparticles comprise other lipoprotein-based nanoparticles, such as HDL, HDL-like lipoprotein particles, or synthetic HDL-like particles (See, e.g., U.S. Pat. Publ. No. 2009/0110739 and U.S. Pat. No. 7,824,709).

In some embodiments, nanoparticles with increased macrophage targeted delivery are used to encapsulate a composition as described herein. In some embodiments, the nanoparticle is a GP nanoparticle comprising 1,3-D-glucan (Soto *et al.* (2012) *J. Drug. Deliv.* e143524), or a mannosylated chitosan (MCS) nanoparticle (Peng *et al.* (2015) *J. Nanosci. Nanotechnol.* 15:2619-2627).

The nanoparticle formulations can be a carbohydrate nanoparticle comprising a carbohydrate carrier. As a non-limiting example, the carbohydrate carrier can include, but is not limited to, an anhydride-modified phytoglycogen or glycogen-type material, phytoglycogen octenyl succinate, phytoglycogen beta-dextrin, anhydride-modified phytoglycogen beta-dextrin. (see, e.g., PCT Publ. No. WO 2012/109121).

In some embodiments, lipid nanoparticles can be engineered to alter the surface properties of particles so the lipid nanoparticles can penetrate the mucosal barrier. Mucus is located on mucosal tissue such as, but not limited to, oral (e.g., the buccal and esophageal membranes and tonsil tissue), ophthalmic, gastrointestinal (e.g., stomach, small intestine, large intestine, colon, rectum), nasal, respiratory (e.g., nasal, pharyngeal, tracheal and bronchial membranes), genital (e.g., vaginal, cervical and urethral membranes).

Nanoparticles larger than 10-200 nm which are preferred for higher drug encapsulation efficiency and the ability to provide the sustained delivery of a wide array of drugs have been thought to be too large to rapidly diffuse through mucosal barriers. Mucus is continuously secreted, shed, discarded or digested and recycled so most of the trapped particles can be removed from the mucosa tissue within seconds or within a few hours. Large polymeric nanoparticles (200nm -500nm in diameter) which have been coated densely with a low molecular weight polyethylene glycol (PEG) diffused through mucus only 4 to 6-fold lower than the same particles diffusing in water (Lai *et al.* (2007) *Proc. Natl. Acad. Sci. U.S.A.* 104:1482-1487; Lai *et al.* (2009) *Adv Drug Deliv Rev.* 61:158-171).

The transport of nanoparticles can be determined using rates of permeation and/or fluorescent microscopy techniques including, but not limited to, fluorescence recovery after photo bleaching (FRAP) and high resolution multiple particle tracking (MPT). As a non-limiting example, compositions which can penetrate a mucosal barrier can be made as described in U.S. Pat. No. 8,241,670.

Lipid nanoparticle engineered to penetrate mucus can comprise a polymeric material (*i.e.*, a polymeric core) and/or a polymer-vitamin conjugate and/or a tri-block co-polymer. The polymeric material can include, but is not limited to, polyamines, polyethers, polyamides, polyesters, polycarbamates, polyureas, polycarbonates, poly(styrenes), polyimides, polysulfones, polyurethanes, polyacetylenes, polyethylenes, polyethyleneimines, polyisocyanates, polyacrylates, polymethacrylates, polyacrylonitriles, and polyarylates. The polymeric material can be biodegradable and/or biocompatible. The polymeric material can additionally be irradiated. As a non-limiting example, the polymeric material can be gamma irradiated (see, *e.g.*, PCT Publ. No. WO 2012/082165).

Non-limiting examples of specific polymers include poly(caprolactone) (PCL), ethylene vinyl acetate polymer (EVA), poly(lactic acid) (PLA), poly(L-lactic acid) (PLLA), poly(glycolic acid) (PGA), poly(lactic acid-co-glycolic acid) (PLGA), poly(L-lactic acid-co-glycolic acid) (PLLGA), poly(D,L-lactide) (PDLA), poly(L-lactide) (PLLA), poly(D,L-lactide-co-caprolactone), poly(D,L-lactide-co-caprolactone-co-glycolide), poly(D,L-lactide-co-PEO-co-D,L-lactide), poly(D,L-lactide-co-PPO-co-D,L-lactide), polyalkyl cyanoacralate, polyurethane, poly-L-lysine (PLL), hydroxypropyl methacrylate (HPMA), polyethyleneglycol, poly-L-glutamic acid, poly(hydroxy acids), polyanhydrides, polyorthoesters, poly(ester amides), polyamides, poly(ester ethers), polycarbonates, polyalkylenes such as polyethylene and polypropylene, polyalkylene glycols such as poly(ethylene glycol) (PEG), polyalkylene oxides (PEO), polyalkylene terephthalates such as poly(ethylene terephthalate), polyvinyl alcohols (PVA), polyvinyl ethers, polyvinyl esters such as poly(vinyl acetate), polyvinyl halides such as poly(vinyl chloride) (PVC), polyvinylpyrrolidone, polysiloxanes, polystyrene (PS), polyurethanes, derivatized celluloses such as alkyl celluloses, hydroxyalkyl celluloses, cellulose ethers, cellulose esters, nitro celluloses, hydroxypropylcellulose, carboxymethylcellulose, polymers of acrylic acids, such as poly(methyl(meth)acrylate) (PMMA), poly(ethyl(meth)acrylate), poly(butyl(meth)acrylate), poly(isobutyl(meth)acrylate), poly(hexyl(meth)acrylate), poly(isodecyl(meth)acrylate), poly(lauryl(meth)acrylate), poly(phenyl(meth)acrylate),

poly(methyl acrylate), poly(isopropyl acrylate), poly(isobutyl acrylate), poly(octadecyl acrylate) and copolymers and mixtures thereof, polydioxanone and its copolymers, polyhydroxyalkanoates, polypropylene fumarate, polyoxymethylene, poloxamers, poly(ortho)esters, poly(butyric acid), poly(valeric acid), poly(lactide-co-caprolactone), and trimethylene carbonate, polyvinylpyrrolidone. The lipid nanoparticle can be coated or associated with a co-polymer such as, but not limited to, a block co-polymer, and (poly(ethylene glycol))-(poly(propylene oxide))-(poly(ethylene glycol)) triblock copolymer (see, *e.g.*, U.S. Pat. Publ. Numbers 2012/0121718 and 2010/0003337; and U.S. Pat. No. 8,263,665). The co-polymer can be a polymer that is generally regarded as safe (GRAS) and the formation of the lipid nanoparticle can be in such a way that no new chemical entities are created. For example, the lipid nanoparticle can comprise poloxamers coating PLGA nanoparticles without forming new chemical entities which are still able to rapidly penetrate human mucus (Yang *et al.* (2011) *Angew. Chem. Int. Ed.* 50:2597-2600).

For example, LNPs encompassed by the present invention can comprise a PLGA-PEG block copolymer (see, *e.g.*, U.S. Pat. Publ. No. 2012/0004293 and U.S. Pat. No. 8,236,330); a diblock copolymer of PEG and PLA or PEG and PLGA (see, *e.g.*, U.S. Pat. No. 8,246,968); a multiblock copolymer (see, *e.g.*, U.S. Pat. Numbers 8,263,665 and 8,287,910); a polyion complex comprising a non-polymeric micelle and the block copolymer (see, *e.g.*, U.S. Pat. Publ. No. 2012/00768); or amine-containing polymer such as, but not limited to polylysine, polyethylene imine, poly(amidoamine) dendrimers, poly(beta-amino esters) (see, *e.g.*, U.S. Pat. No. 8,287,849).

LNPs encompassed by the present invention can comprise one or more other polymer such as acrylic polymers. Acrylic polymers can include but are not limited to, acrylic acid, methacrylic acid and methacrylic acid copolymers, methyl methacrylate copolymers, ethoxyethyl methacrylates, cyanoethyl methacrylate, amino alkyl methacrylate copolymer, poly(acrylic acid), poly(methacrylic acid), polycyanoacrylates and combinations thereof.

LNPs encompassed by the present invention can comprise at least one degradable polyester which can contain polycationic side chains. Degradable polyesters include, but are not limited to, poly(serine ester), poly(L-lactide-co-L-lysine), poly(4-hydroxy-L-proline ester), and combinations thereof. In another embodiment, the degradable polyesters can include a PEG conjugation to form a PEGylated polymer. The LNPs can further include at least one targeting ligand. The targeting ligand can be any ligand known in the art such as,

but not limited to, a monoclonal antibody (Kirpotin *et al.* (2006) *Cancer Res.* 66:6732-6740).

In some embodiments, compositions encompassed by the present invention can be formulated as a solid lipid nanoparticle. A solid lipid nanoparticle (SLN) can be spherical
5 with an average diameter between 10 to 1000 nm. SLN possess a solid lipid core matrix that can solubilize lipophilic molecules and can be stabilized with surfactants and/or emulsifiers. In a further embodiment, the lipid nanoparticle can be a self-assembly lipid-polymer nanoparticle (see, *e.g.*, Zhang *et al.* (2008) *ACS Nano* 2:1696-1702).

In some embodiments, agents encompassed by the present invention can be
10 sustained release formulations, such as encapsulated into a nanoparticle or a rapidly eliminated nanoparticle and the nanoparticles or a rapidly eliminated nanoparticle can then be encapsulated into a polymer, hydrogel and/or surgical sealant described herein and/or known in the art. As a non-limiting example, the polymer, hydrogel or surgical sealant can be PLGA, ethylene vinyl acetate (EVAc), poloxamer, GELSITE® (Nanotherapeutics, Inc.
15 Alachua, FL), HYLENEX® (Halozyme Therapeutics, San Diego CA), surgical sealants such as fibrinogen polymers (Ethicon Inc. Cornelia, GA), TISSELL® (Baxter International, Inc Deerfield, IL), PEG-based sealants, and COSEAL® (Baxter International, Inc Deerfield, IL). In another embodiment, the nanoparticle can be encapsulated into any polymer known in the art which can form a gel when injected into a subject. As a non-
20 limiting example, the nanoparticle can be encapsulated into a polymer matrix which can be biodegradable.

In some embodiments, compositions encompassed by the present invention can be formulated as controlled release nanoparticles. In one example, the nanoparticle formulation for controlled release and/or targeted delivery can further include at least one
25 controlled release coating. Controlled release coatings include, but are not limited to, OPADRY®, polyvinylpyrrolidone/vinyl acetate copolymer, polyvinylpyrrolidone, hydroxypropyl methylcellulose, hydroxypropyl cellulose, hydroxyethyl cellulose, EUDRAGIT RL®, EUDRAGIT RS® and cellulose derivatives such as ethylcellulose aqueous dispersions (AQUACOAT® and SURELEASE®). In another example, the
30 controlled release and/or targeted delivery formulation can comprise at least one degradable polyester which can contain polycationic side chains. Degradable polyesters include, but are not limited to, poly(serine ester), poly(L-lactide-co-L-lysine), poly(4-hydroxy-L-proline ester), and combinations thereof.

In another embodiment, the degradable polyesters can include a PEG conjugation to form a PEGylated polymer.

In some embodiments, compositions encompassed by the present invention can be formulated as a lipoplex, such as, without limitation, the ATUPLEX™ system, the DACC
5 system, the DBTC system and other conjugate-lipoplex technology from Silence
Therapeutics (London, United Kingdom), STEMFECT™ from STEMGENT® (Cambridge,
MA), and polyethylenimine (PEI) or protamine-based targeted and non-targeted delivery of
therapeutic agents (Aleku *et al.* (2008) *Cancer Res.* 68: 9788-9798; Strumberg *et al.* (2012)
10 *Int. J. Clin. Pharmacol. Ther.* (2012) 50:76-78; Santel *et al.* (2006) *Gene Ther.* 13:1222-
1234; Santel *et al.* (2006) *Gene Ther.* 13:1360-1370; Gutbier *et al.* (2010) *Pulm.*
Pharmacol. Ther. 23:334-344; Kaufmann *et al.* (2010) *Microvasc. Res.* 80:286-293; Weide
et al. (2009) *J. Immunother.* 32:498-507; Weide *et al.* (2008) *J. Immunother.* 31:180-188;
Pascolo (2004) *Exp. Opin. Biol. Ther.* 4:1285-1294; Fotin-Mleczek *et al.* (2011) *J.*
Immunother. 34:1-15; Song *et al.* (2005) *Nature Biotechnol.* 23:709-717; Peer *et al.* (2007)
15 *Proc. Natl. Acad. Sci. U.S.A.* 6:4095-4100; and deFougerolles (2008) *Hum. Gene Ther.*
19:125-132).

In some embodiments, therapeutic agents and compositions encompassed by the
present invention can be encapsulated in, linked to and/or associated with synthetic
nanocarriers. Synthetic nanocarriers include, but are not limited to, those described in
20 International Pub. Nos. WO 2010/005740, WO 2010/030763, WO 2012/13501, WO
2012/149252, WO 2012/149255, WO 2012/149259, WO 2012/149265, WO 2012/149268,
WO 2012/149282, WO 2012/149301, WO 2012/149393, WO 2012/149405, WO
2012/149411, and WO 2012/149454, and U.S. Pat. Publ. Numbers 2011/0262491,
2010/0104645, 2010/0087337, and 2012/0244222. In another embodiment, the synthetic
25 nanocarrier formulations can be lyophilized, such as by methods described in PCT Publ.
No. WO 2011/072218 and U.S. Pat No. 8,211,473.

In some embodiments, the synthetic nanocarriers can contain reactive groups to
release the conjugates described herein (see, *e.g.*, PCT Publ. No. WO 2012/0952552 and
U.S. Pat. Publ. No. 2012/0171229). In one embodiment, the synthetic nanocarriers can be
30 formulated for targeted release. In one embodiment, the synthetic nanocarrier is formulated
to release the therapeutic agents at a specified pH and/or after a desired time interval. As a
non-limiting example, the synthetic nanoparticle can be formulated to release the
conjugates after 24 hours and/or at a pH of 4.5 (see, *e.g.*, PCT Publ. Numbers WO

2010/138193 and WO 2010/138194 and U.S. Pat. Publ. Numbers 2011/0020388 and 2011/0027217). In some embodiments, the synthetic nanocarriers can be formulated for controlled and/or sustained release of conjugates described herein. As a non-limiting example, the synthetic nanocarriers for sustained release can be formulated by methods
5 known in the art, described herein and/or as described in PCT Publ. No. WO 2010/138192 and U.S. Pat. Publ. No. 2010/0303850.

In some embodiments, the nanoparticle can be optimized for oral administration. The nanoparticle can comprise at least one cationic biopolymer such as, but not limited to, chitosan or a derivative thereof. As a non-limiting example, the nanoparticle can be
10 formulated by the methods described in U.S. Pat. Publ. No. 20120282343.

In some embodiments, agents encompassed by the present invention can also be formulated using natural and/or synthetic polymers. Non-limiting examples of polymers which can be used for drug delivery include, but are not limited to, DYNAMIC POLYCONJUGATE® (Arrowhead Research Corp., Pasadena, CA) formulations from
15 MIRUS® Bio (Madison, WI) and Roche Madison (Madison, WI), PHASERX™ polymer formulations such as, without limitation, SMARTT POLYMER TECHNOLOGY™ (Seattle, WA), DMRI/DOPE, poloxamer, VAXFECTIN® adjuvant from Vical (San Diego, CA), chitosan, cyclodextrin from Calando Pharmaceuticals (Pasadena, CA), dendrimers and poly(lactic-co-glycolic acid) (PLGA) polymers, RONDEL™ (RNAi/Oligonucleotide
20 Nanoparticle Delivery) polymers (Arrowhead Research Corporation, Pasadena, CA) and pH responsive co-block polymers such as, but not limited to, PHASERX™ (Seattle, WA). For example, agents and compositions encompassed by the present invention can be formulated in a pharmaceutical compound including a poly(alkylene imine), a biodegradable cationic lipopolymer, a biodegradable block copolymer, a biodegradable
25 polymer, or a biodegradable random copolymer, a biodegradable polyester block copolymer, a biodegradable polyester polymer, a biodegradable polyester random copolymer, a linear biodegradable copolymer, PGA, a biodegradable cross-linked cationic multi-block copolymer or combinations thereof.

The polymers used in the present invention can have undergone processing to
30 reduce and/or inhibit the attachment of unwanted substances such as, but not limited to, bacteria, to the surface of the polymer. The polymer can be processed by methods known and/or described in the art and/or described in PCT Publ. No. WO 2011/50467.

Nanoparticles can contain one or more polymers. Polymers can contain one more of the following polyesters: homopolymers including glycolic acid units, referred to herein as “PGA,” and lactic acid units, such as poly-L-lactic acid, poly-D-lactic acid, poly-D,L-lactic acid, poly-L-lactide, poly-D-lactide, and poly-D,L-lactide, collectively referred to herein as “PLA,” and caprolactone units, such as poly(ϵ -caprolactone), collectively referred to herein as “PCL,” and copolymers including lactic acid and glycolic acid units, such as various forms of poly(lactic acid-co-glycolic acid) and poly(lactide-co-glycolide) characterized by the ratio of lactic acid:glycolic acid, collectively referred to herein as “PLGA,” and polyacrylates, and derivatives thereof. Exemplary polymers also include copolymers of polyethylene glycol (PEG) and the aforementioned polyesters, such as various forms of PLGA-PEG or PLA-PEG copolymers, collectively referred to herein as “PEGylated polymers.” In certain embodiments, the PEG region can be covalently associated with polymer to yield “PEGylated polymers” by a cleavable linker.

The nanoparticles can contain one or more hydrophilic polymers. Hydrophilic polymers include cellulosic polymers such as starch and polysaccharides; hydrophilic polypeptides; poly(amino acids) such as poly-L-glutamic acid (PGS), gamma-polyglutamic acid, poly-L-aspartic acid, poly-L-serine, or poly-L-lysine; polyalkylene glycols and polyalkylene oxides such as polyethylene glycol (PEG), polypropylene glycol (PPG), and poly(ethylene oxide) (PEO); poly(oxyethylated polyol); poly(olefinic alcohol); polyvinylpyrrolidone); poly(hydroxyalkylmethacrylamide); poly(hydroxyalkylmethacrylate); poly(saccharides); poly(hydroxy acids); poly(vinyl alcohol); polyoxazoline; and copolymers thereof.

The nanoparticles can contain one or more hydrophobic polymers. Examples of suitable hydrophobic polymers include polyhydroxyacids such as poly(lactic acid), poly(glycolic acid), and poly(lactic acid-co-glycolic acids); polyhydroxyalkanoates such as poly3-hydroxybutyrate or poly4-hydroxybutyrate; polycaprolactones; poly(orthoesters); polyanhydrides; poly(phosphazenes); poly(lactide-co-caprolactones); polycarbonates such as tyrosine polycarbonates; polyamides (including synthetic and natural polyamides), polypeptides, and poly(amino acids); polyesteramides; polyesters; poly(dioxanones); poly(alkylene alkylates); hydrophobic polyethers; polyurethanes; polyetheresters; polyacetals; polycyanoacrylates; polyacrylates; polymethylmethacrylates; polysiloxanes; poly(oxyethylene)/poly(oxypropylene) copolymers; polyketals; polyphosphates;

polyhydroxyvalerates; polyalkylene oxalates; polyalkylene succinates; poly(maleic acids), as well as copolymers thereof.

In certain embodiments, the hydrophobic polymer is an aliphatic polyester. In some embodiments, the hydrophobic polymer is poly(lactic acid), poly(glycolic acid), or
5 poly(lactic acid-*co*-glycolic acid).

The nanoparticles can contain one or more amphiphilic polymers. Amphiphilic polymers can be polymers containing a hydrophobic polymer block and a hydrophilic polymer block. The hydrophobic polymer block can contain one or more of the hydrophobic polymers above or a derivative or copolymer thereof. The hydrophilic polymer
10 block can contain one or more of the hydrophilic polymers above or a derivative or copolymer thereof. In some embodiments the amphiphilic polymer is a di-block polymer containing a hydrophobic end formed from a hydrophobic polymer and a hydrophilic end formed of a hydrophilic polymer. In some embodiments, a moiety can be attached to the hydrophobic end, to the hydrophilic end, or both. The particle can contain two or more
15 amphiphilic polymers.

The polymer can also include but is not limited to, polyethenes, polyethylene glycol (PEG), poly(l-lysine) (PLL), PEG grafted to PLL, cationic lipopolymer, biodegradable cationic lipopolymer, polyethylenimine (PEI), cross-linked branched poly(alkylene imines), a polyamine derivative, a modified poloxamer, a biodegradable polymer, elastic
20 biodegradable polymer, biodegradable block copolymer, biodegradable random copolymer, biodegradable polyester copolymer, biodegradable polyester block copolymer, biodegradable polyester block random copolymer, multiblock copolymers, linear biodegradable copolymer, poly[α -(4-aminobutyl)-L-glycolic acid] (PAGA), biodegradable cross-linked cationic multi-block copolymers, polycarbonates, polyanhydrides,
25 polyhydroxyacids, polypropylfumerates, polycaprolactones, polyamides, polyacetals, polyethers, polyesters, poly(orthoesters), polycyanoacrylates, polyvinyl alcohols, polyurethanes, polyphosphazenes, polyacrylates, polymethacrylates, polycyanoacrylates, polyureas, polystyrenes, polyamines, polylysine, poly(ethylene imine), poly(serine ester), poly(L-lactide-*co*-L-lysine), poly(4-hydroxy-L-proline ester), acrylic polymers, amine-
30 containing polymers, dextran polymers, dextran polymer derivatives or combinations thereof.

The polymers can be a cross linkable polyester. Cross linkable polyesters include those known in the art and described in U.S. Pat. Publ. No. 2012/0269761.

The nanoparticles can contain one or more biodegradable polymers. Biodegradable polymers can include polymers that are insoluble or sparingly soluble in water that are converted chemically or enzymatically in the body into water-soluble materials.

Biodegradable polymers can include soluble polymers crosslinked by hydrolyzable cross-
5 linking groups to render the crosslinked polymer insoluble or sparingly soluble in water.

Biodegradable polymers can include polyamides, polycarbonates, polyalkylenes, polyalkylene glycols, polyalkylene oxides, polyalkylene terephthalates, polyvinyl alcohols, polyvinyl ethers, polyvinyl esters, polyvinyl halides, polyvinylpyrrolidone, polyglycolides, polysiloxanes, polyurethanes and copolymers thereof, alkyl cellulose such as methyl
10 cellulose and ethyl cellulose, hydroxyalkyl celluloses such as hydroxypropyl cellulose, hydroxy-propyl methyl cellulose, and hydroxybutyl methyl cellulose, cellulose ethers, cellulose esters, nitro celluloses, cellulose acetate, cellulose propionate, cellulose acetate butyrate, cellulose acetate phthalate, carboxylethyl cellulose, cellulose triacetate, cellulose sulphate sodium salt, polymers of acrylic and methacrylic esters such as poly (methyl
15 methacrylate), poly(ethylmethacrylate), poly(butylmethacrylate), poly(isobutylmethacrylate), poly(hexylmethacrylate), poly(isodecylmethacrylate), poly(lauryl methacrylate), poly (phenyl methacrylate), poly(methyl acrylate), poly(isopropyl acrylate), poly(isobutyl acrylate), poly(octadecyl acrylate), polyethylene, polypropylene poly(ethylene glycol), poly(ethylene oxide), poly(ethylene terephthalate),
20 poly(vinyl alcohols), poly(vinyl acetate, poly vinyl chloride polystyrene and polyvinylpyrrolidone, derivatives thereof, linear and branched copolymers and block copolymers thereof, and blends thereof. Exemplary biodegradable polymers include polyesters, poly(ortho esters), poly(ethylene imines), poly(caprolactones), poly(hydroxyalkanoates), poly(hydroxyvalerates), polyanhydrides, poly(acrylic acids),
25 polyglycolides, poly(urethanes), polycarbonates, polyphosphate esters, polyphosphazenes, derivatives thereof, linear and branched copolymers and block copolymers thereof, and blends thereof. In some embodiments the particle contains biodegradable polyesters or polyanhydrides such as poly(lactic acid), poly(glycolic acid), and poly(lactic-co-glycolic acid).

30 Degradable polyesters can contain polycationic side chains. Degradable polyesters include, but are not limited to, poly(serine ester), poly(L-lactide-co-L-lysine), poly(4-hydroxy-L-proline ester), and combinations thereof. In another embodiment, the degradable polyesters can include a PEG conjugation to form a PEGylated polymer.

The biodegradable cationic lipopolymer can be made by methods known in the art, such as those described in U.S. Pat. No. 6,696,038 and U.S. Pat. Publ. Numbers 2003/0073619 and 2004/0142474. The poly(alkylene imine) can be made using methods known in the art, such as those described in U.S. Pat. Publ. No. 2010/0004315. The biodegradable polymer, biodegradable block copolymer, the biodegradable random copolymer, biodegradable polyester block copolymer, biodegradable polyester polymer, or biodegradable polyester random copolymer can be made using methods known in the art, such as those described in U.S. Pat. Numbers 6,517,869 and 6,267,987. The linear biodegradable copolymer can be made using methods known in the art, such as those described in U.S. Pat. No. 6,652,886. The PGA polymer can be made using methods known in the art, such as those described in U.S. Pat. No. 6,217,912. The PGA polymer can be copolymerized to form a copolymer or block copolymer with polymers such as but not limited to, poly-L-lysine, polyarginine, polyornithine, histones, avidin, protamines, polylactides and poly(lactide-co-glycolides). The biodegradable cross-linked cationic multi-block copolymers can be made using methods known in the art, such as those described in U.S. Pat. No. 8,057,821 and U.S. Pat. Publ. No. 2012/009145. For example, the multi-block copolymers can be synthesized using linear polyethylenimine (LPEI) blocks which have distinct patterns as compared to branched polyethyleneimines.

The polymers described herein can be conjugated to a lipid-terminating PEG. As a non-limiting example, PLGA can be conjugated to a lipid-terminating PEG forming PLGA-DSPE-PEG. As another non-limiting example, PEG conjugates for use according to the present invention are described in PCT Publ. No. WO 2008/103276. The polymers can be conjugated using a ligand conjugate such as, but not limited to, conjugates described in U.S. Pat. No. 8,273,363.

Polymer nanoparticles can also comprise chitosan. The chitosan formulation includes a core of positively charged chitosan and an outer portion of negatively charged substrate (see, *e.g.*, U.S. Pat. Publ. No. 2012/0258176). Chitosan includes, but is not limited to N-trimethyl chitosan, mono-N-carboxymethyl chitosan (MCC), N-palmitoyl chitosan (NPCS), EDTA-chitosan, low molecular weight chitosan, chitosan derivatives, or combinations thereof.

Polymer nanoparticles can also comprise PLGA. The PLGA formulations can include, but are not limited to, PLGA injectable depots (*e.g.*, ELIGARD® which is formed by dissolving PLGA in 66% N-methyl-2-pyrrolidone (NMP) and the remainder being

aqueous solvent and leuprolide. Once injected, the PLGA and leuprolide peptide precipitates into the subcutaneous space. In other examples, PLGA microspheres can be formulated by preparing the PLGA microspheres with tunable release rates (*e.g.*, days and weeks) and encapsulating the active agents in the PLGA microspheres while maintaining
5 the integrity of the agent during the encapsulation process.

In some embodiments, Evac, which are non-biodegradable, biocompatible polymers used extensively in pre-clinical sustained release implant applications (*e.g.*, extended release products Ocusert a pilocarpine ophthalmic insert for glaucoma or progestasert a sustained release progesterone intrauterine device; transdermal delivery systems Testoderm,
10 Duragesic and Selegiline; and catheters), can be used. Poloxamer F-407 NF is a hydrophilic, non-ionic surfactant triblock copolymer of polyoxyethylene-polyoxypropylene-polyoxyethylene having a low viscosity at temperatures less than 5°C and forms a solid gel at temperatures greater than 15°C. PEG-based surgical sealants comprise two synthetic PEG components mixed in a delivery device which can be prepared
15 in one minute, seals in 3 minutes and is reabsorbed within 30 days. GELSITE® and natural polymers are capable of in-situ gelation at the site of administration. They have been shown to interact with protein and peptide therapeutic candidates through ionic interaction to provide a stabilizing effect.

Other representative examples of polymer nanoparticles useful according to the
20 present invention include the polymeric compound of PEG grafted with PLL as described in U.S. Pat. No. 6,177,274, as well as suspensions in a solution or medium with a cationic polymer, in a dry pharmaceutical composition or in a solution that is capable of being dried as described in U.S. Pat. Publ. Numbers 2009/0042829 and 2009/0042825.

A polyamine derivative can be used to deliver therapeutic agents and compositions
25 encompassed by the present invention or to treat and/or prevent a disease or to be included in an implantable or injectable device (U.S. Pat. Publ. No. 2010/0260817). As a non-limiting example the agents encompassed by the present invention can be delivered using a polyamide polymer comprising a 1,3-dipolar addition polymer prepared by combining a carbohydrate diazide monomer with a dialkyne unit comprising oligoamines (U.S. Pat. No.
30 8,236,280).

Other polymers can include acrylic polymers, such as acrylic acid, methacrylic acid, acrylic acid and methacrylic acid copolymers, methyl methacrylate copolymers, ethoxyethyl methacrylates, cyanoethyl methacrylate, amino alkyl methacrylate copolymer,

poly(acrylic acid), poly(methacrylic acid), polycyanoacrylates and combinations thereof; or amine-containing polymers such as, but not limited to polylysine, polyethylene imine, poly(amidoamine) dendrimers or combinations thereof; or a PEG-charge-conversional polymer (Pitella *et al.* (2011) *Biomat.* 32:3106-3114).

5 Polymer nanoparticle can further comprise a diblock copolymer. In one embodiment, the diblock copolymer can include PEG in combination with a polymer such as, but not limited to, polyethylenes, polycarbonates, polyanhydrides, polyhydroxyacids, polypropylfumerates, polycaprolactones, polyamides, polyacetals, polyethers, polyesters, poly(orthoesters), polycyanoacrylates, polyvinyl alcohols, polyurethanes,
 10 polyphosphazenes, polyacrylates, polymethacrylates, polycyanoacrylates, polyureas, polystyrenes, polyamines, polylysine, poly(ethylene imine), poly(serine ester), poly(L-lactide-co-L-lysine), poly(4-hydroxy-L-proline ester) or combinations thereof. In some embodiments, agents encompassed by the present invention can be formulated with a PLGA-PEG block copolymer (see, *e.g.*, U.S. Pat. Publ. No. US 2012/0004293 and U.S. Pat.
 15 No.. 8,236,330) or PLGA-PEG-PLGA block copolymers (see, *e.g.*, U.S. Pat. No. 6,004,573). As a non-limiting example, the agents encompassed by the present invention can be formulated with a diblock copolymer of PEG and PLA or PEG and PLGA (see, *e.g.*, U.S. Pat. No. 8,246,968).

In some embodiments, polymer nanoparticles can comprise a plurality of polymers
 20 such as, but not limited to hydrophilic-hydrophobic polymers (*e.g.*, PEG-PLGA), hydrophobic polymers (*e.g.*, PEG) and/or hydrophilic polymers (see, *e.g.*, PCT Publ. No. WO 2012/0225129).

In some embodiments, polymer nanoparticles can be formulated as therapeutic nanoparticles. Therapeutic nanoparticles can be formulated by methods and polymers
 25 described herein and known in the art such as, but not limited to, PCT Publ. Numbers WO 2010/005740, WO 2010/030763, WO 2010/005721, WO 2010/005723, and WO 2012/054923, and U.S. Pat. Publ. Numbers 2011/0262491, 2010/0104645, 2010/0087337, 2010/0068285, 2011/0274759, 2010/0068286, and 2012/0288541, and U.S. Pat. Numbers 8,206,747; 8,293,276; 8,318,208; and 8,318,211. In some embodiments, therapeutic
 30 polymer nanoparticles can be identified by the methods described in U.S. Pat. Publ. No. 2012/0140790.

Polymer formulations can also be selectively targeted through expression of different ligands as exemplified by, but not limited by, folate, transferrin, and N-

acetylgalactosamine (GalNAc) (Benoit *et al.* (2011) *Biomacromol.* 12:2708-2714; Rozema *et al.* (2007) *Proc. Natl. Acad. Sci. U.S.A.* 104:12982-12887; Davis (2009) *Mol. Pharm.* 6:659-668; Davis (2010) *Nature* 464:1067-1070).

In some embodiments, the polymer formulation encompassed by the present invention can be stabilized by contacting the polymer formulation, which can include a cationic carrier, with a cationic lipopolymer which can be covalently linked to cholesterol and polyethylene glycol groups. The polymer formulation can be contacted with a cationic lipopolymer using the methods described in U.S. Pat. Publ. No. 2009/0042829. The cationic carrier can include, but is not limited to, polyethylenimine, poly(trimethylenimine), poly(tetramethylenimine), polypropylenimine, aminoglycoside-polyamine, dideoxy-diamino-b-cyclodextrin, spermine, spermidine, poly(2-dimethylamino)ethyl methacrylate, poly(lysine), poly(histidine), poly(arginine), cationized gelatin, dendrimers, chitosan, 1,2-Dioleoyl-3-Trimethylammonium-Propane (DOTAP), N-[1-(2,3-dioleoyloxy)propyl]-N,N,N-trimethylammonium chloride (DOTMA), 1-[2-(oleoyloxy)ethyl]-2-oleyl-3-(2-hydroxyethyl)imidazolium chloride (DOTIM), 2,3-dioleoyloxy-N-[2(sperminecarboxamido)ethyl]-N,N-dimethyl-1-propanaminium trifluoroacetate (DOSPA), 3B-[N—(N',N'-Dimethylaminoethane)-carbonyl]Cholesterol Hydrochloride (DC-Cholesterol HCl) diheptadecylamidoglycyl spermidine (DOGS), N,N-distearyl-N,N-dimethylammonium bromide (DDAB), N-(1,2-dimyristyloxyprop-3-yl)-N,N-dimethyl-N-hydroxyethyl ammonium bromide (DMRIE), N,N-dioleoyl-N,N-dimethylammonium chloride (DODAC) and combinations thereof.

The conjugates encompassed by the present invention can be formulated in a polyplex of one or more polymers (see, *e.g.*, U.S. Pat. Publ. Numbers 2012/0237565 and 2012/0270927). In one embodiment, the polyplex comprises two or more cationic polymers. The cationic polymer can comprise a poly(ethylene imine) (PEI), such as linear PEI.

In some embodiments, other forms of nanoparticles can be used.

For example, agents and compositions encompassed by the present invention can be formulated as a nanoparticle using a combination of polymers, lipids, and/or other biodegradable agents, such as, but not limited to, calcium phosphate. Components can be combined in a core-shell, hybrid, and/or layer-by-layer architecture, to allow for fine-tuning of the nanoparticle so that delivery of the composition encompassed by the present invention. Biodegradable calcium phosphate nanoparticles in combination with lipids

and/or polymers have been shown to deliver therapeutic agents *in vivo*. In one embodiment, a lipid coated calcium phosphate nanoparticle, which can also contain a targeting ligand such as anisamide, can be used to deliver the composition encompassed by the present invention (see, *e.g.*, Li *et al.* (2010) *J. Contr. Rel.* 142:416-421; Li *et al.* (2012) *J. Contr. Rel.* 158:108-114; Yang *et al.* (2012) *Mol. Ther.* 20:609-615). This delivery system combines both a targeted nanoparticle and a component to enhance the endosomal escape, calcium phosphate, in order to improve delivery of the agent.

In some embodiments, the particles can be hydrophobic ion-pairing complexes or hydrophobic ion-pairs formed by one or more conjugates described above and counterions.

In some embodiments, core-shell nanoparticles can be used for pharmaceutical formulations. The use of core-shell nanoparticles has additionally focused on a high-throughput approach to synthesize cationic cross-linked nanogel cores and various shells (Siegwart *et al.* (2011) *Proc. Natl. Acad. Sci. U.S.A.* 108:12996-13001). The complexation, delivery, and internalization of the polymeric nanoparticles can be precisely controlled by altering the chemical composition in both the core and shell components of the nanoparticle. For example, the core-shell nanoparticles can efficiently deliver a therapeutic agent to mouse hepatocytes after they covalently attach cholesterol to the nanoparticle. Core-shell nanoparticles for use with the composition encompassed by the present invention are described and can be formed by the methods described in U.S. Pat. No. 8,313,777.

Inorganic nanoparticles exhibit a combination of physical, chemical, optical and electronic properties and provide a highly multifunctional platform to image and diagnose diseases, to selectively deliver therapeutic agents, and to sensitive cells and tissues to treatment regimens. Not wishing to be bound to any theory, enhanced permeability and retention (EPR) effect of inorganic nanoparticle provides a basis for the selective accumulation of many high-molecular-weight drugs. Circulating inorganic nanoparticles preferentially accumulate at tumor sites and in inflamed tissues (Yuan *et al.* (1995) *Cancer Res.* 55:3752-3756) and remain lodged due to their low diffusivity (Pluen *et al.* (2001) *Proc. Natl. Acad. Sci. U.S.A.* 98:4628-4633). The size of the inorganic nanoparticles can be 10 nm-500 nm, 10 nm-100 nm, or 100 nm-500 nm. The inorganic nanoparticles can comprise metal (gold, iron, silver, copper, nickel, etc.), oxides (ZnO, TiO₂, Al₂O₃, SiO₂, iron oxide, copper oxide, nickel oxide, etc.), or semiconductor (CdS, CdSe, etc.). The inorganic nanoparticles can also be perfluorocarbon or FeCo.

Inorganic nanoparticles have high surface area per unit volume. Therefore, they can be loaded with therapeutic drugs and imaging agents at high densities. A variety of methods can be used to load therapeutic drugs into/onto the inorganic nanoparticles, including but not limited to, covalent bonds, electrostatic interactions, entrapment, and encapsulation. In addition to therapeutic agent drug loads, the inorganic nanoparticles can be functionalized with targeting moieties, such as tumor-targeting ligands, on the surface. Formulating therapeutic agents with inorganic nanoparticles allows imaging, detection and monitoring of the therapeutic agents.

In some embodiments, agents and compositions encompassed by the present invention is hydrophobic and can be form a kinetically stable complex with gold nanoparticles functionalized with water-soluble zwitterionic ligands (see, *e.g.*, Kim *et al.* (2009) *JACS* 131:1360-1361).

Agents and compositions encompassed by the present invention can be formulated with gold nanoshells. As a non-limiting example, the compositions can be delivered with a temperature sensitive system comprising polymers and gold nanoshells and can be released photothermally (see, *e.g.*, Sershen *et al.* (2000) *J. Biomed. Mater.* 51:293-298). Irradiation at 1064 nm was absorbed by the nanoshells and converted to heat, which led to the collapse of the hydrogen and release of the drug. Agents can also be encapsulated inside hollow gold nanoshells, such as by covalent bonding between agents and nanoparticles. Covalent attachment to gold nanoparticles can be achieved through a linker, such as a free thiol, amine or carboxylate functional group. In some embodiments, the linkers are located on the surface of the gold nanoparticles. In some embodiments, agents encompassed by the present invention can be modified to comprise the linkers. The linkers can comprise a PEG or oligoethylene glycol moiety with varying length to increase the particles' stability in biological environment and to control the density of the drug loads. PEG or oligoethylene glycol moieties also minimize nonspecific adsorption of undesired biomolecules. PEG or oligoethylene glycol moieties can be branched or linear (see, *e.g.*, Tong *et al.* (2009) *Langmuir* 25:12454-12549). Agents encompassed by the present invention can be tethered to an amine-functionalized gold nanoparticles (see, *e.g.*, Lippard *et al.* (2009) *JACS* 131:14652-14653). The cytotoxic effects for the Pt(IV)-gold nanoparticle complex are higher than the free Pt(IV) drugs and free cisplatin.

In some embodiments, agents encompassed by the present invention can be formulated with magnetic nanoparticles, such as those made from iron, cobalt, nickel, and

oxides thereof, or iron hydroxide nanoparticles. Localized magnetic field gradients can be used to attract magnetic nanoparticles to a chosen site, to hold them until the therapy is complete, and then to remove them (see, *e.g.*, Alexiou *et al.* (2000) *Cancer Res.* 60:6641-6648). In some embodiments, agents encompassed by the present invention can be bonded to magnetic nanoparticles with a linker. The linker can be a linker capable of undergoing an intramolecular cyclization to release agents. Any linker and nanoparticles disclosed can be used (see, *e.g.*, PCT Publ. No. WO 2014/124329). Cyclization can be induced by heating the magnetic nanoparticle or by application of an alternating electromagnetic field to the magnetic nanoparticles.

In some embodiments, agents encompassed by the present invention are loaded onto iron oxide nanoparticles. In some embodiments, the agents encompassed by the present invention are formulated with super paramagnetic nanoparticles based on a core consisting of iron oxides (SPION). SPION are coated with inorganic materials (silica, gold, etc.) or organic materials (phospholipids, fatty acids, polysaccharides, peptides or other surfactants and polymers) and can be further functionalized with drugs, proteins or plasmids.

In one embodiment, water-dispersible oleic acid (OA)-poloxamer-coated iron oxide magnetic nanoparticles are used (see, *e.g.*, Jain *Mol. Pharm.* (2005) 2:194-205) can be used to deliver the agents. Agents can partition into the OA shell surrounding the iron oxide nanoparticles and the poloxamer copolymers (*e.g.*, Pluronics) confer aqueous dispersity to the formulation.

In some embodiments, nanoparticles having a phosphate moiety are used to deliver agents encompassed by the present invention (see, *e.g.*, U.S. Pat. No. 8,828,975). The nanoparticles can comprise gold, iron oxide, titanium dioxide, zinc oxide, tin dioxide, copper, aluminum, cadmium selenide, silicon dioxide, and/or diamond. The nanoparticles can contain a PEG moiety on the surface.

In some embodiments, agents encompassed by the present invention can be formulated with peptides and/or other conjugates in order to increase penetration of cells such as macrophages and other immune cells. In one embodiment, peptides such as, but not limited to, cell penetrating peptides and proteins and peptides that enable intracellular delivery can be used to deliver pharmaceutical formulations. A non-limiting example of a cell-penetrating peptide that can be used with agents encompassed by the present invention include a cell-penetrating peptide sequence attached to polycations that facilitates delivery

to the intracellular space, *e.g.*, HIV-derived TAT peptide, penetratins, transportans, or hCT derived cell-penetrating peptides (see, *e.g.*, Caron *et al.* (2001) *Mol. Ther.* 3:310-318; Langel, *Cell-Penetrating Peptides: Processes and Applications* (CRC Press, Boca Raton FL, 2002); El-Andaloussi *et al.* (2003) *Curr. Pharm. Des.* 11:3597-35611; and Deshayes *et al.* (2005) *Cell. Mol. Life Sci.* 62:1839-1849).

In some embodiments, agents encompassed by the present invention can further comprise one or more conjugates that enhance delivery of the active agents (*e.g.*, siRNA molecules) to targeted cells (*e.g.*, monocytes, macrophages, and the like). The conjugate can be a ligand that can be incorporated into lipid formulations to specifically target cells of interest. Using a ligand targeting strategy for lipid particle drug delivery has the advantages of potentially increasing target specificity and avoiding the need for cationic lipids to trigger intracellular delivery. The ligand can include peptides, antibodies, proteins, polysaccharides, glycolipids, glycoproteins, and lectins which make use of mononuclear phagocytes characteristic receptor expression and phagocytic innate processes.

In some embodiments, the conjugated ligand can be a cell targeting peptide (CTP) or a cell-penetrating peptide (CPP) which can improve cell-specific targeting and cell uptake. A few example of the peptides include, but are not limited to muramyl tripeptide (MTP), RGD peptide, GGP-peptide that is selectively associated with monocytes (Karathanasis *et al.* (2009) *Ann. Biomed. Engin.* 37:1984–1992). The macrophage peptide targeting agent can also include those identified from phage display and sequencing (see, *e.g.*, Liu *et al.* (2015) *Bioconjug. Chem.* 26:1811-1817). In some embodiments the ligand can be antibodies and fragments thereof. Exemplary antibodies specific to monocytes and macrophages include anti-VCAM-1 antibodies, anti-CC52 antibodies, anti-CC531 antibodies, anti-CD11c/DEC-205 antibodies. For example, antibodies can be coupled to the surface of liposomes or distally via their Fc-region to liposome-attached PEG.

In some embodiments, the nanoparticles can be mannosylated by incorporating into the lipid particles a lectin such as alkyl mannosides, Mann-C4-Chol, Mann-His-C4-Chol, Man2DOG, 4-aminophenyl- α -D-mannopyranoside, Aminophenyl- α -D-mannopyranoside, and Man3-DPPE. Immune cells, including alveolar macrophages, peritoneal macrophages, monocyte-derived dendritic cells, and Kupffer cells, constitutively express high levels of the mannose receptor (MR). Macrophages and DCs can therefore be targeted via mannosylated lipid nanoparticles.

Other ligands can also include maleylated bovine serum albumin (MBSA), O-steroly amylopectin (O-SAP), and fibronectin (see, *e.g.*, Ahsan *et al.* (2002) *J. Cont. Rel.* 79:29-40; Vyas *et al.* (2004) *Intl. J. Pharm.* 269:37-49).

5 *Other components of formulations*

The compositions encompassed by the present invention can be incorporated into various formulations, including pharmaceutical formulations. The term “pharmaceutically acceptable” refers to those agents, materials, compositions, and/or dosage forms which are, within the scope of sound medical judgment, suitable for use in contact with the tissues of
10 human beings and animals without excessive toxicity, irritation, allergic response, or other problem or complication, commensurate with a reasonable benefit/risk ratio.

Pharmaceutical compositions encompassed by the present invention can be presented as anhydrous pharmaceutical formulations and dosage forms, liquid
pharmaceutical formulations, solid pharmaceutical formulations, vaccines, and the like.
15 Suitable liquid preparations can include, but are not limited to, isotonic aqueous solutions, suspensions, emulsions, or viscous compositions that are buffered to a selected pH.

As described in detail below, the agents and other compositions encompassed by the present invention can be specially formulated for administration in solid or liquid form, including those adapted for various routes of administration, such as (1) oral administration,
20 for example, drenches (aqueous or non-aqueous solutions or suspensions), tablets, boluses, powders, granules, pastes; (2) parenteral administration, for example, by subcutaneous, intramuscular or intravenous injection as, for example, a sterile solution or suspension; (3) topical application, for example, as a cream, ointment or spray applied to the skin; (4) intravaginally or intrarectally, for example, as a pessary, cream or foam; or (5) aerosol, for
25 example, as an aqueous aerosol, liposomal preparation or solid particles containing the compound. Any appropriate form factor for an agent or composition described herein, such as, but not limited to, tablets, capsules, liquid syrups, soft gels, suppositories, and enemas, is contemplated.

Pharmaceutical compositions encompassed by the present invention can be
30 presented as discrete dosage forms, such as capsules, sachets, or tablets, or liquids or aerosol sprays each containing a pre-determined amount of an active ingredient as a powder or in granules, a solution, or a suspension in an aqueous or non- aqueous liquid, an oil-in-water emulsion, a water-in-oil liquid emulsion, powders for reconstitution, powders for oral

consumptions, bottles (including powders or liquids in a bottle), orally dissolving films, lozenges, pastes, tubes, gums, and packs. Such dosage forms can be prepared by any of the methods of pharmacy. In some embodiments, the pharmaceutical compositions comprising the oligonucleotide compositions encompassed by the present invention can be formulated
5 as, for example, solutions, emulsions (including microemulsions and creams), powders and liposome-containing formulations. The compositions can be formulated into any possible form factor such as, but not limited to, tablets, capsules, liquid syrups, soft gels, suppositories, and enemas.

In some embodiments, such formulations can also be constructed or compositions
10 altered such that they passively or actively are directed to different cell types *in vivo*, including but not limited to monocytes, macrophages, and other immune cells (*e.g.*, dendritic cells, antigen presenting cells, T lymphocytes, B lymphocytes, and natural killer cells), cancer cells and the like. Formulations can also be selectively targeted through expression of different ligands on their surface as exemplified by, but not limited by, folate,
15 transferrin, N-acetylgalactosamine (GalNAc), and antibody targeted approaches.

The pharmaceutical compositions encompassed by the present invention can be formulated using one or more excipients to: (1) increase stability; (2) permit the sustained or delayed release (*e.g.*, from a depot formulation); (3) alter the biodistribution (*e.g.*, target an agent to a specific tissue or cell type); (4) alter the release profile of the agent *in vivo*.
20 Non-limiting examples of the excipients include any and all solvents, dispersion media, diluents, or other liquid vehicles, dispersion or suspension aids, surface active agents, isotonic agents, thickening or emulsifying agents, and preservatives. Excipients encompassed by the present invention can also include, without limitation, lipidoids, liposomes, lipid nanoparticles, polymers, lipoplexes, core-shell nanoparticles, peptides,
25 proteins, hyaluronidase, nanoparticle mimics and combinations thereof.

The term “pharmaceutically acceptable carrier” or “pharmaceutically acceptable excipient” is intended to include any and all solvents, dispersion media, diluents or other liquid vehicles, dispersion or suspension agents, surface active agents, isotonic agents, thickening or emulsifying agents, disintegrating agents, preservatives, buffering agents,
30 solid binders, lubricants, oils, coatings, antibacterial and antifungal agents, absorption delaying agents, and the like, as suited to the particular dosage form desired. Remington’s The Science and Practice of Pharmacy, 21st Edition, A. R. Gennaro (Lippincott, Williams & Wilkins, Baltimore, MD, 2006) discloses various excipients used in formulating

pharmaceutical compositions and known techniques for the preparation thereof. Except insofar as any conventional excipient medium is incompatible with a substance or its derivatives, such as by producing any undesirable biological effect or otherwise interacting in a deleterious manner with any other component(s) of the pharmaceutical composition, its use is contemplated to be within the scope of this invention. Supplementary active ingredients can also be incorporated into the described compositions.

In some embodiments, a pharmaceutically acceptable excipient is at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99.5%, or at least 99.9% or 100% pure. In some embodiments, an excipient is approved for use in humans and for veterinary use. In some embodiments, an excipient is approved by United States Food and Drug Administration. In some embodiments, an excipient is pharmaceutical grade. In some embodiments, an excipient meets the standards of the United States Pharmacopoeia (USP), the European Pharmacopoeia (EP), the British Pharmacopoeia, and/or the International Pharmacopoeia.

Various embodiments of the formulations can, optionally, include one or more of the following: buffer, pH adjuster, tonicity agent, cosolvent or pharmaceutically acceptable carrier.

In some embodiments, the formulation encompassed by the present invention can further comprise a buffer. A buffer is any substance that, when added to a solution, is capable of neutralizing both acids and bases without appreciably changing acidity or alkalinity of the solution. Examples of buffers include, but are not limited to, pharmaceutically acceptable salts and acids of acetate, glutamate, citrate, tartrate, benzoate, lactate, histidine, or other amino acids, gluconate, phosphate, malate, succinate, formate, propionate and carbonate.

In some embodiments, the formulation encompassed by the present invention can further comprise a pH adjuster. A pH adjuster is used to adjust the pH of the formulation. Suitable pH adjusters typically include at least an acid or a salt thereof and/or a base or a salt thereof. Acids and bases can be added on an as needed basis in order to achieve a desired pH. For example, if the pH is greater than the desired pH, an acid can be used to lower the pH to the desired pH. Examples of acids include, but are not limited to, hydrochloric acid, phosphoric acid, citric acid, ascorbic acid, acetic acid, sulfuric acid, carbonic acid and nitric acid. By way of another example, if the pH is less than the desired pH, a base can be used to adjust the pH to the desired pH. Examples of bases include, but

are not limited to, sodium hydroxide, potassium hydroxide, calcium hydroxide, sodium carbonate, sodium citrate, sodium acetate and magnesium hydroxide.

In some embodiments, the formulation encompassed by the present invention can further comprise a tonicity agent. Tonicity agents are used to adjust the osmolality of the formulation in order to bring it closer to the osmotic pressure of body fluids, such as blood or plasma. Examples of tonicity agents include, but are not limited to, anhydrous or hydrous forms of sodium chloride, dextrose, sucrose, xylitol, fructose, glycerol, sorbitol, mannitol, potassium chloride, mannose, calcium chloride, magnesium chloride and other inorganic salts.

In some embodiments, the formulation encompassed by the present invention can further comprise a cosolvent. A cosolvent is a solvent that is added to the aqueous formulation in a weight amount that is less than that of water and assists in the solubilization of the aptamer. Examples of cosolvents include, but are not limited to, glycols, ethanol and polyhydric alcohols.

In some embodiments, the formulation encompassed by the present invention can further comprise a “pharmaceutically acceptable excipient.” As used herein, the term “pharmaceutically acceptable carrier” or “excipient” is a pharmaceutically acceptable inactive substance formulated alongside with the active ingredient of a medication (*e.g.*, siRNA molecules of CCR2 and/or CSF1R).

The excipient can be liquid or solid and is selected, with the planned manner of administration in mind, so as to provide for the desired bulk, consistency, etc., when combined with a nucleic acid and the other components of a given pharmaceutical composition. The pharmaceutically acceptable excipients can be used for different purposes, for example, as anti-adherents that reduce the adhesion between the powder (*e.g.*, pregelatinized maize starch, polyvinylpyrrolidone or hydroxypropyl methylcellulose, etc.), binders that hold the ingredients in a tablet together (*e.g.*, saccharides and their derivatives, gelatin, synthetic polymers: polyvinylpyrrolidone (PVP), polyethylene glycol (PEG)), coatings (*e.g.*, cellulose ether hydroxypropyl methylcellulose (HPMC) film coating for tablets, polymers, shellac, corn protein zein, polysaccharides, etc.), disintegrants (*e.g.*, crosslinked polymers, crosslinked polyvinylpyrrolidone (crospovidone)), crosslinked sodium carboxymethyl cellulose (croscarmellose sodium), modified starch sodium starch glycolate), fillers (*e.g.*, lactose and other sugars, microcrystalline cellulose, pectin, gelatin, calcium sulfate, ethyl cellulose, polyacrylates or calcium hydrogen phosphate, etc.), flavors

(e.g., natural fruit extracts, etc.), colors (e.g., to improve the appearance of a formulation), lubricants (e.g., magnesium stearate, talc, silica, colloidal silicon dioxide, stearic acid, metallic stearates, hydrogenated vegetable oils, corn starch, polyethylene glycols, sodium benzoate, sodium acetate, etc.), glidants (e.g., fumed silica, talc, and magnesium carbonate, etc.), sorbents, preservatives (e.g., antioxidants amino acids cysteine, methionine, citric acid, methyl paraben, etc.), sweeteners (e.g., sugar), and wetting agents (e.g., sodium lauryl sulphate, etc.). Pharmaceutically acceptable carriers are well known in the art. Examples of pharmaceutically acceptable carriers can be found, for example, in *Goodman and Gillmans*, The Pharmacological Basis of Therapeutics, latest edition.

The formulations encompassed by the present invention can additionally contain other adjunct components conventionally found in pharmaceutical compositions, at their art-established usage levels. Thus, for example, the compositions can contain additional, compatible, pharmaceutically-active materials such as, for example, antipruritics, astringents, local anesthetics or anti-inflammatory agents, or can contain additional materials useful in physically formulating various dosage forms of the composition of present invention, such as dyes, flavoring agents, preservatives, antioxidants, opacifiers, thickening agents and stabilizers. However, such materials, when added, should not unduly interfere with the biological activities of the components (e.g., siRNA molecules of CCR2 and/or CSF1R) of the compositions encompassed by the present invention.

In some embodiments, the composition encompassed by the present invention can also be formulated as suspensions in aqueous, non-aqueous, or mixed media. Aqueous suspensions can further contain substances which increase the viscosity of the suspension including, for example, sodium carboxymethylcellulose, sorbitol and/or dextran. The suspension can also contain stabilizers.

In some embodiments, the pharmaceutical compositions encompassed by the present invention can be formulated and used as foams. Pharmaceutical foams include formulations such as, but not limited to, emulsions, microemulsions, creams, jellies and formulations containing liposomes.

The pharmaceutical compositions encompassed by the present invention can be formulated as emulsions. Emulsions are typically heterogeneous systems of one liquid dispersed in another in the form of droplets usually exceeding 0.1 μm in diameter. (See, e.g. *Idson*, in *Pharmaceutical Dosage Forms. Disperse Systems*, Vol. 1). Emulsions are often biphasic systems comprising of two immiscible liquid phases intimately mixed and

dispersed with each other. In general, emulsions can be either water in oil (w/o) or of the oil in water (o/w) variety. Emulsions can contain additional components in addition to the dispersed phases and the active components (*e.g.*, siRNA molecules specific to CCR2 and/or CSF1R) which can be present as a solution in the aqueous phase, oily phase or itself as a separate phase. Pharmaceutical excipients such as emulsifiers, stabilizers, dyes, and anti-oxidants can also be present in emulsions as needed. Pharmaceutical emulsions can also be multiple emulsions that are comprised of more than two phases, such as, for example, in the case of oil in water in oil (o/w/o) and water in oil in water (w/o/w) emulsions. Such complex formulations often provide certain advantages that simple binary emulsions do not. Multiple emulsions in which individual oil droplets of an o/w emulsion enclose small water droplets constitute a w/o/w emulsion. Likewise, a system of oil droplets enclosed in globules of water stabilized in an oily continuous provides an o/w/o emulsion.

In some embodiments, the pharmaceutical compositions encompassed by the present invention are formulated as microemulsions. A microemulsion can be defined as a system of water, oil and amphiphile which is a single optically isotropic and thermodynamically stable liquid solution (see, *e.g.*, Rosoff, in *Pharmaceutical Dosage Forms: Disperse Systems*, Vol. 1). Microemulsions commonly are prepared via a combination of three to five components that include oil, water, surfactant, cosurfactant and electrolyte.

In some embodiments, the pharmaceutical compositions encompassed by the present invention are reconstituted with a suitable diluent, *e.g.*, sterile water or sterile saline for subcutaneous or intravenous injection.

V. Dosage and Route of Administration

Dosing

The pharmaceutical compositions in accordance with the invention are typically formulated in dosage unit form for ease of administration and uniformity of dosage. It will be understood, however, that the total daily usage of the compositions encompassed by the present invention can be decided by the attending physician within the scope of sound medical judgment. The specific therapeutically effective, prophylactically effective, or appropriate preventing dose level for any particular patient will depend upon a variety of factors including the disorder being treated and the severity of the disorder; the activity of

the specific compound employed; the specific composition employed; the age, body weight, general health, sex and diet of the patient; the time of administration, route of administration, and rate of excretion of the specific compound employed; the duration of the treatment; drugs used in combination or coincidental with the specific compound employed; and like factors well known.

The total dosage can be administered in a single dose, multiple doses, repeated doses, as a continual dose or a combination thereof. In some embodiments, pharmaceutical compositions encompassed by the present invention can be administered in a single daily dose, or the total daily dosage can be administered in divided doses of two, three or four times daily.

The formulations and dosages described herein are designed to maximize clinical efficacy in the treatment of diseases and disorders while simultaneously decreasing or minimizing adverse side effects.

In some embodiments, agents in accordance with the present invention can be administered at dosage levels sufficient to deliver from about 0.0001 mg/kg to about 1000 mg/kg, from about 0.001 mg/kg to about 0.05 mg/kg, from about 0.005 mg/kg to about 0.05 mg/kg, from about 0.001 mg/kg to about 0.005 mg/kg, from about 0.05 mg/kg to about 0.5 mg/kg, from about 0.01 mg/kg to about 50 mg/kg, from about 0.1 mg/kg to about 40 mg/kg, from about 0.5 mg/kg to about 30 mg/kg, from about 0.01 mg/kg to about 10 mg/kg, from about 0.1 mg/kg to about 10 mg/kg, or from about 1 mg/kg to about 25 mg/kg, or from about 10 mg/kg to about 100 mg/kg, or from about 100 mg/kg to about 500 mg/kg, of subject body weight per day, one or more times a day, to obtain the desired therapeutic, diagnostic, prophylactic, or imaging effect. The desired dosage can be delivered three times a day, two times a day, once a day, every other day, every third day, every week, every two weeks, every three weeks, or every four weeks, or every two months. In some embodiments, the desired dosage can be delivered using multiple administrations (*e.g.*, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, or more administrations). When multiple administrations are employed, split dosing regimens such as those described herein can be used.

In some embodiments, an agent encompassed by the present invention is an antibody. As defined herein, a therapeutically effective amount of antibody (*i.e.*, an effective dosage) ranges from about 0.001 to 30 mg/kg body weight, preferably about 0.01 to 25 mg/kg body weight, more preferably about 0.1 to 20 mg/kg body weight, and even

more preferably about 1 to 10 mg/kg, 2 to 9 mg/kg, 3 to 8 mg/kg, 4 to 7 mg/kg, or 5 to 6 mg/kg body weight. The skilled artisan will appreciate that certain factors can influence the dosage required to effectively treat a subject, including but not limited to the severity of the disease or disorder, previous treatments, the general health and/or age of the subject, and other diseases present. Moreover, treatment of a subject with a therapeutically effective amount of an antibody can include a single treatment or, preferably, can include a series of treatments. In a preferred example, a subject is treated with antibody in the range of between about 0.1 to 20 mg/kg body weight, one time per week for between about 1 to 10 weeks, preferably between 2 to 8 weeks, more preferably between about 3 to 7 weeks, and even more preferably for about 4, 5, or 6 weeks. It will also be appreciated that the effective dosage of antibody used for treatment can increase or decrease over the course of a particular treatment. Changes in dosage can result from the results of diagnostic assays.

As used herein, a “split dose” is the division of single unit dose or total daily dose into two or more doses, *e.g.*, two or more administrations of the single unit dose. As used herein, a “single unit dose” is a dose of any therapeutic administered in one dose/at one time/single route/single point of contact, *i.e.*, single administration event. As used herein, a “total daily dose” is an amount given or prescribed in 24 hour period. It can be administered as a single unit dose.

Cells can be administered at 0.1×10^6 , 0.2×10^6 , 0.3×10^6 , 0.4×10^6 , 0.5×10^6 , 0.6×10^6 , 0.7×10^6 , 0.8×10^6 , 0.9×10^6 , 1.0×10^6 , 5.0×10^6 , 1.0×10^7 , 5.0×10^7 , 1.0×10^8 , 5.0×10^8 , or more, or any range in between or any value in between, cells per kilogram of subject body weight. The number of cells transplanted can be adjusted based on the desired level of engraftment in a given amount of time. Generally, 1×10^5 to about 1×10^9 cells/kg of body weight, from about 1×10^6 to about 1×10^8 cells/kg of body weight, or about 1×10^7 cells/kg of body weight, or more cells, as necessary, can be transplanted. In some embodiment, transplantation of at least about 0.1×10^6 , 0.5×10^6 , 1.0×10^6 , 2.0×10^6 , 3.0×10^6 , 4.0×10^6 , or 5.0×10^6 total cells relative to an average size mouse is effective.

Cells can be administered in any suitable route as described herein, such as by infusion. Cells can also be administered before, concurrently with, or after, other anti-cancer agents.

Routes of administration

Administration can be accomplished using methods generally known in the art. Agents, including cells, can be introduced to the desired site by direct injection, or by any

other means used in the art including, but are not limited to, intra-tumoral, intravascular, intracerebral, parenteral, intraperitoneal, intravenous, epidural, intraspinal, intrasternal, intra-articular, intra-synovial, intrathecal, intra-arterial, intracardiac, or intramuscular administration.

5 For example, compositions and formulations are usually administered through either parenteral or non-parenteral routes to a subject. Parenteral administration relates to a pharmaceutical composition administered to a body in a manner other than through the digestive tract, such as by intravenous or intramuscular injection. Parenteral administration can include administration intraarticularly, intravenously, intraperitoneally, subcutaneously,
10 and intramuscularly.

 In some embodiments, non-parenteral administration can be used including, but not limited to, buccal, sublingual, endoscopic, oral, rectal, transdermal, topical, nasal, intratracheal, pulmonary, urethral, vaginal, and ocular. When administered by such non-parenteral modes, the methods and pharmaceutical composition encompassed by the
15 present invention can deliver the drug both locally and systemically as desired.

 Cell-based agents can be administered in one infusion, or through successive infusions over a defined time period sufficient to generate a desired effect. Exemplary methods for transplantation, engraftment assessment, and marker phenotyping analysis of transplanted cells are well-known in the art (see, for example, Pearson *et al.* (2008) *Curr. Protoc. Immunol.* 81:15.21.1-15.21.21; Ito *et al.* (2002) *Blood* 100:3175-3182; Traggiai *et al.* (2004) *Science* 304:104-107; Ishikawa *et al.* *Blood* (2005) 106:1565-1573; Shultz *et al.* (2005) *J. Immunol.* 174:6477-6489; and Holyoake *et al.* (1999) *Exp. Hematol.* 27:1418-1427).
20

 Two or more cell types can be combined and administered, such as cell-based
25 therapy and adoptive cell transfer of stem cells, cancer vaccines and cell-based therapy, and the like. For example, adoptive cell-based immunotherapies can be combined with the cell-based therapies of the present invention. In some embodiments, the cell-based agents can be used alone or in combination with additional cell-based agents, such as immunotherapies like adoptive T cell therapy (ACT). For example, T cells genetically engineered to
30 recognize CD19 used to treat follicular B cell lymphoma. Immune cells for ACT can be dendritic cells, T cells such as CD8⁺ T cells and CD4⁺ T cells, natural killer (NK) cells, NK T cells, cytotoxic T lymphocytes (CTLs), tumor infiltrating lymphocytes (TILs), lymphokine activated killer (LAK) cells, memory T cells, regulatory T cells (Tregs), helper

T cells, cytokine-induced killer (CIK) cells, and any combination thereof. Well-known adoptive cell-based immunotherapeutic modalities, including, without limitation, irradiated autologous or allogeneic tumor cells, tumor lysates or apoptotic tumor cells, antigen-presenting cell-based immunotherapy, dendritic cell-based immunotherapy, adoptive T cell transfer, adoptive CAR T cell therapy, autologous immune enhancement therapy (AIET), cancer vaccines, and/or antigen presenting cells. Such cell-based immunotherapies can be further modified to express one or more gene products to further modulate immune responses, such as expressing cytokines like GM-CSF, and/or to express tumor-associated antigen (TAA) antigens, such as Mage-1, gp-100, and the like. The ratio of an agent encompassed by the present invention, such as cancer cells, to another agent encompassed by the present invention or other composition can be 1:1 relative to each other (*e.g.*, equal amounts of 2 agents, 3 agents, 4 agents, etc.), but can be modulated in any amount desired (*e.g.*, 1:1, 1.1:1, 1.2:1, 1.3:1, 1.4:1, 1.5:1, 2:1, 2.5:1, 3:1, 3.5:1, 4:1, 4.5:1, 5:1, 5.5:1, 6:1, 6.5:1, 7:1, 7.5:1, 8:1, 8.5:1, 9:1, 9.5:1, 10:1, or greater).

Engraftment of transplanted cells can be assessed by any of various methods, such as, but not limited to, tumor volume, cytokine levels, time of administration, flow cytometric analysis of cells of interest obtained from the subject at one or more time points following transplantation, and the like. For example, a time-based analysis of waiting 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28 days or can signal the time for tumor harvesting. Any such metrics are variables that can be adjusted according to well-known parameters in order to determine the effect of the variable on a response to anti-cancer immunotherapy. In addition, the transplanted cells can be co-transplanted with other agents, such as cytokines, extracellular matrices, cell culture supports, and the like.

The pharmaceutical compositions comprising the siRNA molecules of CCR2 and CSF1R are administered to subjects in need, preferably human subjects, in an amount effective to modulate the activity of myeloid-derived cells, such as monocytes and/or macrophages, associated with diseases, such as cancers.

VI. Uses and methods

The present invention provides methods of inhibiting the activity of CCR2 and CSF1R receptors comprising contacting a myeloid-derived cell (*e.g.*, a monocyte and/or macrophage) with an effective amount of an oligonucleotide composition targeting CCR2,

an oligonucleotide composition targeting CSF1R, an oligonucleotide targeting both CCR2 and CSF1R, and/or an oligonucleotide composition targeting CCR2 in combination with an oligonucleotide composition targeting CSF1R, encompassed by the present invention, wherein the siRNA molecule cocktail is sufficient to inhibit the expression of CCR2 and/or
5 CSF1R in the cell. In some embodiments, the oligonucleotide composition can further comprise at least one additional therapeutic agent, such one or more antagonists of CCL2 and CSF1, immunotherapeutic agent, and the like.

The compositions, agents, and formulations described herein can be used in a variety of modulatory, therapeutic, screening, diagnostic, prognostic, and therapeutic
10 applications described herein, such as a modulatory method, therapeutic method, screening method, diagnostic method, prognostic method, or combinations thereof. All steps of any such method or methods can be performed by a single actor or, alternatively, by more than one actor. For example, diagnosis can be performed directly by the actor providing therapeutic treatment. Alternatively, a person providing a therapeutic agent can request that
15 a diagnostic assay be performed. The diagnostician and/or the therapeutic interventionist can interpret the diagnostic assay results to determine a therapeutic strategy. Similarly, such alternative processes can apply to other assays, such as prognostic assays.

In addition, any aspect of the present invention described herein can be performed either alone or in combination with any other aspect of the present invention, including one,
20 more than one, or all embodiments thereof. For example, diagnostic and/or screening methods can be performed alone or in combination with a treatment step, such as providing an appropriate therapy upon determining an appropriate diagnosis and/or screening result.

One aspect encompassed by the present invention relates to methods of modulating the copy number, amount (*e.g.*, expression), and/or activity (*e.g.*, modulating subcellular
25 localization) of at least one biomarker (*e.g.*, one or more targets listed in Table 1, Table 2, the Examples, etc.) described herein, such as for therapeutic purposes. Such agents can be used to manipulate myeloid-derived cells. In one embodiment, a particular subpopulation of monocytes and/or macrophages is manipulated to regulate their numbers and/or activities in a physiological condition. For example, compositions encompassed by the present
30 invention can modulate the expression of CCR2 and/or CSF1R to thereby modulate the inflammatory phenotype of myeloid-derived cells, including monocytes and macrophages, and further modulate immune responses. In some embodiments, cell activities (*e.g.*, cytokine secretion, cell population ratios, etc.) are modulated rather than modulating

immune responses *per se*. Methods for modulating myeloid-cell derived cell inflammatory phenotypes using the compositions and formulations disclosed herein, are provided.

Accordingly, the compositions and methods can be used for modulating immune responses by modulating CCR2 and/or CSF1R expression, which depletes or enriches certain types of cells and/or to modulate the ratio of cell types. For example, inhibiting CCR2 and/or CSF1R expression on such cells increases pro-inflammatory monocytes/macrophages versus anti-inflammatory monocytes/macrophages. In some embodiments, the compositions are used to treat cancer in a subject afflicted with a cancer.

The present disclosure demonstrates that the downregulation of the expression of CCR2 and/or CSF1R in myeloid-derived cells, including monocytes and macrophages can re-polarize (*e.g.*, change the inflammatory phenotype) of the cells. In some embodiments, the phenotype of an M2 macrophage is changed to result in a macrophage with a Type 1 or M1 phenotype, or vice versa regarding M1 macrophages and Type 2 or M2 phenotypes. In some embodiments, compositions encompassed by the present invention are used to inhibit the trafficking, polarization, and/or activation of monocytes and macrophages with an M2 phenotype, or vice versa regarding Type 1 and M1 macrophages. The present invention further provides methods for reducing populations of monocytes and/or macrophages of interest, such as M1 macrophages, M2 macrophages (*e.g.*, TAMs in a tumor), and the like.

In some embodiments, the present invention provides methods for changing the distribution of monocytes and/or macrophages, including subtypes thereof, such as pro-tumoral macrophages and anti-tumoral macrophages. In one example, the present invention provides methods for driving macrophages towards a pro-inflammatory immune response from an anti-inflammatory immune response and vice versa. Cell types can be depleted and/or enriched by 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 99%, or more, or any range in between inclusive, such as 45-55%.

In some embodiments, the modulation occurs in cells, such as monocyte, macrophage, or other phagocyte, like a dendritic cell. In some embodiments, the cell is a macrophage subtype, such as a macrophage subtype described herein. For example, the macrophage can be a tissue resident macrophage (TAM) or a macrophage derived from a circulating monocyte in the bloodstream.

In some embodiments, modulating monocyte and/or macrophage inflammatory phenotypes results in desired modulated immune responses, such as modulation of

abnormal monocyte migration and proliferation, unregulated proliferation of tissue resident macrophages, unregulated pro-inflammatory macrophages, unregulated anti-inflammatory macrophages, unbalanced distribution of pro-inflammatory and anti-inflammatory macrophage subpopulations in a tissue, an abnormally adopted activation state of
5 monocytes and macrophages in a disease condition, modulated cytotoxic T-cell activation and function, overcoming of resistance of cancer cells to therapy, and sensitivity of cancer cells to immunotherapy, such as immune checkpoint therapy.

Methods for treating and/or preventing a disease associated with unwanted myeloid-derived cell phenotypes comprise contacting such cells, either *in vitro*, *ex vivo*, or *in vivo*
10 (*e.g.*, administering to a subject), with compositions encompassed by the present invention, wherein the compositions manipulate the migration, recruitment, differentiation and polarization, activation, function, and/or survival of the cells.

In one aspect encompassed by the present invention, methods for increasing pro-inflammatory activities of monocytes and/or macrophages are provided.

15 In another aspect encompassed by the present invention, methods for balancing pro-inflammatory monocytes and macrophages and anti-inflammatory monocytes and macrophages in a tissue are provided.

Subjects

20 The present invention provides methods of treating an individual afflicted with a condition or disorder that would benefit from inhibition of CCR2 and/or CSF1R, *e.g.*, a disorder characterized by unwanted CCR2 and/or CSF1R expression or activity comprising contacting myeloid-derived cells of interest with at least one composition encompassed by the present invention.

25 In some embodiments, the subject is an animal. The animal can be of either sex and can be at any stage of development. In some embodiments, the animal is a vertebrate, such as a mammal. In some embodiments, the subject is a non-human mammal. In some embodiments, the subject is a domesticated animal, such as a dog, cat, cow, pig, horse, sheep, or goat. In some embodiments, the subject is a companion animal, such as a dog or
30 cat. In some embodiments, the subject is a livestock animal, such as a cow, pig, horse, sheep, or goat. In some embodiments, the subject is a zoo animal. In some embodiments, the subject is a research animal, such as a rodent (*e.g.*, mouse or rat), dog, pig, or non-human primate. In some embodiments, the animal is a genetically engineered animal. In some embodiments, the animal is a transgenic animal (*e.g.*, transgenic mice and transgenic

pigs). In some embodiments, the subject is a fish or reptile. In some embodiments, the subject is a human. In some embodiments, the subject is an animal model of cancer. For example, the animal model can be an orthotopic xenograft animal model of a human-derived cancer.

5 In some embodiments of the methods encompassed by the present invention, the subject has not undergone treatment, such as chemotherapy, radiation therapy, targeted therapy, and/or immunotherapies. In some embodiments, the subject has undergone treatment, such as chemotherapy, radiation therapy, targeted therapy, and/or immunotherapies.

10 In some embodiments, the subject has had surgery to remove cancerous or precancerous tissue. In some embodiments, the cancerous tissue has not been removed, *e.g.*, the cancerous tissue can be located in an inoperable region of the body, such as in a tissue that is essential for life, or in a region where a surgical procedure would cause considerable risk of harm to the patient.

15 In some embodiments, the subject or cells thereof are resistant to a therapy of relevance, such as resistant to immune checkpoint inhibitor therapy. For example, modulating one or more biomarkers encompassed by the present invention can overcome resistance to immune checkpoint inhibitor therapy.

In some embodiments, the subjects are in need of modulation according to
20 compositions and methods described herein, such as having been identified as having an unwanted absence, presence, or aberrant expression and/or activity of one or more biomarkers described herein.

In addition, these modulatory agents can also be administered in combination therapy to further modulate a desired activity, such as stimulating immune responses. For
25 examples, agents and compositions that target to IL-4, IL-4R α , IL-13, and CD40 can be used to modulate monocyte and/or macrophage differentiation and/or polarization. Agents and compositions that target to CD11b, CSF-1R, CCL2, neurophilin-1 and ANG-2 can be used to modulate macrophage recruitment to a tissue. Agents and compositions that target to IL-6, IL-6R and TNF- α can be used to modulate macrophage function. Additional
30 agents include, without limitations, chemotherapeutic agents, hormones, antiangiogens, radiolabelled, compounds, or with surgery, cryotherapy, and/or radiotherapy. The preceding treatment methods can be administered in conjunction with other forms of conventional therapy (*e.g.*, standard-of-care treatments for cancer well-known to the skilled

artisan), either consecutively with, pre- or post-conventional therapy. For example, these modulatory agents can be administered with a therapeutically effective dose of chemotherapeutic agent. In another embodiment, these modulatory agents are administered in conjunction with chemotherapy to enhance the activity and efficacy of the

5 chemotherapeutic agent. The Physicians' Desk Reference (PDR) discloses dosages of chemotherapeutic agents that have been used in the treatment of various cancers. The dosing regimen and dosages of these aforementioned chemotherapeutic drugs that are therapeutically effective will depend on the particular melanoma, being treated, the extent of the disease and other factors familiar to the physician of skill in the art and can be

10 determined by the physician.

Cancer therapies

In some embodiments, compositions encompassed by the present invention are used to treat cancer. For example, the present invention provides methods for reducing pro-

15 tumoral functions of myeloid-derived cells including monocytes and macrophages (*i.e.*, tumorigenicity) and/or increasing anti-tumoral functions of myeloid-derived cells including monocytes and macrophages. In some particular embodiments, the method encompassed by the present invention can reduce at least one of the pro-tumoral functions of macrophages including 1) recruitment and polarization of tumor associate macrophages

20 (TAMs), 2) tumor angiogenesis, 3) tumor growth, 4) tumor cell differentiation, 5) tumor cell survival, 6) tumor invasion and metastasis, 7) immune inhibition, and 8) immunosuppressive tumor microenvironment.

Cancer therapy or combinations of therapies including the use of compositions encompassed by the present invention can be used to contact cancer cells and/or

25 administered to a desired subject, such as a subject that is indicated as being a likely responder to cancer therapy. In another embodiment, such cancer therapy can be avoided once a subject is indicated as not being a likely responder to the cancer therapy (*e.g.*, a subject whose myeloid-derived cells do not express appreciable or desired levels of CCR2 and/or CSF1R) and an alternative treatment regimen, such as targeted and/or untargeted

30 cancer therapies can be administered. Combination therapies are also contemplated and can comprise, for example, one or more chemotherapeutic agents and radiation, one or more chemotherapeutic agents and immunotherapy, or one or more chemotherapeutic agents, radiation and chemotherapy, each combination of which can be with or without cancer therapy (*e.g.*, at least one modulator of one or more targets listed in Table 1 and/or Table 2).

Representative exemplary compositions useful for inhibiting CCR2 and/or CSF1R are described above. As described further below, anti-cancer agents encompass biotherapeutic anti-cancer agents (*e.g.*, interferons, cytokines (*e.g.*, tumor necrosis factor, interferon α , interferon γ , etc.), vaccines, hematopoietic growth factors, monoclonal serotherapy, immunostimulants and/or immunomodulatory agents (*e.g.*, IL-1, 2, 4, 6, and/or 12), immune cell growth factors (*e.g.*, GM-CSF), and antibodies (*e.g.*, trastuzumab, T-DM1, bevacizumab, cetuximab, panitumumab, rituximab, tositumomab, and the like), as well as chemotherapeutic agents.

The term “targeted therapy” refers to administration of agents that selectively interact with a chosen biomolecule to thereby treat cancer. For example, targeted therapy regarding the inhibition of immune checkpoint inhibitor is useful in combination with the methods encompassed by the present invention.

The term “immunotherapy” or “immunotherapies” generally refers to any strategy for modulating an immune response in a beneficial manner and encompasses the treatment of a subject afflicted with, or at risk of contracting or suffering a recurrence of, a disease by a method comprising inducing, enhancing, suppressing or otherwise modifying an immune response, as well as any treatment that uses certain parts of a subject’s immune system to fight diseases, such as cancer. The subject’s own immune system is stimulated (or suppressed), with or without administration of one or more agent for that purpose. Immunotherapies that are designed to elicit or amplify an immune response are referred to as “activation immunotherapies.” Immunotherapies that are designed to reduce or suppress an immune response are referred to as “suppression immunotherapies.” In some embodiments, an immunotherapy is specific for cells of interest, such as cancer cells. In some embodiments, immunotherapy can be “untargeted,” which refers to administration of agents that do not selectively interact with immune system cells, yet modulates immune system function. Representative examples of untargeted therapies include, without limitation, chemotherapy, gene therapy, and radiation therapy.

Some forms of immunotherapy are targeted therapies that can comprise, for example, the use of cancer vaccines and/or sensitized antigen presenting cells. For example, an oncolytic virus is a virus that is able to infect and lyse cancer cells, while leaving normal cells unharmed, making them potentially useful in cancer therapy. Replication of oncolytic viruses both facilitates tumor cell destruction and also produces dose amplification at the tumor site. They can also act as vectors for anticancer genes,

allowing them to be specifically delivered to the tumor site. The immunotherapy can involve passive immunity for short-term protection of a host, achieved by the administration of pre-formed antibody directed against a cancer antigen or disease antigen (*e.g.*, administration of a monoclonal antibody, optionally linked to a chemotherapeutic agent or toxin, to a tumor antigen). For example, anti-VEGF and mTOR inhibitors are known to be effective in treating renal cell carcinoma. Immunotherapy can also focus on using the cytotoxic lymphocyte-recognized epitopes of cancer cell lines. Alternatively, antisense polynucleotides, ribozymes, RNA interference molecules, triple helix polynucleotides and the like, can be used to selectively modulate biomolecules that are linked to the initiation, progression, and/or pathology of a tumor or cancer. Similarly, immunotherapy can take the form of cell-based therapies. For example, adoptive cellular immunotherapy is a type of immunotherapy using immune cells, such as T cells, that have a natural or genetically engineered reactivity to a patient's cancer are generated and then transferred back into the cancer patient. The injection of a large number of activated tumor-specific T cells can induce complete and durable regression of cancers.

Immunotherapy can involve passive immunity for short-term protection of a host, achieved by the administration of pre-formed antibody directed against a cancer antigen or disease antigen (*e.g.*, administration of a monoclonal antibody, optionally linked to a chemotherapeutic agent or toxin, to a tumor antigen). Immunotherapy can also focus on using the cytotoxic lymphocyte-recognized epitopes of cancer cell lines. Alternatively, antisense polynucleotides, ribozymes, RNA interference molecules, triple helix polynucleotides and the like, can be used to selectively modulate biomolecules that are linked to the initiation, progression, and/or pathology of a tumor or cancer.

In some embodiments, an immunotherapeutic agent is an agonist of an immune-stimulatory molecule; an antagonist of an immune-inhibitory molecule; an antagonist of a chemokine; an agonist of a cytokine that stimulates T cell activation; an agent that antagonizes or inhibits a cytokine that inhibits T cell activation; and/or an agent that binds to a membrane bound protein of the B7 family. In some embodiments, the immunotherapeutic agent is an antagonist of an immune-inhibitory molecule. In some embodiments, the immunotherapeutic agents can be agents for cytokines, chemokines and growth factors, for examples, neutralizing antibodies that neutralize the inhibitory effect of tumor associated cytokines, chemokines, growth factors and other soluble factors including IL-10, TGF- β and VEGF.

In some embodiments, immunotherapy comprises inhibitors of one or more immune checkpoints. The term “immune checkpoint” refers to a group of molecules on the cell surface of CD4⁺ and/or CD8⁺ T cells that fine-tune immune responses by modulating anti-cancer immune responses, such as down-modulating or inhibiting an anti-tumor immune response. Immune checkpoint proteins are well-known in the art and include, without limitation, CTLA-4, PD-1, VISTA, B7-H2, B7-H3, PD-L1, B7-H4, B7-H6, ICOS, HVEM, PD-L2, CD200R, CD160, gp49B, PIR-B, KRLG-1, KIR family receptors, TIM-1, TIM-3, TIM-4, LAG-3 (CD223), IDO, GITR, 4-1BB, OX-40, BTLA, SIRPalpha (CD47), CD48, 2B4 (CD244), B7.1, B7.2, ILT-2, ILT-4, TIGIT, HHLA2, butyrophilins, and A2aR (see, for example, WO 2012/177624).

Some immune checkpoints are “immune-inhibitory immune checkpoints” encompassing molecules (*e.g.*, proteins) that inhibit, down-regulate, or suppress a function of the immune system (*e.g.*, an immune response). For example, PD-L1 (programmed death-ligand 1), also known as CD274 or B7-H1, is a protein that transmits an inhibitory signal that reduces proliferation of T cells to suppress the immune system. CTLA-4 (cytotoxic T-lymphocyte-associated protein 4), also known as CD152, is a protein receptor on the surface of antigen-presenting cells that serves as an immune checkpoint (“off” switch) to downregulate immune responses. TIM-3 (T-cell immunoglobulin and mucin-domain containing-3), also known as HAVCR2, is a cell surface protein that serves as an immune checkpoint to regulate macrophage activation. VISTA (V-domain Ig suppressor of T cell activation) is a type I transmembrane protein that functions as an immune checkpoint to inhibit T cell effector function and maintain peripheral tolerance. LAG-3 (lymphocyte-activation gene 3) is an immune checkpoint receptor that negatively regulates proliferation, activation, and homeostasis of T cells. BTLA (B- and T-lymphocyte attenuator) is a protein that displays T cell inhibition via interactions with tumor necrosis family receptors (TNF-R). KIR (killer-cell immunoglobulin-like receptor) is a family of proteins expressed on NK cells, and a minority of T cells, that suppress the cytotoxic activity of NK cells. In some embodiments, immunotherapeutic agents can be agents specific to immunosuppressive enzymes such as inhibitors that can block the activities of arginase (ARG) and indoleamine 2,3-dioxygenase (IDO), an immune checkpoint protein that suppresses T cells and NK cells, which change the catabolism of the amino acids arginine and tryptophan in the immunosuppressive tumor microenvironment. The inhibitors can include, but are not limited to, *N*-hydroxy-L-Arg (NOHA) targeting to ARG-expressing M2 macrophages,

nitroaspirin or sildenafil (Viagra®), which blocks ARG and nitric oxide synthase (NOS) simultaneously; and IDO inhibitors, such as 1-methyl-tryptophan. The term further encompasses biologically active protein fragment, as well as nucleic acids encoding full-length immune checkpoint proteins and biologically active protein fragments thereof. In
5 some embodiment, the term further encompasses any fragment according to homology descriptions provided herein.

By contrast, other immune checkpoints are “immune-stimulatory” encompassing molecules (*e.g.*, proteins) that activate, stimulate, or promote a function of the immune system (*e.g.*, an immune response). In some embodiments, the immune-stimulatory
10 molecule is CD28, CD80 (B7.1), CD86 (B7.2), 4-1BB (CD137), 4-1BBL (CD137L), CD27, CD70, CD40, CD40L, CD122, CD226, CD30, CD30L, OX40, OX40L, HVEM, BTLA, GITR and its ligand GITRL, LIGHT, LTβR, LTαβ, ICOS (CD278), ICOSL (B7-H2), and NKG2D. CD40 (cluster of differentiation 40) is a costimulatory protein found on antigen presenting cells that is required for their activation. OX40, also known as tumor
15 necrosis factor receptor superfamily member 4 (TNFRSF4) or CD134, is involved in maintenance of an immune response after activation by preventing T-cell death and subsequently increasing cytokine production. CD137 is a member of the tumor necrosis factor receptor (TNF-R) family that co-stimulates activated T cells to enhance proliferation and T cell survival. CD122 is a subunit of the interleukin-2 receptor (IL-2) protein, which
20 promotes differentiation of immature T cells into regulatory, effector, or memory T cells. CD27 is a member of the tumor necrosis factor receptor superfamily and serves as a co-stimulatory immune checkpoint molecule. CD28 (cluster of differentiation 28) is a protein expressed on T cells that provides co-stimulatory signals required for T cell activation and survival. GITR (glucocorticoid-induced TNFR-related protein), also known as TNFRSF18
25 and AITR, is a protein that plays a key role in dominant immunological self-tolerance maintained by regulatory T cells. ICOS (inducible T-cell co-stimulator), also known as CD278, is a CD28-superfamily costimulatory molecule that is expressed on activated T cells and play a role in T cell signaling and immune responses.

Immune checkpoints and their sequences are well-known in the art and
30 representative embodiments are described further below. Immune checkpoints generally relate to pairs of inhibitory receptors and the natural binding partners (*e.g.*, ligands). For example, PD-1 polypeptides are inhibitory receptors capable of transmitting an inhibitory signal to an immune cell to thereby inhibit immune cell effector function, or are capable of

promoting costimulation (*e.g.*, by competitive inhibition) of immune cells, *e.g.*, when present in soluble, monomeric form. Preferred PD-1 family members share sequence identity with PD-1 and bind to one or more B7 family members, *e.g.*, B7-1, B7-2, PD-1 ligand, and/or other polypeptides on antigen presenting cells. The term “PD-1 activity,”

5 includes the ability of a PD-1 polypeptide to modulate an inhibitory signal in an activated immune cell, *e.g.*, by engaging a natural PD-1 ligand on an antigen presenting cell.

Modulation of an inhibitory signal in an immune cell results in modulation of proliferation of, and/or cytokine secretion by, an immune cell. Thus, the term “PD-1 activity” includes the ability of a PD-1 polypeptide to bind its natural ligand(s), the ability to modulate

10 immune cell inhibitory signals, and the ability to modulate the immune response. The term “PD-1 ligand” refers to binding partners of the PD-1 receptor and includes both PD-L1 (Freeman *et al.* (2000) *J. Exp. Med.* 192:1027-1034) and PD-L2 (Latchman *et al.* (2001) *Nat. Immunol.* 2:261). The term “PD-1 ligand activity” includes the ability of a PD-1 ligand polypeptide to bind its natural receptor(s) (*e.g.*, PD-1 or B7-1), the ability to
15 modulate immune cell inhibitory signals, and the ability to modulate the immune response.

As used herein, the term “immune checkpoint therapy” refers to the use of agents that inhibit immune-inhibitory immune checkpoints, such as inhibiting their nucleic acids and/or proteins. Inhibition of one or more such immune checkpoints can block or otherwise neutralize inhibitory signaling to thereby upregulate an immune response in order to more
20 efficaciously treat cancer. Exemplary agents useful for inhibiting immune checkpoints include antibodies, small molecules, peptides, peptidomimetics, natural ligands, and derivatives of natural ligands, that can either bind and/or inactivate or inhibit immune checkpoint proteins, or fragments thereof; as well as RNA interference, antisense, nucleic acid aptamers, etc. that can downregulate the expression and/or activity of immune
25 checkpoint nucleic acids, or fragments thereof. Exemplary agents for upregulating an immune response include antibodies against one or more immune checkpoint proteins that block the interaction between the proteins and its natural receptor(s); a non-activating form of one or more immune checkpoint proteins (*e.g.*, a dominant negative polypeptide); small molecules or peptides that block the interaction between one or more immune checkpoint
30 proteins and its natural receptor(s); fusion proteins (*e.g.*, the extracellular portion of an immune checkpoint inhibition protein fused to the Fc portion of an antibody or immunoglobulin) that bind to its natural receptor(s); nucleic acid molecules that block immune checkpoint nucleic acid transcription or translation; and the like. Such agents can

directly block the interaction between the one or more immune checkpoints and its natural receptor(s) (e.g., antibodies) to prevent inhibitory signaling and upregulate an immune response. Alternatively, agents can indirectly block the interaction between one or more immune checkpoint proteins and its natural receptor(s) to prevent inhibitory signaling and upregulate an immune response. For example, a soluble version of an immune checkpoint protein ligand such as a stabilized extracellular domain can binding to its receptor to indirectly reduce the effective concentration of the receptor to bind to an appropriate ligand. In one embodiment, anti-PD-1 antibodies, anti-PD-L1 antibodies, and/or anti-PD-L2 antibodies, either alone or in combination, are used to inhibit immune checkpoints.

Therapeutic agents used for blocking the PD-1 pathway include antagonistic antibodies and soluble PD-L1 ligands. The antagonist agents against PD-1 and PD-L1/2 inhibitory pathway can include, but are not limited to, antagonistic antibodies to PD-1 or PD-L1/2 (e.g., 17D8, 2D3, 4H1, 5C4 (also known as nivolumab or BMS-936558), 4A11, 7D3 and 5F4 disclosed in U.S. Pat. No. 8,008,449; AMP-224, pidilizumab (CT-011), pembrolizumab, and antibodies disclosed in U.S. Pat. Numbers 8,779,105; 8,552,154; 8,217,149; 8,168,757; 8,008,449; 7,488,802; 7,943,743; 7,635,757; and 6,808,710. Similarly, additional representative checkpoint inhibitors can be, but are not limited to, antibodies against inhibitory regulator CTLA-4 (anti-cytotoxic T-lymphocyte antigen 4 anti-cytotoxic T-lymphocyte antigen 4), such as ipilimumab, tremelimumab (fully humanized), anti-CD28 antibodies, anti-CTLA-4 adnectins, anti-CTLA-4 domain antibodies, single chain anti-CTLA-4 antibody fragments, heavy chain anti-CTLA-4 fragments, light chain anti-CTLA-4 fragments, and other antibodies, such as those disclosed in U.S. Pat. Numbers 8,748, 815; 8,529,902; 8,318,916; 8,017,114; 7,744,875; 7,605,238; 7,465,446; 7,109,003; 7,132,281; 6,984,720; 6,682,736; 6,207,156; and 5,977,318, as well as EP Pat. No. 1212422, U.S. Pat Publ. Numbers 2002/0039581 and 2002/086014, and Hurwitz *et al.* (1998) *Proc. Natl. Acad. Sci. U.S.A.* 95:10067-10071.

The representative definitions of immune checkpoint activity, ligand, blockade, and the like exemplified for PD-1, PD-L1, PD-L2, and CTLA-4 apply generally to other immune checkpoints.

The term “untargeted therapy” refers to administration of agents that do not selectively interact with a chosen biomolecule yet treat cancer. Representative examples of untargeted therapies include, without limitation, chemotherapy, gene therapy, and radiation therapy.

In one embodiment, chemotherapy is used. Chemotherapy includes the administration of a chemotherapeutic agent. Such a chemotherapeutic agent can be, but is not limited to, those selected from among the following groups of compounds: platinum compounds, cytotoxic antibiotics, antimetabolites, anti-mitotic agents, alkylating agents, arsenic compounds, DNA topoisomerase inhibitors, taxanes, nucleoside analogues, plant alkaloids, and toxins; and synthetic derivatives thereof. Exemplary agents include, but are not limited to, alkylating agents: nitrogen mustards (*e.g.*, cyclophosphamide, ifosfamide, trofosfamide, chlorambucil, estramustine, and melphalan), nitrosoureas (*e.g.*, carmustine (BCNU) and lomustine (CCNU)), alkylsulphonates (*e.g.*, busulfan and treosulfan), triazenes (*e.g.*, dacarbazine, temozolomide), cisplatin, treosulfan, and trofosfamide; plant alkaloids: vinblastine, paclitaxel, docetaxol; DNA topoisomerase inhibitors: teniposide, crisnatol, and mitomycin; anti-folates: methotrexate, mycophenolic acid, and hydroxyurea; pyrimidine analogs: 5-fluorouracil, doxifluridine, and cytosine arabinoside; purine analogs: mercaptopurine and thioguanine; DNA antimetabolites: 2'-deoxy-5-fluorouridine, aphidicolin glycinate, and pyrazoloimidazole; and antimitotic agents: halichondrin, colchicine, and rhizoxin. Similarly, additional exemplary agents including platinum-containing compounds (*e.g.*, cisplatin, carboplatin, oxaliplatin), vinca alkaloids (*e.g.*, vincristine, vinblastine, vindesine, and vinorelbine), taxoids (*e.g.*, paclitaxel or a paclitaxel equivalent such as nanoparticle albumin-bound paclitaxel (ABRAXANE), docosahexaenoic acid bound-paclitaxel (DHA-paclitaxel, Taxoprexin), polyglutamate bound-paclitaxel (PG-paclitaxel, paclitaxel poliglumex, CT-2103, XYOTAX), the tumor-activated prodrug (TAP) ANG1005 (Angiopep-2 bound to three molecules of paclitaxel), paclitaxel-EC-1 (paclitaxel bound to the erbB2-recognizing peptide EC-1), and glucose-conjugated paclitaxel, *e.g.*, 2'-paclitaxel methyl 2-glucopyranosyl succinate; docetaxel, taxol), epipodophyllins (*e.g.*, etoposide, etoposide phosphate, teniposide, topotecan, 9-aminocamptothecin, camptothecin, irinotecan, crisnatol, mitomycin C), anti-metabolites, DHFR inhibitors (*e.g.*, methotrexate, dichloromethotrexate, trimetrexate, edatrexate), IMP dehydrogenase inhibitors (*e.g.*, mycophenolic acid, tiazofurin, ribavirin, and EICAR), ribonucleotide reductase inhibitors (*e.g.*, hydroxyurea and deferoxamine), uracil analogs (*e.g.*, 5-fluorouracil (5-FU), floxuridine, doxifluridine, raltitrexed, tegafur-uracil, capecitabine), cytosine analogs (*e.g.*, cytarabine (ara C), cytosine arabinoside, and fludarabine), purine analogs (*e.g.*, mercaptopurine and Thioguanine), Vitamin D3 analogs (*e.g.*, EB 1089, CB 1093, and KH 1060), isoprenylation inhibitors (*e.g.*, lovastatin), dopaminergic neurotoxins

(*e.g.*, 1-methyl-4-phenylpyridinium ion), cell cycle inhibitors (*e.g.*, staurosporine), actinomycin (*e.g.*, actinomycin D, dactinomycin), bleomycin (*e.g.*, bleomycin A2, bleomycin B2, peplomycin), anthracycline (*e.g.*, daunorubicin, doxorubicin, pegylated liposomal doxorubicin, idarubicin, epirubicin, pirarubicin, zorubicin, mitoxantrone), MDR inhibitors (*e.g.*, verapamil), Ca²⁺ ATPase inhibitors (*e.g.*, thapsigargin), imatinib, thalidomide, lenalidomide, tyrosine kinase inhibitors (*e.g.*, axitinib (AG013736), bosutinib (SKI-606), cediranib (RECENTINTM, AZD2171), dasatinib (SPRYCEL®, BMS-354825), erlotinib (TARCEVA®), gefitinib (IRESSA®), imatinib (Gleevec®, CGP57148B, STI-571), lapatinib (TYKERB®, TYVERB®), lestaurtinib (CEP-701), neratinib (HKI-272), nilotinib (TASIGNA®), semaxanib (semaxinib, SU5416), sunitinib (SUTENT®, SU11248), toceranib (PALLADIA®), vandetanib (ZACTIMA®, ZD6474), vatalanib (PTK787, PTK/ZK), trastuzumab (HERCEPTIN®), bevacizumab (AVASTIN®), rituximab (RITUXAN®), cetuximab (ERBITUX®), panitumumab (VECTIBIX®), ranibizumab (Lucentis®), nilotinib (TASIGNA®), sorafenib (NEXAVAR®), everolimus (AFINITOR®), alemtuzumab (CAMPATH®), gemtuzumab ozogamicin (MYLOTARG®), temsirolimus (TORISEL®), ENMD-2076, PCI-32765, AC220, dovitinib lactate (TKI258, CHIR-258), BIBW 2992 (TOVOKTM), SGX523, PF-04217903, PF-02341066, PF-299804, BMS-777607, ABT-869, MP470, BIBF 1120 (VARGATEF®), AP24534, JNJ-26483327, MGCD265, DCC-2036, BMS-690154, CEP-11981, tivozanib (AV-951), OSI-930, MM-121, XL-184, XL-647, and/or XL228), proteasome inhibitors (*e.g.*, bortezomib (VELCADE)), mTOR inhibitors (*e.g.*, rapamycin, temsirolimus (CCI-779), everolimus (RAD-001), ridaforolimus, AP23573 (Ariad), AZD8055 (AstraZeneca), BEZ235 (Novartis), BGT226 (Novartis), XL765 (Sanofi Aventis), PF-4691502 (Pfizer), GDC0980 (Genentech), SF1126 (Semafoe) and OSI-027 (OSI)), oblimersen, gemcitabine, carminomycin, leucovorin, pemetrexed, cyclophosphamide, dacarbazine, procarbazine, prednisolone, dexamethasone, campathecin, plicamycin, asparaginase, aminopterin, methopterin, porfiromycin, melphalan, leurosine, leurosine, chlorambucil, trabectedin, procarbazine, discodermolide, carminomycin, aminopterin, and hexamethyl melamine. Compositions comprising one or more chemotherapeutic agents (*e.g.*, FLAG, CHOP) can also be used. FLAG comprises fludarabine, cytosine arabinoside (Ara-C) and G-CSF. CHOP comprises cyclophosphamide, vincristine, doxorubicin, and prednisone. In another embodiment, PARP (*e.g.*, PARP-1 and/or PARP-2) inhibitors are used and such inhibitors are well-known in the art (*e.g.*, Olaparib, ABT-888, BSI-201, BGP-15 (N-Gene Research

Laboratories, Inc.); INO-1001 (Inotek Pharmaceuticals Inc.); PJ34 (Soriano *et al.*, 2001; Pacher *et al.*, 2002b); 3-aminobenzamide (Trevigen); 4-amino-1,8-naphthalimide; (Trevigen); 6(5H)-phenanthridinone (Trevigen); benzamide (U.S. Pat. Re. 36,397); and NU1025 (Bowman *et al.*). The mechanism of action is generally related to the ability of PARP inhibitors to bind PARP and decrease its activity. PARP catalyzes the conversion of beta-nicotinamide adenine dinucleotide (NAD⁺) into nicotinamide and poly-ADP-ribose (PAR). Both poly (ADP-ribose) and PARP have been linked to regulation of transcription, cell proliferation, genomic stability, and carcinogenesis (Bouchard *et al.* (2003) *Exp. Hematol.* 31:446-454); Herceg (2001) *Mut. Res.* 477:97-110). Poly(ADP-ribose) polymerase 1 (PARP1) is a key molecule in the repair of DNA single-strand breaks (SSBs) (de Murcia J. *et al.* (1997) *Proc. Natl. Acad. Sci. U.S.A.* 94:7303-7307; Schreiber *et al.* (2006) *Nat. Rev. Mol. Cell Biol.* 7:517-528; Wang *et al.* (1997) *Genes Dev.* 11:2347-2358). Knockout of SSB repair by inhibition of PARP1 function induces DNA double-strand breaks (DSBs) that can trigger synthetic lethality in cancer cells with defective homology-directed DSB repair (Bryant *et al.* (2005) *Nature* 434:913-917; Farmer *et al.* (2005) *Nature* 434:917-921). The foregoing examples of chemotherapeutic agents are illustrative and are not intended to be limiting.

In another embodiment, radiation therapy is used. The radiation used in radiation therapy can be ionizing radiation. Radiation therapy can also be gamma rays, X-rays, or proton beams. Examples of radiation therapy include, but are not limited to, external-beam radiation therapy, interstitial implantation of radioisotopes (I-125, palladium, iridium), radioisotopes such as strontium-89, thoracic radiation therapy, intraperitoneal P-32 radiation therapy, and/or total abdominal and pelvic radiation therapy. For a general overview of radiation therapy, see Hellman, Chapter 16: Principles of Cancer Management: Radiation Therapy, 6th edition, 2001, DeVita *et al.*, eds., J. B. Lippencott Company, Philadelphia. The radiation therapy can be administered as external beam radiation or teletherapy wherein the radiation is directed from a remote source. The radiation treatment can also be administered as internal therapy or brachytherapy wherein a radioactive source is placed inside the body close to cancer cells or a tumor mass. Also encompassed is the use of photodynamic therapy comprising the administration of photosensitizers, such as hematoporphyrin and its derivatives, Vertoporphin (BPD-MA), phthalocyanine, photosensitizer Pc4, demethoxy-hypocrellin A; and 2BA-2-DMHA.

In another embodiment, hormone therapy is used. Hormonal therapeutic treatments can comprise, for example, hormonal agonists, hormonal antagonists (*e.g.*, flutamide, bicalutamide, tamoxifen, raloxifene, leuprolide acetate (LUPRON), LH-RH antagonists), inhibitors of hormone biosynthesis and processing, and steroids (*e.g.*, dexamethasone, retinoids, deltoids, betamethasone, cortisol, cortisone, prednisone, dehydrotestosterone, glucocorticoids, mineralocorticoids, estrogen, testosterone, progestins), vitamin A derivatives (*e.g.*, all-trans retinoic acid (ATRA)); vitamin D3 analogs; antigestagens (*e.g.*, mifepristone, onapristone), or antiandrogens (*e.g.*, cyproterone acetate).

In another embodiment, hyperthermia, a procedure in which body tissue is exposed to high temperatures (up to 106°F.) is used. Heat can help shrink tumors by damaging cells or depriving them of substances they need to live. Hyperthermia therapy can be local, regional, and whole-body hyperthermia, using external and internal heating devices. Hyperthermia is almost always used with other forms of therapy (*e.g.*, radiation therapy, chemotherapy, and biological therapy) to try to increase their effectiveness. Local hyperthermia refers to heat that is applied to a very small area, such as a tumor. The area can be heated externally with high-frequency waves aimed at a tumor from a device outside the body. To achieve internal heating, one of several types of sterile probes can be used, including thin, heated wires or hollow tubes filled with warm water; implanted microwave antennae; and radiofrequency electrodes. In regional hyperthermia, an organ or a limb is heated. Magnets and devices that produce high energy are placed over the region to be heated. In another approach, called perfusion, some of the patient's blood is removed, heated, and then pumped (perfused) into the region that is to be heated internally. Whole-body heating is used to treat metastatic cancer that has spread throughout the body. It can be accomplished using warm-water blankets, hot wax, inductive coils (like those in electric blankets), or thermal chambers (similar to large incubators). Hyperthermia does not cause any marked increase in radiation side effects or complications. Heat applied directly to the skin, however, can cause discomfort or even significant local pain in about half the patients treated. It can also cause blisters, which generally heal rapidly.

In still another embodiment, photodynamic therapy (also called PDT, photoradiation therapy, phototherapy, or photochemotherapy) is used for the treatment of some types of cancer. It is based on the discovery that certain chemicals known as photosensitizing agents can kill one-celled organisms when the organisms are exposed to a particular type of light. PDT destroys cancer cells through the use of a fixed-frequency laser light in combination

with a photosensitizing agent. In PDT, the photosensitizing agent is injected into the bloodstream and absorbed by cells all over the body. The agent remains in cancer cells for a longer time than it does in normal cells. When the treated cancer cells are exposed to laser light, the photosensitizing agent absorbs the light and produces an active form of oxygen that destroys the treated cancer cells. Light exposure must be timed carefully so that it occurs when most of the photosensitizing agent has left healthy cells but is still present in the cancer cells. The laser light used in PDT can be directed through a fiber-optic (a very thin glass strand). The fiber-optic is placed close to the cancer to deliver the proper amount of light. The fiber-optic can be directed through a bronchoscope into the lungs for the treatment of lung cancer or through an endoscope into the esophagus for the treatment of esophageal cancer. An advantage of PDT is that it causes minimal damage to healthy tissue. However, because the laser light currently in use cannot pass through more than about 3 centimeters of tissue (a little more than one and an eighth inch), PDT is mainly used to treat tumors on or just under the skin or on the lining of internal organs.

Photodynamic therapy makes the skin and eyes sensitive to light for 6 weeks or more after treatment. Patients are advised to avoid direct sunlight and bright indoor light for at least 6 weeks. If patients must go outdoors, they need to wear protective clothing, including sunglasses. Other temporary side effects of PDT are related to the treatment of specific areas and can include coughing, trouble swallowing, abdominal pain, and painful breathing or shortness of breath. In December 1995, the U.S. Food and Drug Administration (FDA) approved a photosensitizing agent called porfimer sodium, or Photofrin®, to relieve symptoms of esophageal cancer that is causing an obstruction and for esophageal cancer that cannot be satisfactorily treated with lasers alone. In January 1998, the FDA approved porfimer sodium for the treatment of early nonsmall cell lung cancer in patients for whom the usual treatments for lung cancer are not appropriate. The National Cancer Institute and other institutions are supporting clinical trials (research studies) to evaluate the use of photodynamic therapy for several types of cancer, including cancers of the bladder, brain, larynx, and oral cavity.

In yet another embodiment, laser therapy is used to harness high-intensity light to destroy cancer cells. This technique is often used to relieve symptoms of cancer such as bleeding or obstruction, especially when the cancer cannot be cured by other treatments. It can also be used to treat cancer by shrinking or destroying tumors. The term “laser” stands for light amplification by stimulated emission of radiation. Ordinary light, such as that

from a light bulb, has many wavelengths and spreads in all directions. Laser light, on the other hand, has a specific wavelength and is focused in a narrow beam. This type of high-intensity light contains a lot of energy. Lasers are very powerful and can be used to cut through steel or to shape diamonds. Lasers also can be used for very precise surgical work, such as repairing a damaged retina in the eye or cutting through tissue (in place of a scalpel). Although there are several different kinds of lasers, only three kinds have gained wide use in medicine: Carbon dioxide (CO₂) lasers can remove thin layers from the skin's surface without penetrating the deeper layers. This technique is particularly useful in treating tumors that have not spread deep into the skin and certain precancerous conditions. As an alternative to traditional scalpel surgery, the CO₂ laser is also able to cut the skin. The laser is used in this way to remove skin cancers. Neodymium:yttrium-aluminum-garnet (Nd:YAG) laser-- Light from this laser can penetrate deeper into tissue than light from the other types of lasers, and it can cause blood to clot quickly. It can be carried through optical fibers to less accessible parts of the body. This type of laser is sometimes used to treat throat cancers. Argon laser--This laser can pass through only superficial layers of tissue and is therefore useful in dermatology and in eye surgery. It also is used with light-sensitive dyes to treat tumors in a procedure known as photodynamic therapy (PDT). Lasers have several advantages over standard surgical tools, including: Lasers are more precise than scalpels. Tissue near an incision is protected, since there is little contact with surrounding skin or other tissue. The heat produced by lasers sterilizes the surgery site, thus reducing the risk of infection. Less operating time can be needed because the precision of the laser allows for a smaller incision. Healing time is often shortened; since laser heat seals blood vessels, there is less bleeding, swelling, or scarring. Laser surgery can be less complicated. For example, with fiber optics, laser light can be directed to parts of the body without making a large incision. More procedures can be done on an outpatient basis. Lasers can be used in two ways to treat cancer: by shrinking or destroying a tumor with heat, or by activating a chemical--known as a photosensitizing agent--that destroys cancer cells. In PDT, a photosensitizing agent is retained in cancer cells and can be stimulated by light to cause a reaction that kills cancer cells. CO₂ and Nd:YAG lasers are used to shrink or destroy tumors. They can be used with endoscopes, tubes that allow physicians to see into certain areas of the body, such as the bladder. The light from some lasers can be transmitted through a flexible endoscope fitted with fiber optics. This allows physicians to see and work in parts of the body that could not otherwise be reached except by surgery and

therefore allows very precise aiming of the laser beam. Lasers also can be used with low-power microscopes, giving the doctor a clear view of the site being treated. Used with other instruments, laser systems can produce a cutting area as small as 200 microns in diameter--less than the width of a very fine thread. Lasers are used to treat many types of cancer. Laser surgery is a standard treatment for certain stages of glottis (vocal cord), cervical, skin, lung, vaginal, vulvar, and penile cancers. In addition to its use to destroy the cancer, laser surgery is also used to help relieve symptoms caused by cancer (palliative care). For example, lasers can be used to shrink or destroy a tumor that is blocking a patient's trachea (windpipe), making it easier to breathe. It is also sometimes used for palliation in colorectal and anal cancer. Laser-induced interstitial thermotherapy (LITT) is one of the most recent developments in laser therapy. LITT uses the same idea as a cancer treatment called hyperthermia; that heat can help shrink tumors by damaging cells or depriving them of substances they need to live. In this treatment, lasers are directed to interstitial areas (areas between organs) in the body. The laser light then raises the temperature of the tumor, which damages or destroys cancer cells.

VII. Kits

The present invention also encompasses kits comprising the compositions and formulations encompassed by the present invention. A "kit" is any manufacture (*e.g.* a package or container) comprising at least one reagent, *e.g.* an oligonucleotide composition, for specifically detecting and/or affecting the expression of CCR2 and/or CSF1R. The kit can be promoted, distributed, or sold as a unit for performing the methods of the present invention. The kit can comprise one or more reagents necessary to detect, inhibit, screen, etc. that are useful in the methods of the present invention.

Reagents in the kit can be provided in individual containers or as mixtures of two or more reagents in a single container. In addition, instructional materials which describe the use of the compositions within the kit can be included. A kit encompassed by the present invention can also include instructional materials disclosing or describing the use of the kit for a method encompassed by the present invention as provided herein. A kit can also include additional components to facilitate the particular application for which the kit is designed. For example, a kit can additionally contain controls (*e.g.*, control biological samples or standards). A kit can additionally include buffers and other reagents recognized for use in a method of the disclosed invention.

Other embodiments encompassed by the present invention are described in the following Examples. The present invention is further illustrated by the following examples which should not be construed as further limiting.

5 **EXAMPLES**

Example 1: Identification of candidate siRNAs targeting the human CCR2 mRNA

Design of siRNAs using bioinformatics algorithms

Human CCR2 mRNA sequence (Gene Bank NO. NM_001123041.2; SEQ ID NO:
10 1) was used as the target template. All possible 19-mer siRNA molecules were created from this reference sequence. At the same time, the off-target genes of all possible siRNAs were predicted for human, non-human primates (NHPs), such as rhesus monkey and cynomolgus monkey, and mouse and rat, as well. A specificity score was assigned to each siRNA strand analyzed and compared. More than 900 siRNA candidates directed against
15 human CCR2 transcripts were created and further evaluated.

Evaluation of siRNA candidates

For all the siRNA candidates, target specificity, intra- and inter-species cross-activity, activity and other key features were evaluated.

20

Target specificity

The siRNA candidates with lowest sequence complementarity to any non-target transcript and siRNA candidates whose seed regions (around positions 2-7) is ideally not identical to a seed region (positions 2-7) of known microRNA molecules are identified.

25

For each predicted siRNA candidate, off-gene targets were predicted for human, rhesus monkey and cynomolgus monkey. A specificity score was assigned to each siRNA strand (*i.e.*, sense strand and antisense strand). Each siRNA strand with a specificity score was categorized and analyzed. The specificity score considers the likelihood of unintended downregulation of any other transcript by full or partial complementarity of a siRNA strand
30 (up to 4 mismatches within positions 2-18 of 19-mer) and the score describes the predicted most likely off-target(s) for antisense and sense strand of each siRNA molecule by transcriptome-wide off-target analysis. The off-target frequency was categorized by numbers of mismatches (*e.g.*, from 0 mismatch to 4 mismatches). Another criteria then was analyzed for target specificity. siRNAs can function in a miRNA-like manner via base-

pairing with complementary sequences within the 3'-UTR of mRNA molecules. That complementarity typically encompasses the 5'-end 2-7 of the miRNA (seed region). In order to circumvent siRNAs to act via functional miRNA binding sites, siRNA strands that contain natural miRNA seed regions were evaluated and avoided. Furthermore, conserved seed regions in miRNAs from human, mouse, rat, rhesus monkey, dog and pig were also examined (data received from the miRBase database).

Table 6: Target specificity classification criteria

Category		Specificity score	Contain miRNA seed	Contain conserved miRNA seed
1	highly specific	≥ 3	NO	NO
2	specific	≥ 2	YES/NO	NO
3	minimal specificity	≥ 1	YES/NO	NO
4	(A) Specificity not considered	-	YES/NO	YES/NO
	(B) unspecific	0	YES/NO	YES/NO
	(C) unspecific	-	YES/NO	YES

Based on these criteria (as shown in Table 6), highly specific siRNA molecules were selected for further evaluation.

Cross-species reactivity

siRNA candidates that target at least all-protein coding transcripts of the target gene CCR2 and for each species were selected. Sequences including transcript variants from different species were analyzed for cross-reactivity (Table 7). The analysis was separately performed for all 19-mers and 17-mers (positions of 2-18 of 19-mer) with full match to the target sequences in primary species, and for siRNAs that match their respective target site with 19-mer or 17-mer, with full match or with single mismatch to the target sequences in the secondary species. About 553 to 847 siRNAs were predicted without considering specificity. About 108-221 siRNAs were predicted to be specific in human and about 84 to 173 siRNAs were predicted to be specific in both human and NHPs (rhesus and cynomolgus monkey).

Table 7: CCR2 transcripts for cross-reactivity analysis

Species	Transcript (Accession/ID)	Number of 19-mers cross-reactive with NM_001123041.2	19-mers in common	Type
Human	NM_001123041.2	2650	962	mRNA
	NM_001123396.1	1402		mRNA
	XM_011534069.1	2235		mRNA
	ENST00000445132	1402		Known protein coding
	ENST00000400888	2204		Known protein coding
	ENST00000292301	2643		Known protein coding
	ENST00000421659	433		Known protein coding
	ENST00000465202	625		Known processed transcript
Rhesus	By prediction	1181	1181	By prediction
	NM_001032806.1	537		mRNA
	ENSMUT00000020033	616		Known by projection protein coding
Cynomolgus	XM_005546901.2	1196	1196	mRNA
Mouse	NM_009915.2	36	36	mRNA
	XM_006512428.2	36		mRNA
	XM_011243063.1	56		mRNA
	XM_011243064.2	36		mRNA
	ENSMUST00000171719	53		Known protein coding
	ENSMUST00000168841	36		Known protein coding
	ENSMUST00000055918	36		Known protein coding
	ENSMUST00000165984	36		Known protein coding
Rat	NM_021866.1	35	35	mRNA
	ENSRNOT00000078529	0		Known protein coding
Dog	XM_005632629.1	47	36	mRNA
	XM_005632630.2	46		mRNA
	XM_005632631.2	46		mRNA
	ENSCAFT00000021891	36		Known by projection protein coding
Pig	NM_001001619.1	75	75	mRNA
	ENSSSCT00000028261	75		Known protein coding
Rabbit	XM_002713280.3	53	53	mRNA

A separate specificity analysis of siRNA candidates for each species was also performed. Through this analysis, 962 siRNA candidates directed against human CCR2 were analyzed. 274 antisense strands were specific in humans and 896 sense strands only have minimal specificity in humans. Among all siRNA candidates, 262 siRNA candidates were specific in humans and 108 of 553 rhesus and cynomolgus (*i.e.*, non-human primates) cross-reactive siRNAs (human X NHP) were specific in humans.

553 siRNAs were analyzed for predicted specificity in NHP. It was found that 146 antisense strands were specific in NHP and 512 sense strands only have minimal specificity in NHP. Among all siRNA candidates, 138 siRNA candidates were specific in humans and showed humans and NHP cross-reactivity.

Another specificity analysis between humans and NHP was also performed. In the analysis of 19-mer, 84 siRNAs out of the total 553 siRNAs were specific in human and NHP. 4 siRNAs were highly specific in human. In the analysis with 17-mer (positions 2-

18 of 19-mer), 90 siRNAs out of the total 581 siRNAs were specific in human and NHP. 6 siRNAs were highly specific in human.

These siRNAs can be further filtered according to the specificity criteria (*e.g.*, absence of human miRNA seeds, absence of rhesus miRNA seeds, absence of conserved
5 miRNA seeds among human, mouse and rat; off target frequency and two-or-more mismatches) and predicted siRNA activity.

siRNA activity prediction

Selected siRNA candidates were further evaluated for predicted siRNA activity. In
10 order to obtain the specific activity, siRNAs with target sites that are abundant with SNPs (single nucleotide polymorphisms) were excluded. Human SNPs were mapped to siRNA target sites in the CCR2 transcript and analyzed. siRNA candidates for which the target sites were free from SNPs were selected.

The siRNA activity was also predicted based on selected siRNA chemistry and
15 other algorithms. The siRNA candidate that is predicted to most likely be inactive siRNA is removed from the evaluation list.

siRNA selection

Selected siRNA candidates after evaluation were listed in Table 2. The location of
20 the target site for each siRNA molecule on human CCR2 mRNA (SEQ ID NO: 1) is also indicated in Table 2. The selected siRNAs target the coding region of human CCR2 mRNA.

Example 2: Identification of candidate siRNAs targeting CSF1R

25 A similar approach to the identification of siRNA candidates targeting CCR2 was used to identify siRNA candidates targeting human CSF1R.

Human CSF1R mRNA sequence (Gene Bank NO. NM_005211.3; SEQ ID NO: 2) was used as the target template. All possible 19-mer siRNA molecules were created from this reference sequence. For all the siRNA candidates, target specificity, intra- and inter-
30 species cross-activity, activity and other key features were evaluated.

The off-target genes for each siRNA strand were predicted for human, rhesus monkey, cynomolgus monkey. A specific score according to the off-target frequency was assigned to each siRNA strand. All the siRNA strands were analyzed for presence of human, rhesus monkey, dog, pig, rat, and mouse miRNA seed regions. Each siRNA

candidate was then assigned to a specificity category in consideration of both the specificity score and miRNA seed analysis (as shown in Table 6).

The inter- and intra-species cross-reactivity of siRNA candidates were then calculated for transcript variants and different species, for 19-mers and 17-mers

- 5 (nucleotides 2-18 of 19-mer), and for 19-mers and 17-mers with a single mismatch. About 1770 to 2957 siRNAs were predicted without considering specificity. About 623 to 1051 siRNAs were predicted to be specific in human and about 444 to 771 siRNAs were predicted to be specific in both human and NHPs (rhesus and cynomolgus monkey). Sequences including transcript variants from different species analyzed for cross-reactivity
10 were in Table 8.

Table 8: CSF1R transcripts for cross-reactivity analysis

Species	Transcript (Accession/ID)	Number of 19-mers cross-reactive with NM_005211.3	19-mers in common	Type
Human	NM_005211.3	3977	3860	mRNA
	NM_001288705.2	3866		mRNA
	NM_001349736.1	3866		mRNA
	ENST00000286301	3971		Known protein coding
	NR_109969.1	3688		non-coding RNA
	ENST00000504875	3664		Known nonsense mediated decay
	ENST00000509861	478		Known retained intron
	ENST00000515068	499		Known nonsense mediated decay
	ENST00000515239	411		Known processed transcript
	ENST00000513609	396		Known protein coding
	ENST00000502660	998		Known protein coding
	ENST00000511344	620		Known protein coding
	ENST00000543093	887		Known protein coding
Rhesus	XM_001107711.3	1878	1878	mRNA
	ENSMMUT00000016183	1598		Known by projection_protein coding
	ENSMMUT00000040845	1430		Known by projection_protein coding
	ENSMMUT00000064465	333		Known by projection_protein coding
Cyno	XM_005558240.2	1933	1849	mRNA
	XM_015452130.1	1849		mRNA
Mouse	NM_001037859.2	115	115	mRNA
	XM_006525584.1	115		mRNA
	XM_006525585.3	115		mRNA
	XM_006525586.3	115		mRNA
	XM_017317810.1	115		mRNA
	ENSMUST00000025523	115		Known protein coding
	ENSMUST000000115268	115		Known protein coding
	XR_001782332.1	109		misc_RNA
Rat	NM_001029901.1	105	102	mRNA
	XM_006254813.3	108		mRNA

	XM_008772147.2	108		mRNA
	XM_008772148.2	108		mRNA
	ENSRNOT00000079360	105		Known protein coding
	ENSRNOT00000049357	105		Known protein coding
	ENSRNOT00000088988	22		Known protein coding
Dog	XM_546306.5	304	274	mRNA
	ENSCAFT00000028942	309		Known by projection_protein coding
Pig	XM_003124100.5	222	214	mRNA
	XM_013995332.1	222		mRNA
	ENSSSCT00000015787	214		Novel_protein coding
Rabbit	XM_017341189.1	220	218	mRNA
	ENSOCUT00000021641	224		Known by projection_protein coding

A separate specificity analysis of siRNA candidates to CSF1R for each species was also performed. Through the analysis, 3860 siRNA candidates directed against human CSF1R were analyzed. 1493 antisense strands were specific in humans, and 3504 sense strands only have minimal specificity in humans. Among all siRNA candidates, 1418 siRNA candidates were specific in humans and 623 of 1770 rhesus and cynomolgus cross-reactive siRNAs (human and NHP) were specific in humans.

siRNAs were analyzed for predicted specificity in NHP. It was found that 691 antisense strands were specific in NHP and 1636 sense strands only have minimal specificity in NHP. Among all siRNA candidates, 655 siRNA candidates were specific in humans and showed human and NHP cross-reactivity.

Another specificity analysis between humans and NHP was also performed. In the analysis of 19-mer, 444 siRNAs out of the total 1770 siRNAs were specific in human and NHP. 21 siRNAs were highly specific in humans. In the analysis with 17-mers (positions 2-18 of 19-mer), 481 siRNAs out of the total 1901 siRNAs were specific in humans and NHP. 23 siRNAs were highly specific in humans.

These siRNAs can be further filtered according to the specificity criteria (*e.g.*, absence of human miRNA seeds, absence of rhesus miRNA seeds, absence of conserved miRNA seeds among human, mouse and rat; off target frequency and two-or-more mismatches) and predicted siRNA activity.

Selected siRNA candidates were further evaluated for predicted siRNA activity. In order to obtain the specific activity, siRNAs with target sites that are abundant with SNPs will be excluded. Human SNPs were mapped to siRNA target sites in the CSF1R transcript and analyzed. siRNA candidates for which the target sites were free from SNPs were selected. The siRNA activity was also predicted based on selected siRNA chemistry and

other algorithms. The siRNA candidate that is predicted most likely to be inactive siRNA is removed from the evaluation list.

The selected siRNA candidates specific to CSF1R after evaluation were listed in Table 3 and modified siRNA strands are in Table 4. The location of the target site for each siRNA molecule on human CSF1R mRNA (SEQ ID NO: 2) is also indicated in the Tables. The selected siRNAs target both the coding region and 3' UTR region of human CSF1R mRNA.

Example 3: CSF1R siRNA screening

10 *Dual dose screening of CSF1R siRNA duplexes*

Human monocytic THP-1 cells were cultured and maintained in 96-well plates at a density of 25,000 cells per well. THP-1 monocytes were transfected with CSF1R siRNA duplexes (see Table 9) using Lipofectomine® 2000 (0.5 µl/well). The CSF1R siRNAs were transfected at a final concentration of 0.2 nM and 20 nM, respectively. An anti-Aha1 siRNA (XD-00033) was transfected as a positive control. Two scramble siRNA sequences (XD-00379 and XD-00385) were used as negative control. After incubating for 24 hours, the treated cells were harvested and the remaining CSF1R mRNA level was measured (Table 10).

20 Table 9: CSF1R siRNA duplexes and sequences

Duplex-ID	Sense Sequence	SEQ ID NO:	Antisense Sequence	SEQ ID NO
XD-08903	ggGAAucccAGuGauAGAGdTsdT	368	CUCuAUcACUGGGAUUCCcdTsdT	487
XD-08904	uuGcGAuGuGuGGgcAAuGdTsdT	369	cAUUGCCcAcAcAUCGcAAdTsdT	488
XD-08905	gcGAuGuGuGGGcaAuGGcdTsdT	370	GCcAUUGCCcAcAcAUCGcdTsdT	489
XD-08906	caAcGcuAccuuccAAAcdTsdT	371	GUUUUGGAAGGuAGCGUUGdTsdT	490
XD-08907	acGcuAccuuccAaAAcAcdTsdT	372	GUGUUUUGGAAGGuAGCGUdTsdT	491
XD-08908	cgcUAccuuccAAaAcAcGdTsdT	373	CGUGUUUUGGAAGGuAGCGdTsdT	492
XD-08909	ugcccGGccuGGaAcGuGdTsdT	374	cACGUUCcAGGGCCGGGcAdTsdT	493
XD-08910	ugcucAcAGAcccgGuGcudTsdT	375	AGcACCGGGUCUGUGAGcAdTsdT	494
XD-08911	agGcGucucGcuGguGcGudTsdT	376	ACGcACcAGCGAGACGCCUdTsdT	495
XD-08912	ucAAuGcAGuGccuGAuGdTsdT	377	cAUcAGGGcACUGcAUUGAdTsdT	496
XD-08913	caGcAuucGGcuGaAGuGdTsdT	378	cACUUUcAGCCGGAUGCUGdTsdT	497
XD-08914	caGAGcuGGuGcGgAuucGdTsdT	379	CGAAUCCGcAcAcAGCUCUGdTsdT	498
XD-08915	gaGcuGGuGcGGAuucGAGdTsdT	380	CUCGAAUCCGcAcAcAGCUCdTsdT	499
XD-08916	ugcGGAuucGAGGgGAGGcdTsdT	381	GCCUCCCCUCGAAUCCGcAdTsdT	500
XD-08917	cuGcccAGAuGuguGcuCdTsdT	382	GAGcAcACGAUCUGGGcAGdTsdT	501
XD-08918	gcccAGAuGuguGucucAGdTsdT	383	CUGAGcAcACGAUCUGGGCdTsdT	502

XD-08919	caGAucGuGuGcucAGccAdTsdT	384	UGGCUGAGcAcACGAUCUGdTsdT	503
XD-08920	auAAccGuuAccAaAAAGudTsdT	385	ACUUUUUGGuAACGGUuAUdTsdT	504
XD-08921	aaccGuuAccAAAAAGuccdTsdT	386	GGACUUUUUGGuAACGGUuAdTsdT	505
XD-08922	accGuuAccAAAAAGuccudTsdT	387	AGGACUUUUUGGuAACGGUdTsdT	506
XD-08923	uuAccAAAAAGuccuGAccdTsdT	388	GGUcAGGACUUUUUGGuAAAdTsdT	507
XD-08924	agGuuuuAAcuGGaccuAcdTsdT	389	GuAGGUcCAGUuAAAACCUdTsdT	508
XD-08925	gguuuuAAcuGGAccuAccdTsdT	390	GGuAGGUcCAGUuAAAACCUdTsdT	509
XD-08926	uuuAAcuGGAccuaccuGGdTsdT	391	CcAGGuAGGUcCAGUuAAAdTsdT	510
XD-08927	uuAAcuGGAccuAccuGGdTsdT	392	CCcAGGuAGGUcCAGUuAAAdTsdT	511
XD-08928	gaccuAccuGGGAccuudTsdT	393	AAAGGGUCCcAGGuAGGUcCdTsdT	512
XD-08929	ugAcGuuuGAGcucAccudTsdT	394	AGGGUGAGCUcAAACGUcAdTsdT	513
XD-08930	gacGuuuGAGcucaccuudTsdT	395	AAGGGUGAGCUcAAACGUcAdTsdT	514
XD-08931	uuGAGcucAcccuucGAuAdTsdT	396	uAUCGAAGGGUGAGCUcAAAdTsdT	515
XD-08932	agcucAcccuucGauAccdTsdT	397	GGGuAUCGAAGGGUGAGCUdTsdT	516
XD-08933	uucGAuAccccccGAGGudTsdT	398	ACCUCUGGGGGGuAUCGAAdTsdT	517
XD-08934	gauAccccccAGAgGuAAGdTsdT	399	CUuACCUCUGGGGGGuAUCdTsdT	518
XD-08935	gaGAccuuAGAGcacAAcdTsdT	400	GGUUGUGCUCuAAGGUCUCdTsdT	519
XD-08936	gaccuuAGAGcAcaAccAAdTsdT	401	UUGGUUGUGCUCuAAGGUCdTsdT	520
XD-08937	caGcGuGGGGAGugGcuccdTsdT	402	GGAGCcACUCCcACGCUGdTsdT	521
XD-08938	aucccccGGAuGAguccudTsdT	403	AGGAACUcAUCCGGGGGAUdTsdT	522
XD-08939	cccGGAuGAGuuccucuudTsdT	404	GAAGAGGAACUcAUCCGGGdTsdT	523
XD-08940	guGGucGccuGcAuGuccAdTsdT	405	UGGAcAUGcAGGCGACcACdTsdT	524
XD-08941	ugcuAuuGuAcAAguAuAAdTsdT	406	UuAuACUUGuAcAAuAGcAdTsdT	525
XD-08942	caGGuccGcuGGAAGaucAdTsdT	407	UGAUCUUCcAGCGGACCUGdTsdT	526
XD-08943	gguccGcuGGAAGaucAucdTsdT	408	GAUGAUCUUCcAGCGGACCdTsdT	527
XD-08944	uccGcuGGAAGaucAucGAdTsdT	409	UCGAUGAUCUUCcAGCGGAdTsdT	528
XD-08945	ccGcuGGAAGaucaucGAGdTsdT	410	CUCGAUGAUCUUCcAGCGGdTsdT	529
XD-08946	aucAucGAGAGcuauGAGdTsdT	411	CCUcAuAGCUCUCGAUGAUdTsdT	530
XD-08947	caucGAGAGcuAugAGGGcdTsdT	412	GCCCUcAuAGCUCUCGAUGdTsdT	531
XD-08948	uauGAGGGcAAcAguuAuAdTsdT	413	uAuAACUGUUGCCCUcAuAdTsdT	532
XD-08718	agGGcAAcAGuuAuAcuuudTsdT	414	AAAGuAuAACUGUUGCCCUdTsdT	533
XD-08950	ggcAAcAGuuAuAcuuucAdTsdT	415	UGAAAGuAuAACUGUUGCCdTsdT	534
XD-08751	cacGcAGcuGccuuAcAAcdTsdT	416	GUUGuAAGGcAGCUGCGUGdTsdT	535
XD-08952	uucccccGGAAcAaccuGcdTsdT	417	GcAGGUUGUUCGGGGGAAdTsdT	536
XD-08953	ccGGAAcAaccuGcAGuuudTsdT	418	AAACUGcAGGUUGUUCGGdTsdT	537
XD-08954	uuuGGuAAGAccucGGAGdTsdT	419	CUCCGAGGGUCUuACcAAAdTsdT	538
XD-08955	ugGuAAGAccucgGAGcudTsdT	420	AGCUCCGAGGGUCUuACcAdTsdT	539
XD-08956	ugAAGuccAcGGcccAuGcdTsdT	421	GcAUGGGCCGUGGACUUCdTsdT	540
XD-08957	gaAGuccAcGGcccAuGcudTsdT	422	AGcAUGGGCCGUGGACUUCdTsdT	541
XD-08958	ccuGuAcuGGucAucAcGGdTsdT	423	CCGUGAUGACcAGuAcAGdTsdT	542
XD-08959	cuGuAcuGGucAucAcGGAdTsdT	424	UCCGUGAUGACcAGuAcAGdTsdT	543
XD-08960	uguAcuGGucAucacGGAGdTsdT	425	CUCCGUGAUGACcAGuAcAdTsdT	544
XD-08961	uacuGGucAucAcgGAGuAdTsdT	426	uACUCCGUGAUGACcAGuAdTsdT	545
XD-08962	ggucAucAcGGAGuAcuGudTsdT	427	AcAGuACUCCGUGAUGACCdTsdT	546

XD-08963	aucAcGGAGuAcuguuGcudTsdT	428	AGcAAcAGuACUCCGUGAUdTsdT	547
XD-08964	ucAcGGAGuAcuGuuGcuAdTsdT	429	uAGcAAcAGuACUCCGUGAdTsdT	548
XD-08965	acGGAGuAcuGuugcuAuGdTsdT	430	cAuAGcAAcAGuACUCCGUdTsdT	549
XD-08966	aguAcuGuuGcuAuGGcGAdTsdT	431	UCGCcAuAGcAAcAGuACUdTsdT	550
XD-08967	uguuGcuAuGGcGaccuGcdTsdT	432	GcAGGUCGCcAuAGcAAcAdTsdT	551
XD-08968	gcuAuGGcGAccugcucAAAdTsdT	433	UUGAGcAGGUCGCcAuAGCdTsdT	552
XD-08969	auGGcGAccuGcucAAcuudTsdT	434	AAGUUGAGcAGGUCGCcAUdTsdT	553
XD-08970	gcucAAcuuucuGcGAAGGdTsdT	435	CCUUCGcAGAAAGUUGAGCdTsdT	554
XD-08971	caAcuuucuGcGAAGGAAGdTsdT	436	CUUCCUUCGcAGAAAGUUGdTsdT	555
XD-08972	uuuGcGAAGGAAGGcuGAdTsdT	437	UcAGCCUUCUUCGcAGAAAdTsdT	556
XD-08973	caGGGuGuGGAcAccuAuGdTsdT	438	cAuAGGUGUCcAcACCCUGdTsdT	557
XD-08974	ggAcAAGGAGGAUGGAcGGdTsdT	439	CCGUCcAUCCUCCUUGUCCdTsdT	558
XD-08975	gcuuccAAGAAuugcAuccdTsdT	440	GGAUGcAAUUCUUGGAAGCdTsdT	559
XD-08976	acuucGGGcuGGcuAGGGAdTsdT	441	UCCCuAGCcAGCCGAAGUdTsdT	560
XD-08977	cuGGcuAGGGAcAucAuGAdTsdT	442	UcAUGAUGUCCCuAGCcAGdTsdT	561
XD-08978	ggcuAGGGAcAucAuGAAudTsdT	443	AUUCaUGAUGUCCCuAGCCdTsdT	562
XD-08979	uuuGAcuGuGucuacAcGGdTsdT	444	CCGUGuAGAcAcAGUcAAAdTsdT	563
XD-08980	ugAcuGuGucuAcacGGuudTsdT	445	AACCGUGuAGAcAcAGUcAdTsdT	564
XD-08981	acuGuGucuAcAcgGuucAdTsdT	446	UGAACCGUGuAGAcAcAGUdTsdT	565
XD-08982	guGucuAcAcGGuucAGAGdTsdT	447	CUCUGAACCGUGuAGAcACdTsdT	566
XD-08983	cuAcAcGGuucAGaGcGAdTsdT	448	GUCGCUCUGAACCGUGuAGdTsdT	567
XD-08984	cacGGuucAGAGcgAcGucdTsdT	449	GACGUCGCUCUGAACCGUGdTsdT	568
XD-08985	gguucAGAGcGAcgucuGGdTsdT	450	CcAGACGUCGCUCUGAACCDTsdT	569
XD-08986	uucAGAGcGAcGucuGGucdTsdT	451	GACcAGACGUCGCUCUGAAdTsdT	570
XD-08987	cuuGGGcuGAAuccuAccdTsdT	452	GGuAGGGAUUCAGCCcAAGdTsdT	571
XD-08988	ugAAcAGcAAGuucuAuAAdTsdT	453	UuAuAGAACUUGCUGUUCAdTsdT	572
XD-08989	gcAAGuucuAuAAacuGGudTsdT	454	ACcAGUuAuAGAACUUGCdTsdT	573
XD-08990	agAAuAuAuAcAGcAucAudTsdT	455	AUGAUGCUGuAuAuAUUCUdTsdT	574
XD-08991	agAGAGcGGGAcuauAccAdTsdT	456	UGGuAuAGUCCCGCUCUCUdTsdT	575
XD-08992	gaGAGcGGGAcuAuAccAAdTsdT	457	UUGGuAuAGUCCCGCUCUCdTsdT	576
XD-08993	agAGcGGGAcuAuaccAAudTsdT	458	AUUGGuAuAGUCCCGCUCUdTsdT	577
XD-08994	gcGGGAcuAuAccaAucGdTsdT	459	cAGAUUGGuAuAGUCCCGCdTsdT	578
XD-08995	ggAcuAuAccAAucGccGdTsdT	460	CGGcAGAUUGGuAuAGUCCdTsdT	579
XD-08996	ugcuGcGAGcAAGgGGAuAdTsdT	461	uAUCCCCUUGCUCGcAGcAdTsdT	580
XD-08997	gcGAGcAAGGGGAuAucGcdTsdT	462	GCGAuAUCCCCUUGCUCGcdTsdT	581
XD-08998	cgAGcAAGGGGAuaucGccdTsdT	463	GGCGAuAUCCCCUUGCUCGdTsdT	582
XD-08999	gauAucGcccAGcccuGcdTsdT	464	GcAAGGGCUGGGCGAuAUCdTsdT	583
XD-09000	agcccAAcAAcuAucAGuudTsdT	465	AACUGAuAGUUGUUGGGCUdTsdT	584
XD-09001	gcccAAcAAcuAucAGuucdTsdT	466	GAACUGAuAGUUGUUGGGCdTsdT	585
XD-09002	cccAAcAAcuAucaGuucudTsdT	467	AGAACUGAuAGUUGUUGGGdTsdT	586
XD-09003	acAAAcucuGccuucGGucdTsdT	468	GACCGAAGGcAGAGUUUGUdTsdT	587
XD-09004	ucuGccuucGGucauuucAdTsdT	469	UGAAAUGACCGAAGGcAGAdTsdT	588
XD-09005	gccuucGGucAuucAcucdTsdT	470	GAGUGAAAUGACCGAAGGCdTsdT	589
XD-09006	ucGGucAuucAcucAAcAdTsdT	471	UGUUGAGUGAAAUGACCGAdTsdT	590

XD-09007	cucAuGGuGuuGGccucGudTsdT	472	ACGAGGCcAAcACcAUGAGdTsdT	591
XD-09008	ucAuGGuGuuGGccucGuGdTsdT	473	cACGAGGCcAAcACcAUGAdTsdT	592
XD-09009	cauGGuGuuGGccucGuGdTsdT	474	AcACGAGGCcAAcACcAUGdTsdT	593
XD-09010	gguGuuGGccucGuGuuuGdTsdT	475	cAAAcACGAGGCcAAcACCdTsdT	594
XD-09011	cguGuuuGcuAuGccAAcudTsdT	476	AGUUGGcAuAGcAAAcACGdTsdT	595
XD-09012	agcuAAAAGuuGGgGGuGdTsdT	477	AcACCCcAACUUUuAGCUdTsdT	596
XD-09013	ccAAGcuGAcucAuccuAAdTsdT	478	UuAGGAUGAGUcAGCUUGdTsdT	597
XD-09014	agcuGAcucAuccuAAcuAdTsdT	479	uAGUuAGGAUGAGUcAGCUdTsdT	598
XD-09015	cuGAcucAuccuAacuAAcdTsdT	480	GUuAGUuAGGAUGAGUcAGdTsdT	599
XD-09016	ugAcucAuccuAAcuAAcAdTsdT	481	UGUuAGUuAGGAUGAGUcAdTsdT	600
XD-09017	gacucAuccuAAcuAAcAGdTsdT	482	CUGUuAGUuAGGAUGAGUCdTsdT	601
XD-09018	uccuAAcuAAcAGucAcGcdTsdT	483	GCGUGACUGUuAGUuAGGAdTsdT	602
XD-09019	ccuAAcuAAcAGucAcGcdTsdT	484	GGCGUGACUGUuAGUuAGGdTsdT	603
XD-09020	uccAcAuuAAAcuaAcAGcdTsdT	485	GCUGUuAGUuAAUGUGGAdTsdT	604
XD-09021	ccAcAuuAAAcuaAcAGcdTsdT	486	UGCUGUuAGUuAAUGUGGdTsdT	605

Table 10: CSF1R mRNA expression level after siRNA duplex treatment

SiRNA Duplex ID	Remaining CSF1R mRNA (20 nM)	SD	Remaining CSF1R mRNA (0.2 nM)	SD
XD-09016	0.18537	0.02284	0.50702	0.06445
XD-08982	0.18692	0.00529	0.78050	0.02888
XD-08947	0.19355	0.01912	0.55900	0.06748
XD-08993	0.19394	0.04830	0.58760	0.02935
XD-08988	0.21506	0.01206	0.57405	0.06757
XD-08944	0.21750	0.01495	0.62030	0.07051
XD-08969	0.21805	0.01873	0.72911	0.04768
XD-09003	0.22426	0.02053	0.73782	0.01199
XD-09002	0.23038	0.00631	0.90398	0.07340
XD-08917	0.23503	0.05984	0.80799	0.08275
XD-08936	0.24159	0.01493	0.60641	0.05563
XD-08923	0.24349	0.03950	0.69406	0.06145
XD-09021	0.24489	0.02555	0.80475	0.07459
XD-08989	0.25338	0.01847	0.82919	0.06989
XD-08963	0.25451	0.01114	0.77794	0.04950
XD-08986	0.25769	0.01899	0.71013	0.10820
XD-08922	0.26956	0.05050	0.67210	0.05036
XD-08985	0.27418	0.01579	0.81107	0.05929
XD-08911	0.27698	0.02007	0.97347	0.05620
XD-08975	0.27764	0.02523	0.80713	0.06685
XD-08998	0.27953	0.02538	0.92203	0.05824
XD-08920	0.28126	0.01955	0.88899	0.04191
XD-08910	0.28392	0.04528	0.97103	0.05298

XD-08919	0.28978	0.00295	0.82317	0.07477
XD-09000	0.29223	0.02449	1.01798	0.07085
XD-09005	0.29234	0.01560	0.80071	0.12501
XD-09006	0.29309	0.01102	0.66257	0.06075
XD-09015	0.29864	0.02154	0.77911	0.04748
XD-08959	0.30378	0.01653	0.88676	0.05556
XD-09020	0.30655	0.03732	0.91608	0.06192
XD-08965	0.30676	0.01428	0.94295	0.08738
XD-08983	0.30887	0.04038	0.95985	0.11313
XD-09017	0.31064	0.01470	0.86726	0.07573
XD-08718	0.31191	0.02699	0.89423	0.07456
XD-08921	0.31315	0.03781	0.95873	0.10268
XD-08964	0.31794	0.00603	0.87172	0.02964
XD-08937	0.33454	0.04225	0.67101	0.06215
XD-09014	0.33545	0.02391	0.82205	0.06377
XD-08946	0.34265	0.01887	0.86198	0.07153
XD-08970	0.34529	0.02865	1.03488	0.06560
XD-08961	0.35079	0.02145	1.00360	0.07367
XD-08929	0.35756	0.04288	0.95156	0.18035
XD-08974	0.35893	0.01063	0.89774	0.08100
XD-08906	0.35986	0.01554	0.97084	0.05452
XD-09004	0.36750	0.02836	0.62993	0.04527
XD-08954	0.37519	0.03992	0.84890	0.02625
XD-09011	0.37644	0.03108	0.96006	0.09453
XD-08908	0.37894	0.03524	1.00367	0.06173
XD-08925	0.37905	0.09014	0.83044	0.08860
XD-09001	0.37916	0.01949	1.11165	0.09949
XD-08996	0.41014	0.02609	0.94661	0.02649
XD-08945	0.41198	0.02662	0.95633	0.05070
XD-08907	0.43809	0.03115	0.96289	0.06900
XD-08930	0.44301	0.02980	0.98719	0.03229
XD-08973	0.44496	0.05228	0.90093	0.10734
XD-08976	0.44526	0.01723	0.82831	0.03961
XD-08939	0.44655	0.02934	0.93025	0.04863
XD-09018	0.46374	0.03399	0.88168	0.03309
XD-08955	0.46474	0.04281	0.83119	0.08266
XD-09013	0.48310	0.03093	0.96855	0.01648
XD-08992	0.48411	0.03658	0.98462	0.09052
XD-08977	0.48602	0.04398	0.95141	0.08327
XD-08971	0.51621	0.02496	0.97747	0.09487
XD-08914	0.52102	0.00757	0.97345	0.07494
XD-08995	0.54138	0.01044	1.02092	0.08231

XD-08991	0.55009	0.02018	1.04190	0.07506
XD-08987	0.55465	0.01375	0.93050	0.10621
XD-09008	0.55637	0.02834	1.03410	0.05269
XD-09007	0.56457	0.05419	0.95311	0.04485
XD-08950	0.57008	0.03851	0.94692	0.06396
XD-08984	0.57905	0.03816	0.92953	0.04740
XD-08980	0.58398	0.05652	1.02200	0.07496
XD-08927	0.59037	0.04877	0.92002	0.17925
XD-08994	0.59708	0.06231	0.97299	0.11487
XD-08948	0.60345	0.01408	0.97558	0.04949
XD-08943	0.61742	0.03261	0.88335	0.05723
XD-09010	0.63971	0.06697	1.09204	0.13856
XD-08979	0.65838	0.09571	1.01448	0.09057
XD-08913	0.66500	0.04354	0.95628	0.06459
XD-08960	0.67138	0.03943	1.08670	0.07317
XD-08978	0.67992	0.06028	0.96962	0.06596
XD-08718	0.68433	0.02467	0.94005	0.03550
XD-09019	0.68810	0.05982	0.98429	0.04044
XD-08931	0.71472	0.01747	1.02415	0.09088
XD-08942	0.71682	0.06685	0.92023	0.04772
XD-08967	0.71778	0.05235	1.11323	0.06628
XD-08997	0.72882	0.01181	1.06092	0.05433
XD-08968	0.73791	0.02149	1.03693	0.14572
XD-08941	0.75432	0.04593	0.98308	0.04523
XD-08972	0.76128	0.10513	0.95568	0.06176
XD-08966	0.79411	0.03587	0.81351	0.13077
XD-08953	0.80859	0.06608	0.90581	0.07752
XD-08903	0.81277	0.05747	1.00663	0.04189
XD-08904	0.81916	0.05336	1.00953	0.04823
XD-08990	0.83319	0.06048	0.91711	0.07383
XD-08909	0.83663	0.07080	0.96907	0.10826
XD-08981	0.84219	0.15995	1.09766	0.11967
XD-08918	0.84787	0.01734	0.95026	0.05807
XD-08916	0.85213	0.04898	0.97463	0.06636
XD-09009	0.85404	0.03917	1.15060	0.04359
XD-08915	0.86321	0.12021	1.01780	0.18566
XD-08956	0.86690	0.08694	0.85477	0.07408
XD-08962	0.87373	0.05496	1.10057	0.02479
XD-08957	0.90137	0.03356	0.88267	0.08385
XD-08928	0.90659	0.10278	0.95260	0.20736
XD-08933	0.92109	0.09930	0.91102	0.06753
XD-08958	0.92751	0.02078	1.00619	0.06992

XD-08926	0.92776	0.12489	0.91675	0.12077
XD-08932	0.93011	0.10329	1.02311	0.09976
XD-08912	0.93804	0.02806	1.02081	0.08995
XD-08935	0.97156	0.06127	0.83523	0.06430
XD-08924	0.98158	0.06688	0.89400	0.07711
XD-08940	0.99113	0.01645	0.94643	0.01959
XD-08934	0.99225	0.08202	0.89670	0.08148
XD-08905	0.99864	0.05744	0.91416	0.14105
XD-08938	1.02480	0.06030	0.82452	0.10330
XD-08952	1.03108	0.06577	0.89369	0.03782
XD-08999	1.11078	0.06150	1.08661	0.10997
XD-00379 (Negative Control)	0.86933	0.02880	1.12239	0.02086
XD-00385 (Negative control)	0.90707	0.03773	1.03351	0.03986
XD-00033 (Aha-1; positive control)	0.18975	0.01787	0.66840	0.04754

Dose response of selected CSF1R siRNA duplexes

CSF1R siRNA duplexes that caused a significant reduction of CSF1R mRNA level in the dual dose screening were selected and further tested for the dose response. Human monocytic THP-1 cells were cultured and maintained in 96-well plates at a density of 25,000 cells per well. THP-1 monocytes were transfected with CSF1R siRNA duplexes selected from the previous dual dose screening at various concentrations using Lipofectomine® 2000 (0.5 μ l/well). The doses for each CSF1R siRNA duplex included 50 nM, 6.25 nM, 0.78 nM, 1.2×10^{-2} nM, 1.5×10^{-3} nM, 1.9×10^{-4} nM, 3.0×10^{-6} nM, and 3.7×10^{-7} nM. Following incubation of 24 hours, the treated cells were harvested and the remaining CSF1R mRNA level was measured in each condition. The IC₅₀ value of each CSF1R duplex was determined as shown in Table 11 and each dose response curve is shown in Figure 1A.

Table 11: IC₅₀ of CSF1R siRNA duplexes

siRNA Duplex ID	IC ₅₀ (nM)
XD-08917	1.292
XD-08922	0.494
XD-08923	1.283
XD-08936	1.251
XD-08944	0.349
XD-08947	0.495
XD-08969	1.452

XD-08982	0.906
XD-08988	0.348
XD-08993	0.267
XD-09003	0.981
XD-09016	0.167

Example 4: CCR2 siRNA screening

Dual Dose screening of CCR2 siRNA duplexes

Human monocytic THP-1 cells were cultured and maintained in 96-well plates at a density of 25,000 cells per well. THP-1 monocytes were transfected with CCR2 siRNA duplexes (Table 12) using Lipofectomine® 2000 (0.5µl/well). The CCR2 siRNAs were transfected at a final concentration of 0.2 nM and 20 nM, respectively. An anti-Aha1 siRNA (XD-00033) was transfected as a positive control. Two scramble siRNA sequences (XD-00379 and XD-00385) were used as negative control. Following incubation of 24 hours, the treated cells were harvested and the remaining CCR2 mRNA level was measured (Table 13).

Table 12: CCR2 siRNA duplexes and sequences

Duplex ID	Sense Sequence	SEQ ID NO:	Antisense Sequence	SEQ ID NO:
XD-09027	caAGGAcGcAuuuuccccAGdTsdT	606	CUGGGGAAAUGCGUCCUUGdTsdT	744
XD-09028	aaGGAcGcAuuuuccccAGudTsdT	607	ACUGGGGAAAUGCGUCCUdTsdT	745
XD-09029	ggAcGcAuuuuccccAGuAcdTsdT	608	GuACUGGGGAAAUGCGUCCdTsdT	746
XD-09030	gacGcAuuuuccccaGuAcAdTsdT	609	UGuACUGGGGAAAUGCGUCdTsdT	747
XD-09031	acGcAuuuuccccAguAcAdTsdT	610	AUGuACUGGGGAAAUGCGUdTsdT	748
XD-09032	cgcAuuuuccccAGuAcAucdTsdT	611	GAUGuACUGGGGAAAUGCGdTsdT	749
XD-09033	cauuuuccccAGuAcAuccAdTsdT	612	UGGAUGuACUGGGGAAAUGdTsdT	750
XD-09034	auuuuccccAGuAcauccAcdTsdT	613	GUGGAUGuACUGGGGAAAUDTsdT	751
XD-09035	uuuuccccAGuAcAuccAcAdTsdT	614	UGUGGAUGuACUGGGGAAAdTsdT	752
XD-09036	uccccAGuAcAuccAcAAcdTsdT	615	GUUGGAUGuACUGGGGAdTsdT	753
XD-09037	caGuAcAuccAcAacAuGcdTsdT	616	GcAUGUUGUGGAUGuACUGdTsdT	754
XD-09038	guAcAuccAcAAcauGcuGdTsdT	617	cAGcAUGUUGUGGAUGuACdTsdT	755
XD-09039	acAuccAcAAcAugcuGucdTsdT	618	GAcAGcAUGUUGUGGAUGuGdTsdT	756
XD-09040	auGcuGuccAcAucucGuudTsdT	619	AACGAGAUGUGGAcAGcAuGdTsdT	757
XD-09041	ugcuGuccAcAucucGuucdTsdT	620	GAACGAGAUGUGGAcAGcAdTsdT	758
XD-09042	gcuGuccAcAucucGuucdTsdT	621	AGAACGAGAUGUGGAcAGCdTsdT	759
XD-09043	cuGuccAcAucucguucdTsdT	622	GAGAACGAGAUGUGGAcAGdTsdT	760
XD-09044	guccAcAucucGuucucGGdTsdT	623	CCGAGAACGAGAUGUGGAcCdTsdT	761
XD-09045	uccAcAucucGuucucGGdTsdT	624	ACCGAGAACGAGAUGUGGAdTsdT	762
XD-09046	ccAcAucucGuucucGGuudTsdT	625	AACCGAGAACGAGAUGUGGdTsdT	763

XD-09047	cacAucucGuucucGGuuudTsdT	626	AAACCGAGAACGAGAUGUGdTsdT	764
XD-09048	acAucucGuucucgGuuuAdTsdT	627	uAAACCGAGAACGAGAUGuDtTsdT	765
XD-09049	caucucGuucucGguuuAudTsdT	628	AuAAACCGAGAACGAGAUGdTsdT	766
XD-09050	ucucGuucucGGuuuAucAdTsdT	629	UGAuAAACCGAGAACGAGAdTsdT	767
XD-09051	cucGuucucGGuuuAucAGdTsdT	630	CUGAuAAACCGAGAACGAGdTsdT	768
XD-09052	ucGuucucGGuuuauAGAdTsdT	631	UCUGAuAAACCGAGAACGAdTsdT	769
XD-09053	cguucucGGuuuAucAGAAdTsdT	632	UUCUGAuAAACCGAGAACGdTsdT	770
XD-09054	uucucGGuuuAucaGAAAdTsdT	633	AUUUCUGAuAAACCGAGAAdTsdT	771
XD-09055	ucucGGuuuAucAgAAuAdTsdT	634	uAUUUCUGAuAAACCGAGAdTsdT	772
XD-09056	cucGGuuuAucAGAAuAcdTsdT	635	GuAUUUCUGAuAAACCGAGdTsdT	773
XD-09057	ucGGuuuAucAGAAuAccdTsdT	636	GGuAUUUCUGAuAAACCGAdTsdT	774
XD-09058	uuuAucAGAAuAccAAcGdTsdT	637	CGUUGGuAUUUCUGAuAAAdTsdT	775
XD-09059	agAGcGGuGAAGAAgucAcdTsdT	638	GUGACUUCUcACCGCUCUdTsdT	776
XD-09060	cgGuGAAGAAgucaccAccdTsdT	639	GGUGGUGACUUCUcACCGdTsdT	777
XD-09061	aaGucAccAccuuuuuuGAdTsdT	640	UcAAAAAAGGUGGUGACUdTsdT	778
XD-09062	ucAccAccuuuuuuGAuuAdTsdT	641	uAAUcAAAAAAGGUGGUGAdTsdT	779
XD-09063	caccAccuuuuuuGauuAudTsdT	642	AuAAUcAAAAAAGGUGGUGdTsdT	780
XD-09064	accAccuuuuuuGauuAuGdTsdT	643	cAuAAUcAAAAAAGGUGGUdTsdT	781
XD-09065	uuuuGAuuAuGAuuAcGGudTsdT	644	ACCGuAAUcAuAAUcAAAAdTsdT	782
XD-09066	ugAuAuGAuuAcgGuGcudTsdT	645	AGcACCGuAAUcAuAAUcAdTsdT	783
XD-09067	uuAuGAuuAcGGugcucccdTsdT	646	GGGAGcACCGuAAUcAuAAdTsdT	784
XD-09068	uauGAuuAcGGuGcucccdTsdT	647	AGGGAGcACCGuAAUcAuAdTsdT	785
XD-09069	ugAuAcGGuGcucccuGudTsdT	648	AcAGGGAGcACCGuAAUcAdTsdT	786
XD-09070	gauuAcGGuGcucccuGudTsdT	649	GAcAGGGAGcACCGuAAUCdTsdT	787
XD-09071	auuAcGGuGcucccuGucAdTsdT	650	UGAcAGGGAGcACCGuAAUdTsdT	788
XD-09072	uuAcGGuGcucccuGucAudTsdT	651	AUGAcAGGGAGcACCGuAAdTsdT	789
XD-09073	acGGuGcucccuGucAuAAdTsdT	652	UuAUGAcAGGGAGcACCGUdTsdT	790
XD-09074	guGcucccuGucAuAAAuudTsdT	653	AAUUuAUGAcAGGGAGcACdTsdT	791
XD-09075	ugcucccuGucAuAAAuudTsdT	654	AAAUUuAUGAcAGGGAGcAdTsdT	792
XD-09076	cucccuGucAuAAAuuuGAdTsdT	655	UcAAAUUuAUGAcAGGGAGdTsdT	793
XD-09077	ccuGucAuAAAuuuGAcGudTsdT	656	ACGUcAAAUUuAUGAcAGGdTsdT	794
XD-09078	ugucAuAAAuuuGacGuGAdTsdT	657	UcACGUcAAAUUuAUGAcAdTsdT	795
XD-09079	gucAuAAAuuuGacGuGAAdTsdT	658	UUcACGUcAAAUUuAUGACdTsdT	796
XD-09080	ucAuAAAuuuGacguGAAGdTsdT	659	CUUcACGUcAAAUUuAUGAdTsdT	797
XD-09081	auAAAuuuGAcGugAAGcAdTsdT	660	UGCUUcACGUcAAAUUuAUdTsdT	798
XD-09082	aaauuGAcGuGAAGcAAAdTsdT	661	AUUUGCUUcACGUcAAAUUdTsdT	799
XD-09083	auuuGAcGuGAAGcAAAuudTsdT	662	AAUUUGCUUcACGUcAAAUdTsdT	800
XD-09084	uuuGAcGuGAAGcAAAuGdTsdT	663	cAAUUUGCUUcACGUcAAAdTsdT	801
XD-09085	uuGAcGuGAAGcAAAuGGdTsdT	664	CcAAUUUGCUUcACGUcAAdTsdT	802
XD-09086	ugAcGuGAAGcAAAuGGdTsdT	665	CCcAAUUUGCUUcACGUcAdTsdT	803
XD-09087	gacGuGAAGcAAAuGGGdTsdT	666	CCCcAAUUUGCUUcACGUCdTsdT	804
XD-09088	acGuGAAGcAAAuGGGcdTsdT	667	GCCCCcAAUUUGCUUcACGUdTsdT	805
XD-09089	cguGAAGcAAAuGGGccdTsdT	668	GGCCCCcAAUUUGCUUcACGdTsdT	806
XD-09090	gaAGcAAAuGGGgcccAAdTsdT	669	UUGGGCCCCcAAUUUGCUUCdTsdT	807

XD-09091	aaGcAAAUuGGGgcccAAcdTsdT	670	GUUGGGCCCCcAAUUUGCUUdTsdT	808
XD-09092	agcAAAUuGGGgcccAAcudTsdT	671	AGUUGGGCCCCcAAUUUGCudTsdT	809
XD-09093	gcAAAUuGGGgcccAAcudTsdT	672	GAGUUGGGCCCCcAAUUUGCdTsdT	810
XD-09094	ugcAAAAAGcuGAAGuGcudTsdT	673	AGcACUUCAGCUUUUUGcAdTsdT	811
XD-09095	aaAGcuGAAGuGcuuGAcudTsdT	674	AGUcAAGcACUUCAGCUUUdTsdT	812
XD-09096	ugcuuGAcuGAcAuuuAccdTsdT	675	GGuAAAUGUcAGUcAAGcAdTsdT	813
XD-09097	cuuGAcuGAcAuuuAccuGdTsdT	676	cAGGuAAAUGUcAGUcAAGdTsdT	814
XD-09098	ugcuuuuucuuAuAcucudTsdT	677	AGAGuAAuAAGAAAAAGcAdTsdT	815
XD-09099	uucuuAuAcucucccAuudTsdT	678	AAUGGGAGAGuAAuAAGAAdTsdT	816
XD-09100	cucccAuGuGGGcucAcudTsdT	679	AGUGAGCCcAcAAUGGGAGdTsdT	817
XD-09101	cccAuGuGGGcucAcucudTsdT	680	AGAGUGAGCCcAcAAUGGGdTsdT	818
XD-09102	cacucuGcuGcAAuGAGudTsdT	681	ACUcAUUUGcAGcAGAGUGdTsdT	819
XD-09103	acucuGcuGcAAuGAGuGdTsdT	682	cACUcAUUUGcAGcAGAGUdTsdT	820
XD-09104	aguGGGucuuuGGgAAuGcdTsdT	683	GcAUUCCcAAAGACCcACudTsdT	821
XD-09105	guGGGucuuuGGGaAuGcAdTsdT	684	UGcAUUCCcAAAGACCcACdTsdT	822
XD-09106	ggGucuuuGGGAuGcAAudTsdT	685	AUUGcAUUCCcAAAGACCCdTsdT	823
XD-09107	uuGGGAuGcAAuGuGcAAdTsdT	686	UUGcAcAUUGcAUUCCcAAdTsdT	824
XD-09108	guGcAAAUuAuucacAGGGdTsdT	687	CCCUGUGAAuAAUUUGcACdTsdT	825
XD-09109	cacAGGGcuGuAucAcAucdTsdT	688	GAUGUGAuAcAGCCCUGUGdTsdT	826
XD-09110	acAGGGcuGuAucAcAucGdTsdT	689	CGAUGUGAuAcAGCCCUGUdTsdT	827
XD-09111	caGGGcuGuAucAcAucGGdTsdT	690	CCGAUGUGAuAcAGCCCUGdTsdT	828
XD-09112	agGGcuGuAucAcaucGGdTsdT	691	ACCGAUGUGAuAcAGCCCUDdTsdT	829
XD-09113	ggcuGuAucAcAucGGuAdTsdT	692	uAACCGAUGUGAuAcAGCCdTsdT	830
XD-09114	gcuGuAucAcAucGGuAdTsdT	693	AuAACCGAUGUGAuAcAGCdTsdT	831
XD-09115	cuGuAucAcAucGGuAuudTsdT	694	AAuAACCGAUGUGAuAcAGdTsdT	832
XD-09116	uguAucAcAucGGuAuudTsdT	695	AAAUAACCGAUGUGAuAcAdTsdT	833
XD-09117	guAucAcAucGGuAuudTsdT	696	AAAAuAACCGAUGUGAuACdTsdT	834
XD-09118	uauAcAucGGuauuuGdTsdT	697	cAAAAuAACCGAUGUGAuAdTsdT	835
XD-09119	ucAcAucGGuAuuuGGcdTsdT	698	GCCAAAAuAACCGAUGUGAdTsdT	836
XD-09120	acAucGGuAuuuGGcGGdTsdT	699	CCGCcAAAAuAACCGAUGUdTsdT	837
XD-09121	caucGGuAuuuGGcGGAdTsdT	700	UCCGCcAAAAuAACCGAUGdTsdT	838
XD-09122	aucGGuAuuuGGcGGAdTsdT	701	UCCGCcAAAAuAACCGAUdTsdT	839
XD-09123	ucGGuAuuuGGcGGAdTsdT	702	AUCCGCcAAAAuAACCGAdTsdT	840
XD-09124	cgGuuAuuuGGcgGAucdTsdT	703	GAUUCGCcAAAAuAACCGdTsdT	841
XD-09125	guuAuuuGGcGGaAucudTsdT	704	AAGAUUCCGCcAAAAuAACdTsdT	842
XD-09126	uuAuuuGGcGGAaucuudTsdT	705	GAAGAUUCCGCcAAAAuAAdTsdT	843
XD-09127	uauuuGGcGGAaucuudTsdT	706	AGAAGAUUCCGCcAAAAuAdTsdT	844
XD-09128	auuuGGcGGAaucuudTsdT	707	AAGAAGAUUCCGCcAAAAuAdTsdT	845
XD-09129	uuuuGGcGGAaucuudTsdT	708	GAAGAAGAUUCCGCcAAAAuAdTsdT	846
XD-09130	uuuGGcGGAaucuucAdTsdT	709	UGAAGAAGAUUCCGCcAAAdTsdT	847
XD-09131	aaGuGuGAucAccuGGuGdTsdT	710	cAACcAGGUGAUcAcACUdTsdT	848
XD-09132	uguGAucAccuGGuGGuGdTsdT	711	cACcAACcAGGUGAUcAcAdTsdT	849
XD-09133	guGAucAccuGGuGGuGdTsdT	712	CcACcAACcAGGUGAUcACdTsdT	850
XD-09134	ugAucAccuGGuGGuGdTsdT	713	GCcACcAACcAGGUGAUcAdTsdT	851

XD-09135	ucAccuGGuuGGuGcuGudTsdT	714	AcAGCcACcAACcAGGUGAdTsdT	852
XD-09136	caccuGGuuGGuGcuGuGdTsdT	715	cAcAGCcACcAACcAGGUGdTsdT	853
XD-09137	agGAuucAucuuuacuAAAdTsdT	716	UUuAGuAAAGAUGAUUCCUdTsdT	854
XD-09138	ucAucuuuAuuAAauGccAdTsdT	717	UGGcAUUuAGuAAAGAUGAdTsdT	855
XD-09139	gaAGAuucGuuuauGucudTsdT	718	AGAcAuAAAcAGAAUCUUCdTsdT	856
XD-09140	cuGuGGccuuAuuuuccAdTsdT	719	UGGAAAAuAAGGGCcAcAGdTsdT	857
XD-09141	ugGccuuAuuuuccAcGAdTsdT	720	UCGUGGAAAAuAAGGGCcAdTsdT	858
XD-09142	ggccuuAuuuuccAcGAGdTsdT	721	CUCGUGGAAAAuAAGGGCCdTsdT	859
XD-09143	gcccuuAuuuuccacGAGdTsdT	722	CCUCGUGGAAAAuAAGGGCdTsdT	860
XD-09144	cuuAuuuuccAcGaGGAuGdTsdT	723	cAUCCUCGUGGAAAAuAAGdTsdT	861
XD-09145	uuAuuuuccAcGAGGAuGGdTsdT	724	CcAUCCUCGUGGAAAAuAAdTsdT	862
XD-09146	uauuuuccAcGAGGAuGGAdTsdT	725	UCcAUCCUCGUGGAAAAuAdTsdT	863
XD-09147	uuuccAcGAGGAuGGAuAdTsdT	726	uAUUCcAUCCUCGUGGAAAdTsdT	864
XD-09148	uuccAcGAGGAuGGAuAAdTsdT	727	UuAUUCcAUCCUCGUGGAAAdTsdT	865
XD-09149	uccAcGAGGAuGGAuAAuAdTsdT	728	AUuAUUCcAUCCUCGUGGAdTsdT	866
XD-09150	cacGAGGAuGGAuAAuuuAdTsdT	729	AAAUuAUUCcAUCCUCGUGdTsdT	867
XD-09151	auuuuccAcAcAAuAAuGAdTsdT	730	UcAUuAUUGUGUGGAAAUdTsdT	868
XD-09152	uuuccAcAcAAuAAuGAGdTsdT	731	CCUcAUuAUUGUGUGGAAAdTsdT	869
XD-09153	cacAcAAuAAuGAGGAAdTsdT	732	UGUUCcAUuAUUGUGUGdTsdT	870
XD-09154	uaAuGAGGAuGGAuGGdTsdT	733	CCcAAAAUGUUCcAUuAdTsdT	871
XD-09155	aacAuuuuGGGcuGGuccdTsdT	734	GGACcAGCCcAAAAUGUdTsdT	872
XD-09156	gccGcuGcuAucuuGGdTsdT	735	GACcAUGAUGAGcAGCGGcdTsdT	873
XD-09157	auuucuuGGccuGGAuAdTsdT	736	UuACUcAGGCCGAAGAAUdTsdT	874
XD-09158	auucuuGGccuGAuAAdTsdT	737	GUuACUcAGGCCGAAGAAUdTsdT	875
XD-09159	uuucuuGGccuGAGuAAdTsdT	738	AGUuACUcAGGCCGAAGAAAdTsdT	876
XD-09160	uucGGccuGAGuAAdTsdT	739	cAcAGUuACUcAGGCCGAAdTsdT	877
XD-09161	ugAGuAAGuGAaAGcAdTsdT	740	GUGCUUUCcAGUuACUcAdTsdT	878
XD-09162	caccAGuAAGuGAGcAdTsdT	741	UUGGUCcAGUUGACUGGUGdTsdT	879
XD-09163	caAuuGGAccAAGccAcGdTsdT	742	GCGUGGCUUGGUCcAGUUGdTsdT	880
XD-09164	aacuGGAccAAGccAcGAdTsdT	743	UGCGUGGCUUGGUCcAGUdTsdT	881

Table 13: CCR2 mRNA expression level after siRNA treatment

SiRNA Duplex ID	Remaining CCR2 mRNA (20 nM)	SD	Remaining CCR2 mRNA (0.2 nM)	SD
XD-09127	0.133	0.012	0.988	0.067
XD-09117	0.150	0.057	0.990	0.136
XD-09098	0.151	0.031	0.715	0.114
XD-09138	0.152	0.022	1.039	0.046
XD-09121	0.156	0.052	1.087	0.272
XD-09062	0.160	0.019	1.487	0.132
XD-09113	0.178	0.024	0.929	0.104
XD-09050	0.198	0.011	1.271	0.081

XD-09048	0.202	0.009	1.230	0.069
XD-09043	0.202	0.011	1.200	0.286
XD-09094	0.203	0.027	0.902	0.162
XD-09086	0.204	0.006	0.952	0.056
XD-09060	0.245	0.046	1.295	0.176
XD-09143	0.257	0.028	1.047	0.074
XD-09095	0.258	0.034	0.843	0.158
XD-09107	0.267	0.024	0.951	0.076
XD-09045	0.278	0.039	1.042	0.115
XD-09149	0.281	0.031	1.055	0.031
XD-09115	0.283	0.012	1.028	0.076
XD-09112	0.289	0.067	0.964	0.138
XD-09147	0.289	0.045	1.001	0.073
XD-09154	0.291	0.049	0.472	0.060
XD-09065	0.306	0.015	1.084	0.168
XD-09146	0.311	0.028	0.979	0.065
XD-09123	0.315	0.121	1.201	0.312
XD-09047	0.320	0.035	1.091	0.147
XD-09125	0.332	0.117	0.750	0.034
XD-09109	0.367	0.037	0.999	0.106
XD-09046	0.370	0.072	1.011	0.103
XD-09044	0.371	0.018	1.187	0.185
XD-09053	0.375	0.071	1.384	0.152
XD-09088	0.379	0.030	0.923	0.076
XD-09139	0.404	0.044	0.980	0.073
XD-09137	0.425	0.051	1.031	0.052
XD-09041	0.443	0.036	1.159	0.233
XD-09055	0.459	0.123	1.159	0.145
XD-09051	0.476	0.049	1.380	0.108
XD-09158	0.483	0.029	0.930	0.116
XD-09027	0.486	0.048	0.980	0.102
XD-09090	0.490	0.012	0.953	0.171
XD-09059	0.494	0.063	1.200	0.186
XD-09052	0.497	0.046	1.392	0.020
XD-09054	0.503	0.071	1.078	0.116
XD-09039	0.512	0.045	1.200	0.180
XD-09161	0.514	0.045	0.816	0.214
XD-09159	0.522	0.049	0.762	0.134
XD-09153	0.541	0.078	0.745	0.085
XD-09130	0.548	0.024	0.770	0.052
XD-09141	0.550	0.064	0.964	0.097
XD-09135	0.551	0.087	0.980	0.104

XD-09049	0.552	0.055	1.320	0.160
XD-09096	0.554	0.055	0.776	0.084
XD-09157	0.556	0.063	0.807	0.197
XD-09036	0.557	0.024	1.067	0.155
XD-09114	0.558	0.076	0.939	0.129
XD-09030	0.559	0.034	1.113	0.172
XD-09035	0.567	0.038	1.127	0.177
XD-09108	0.569	0.093	1.090	0.147
XD-09152	0.576	0.077	1.020	0.072
XD-09101	0.609	0.050	0.945	0.029
XD-09118	0.615	0.262	1.081	0.285
XD-09061	0.620	0.060	1.432	0.132
XD-09140	0.626	0.077	0.951	0.085
XD-09126	0.628	0.082	0.965	0.104
XD-09124	0.631	0.229	0.914	0.177
XD-09028	0.631	0.041	1.100	0.123
XD-09156	0.638	0.086	0.814	0.129
XD-09129	0.657	0.039	0.930	0.137
XD-09150	0.658	0.118	1.020	0.072
XD-09080	0.672	0.025	0.795	0.082
XD-09082	0.672	0.076	0.893	0.073
XD-09122	0.673	0.221	1.062	0.288
XD-09042	0.697	0.060	1.228	0.279
XD-09075	0.705	0.042	1.022	0.040
XD-09164	0.713	0.110	0.659	0.116
XD-09128	0.714	0.081	0.924	0.035
XD-09120	0.716	0.239	1.000	0.210
XD-09163	0.721	0.023	0.756	0.112
XD-09058	0.725	0.096	1.190	0.251
XD-09162	0.737	0.038	0.802	0.111
XD-09116	0.738	0.021	0.969	0.134
XD-09151	0.739	0.056	1.006	0.105
XD-09099	0.742	0.070	1.021	0.046
XD-09105	0.751	0.079	0.895	0.043
XD-09056	0.756	0.232	1.203	0.091
XD-09089	0.765	0.057	0.810	0.078
XD-09110	0.768	0.039	1.071	0.034
XD-09111	0.771	0.096	1.007	0.067
XD-09155	0.772	0.151	1.077	0.267
XD-09160	0.781	0.059	0.983	0.131
XD-09057	0.785	0.158	1.161	0.144
XD-09142	0.787	0.067	0.968	0.039

XD-09145	0.792	0.123	0.878	0.135
XD-09091	0.793	0.156	0.894	0.110
XD-09144	0.797	0.115	0.958	0.078
XD-09119	0.801	0.269	1.095	0.292
XD-09066	0.801	0.053	0.941	0.146
XD-09148	0.804	0.112	1.061	0.102
XD-09081	0.830	0.076	0.893	0.060
XD-09063	0.831	0.105	1.172	0.413
XD-09072	0.841	0.050	0.982	0.123
XD-09033	0.843	0.045	1.072	0.194
XD-09106	0.850	0.100	0.940	0.101
XD-09136	0.855	0.079	0.937	0.113
XD-09087	0.858	0.103	0.878	0.109
XD-09038	0.860	0.020	1.118	0.213
XD-09131	0.862	0.086	0.791	0.172
XD-09037	0.865	0.071	1.062	0.218
XD-09134	0.869	0.118	0.762	0.140
XD-09040	0.883	0.043	1.275	0.273
XD-09100	0.888	0.117	0.930	0.068
XD-09079	0.890	0.040	0.765	0.136
XD-09102	0.901	0.144	0.937	0.123
XD-09032	0.904	0.057	1.036	0.098
XD-09031	0.905	0.048	1.152	0.167
XD-09132	0.911	0.064	0.818	0.056
XD-09076	0.917	0.028	1.040	0.198
XD-09092	0.925	0.093	0.968	0.166
XD-09074	0.937	0.046	0.941	0.172
XD-09085	0.939	0.017	0.925	0.047
XD-09083	0.954	0.098	0.938	0.043
XD-09078	0.962	0.043	0.919	0.144
XD-09073	0.963	0.045	0.905	0.101
XD-09071	0.969	0.085	0.896	0.195
XD-09029	0.972	0.070	1.051	0.101
XD-09084	0.973	0.069	0.869	0.059
XD-09064	0.984	0.054	1.060	0.120
XD-09133	0.987	0.030	0.951	0.170
XD-09103	1.003	0.092	0.946	0.105
XD-09097	1.010	0.140	0.727	0.128
XD-09104	1.014	0.109	0.877	0.072
XD-09034	1.031	0.117	1.186	0.116
XD-09093	1.046	0.130	0.810	0.134
XD-09067	1.058	0.147	1.016	0.127

XD-09069	1.081	0.018	0.886	0.149
XD-09070	1.089	0.064	0.860	0.160
XD-09068	1.102	0.054	0.918	0.138
XD-09077	1.153	0.121	0.943	0.112
XD-00379 (Negative Control)	0.851	0.034	1.020	0.207
XD-00385(Negative control)	0.891	0.095	0.863	0.068
XD-00033 (Aha-1; positive control)	0.186	0.044	0.678	0.067

Dose response of selected CCR2 siRNA duplexes

CCR2 siRNA duplexes that caused a significant reduction of CCR2 mRNA level in the dual dose screening were selected and further tested for the dose response. Human monocyctic THP-1 cells were cultured and maintained in 96-well plates at a density of 25,000 cells per well. THP-1 monocytes were transfected with CCR2 siRNA duplexes selected from the previous dual dose screening at various concentrations using Lipofectomine® 2000 (0.5 µl/well). The doses for each CCR2 siRNA duplex included 50.0 nM, 10.0 nM, 2.0 nM, 0.4 nM, 0.8×10^{-1} nM, 1.6×10^{-2} nM, 3.2×10^{-3} nM, 6.4×10^{-4} nM, 1.28×10^{-4} nM, and 2.6×10^{-5} nM. Following incubation of 24 hours, the treated cells were harvested and the remaining CCR2 mRNA level was measured in each condition. The IC₅₀ value for each CCR2 siRNA duplex was determined as shown in Table 14 and each dose response is shown in Figure 1B.

Table 14: IC₅₀ of CCR2 siRNA duplexes

siRNA Duplex ID	IC ₅₀ (nM)
XD-09048	0.17046435
XD-09050	0.11069267
XD-09062	0.38493077
XD-09086	0.2956292
XD-09094	0.27921953
XD-09098	0.01619127
XD-09113	0.70462092
XD-09117	0.13414519
XD-09121	0.20361795
XD-09127	0.15636242
XD-09138	0.23593031
XD-09154	3.37845447

Example 5: Dual dose screening of CSF1R siRNA duplexes and variants

siRNA modification variants derived from siRNA duplexes with high efficiency and specificity to CSF1R mRNA knock-down were designed by sequence and chemical modifications and the resulting duplex variants were further tested in Hepa 1-6 cells. Hepa 1-6 cells derived from mouse hepatoma were cultured with the standard culture condition and maintained in 96-well plates at a density of 15,000 cells per well. Hepa 1-6 cells were transfected with CSF1R siRNA duplexes and variants using Lipofectomine® 2000 (0.5 µl/well). A total of 59 CSF1R siRNA duplexes including variants from the original modified siRNA duplexes were introduced into Hepa 1-6 cells and further validated (Table 15). The CSF1R siRNAs were transfected at a final concentration of 0.2 nM and 20 nM, respectively. An anti R-Luc siRNA duplex (XD-00379) and a scramble RNA duplex (XD-00194) were used as positive and negative control, respectively. The information and sequences of these siRNA duplexes are shown in Table 15.

Table 15. CSF1R siRNA duplexes and variants

Position	Duplex-ID	SS ID	Sense Sequence	SEQ ID NO	AS ID	Antisense Sequence	SEQ ID NO
948	XD-08917	X28782	cuGcccAGAUcGuguGcudTsdT	382	X28783	GAGcAcACGAUCUGGGcAGdTsdT	501
1056	XD-08922	X28792	accGuuAccAAAAaGuccudTsdT	387	X28793	AGGACUUUUUGGuAACGGUdTsdT	506
1060	XD-08923	X28794	uuAccAAAAAGuccuGAccdTsdT	388	X28795	GGUcAGGACUUUUUGGuAAdTsdT	507
1717	XD-08936	X28820	gaccuuAGAGcAcaAccAAdTsdT	401	X28821	UUGGUUGUGCUCuAAGGUCdTsdT	520
3049	XD-08944	X28836	uccGcuGGAAGAUcAucGAdTsdT	409	X28837	UCGAUGAUCUUCcA GCGGAdTsdT	528
1935	XD-08947	X28842	caucGAGAGcuAugAGGGcdTsdT	431	X28843	GCCCUcAuAGCUCUCGAUGdTsdT	531
2276	XD-08963	X28872	aucAcGGAGuAcuguuGcudTsdT	428	X28873	AGcAAcAGuACUCCGUGAUdTsdT	547
2295	XD-08969	X28884	auGGcGAccuGcucAAcuudTsdT	434	X28885	AAGUUGAGcAGGUCGCcAUdTsdT	553
2600	XD-08975	X28896	gcuuccAAGAAuugcAuccdTsdT	440	X28897	GGAUGcAAUUCUUGGAAGCdTsdT	559
2781	XD-08982	X28910	guGucuAcAcGGuucAGAGdTsdT	447	X28911	CUCUGAACCGUGuAGAcACdTsdT	566
2791	XD-08985	X28916	gguucAGAGcGAcgucuGGdTsdT	450	X28917	CcAGACGUCGCUCUGAACcdTsdT	569
2793	XD-08986	X28918	uucAGAGcGAcGucuGGudTsdT	451	X28919	GACcAGACGUCGUCUGAAAdTsdT	570
2874	XD-08988	X28922	ugAAcAGcAAGuucuuAAdTsdT	453	X28923	UuAuAGAACUUGCUGUUCAdTsdT	572
2880	XD-08989	X28924	gcAAGuucuAuAAacuGGudTsdT	454	X28925	ACcAGUuAuAGAA CUUGCdTsdT	573

1948	XD-08993	X28932	agAGcGGGAcuAua ccAAudTsdT	458	X28933	AUUGGuAuAGUCCC GCUCUdTsdT	577
3292	XD-09003	X28952	acAAAcucuGccuuc GGucdTsdT	468	X28953	GACCGAAGGcAGA GUUUGUdTsdT	587
3305	XD-09006	X28958	ucGGucAuucAcuc AAcAdTsdT	471	X28959	UGUUGAGUGAAAU GACCGAdTsdT	590
3916	XD-09015	X28976	cuGAcucAuccuAac uAAcdTsdT	480	X28977	GUuAGUuAGGAUGA GUcAGdTsdT	599
3917	XD-09016	X28978	ugAcucAuccuAAcu AAcAdTsdT	481	X28979	UGUuAGUuAGGAUG AGUcAdTsdT	600
3959	XD-09021	X28988	ccAcAuAAAcuAa cAGcAdTsdT	486	X28989	UGCUGUuAGUuAA UGUGGdTsdT	605
1935_ var1	XD-10343	X32298	ucCGcuGGAaGAuc AuCgsa	883	X32372	dTCGAUGAUCUUCc AGCGGAusu	922
1948_ var1	XD-10344	X32299	caUcGAGAGcuAug AGGgsa	884	X32373	dTCCCUcAuAGCUcU CGAUGusu	923
2874_ var1	XD-10345	X32300	ugAAcAGCAaGUu cuAUasa	885	X32374	dTUuAuAGAACUUGc UGUUCusu	924
3049_ var1	XD-10346	X32301	agAGcGGGAcuAua ccAasa	886	X32375	dTUUGGuAuAGUCcC GCUCUusu	925
3917_ var1	XD-10347	X32302	ugAcucAUCcuAAc uAAcsa	887	X32376	dTGUuAGUuAGGAu GAGUCusu	926
1935_ var2	XD-10348	X32303	uccGcuGGAaGAuc Aucgsa	888	X32372	dTCGAUGAUCUUCc AGCGGAusu	927
1948_ var2	XD-10349	X32304	caucGAGAGcuAug AGGgsa	889	X32373	dTCCCUcAuAGCUcU CGAUGusu	928
2874_ var2	XD-10350	X32305	ugAAcAGcAaGuuc uAuasa	890	X32374	dTUuAuAGAACUUGc UGUUCusu	929
3049_ var2	XD-10351	X32301	agAGcGGGAcuAua ccAasa	891	X32377	dTUUGGuAuAGUCcC gCUCUusu	930
3917_ var2	XD-10352	X32306	ugAcucAuccuAAcu AAcsa	892	X32376	dTGUuAGUuAGGAu GAGUCusu	931
1935_ var3	XD-10353	X32307	ucCGcuGGAaGAuc AuCga(C6)	893	X32378	UCGAUGAUCUUCcA GCGGAusu	932
1948_ var3	XD-10354	X32308	caUcGAGAGcuAug AGGga(C6)	894	X32379	UCCCUcAuAGCUcU CGAUGusu	933
2874_ var3	XD-10355	X32309	ugAAcAGCAaGUu cuAUaa(C6)	895	X32380	UUuAuAGAACUUGcU GUUCusu	934
3049_ var3	XD-10356	X32310	agAGcGGGAcuAua ccAaa(C6)	896	X32381	UUUGGuAuAGUCcC GCUCUusu	935
3917_ var3	XD-10357	X32311	ugAcucAUCcuAAc uAAca(C6)	897	X32382	UGUuAGUuAGGAuG AGUCusu	936
948_ var1	XD-10358	X32312	cuGcccAGAucGugu GCusa	898	X32383	dTAGcAcACGAUCuG GGcAGusu	937
1056_ var1	XD-10359	X32313	acCGuuACCaAAA aGuCcsa	899	X32384	dTGGACUUUUUGGu AACGGUusu	938
1060_ var1	XD-10360	X32314	uuAccAAAAaGUcc uGAcsa	900	X32385	dTGUCAGGACUUUu UGGuAusu	939
1717_ var1	XD-10361	X32315	gaCcuuAGAgcAca AcCasa	901	X32386	dTUGGUUGUGCUCu AAGGUCusu	940
2276_ var1	XD-10362	X32316	auCAcGGAGuACu guuGcsa	902	X32387	dTGcAAcAGuACUC GUGAUusu	941
2295_ var1	XD-10363	X32317	auGGcGACCuGCu cAACusa	903	X32388	dTAGUUGAGcAGGu CGCcAUusu	942
2600_ var1	XD-10364	X32318	gcUuccAAGaAUug cAUcsa	904	X32389	dTGAUGcAAUUCUu GGAAGCusu	943
2781_ var1	XD-10365	X32319	guGucuACAcGGuu cAGasa	905	X32390	dTUCUGAACCGUGu AGAcACusu	944

2791_ var1	XD- 10366	X32320	ggUucAGAGcGAc gucUgsa	906	X32391	dTCAGACGUCGCuc UGAACcusu	945
2793_ var1	XD- 10367	X32321	uuCAGAGCGacGu cuGGusa	907	X32392	dTACcAGACGUCGc UCUGAAusu	946
2880_ var1	XD- 10368	X32322	gcAAGuUCUauAA acuGsa	908	X32393	dTCcAGUuAuAGaA CUUGCusu	947
3292_ var1	XD- 10369	X32323	acAAAcUCUgcCuu cGGusa	909	X32394	dTACCGAAGGcAGa GUUUGUusu	948
3305_ var1	XD- 10370	X32324	ucGGucAUUucAcu cAAcsa	910	X32395	dTGUUGAGUGAAAu GACCGAusu	949
3916_ var1	XD- 10371	X32325	cuGAcuCAUccUAa cuAasa	911	X32396	dTUuAGUuAGGAUg AGUcAGusu	950
3959_ var1	XD- 10372	X32326	ccAcAuUAAacUAa cAGcsa	912	X32397	dTGCUGUuAGUuua AUGUGGusu	951
973_ var1	XD- 10373	X32327	caGcGuUGAuGUua AcUusa	913	X32398	dTAAGUuAAcAUcaA CGCUGusu	952
1087_ var1	XD- 10374	X32328	cgAucAAGUaGAu uucCasa	914	X32399	dTUGGAAAUcCuAcu UGAUCGusu	953
1941_ var1	XD- 10375	X32329	ggAAGAUCaucG AgAGCusa	915	X32400	dTAGCUCUCGAUGa UCUUCcusu	954
1964_ var1	XD- 10376	X32330	ggCAAcAGUuAU AcuuUcsa	916	X32401	dTGAAAGuAuAACu GUUGCCusu	955
2689_ var1	XD- 10377	X32331	ggCuAGGGAcAUc auGAasa	917	X32402	dTUUcAUGAUGUCc CuAGCCusu	956
2896_ var1	XD- 10378	X32332	ggUGAAGGAuGG AuAcCasa	918	X32403	dTUGGuAUCcAUCcU UcACCusu	957
3527_ var1	XD- 10379	X32333	ggAAAUcGAcuGA cuuUasa	919	X32404	dTUAAGUcAGUCc AUUUCcusu	958
3911_ var1	XD- 10380	X32334	ccAAGcUGAcuCA uccUasa	920	X32405	dTUAGGAUGAGUca GCUUGGusu	959
3962_ var1	XD- 10381	X32335	caUuAAACUaACA gcAUusa	921	X32406	dTAAUGCUGUuAGu UuAAUGusu	960

After incubating for 24 hours, the treated cells were harvested and the remaining CSF1R mRNA level was measured in each condition and ranked. The remaining CSF1R mRNA level after the 24 hours treatment with each siRNA duplex is listed in Table 16.

- 5 Among the 59 duplexes tested, 5 siRNAs and the variants thereof that have the most reduced CSF1R mRNA level were selected, including duplex XD-08944 and its variants, XD-10343, XD-10348 and XD-10353; duplex XD-08947 and its variants, XD-10344, XD-10349 and XD-10354; duplex XD-08988 and its variants, XD-10345, XD-10350 and XD-10355; duplex XD-08993 and its variants, XD-10346, XD-10351 and XD-10356; and
- 10 duplex XD-09016 and its variants, XD-10347, XD-10352 and XD-10357. The top 20 siRNAs and their modification variants were also ranked, including XD-08927 and its variant XD-10358; XD-08922 and its variant XD-10359; XD-08923 and its variant XD-10360; XD-08936 and its variant XD-10361; XD-08963 and its variant XD-10362; XD-08969 and its variant XD-10363; XD-08975 and its variant XD-10364; XD-08982 and its
- 15 variant XD-10365; XD-08985 and its variant XD-10366; XD-08986 and its variant XD-10367; XD-08989 and its variant XD-10368; XD-09003 and its variant XD-10369; XD-

09006 and its variant XD-10370; XD-09015 and its variant XD-10371; and XD-09021 and its variant XD-10372 (Table 16). The data also indicate several other siRNA modifications that result in significant reduction of expression, such as XD-10373, XD-10374, XD-10375, XD-10376, XD-10377, XD-10378, XD-10379, XD-10380, and XD-10381.

5

Table 16. CSF1R mRNA expression after siRNA treatment

Duplex ID	Remaining mRNA (20 nM siRNA)	SD	Remaining mRNA (0.2 nM siRNA)	SD
XD-08944	0.136	0.009	0.244	0.028
XD-10343	0.128	0.007	0.207	0.011
XD-10348	0.145	0.015	0.210	0.007
XD-10353	0.130	0.006	0.269	0.017
XD-08947	0.256	0.012	0.655	0.042
XD-10344	0.231	0.006	0.387	0.028
XD-10349	0.233	0.013	0.380	0.028
XD-10354	0.259	0.019	0.413	0.036
XD-08988	0.162	0.009	0.275	0.009
XD-10345	0.122	0.009	0.161	0.010
XD-10350	0.109	0.007	0.181	0.014
XD-10355	0.112	0.009	0.196	0.013
XD-08993	0.218	0.009	0.403	0.039
XD-10346	0.193	0.011	0.359	0.016
XD-10351	0.233	0.009	0.327	0.016
XD-10356	0.198	0.006	0.369	0.023
XD-09016	0.118	0.007	0.180	0.009
XD-10347	0.110	0.008	0.172	0.007
XD-10352	0.117	0.005	0.181	0.014
XD-10357	0.103	0.010	0.174	0.013
XD-08917	0.120	0.008	0.392	0.003
XD-10358	0.132	0.007	0.194	0.010
XD-08922	0.100	0.005	0.202	0.017
XD-10359	0.078	0.005	0.154	0.023
XD-08923	0.072	0.010	0.236	0.021
XD-10360	0.068	0.002	0.149	0.019
XD-08936	0.131	0.002	0.332	0.030
XD-10361	0.119	0.006	0.290	0.033
XD-08963	0.186	0.006	0.465	0.041
XD-10362	0.207	0.009	0.432	0.044
XD-08969	0.279	0.022	0.465	0.055
XD-10363	0.166	0.006	0.378	0.038

XD-08975	0.167	0.013	0.582	0.036
XD-10364	0.140	0.011	0.352	0.045
XD-08982	0.221	0.026	0.494	0.035
XD-10365	0.166	0.013	0.400	0.024
XD-08985	0.286	0.008	0.784	0.041
XD-10366	0.196	0.017	0.543	0.063
XD-08986	0.195	0.021	0.376	0.019
XD-10367	0.192	0.014	0.284	0.030
XD-08989	0.250	0.025	0.751	0.032
XD-10368	0.206	0.019	0.545	0.045
XD-09003	0.197	0.018	0.591	0.014
XD-10369	0.131	0.014	0.238	0.015
XD-09006	0.146	0.006	0.321	0.030
XD-10370	0.074	0.003	0.214	0.015
XD-09015	0.251	0.012	0.459	0.069
XD-10371	0.159	0.015	0.194	0.009
XD-09021	0.117	0.008	0.224	0.035
XD-10372	0.117	0.006	0.147	0.020
XD-10373	0.042	0.005	0.095	0.020
XD-10374	0.061	0.002	0.111	0.012
XD-10375	0.073	0.007	0.284	0.036
XD-10376	0.202	0.010	0.362	0.036
XD-10377	0.644	0.037	0.571	0.046
XD-10378	0.212	0.008	0.378	0.048
XD-10379	0.077	0.004	0.175	0.013
XD-10380	0.126	0.014	0.191	0.020
XD-10381	0.094	0.005	0.166	0.021
XD-00194 (negative control)	0.965	0.117	0.980	0.048
XD-00379 (<i>Renilla</i> Luciferase control)	0.009	0.003	0.069	0.009

Dose response of selected CSF1R siRNA duplexes and variants

CSF1R siRNA duplexes and variants that caused a significant reduction of CSF1R mRNA level in the dual dose screening were selected and further tested for dose responses.

- Hepa 1-6 cells were cultured and maintained in 96-well plates at a density of 15,000 cells per well. Hepa 1-6 cells were transfected with CSF1R siRNA duplexes and variants selected from the previous dual dose screening at various concentrations using Lipofectomine® 2000 (0.5 µl/well). The doses for each CSF1R siRNA duplex included 50

nM, 10 nM, 2.0 nM, 0.40 nM, 0.08 nM, 1.6×10^{-2} nM, 3.2×10^{-3} nM, 6.4×10^{-4} nM, 1.28×10^{-4} nM, and 2.6×10^{-5} nM. Following incubation of 24 hours, the treated cells were harvested and the remaining CSF1R mRNA level was measured in each condition. The IC_{50} and IC_{80} values of each CSF1R duplex was determined (shown in Table 17) and each dose response curve is shown in Figure 1C.

Table 17. IC_{50} and IC_{80} of CSF1R siRNA duplexes

siRNA Duplex ID	IC_{50} (nM)	IC_{80} (nM)	Maximal KD
XD-10373	0.01566477	0.10114948	95%
XD-10381	0.02151724	0.26504219	88%
XD-09016	0.04774574	0.52067604	87%
XD-10347	0.02366698	0.25339097	87%
XD-10357	0.03270323	0.30401297	96%
XD-10345	0.03142479	0.42640625	87%
XD-10350	0.02893749	0.29063486	86%
XD-10359	0.03676781	0.21262353	91%
XD-10360	0.03227182	0.2567045	92%
XD-10371	0.03299214	0.4377136	84%
XD-09021	0.04241552	0.34612646	87%
XD-10372	0.01809142	0.21942896	87%

Example 6: Dual response screening of CCR2 siRNA duplexes and variants

siRNA modification variants derived from siRNA duplexes with high efficiency and specificity to CCR2 mRNA knock-down were designed according to sequence and chemical modifications and the resulting duplex variants were further tested in Hepa 1-6 cell. Hepa 1-6 cells were cultured using the standard culture condition and maintained in 96-well plates at a density of 15,000 cells per well. Hepa 1-6 cells were transfected with CCR2 siRNA duplexes using Lipofectomine® 2000 (0.5 μ l/well). A total of 61 siRNA duplexes, including variants from the original modified siRNA duplexes, were transfected into Hepa 1-6 cells and further validated (Table 18). The CCR2 siRNAs were transfected at a final concentration of 0.2 nM and 20 nM, respectively. An anti R-Luc siRNA duplex (XD-00379) and a scramble RNA duplex (XD-00194) were used as positive and negative control, respectively. After incubating for 24 hours, the treated cells were harvested and the remaining CCR2 mRNA level was measured and ranked. The information and sequences of these siRNA duplexes are included in Table 18.

Table 18. CCR2 siRNA duplexes and variants

Position	Duplex-ID	SS ID	Sense Sequence	SEQ ID NO	AS ID	Antisense Sequence	SEQ ID NO
489	XD-09043	X29044	cuGuccAcAucucguuc ucdTsdT	622	X29045	GAGAACGAGAUG UGGAcAGdTsdT	760
492	XD-09045	X29048	uccAcAucucGuucuc GGudTsdT	624	X29049	ACCGAGAACGAGA UGUGGAdTsdT	762
495	XD-09048	X29054	acAucucGuucucgGu uuAdTsdT	627	X29055	uAAACCGAGAACG AGAUGuAdTsdT	765
498	XD-09050	X29058	ucucGuucucGGuuuA ucAdTsdT	629	X29059	UGAuAAACCGAGA ACGAGAdTsdT	767
533	XD-09060	X29078	cgGuGAAGAAGuca ccAccdTsdT	639	X29079	GGUGGUGACUUC UUCACCGdTsdT	777
544	XD-09062	X29082	ucAccAccuuuuuuGA uuAdTsdT	641	X29083	uAAUcAAAAAAGG UGGUGAdTsdT	779
590	XD-09086	X29130	ugAcGuGAAGcAAa uuGGGdTsdT	665	X29131	CCcAAUUUGCUUc ACGUcAdTsdT	803
693	XD-09094	X29146	ugcAAAAAGcuGAa GuGcudTsdT	673	X29147	AGcACUUCAGCUU UUUGcAdTsdT	811
698	XD-09095	X29148	aaAGcuGAAGuGcu uGAcudTsdT	674	X29149	AGUcAAGcACUUCa GCUUuAdTsdT	812
751	XD-09098	X29154	ugcuuuuucuuAuAcu cudTsdT	677	X29155	AGAGuAAuAAGAA AAAGcAdTsdT	815
808	XD-09107	X29172	uuGGGAuGcAAug uGcAAdTsdT	686	X29173	UUGcAcAUUGcAU UCCcAAdTsdT	824
838	XD-09113	X29184	ggcuGuAucAcAucG GuuAdTsdT	692	X29185	uAACCGAUGUGAu AcAGCCdTsdT	830
840	XD-09115	X29188	cuGuAucAcAucGgu uAuudTsdT	694	X29189	AAuAACCGAUGUG AuAcAGdTsdT	832
842	XD-09117	X29192	guAucAcAucGGuuA uuuudTsdT	696	X29193	AAAuAACCGAUG UGAuACdTsdT	834
848	XD-09121	X29200	caucGGuuAuuuugGc GGAdTsdT	700	X29201	UCCGCcAAAAuAA CCGAUGdTsdT	838
855	XD-09127	X29212	uauuuuGGcGGAAuc uucudTsdT	706	X29213	AGAAGAUUCCGCc AAAuAdTsdT	844
1012	XD-09138	X29234	ucAucuuuAuuAAau GccAdTsdT	717	X29235	UGGcAUUuAGuAA AGAUGAdTsdT	855
1057	XD-09143	X29244	gccuuAuuuuuccacGA GGdTsdT	722	X29245	CCUCGUGGAAAAu AAGGGCdTsdT	860
1067	XD-09149	X29256	uccAcGAGGAuGGa AuAAudTsdT	728	X29257	AUuAUUCcAUCCU CGUGGAdTsdT	866
1096	XD-09154	X29266	uaAuGAGGAACuu uuGGGdTsdT	733	X29267	CCcAAAAUGUUCc UcAUuAdTsdT	871
495 var1	XD-10302	X32257	acAucCGUucUcgG uUusa	961	X32336	dTAAACCGAGAAC gAGAUGUusu	1002
498 var1	XD-10303	X32258	ucUcGuUCUcGGuu uAUcsa	962	X32337	dTGauAAACCGAGa ACGAGAusu	1003
751 var1	XD-10304	X32259	ugCuuUUCuuAuA cUcsa	963	X32338	dTGAGuAAuAAGAA AAAGcAusu	1004
842 var1	XD-10305	X32260	guAucACAUCGGuu AuUusa	964	X32339	dTAAuAAACCGAUg UGAuACusu	1005
855 var1	XD-10306	X32261	uaUuuuGGCgGAu cuUcsa	965	X32340	dTGAAGAUUCCGC cAAAAuAusu	1006
495 var2	XD-10307	X32262	acAucucGuucucgGu uusa	966	X32336	dTAAACCGAGAAC gAGAUGUusu	1007

498 var2	XD- 10308	X32263	ucucGuucucGGuuuA ucsa	967	X32337	dTGAuAAACCGAGa ACGAGAusu	1008
751 var2	XD- 10309	X32264	ugcuuuuucuuAuuAcu csa	968	X32338	dTGAGuAAuAAGAA AAAGcAusu	1009
842 var2	XD- 10310	X32265	guAucAcAucGGuuA uuusa	969	X32339	dTAAAuAACCGAUg UGAuACusu	1010
855 var2	XD- 10311	X32266	uaauuuGGcgGAuuc uucsa	970	X32340	dTGAAGAUUCCGC cAAAAuAusu	1011
495 var3	XD- 10312	X32267	acAucuCGUucUcgG uUua(C6)	971	X32341	UAAACCGAGAACg AGAUGUusu	1012
498 var3	XD- 10313	X32268	ucUcGuUCUcGGuu uAUca(C6)	972	X32342	UGAuAAACCGAGa ACGAGAusu	1013
751 var3	XD- 10314	X32269	ugCuuUUCuuAuuA cUca(C6)	973	X32343	UGAGuAAuAAGAA AAAGcAusu	1014
842 var3	XD- 10315	X32270	guAucACAUCGGuu AuUua(C6)	974	X32344	UAAAuAACCGAUg UGAuACusu	1015
855 var3	XD- 10316	X32271	uaUuuuGGCgGAu cuUca(C6)	975	X32345	UGAAGAUUCCGCc AAAAuAusu	1016
489 var1	XD- 10317	X32272	cuGuccACAucUcguu Cusa	976	X32346	dTAGAACGAGAUG uGGAcAGusu	1017
492 var1	XD- 10318	X32273	ucCAcAUCUcGUuc ucGgsa	977	X32347	dTCCGAGAACGAG aUGUGGAusu	1018
533 var1	XD- 10319	X32274	cgGuGAAGAAGUca ccAcsa	978	X32348	dTGUGGUGACUUC uUcACCGusu	1019
544 var1	XD- 10320	X32275	ucAccACCUuuUuuG AUusa	979	X32349	dTAAUcAAAAAAG gUGGUGAusu	1020
590 var1	XD- 10321	X32276	ugAcGuGAAGcAAa uuGgsa	980	X32350	dTCcAAUUGCUUc ACGUcAusu	1021
693 var1	XD- 10322	X32277	ugCAAAAAGcuGA aGuGcsa	981	X32351	dTGcACUUCAGCUu UUUGcAusu	1022
698 var1	XD- 10323	X32278	aaAGcuGAAGuGcuu GAcsa	982	X32352	dTGUCaAGcACUUC AGCUUUusu	1023
808 var1	XD- 10324	X32279	uuGGGAUUGcAAu guGCasa	983	X32353	dTUGcAcAUUGcAu UCCcAAusu	1024
836 var1	XD- 10325	X32280	agGGcuGUaucAcau cGgsa	984	X32354	dTCCGAUGUGAUAc AGCCCUusu	1025
838 var1	XD- 10326	X32281	ggCuGuAUCacAucG GUusa	985	X32355	dTAACCGAUGUGA uAcAGCCusu	1026
840 var1	XD- 10327	X32282	cuGuAuCACauCGgu uAusa	986	X32356	dTAuAACCGAUGUg AuAcAGusu	1027
848 var1	XD- 10328	X32283	caUcGGUUAuuUug GcGgsa	987	X32357	dTCCGCcAAAAuAa CCGAUGusu	1028
1012 var1	XD- 10329	X32284	ucAucuUUAcuAAau GCcsa	988	X32358	dTGcAUUuAGuAa AGAUGAusu	1029
1057 var1	XD- 10330	X32285	gcCcuAUUuuCcac GAggsa	989	X32359	dTCUCGUGGAAAA uAAGGGCusu	1030
1067 var1	XD- 10331	X32286	ucCAcGAGGauGGa AuAasa	990	X32360	dTUuAUUCcAUCCu CGUGGAusu	1031
508 var1	XD- 10332	X32287	ggUuuAUCAgAAu AcCasa	991	X32361	dTUGGuAUUUCUGa UAAACCusu	1032
545 var1	XD- 10333	X32288	caCcAcCUUuuUugA uUasa	992	X32362	dTUAUcAAAAAA gGUGGUGusu	1033
547 var1	XD- 10334	X32289	ccAccuUUUuuGAuu AUgsa	993	X32363	dTCAuAAUcAAAAa AGGUGGusu	1034
569 var1	XD- 10335	X32290	cgGuGcUCCcuGucA uAasa	994	X32364	dTUuAUGAcAGGGa GcACCGusu	1035
574 var1	XD- 10336	X32291	cuCccuGUCauAAau uUgsa	995	X32365	dTCAAAUuAUGAc AGGGAGusu	1036

580 var1	XD- 10337	X32292	guCAuAAAUuuGAc GuGasa	996	X32366	dTUcACGUcAAAUu UAUGACusu	1037
1006 var1	XD- 10338	X32293	caGGAAUCAucUuu AcUasa	997	X32367	dTUAGuAAAGAUG aUUCCUGusu	1038
1007 var1	XD- 10339	X32294	agGAAuCAUcuUuac uAasa	998	X32368	dTUuAGuAAAGAUG AUUCCUusu	1039
1069 var1	XD- 10340	X32295	caCGAGGAUgGAA uAAUusa	999	X32369	dTAAUuAUUCcAUc CUCGUGusu	1040
1079 var1	XD- 10341	X32296	gaAuAAUUUccAcac AAusa	1000	X32370	dTAUUGUGUGGAA aUuAUUCusu	1041
1089 var1	XD- 10342	X32297	caCAcAAUAauGAg GAacsa	1001	X32371	dTGUUCCUcAUuAu UGUGUGusu	1042

After incubating for 24 hours, the treated cells were harvested and the remaining CCR2 mRNA level was measured in each condition and ranked. The remaining CCR2 mRNA level after the 24 hours treatment with each siRNA duplex was listed in Table 19.

- 5 Among the 61 duplexes tested, 5 siRNAs and the variants thereof that have the most reduced CCR2 mRNA level were selected, including duplex XD-09048 and its variants, XD-10302, XD-10307 and CD-10321; duplex XD-09050 and its variants, XD-10303, XD-10308 and XD-10313; duplex XD-09098 and its variants, XD-10304, XD-10309 and XD-10314; duplex XD-09117 and its variants, XD-10305, XD-10310 and XD-10315; and
- 10 duplex XD-09127 and its variants, XD-10306, XD-10311 and XD-10316. The top 20 siRNA duplexes their modification variants were also ranked, including XD-09043 and its variant XD-10317; XD-09045 and its variant XD-10318; XD-09060 and its variant XD-10319; XD-09062 and its variant XD-10320; XD-09086 and its variant XD-10321; XD-09094 and its variant XD-10322; XD-09095 and its variant XD-10323; XD-09107 and its
- 15 variant XD-10324; XD-09112 and its variant XD-10325; XD-09113 and XD-10326; XD-09115 and its XD-10327; XD-09121 and its variant XD-10328; XD-09138 and its variant XD-10329; XD-09143 and its variant XD-10330; and XD-09149 and its variant XD-10331 (Table 18). The data also indicate several other siRNA modifications that result in significant reduction of expression, such as XD-10332, XD-10333, XD-10334, XD-10335,
- 20 XD-10335, XD-10336, XD-10337, XD-10338, XD-10339, XD-10340, XD-10341 and XD-10342.

Table 19. CCR2 mRNA expression after siRNA treatment

Duplex ID	Remaining mRNA (20 nM siRNA)	SD	Remaining mRNA (0.2 nM siRNA)	SD
XD-09048	0.0828811	0.01621	0.26202	0.02301
XD-10302	0.0458746	0.00603	0.09770	0.01263

XD-10307	0.0572924	0.00596	0.09821	0.00772
XD-10312	0.05	0.00919	0.07835	0.00144
XD-09050	0.08619	0.00859	0.15136	0.02523
XD-10303	0.05225	0.00315	0.09107	0.01053
XD-10308	0.09851	0.01143	0.09575	0.00460
XD-10313	0.05177	0.00743	0.10762	0.01369
XD-09098	0.11996	0.01069	0.22805	0.01252
XD-10304	0.10572	0.02569	0.15910	0.02864
XD-10309	0.107998	0.02183	0.16562	0.02625
XD-10314	0.0771379	0.00892	0.14788	0.01315
XD-09117	0.1027451	0.02382	0.21454	0.03092
XD-10305	0.08	0.01474	0.13802	0.00828
XD-10310	0.10160	0.00876	0.19002	0.01845
XD-10315	0.06324	0.01587	0.12922	0.01160
XD-09127	0.04650	0.00482	0.19543	0.05751
XD-10306	0.04222	0.00768	0.14426	0.02314
XD-10311	0.04622	0.00548	0.14122	0.02280
XD-10316	0.04534	0.00900	0.12270	0.01968
XD-09043	0.1212235	0.01143	0.50504	0.04412
XD-10317	0.0625109	0.01082	0.97832	0.05761
XD-09045	0.0968615	0.00805	0.54488	0.02852
XD-10318	0.07	0.01043	0.21755	0.01514
XD-09060	0.05680	0.00704	0.38861	0.01861
XD-10319	0.05437	0.00452	0.33435	0.04273
XD-09062	0.08611	0.00674	0.32090	0.02100
XD-10320	0.05999	0.00241	0.12294	0.01148
XD-09086	0.07023	0.00615	0.39757	0.03588
XD-10321	0.07552	0.00698	0.23543	0.03086
XD-09094	0.0856153	0.00829	0.20789	0.01513
XD-10322	0.0760854	0.00779	0.17054	0.02017
XD-09095	0.0900298	0.01120	0.21249	0.01983
XD-10323	0.08	0.01189	0.17035	0.01813
XD-09107	0.07630	0.00240	0.15302	0.01313
XD-10324	0.08814	0.01035	0.14028	0.03762
XD-09112	0.09623	0.00753	0.15433	0.02567
XD-10325	0.10806	0.01872	0.14031	0.01675
XD-09113	0.08627	0.01356	0.33789	0.07231
XD-10326	0.07559	0.01524	0.12001	0.01492
XD-09115	0.1418658	0.02075	0.18826	0.02735
XD-10327	0.0584942	0.00428	0.13135	0.01794
XD-09121	0.0745102	0.00592	0.11849	0.00961
XD-10328	0.06	0.00448	0.09767	0.00895

XD-09138	0.06331	0.01094	0.16493	0.02036
XD-10329	0.05851	0.00823	0.11598	0.02222
XD-09143	0.13552	0.01133	0.38856	0.04295
XD-10330	0.08985	0.01329	0.16521	0.03149
XD-09149	0.11750	0.02240	0.24068	0.02158
XD-10331	0.10518	0.02421	0.24268	0.01657
XD-10332	0.0479462	0.00567	0.28390	0.03031
XD-10333	0.1228451	0.00433	0.19917	0.01957
XD-10334	0.0515203	0.00568	0.09184	0.00562
XD-10335	0.07	0.00693	0.26358	0.02275
XD-10336	0.13570	0.01136	0.23667	0.01347
XD-10337	0.06058	0.01142	0.19522	0.02186
XD-10338	0.05468	0.00741	0.12157	0.01297
XD-10339	0.07645	0.00934	0.13829	0.02922
XD-10340	0.12908	0.01606	0.21778	0.02301
XD-10341	0.07806	0.01851	0.14420	0.01470
XD-10342	0.1353099	0.0149615	0.3257299	0.0421325
XD-00194 (Neg. control)	0.983	0.126	0.99921	0.13987
XD-00379 (Luc; Post. Control)	0.006	0.002	0.04388	0.01031

Dose response of selected CCR2 siRNA duplexes and variants

CSF1R siRNA duplexes and variants that resulted in a significant reduction of CSF1R mRNA level in the dual dose screening were selected and further tested for dose responses. Hepa 1-6 cells were cultured and maintained in 96-well plates at a density of 15,000 cells per well. Hepa 1-6 cells were transfected with CCR2 siRNA duplexes and variants selected from the previous dual dose screening, at various concentrations using Lipofectomine® 2000 (0.5 µl/well). The doses for each CCR2 siRNA duplex included 50 nM, 10 nM, 2.0 nM, 0.40 nM, 0.08 nM, 1.6×10^{-2} nM, 3.2×10^{-3} nM, 6.4×10^{-4} nM, 1.28×10^{-4} nM, and 2.6×10^{-5} nM. Following incubation of 24 hours, the treated cells were harvested and the remaining CCR2 mRNA level was measured in each condition. The IC₅₀ value of each CCR2 duplex was determined as shown in Table 20 and each dose response curve is shown in Figure 1D.

Table 20. IC₅₀ and IC₈₀ of CCR2 siRNA duplexes

siRNA Duplex ID	IC ₅₀ (nM)	IC ₈₀ (nM)	Maximal KD
XD-10311	0.007	0.056	93%

XD-10305	0.007	0.045	91%
XD-09098	0.028	0.246	87%
XD-10309	0.014	0.111	90%
XD-10303	0.004	0.030	94%
XD-10308	0.005	0.021	90%
XD-10302	0.006	0.030	94%
XD-10307	0.007	0.032	93%
XD-10312	0.005	0.035	95%
XD-10329	0.006	0.041	92%
XD-09121	0.009	0.062	93%
XD-10328	0.006	0.038	94%
XD-10320	0.012	0.097	93%
XD-10326	0.010	0.087	91%

Example 7: Dose response of combined CSF1R and CCR2 siRNAs

Human monocytic THP-1 cells were cultured and maintained in 96-well plates at a density of 25,000 cells per well. THP-1 monocytes were transfected with a combination of CSF1R duplex (XD-09016) and CCR2 duplex (XD-09098), CSF1R duplex (XD-09016) alone, CCR2 duplex (XD-09098) alone, or Firefly luciferase siRNA (FLuc, XD-00194) using Lipofectamine® 2000 (0.5 µl/well). After incubating for 24 hours, the cells were harvested and the remaining CSF1R, CCR2, and GAPDH mRNA levels were measured using a branched DNA (bDNA) assay according to the manufacturer's instructions (QuantiGene® SinglePlex Gene Expression Assay, ThermoFisher; CSF1R probe: SA-14861; CCR2 probe: SA-3020026; GAPDH probe: SA-10001). The data are shown in Figure 2 plotted as individual siRNA concentration (nM) vs. remaining mRNA (ratio of target gene to GAPDH, normalized to mock-transfected cells) and represents the mean of duplicates, +/- standard deviation. The results demonstrated that silencing of CSF1R or CCR2 using a combination of siRNAs was as effective as silencing CSF1R or CCR2 using individual siRNAs because no significant difference was observed in the silencing of CSF1R or CCR2 when the siRNAs were transfected in combination with each other as opposed to transfection alone.

Example 8: LNP-formulated CSF1R and CCR2 siRNAs administered intraperitoneally in mice

C57BL/6 mice (7-8 weeks old, female, n = 5 per group) were dosed intraperitoneally (2 mg/kg by total siRNA) of LNPs on Days -4, -1, and 1. LNPs were synthesized at a composition of 50 : 10 : 38.5 : 1.5 molar ratio of C12-200 : 1,2-distearoyl-

- sn*-glycero-3-phosphocholine (DSPC): cholesterol : 1,2-dimyristoyl-*sn*-glycero-3-phosphoethanolamine-N-[methoxy(polyethylene glycol)-2000] (C14 PEG-2000) and a total lipid : total siRNA weight ratio of 9:1. LNPs were formulated with equimolar ratios of either: a) mCSF1R + Luc siRNAs, b) mCCR2 + Luc siRNAs, c) mCSF1R + mCCR2 siRNAs, or d) Luc siRNA. Mouse siRNA sequences are listed in Table 21.

Table 21. Mouse siRNA sequences

Target	Sense Sequence	Antisense Sequence
mCSF1R	cuAcucAAcuuucuccGAAdTsdT	UUCGGAGAAAGUUGAGuAGdTsdT
mCCR2	uGcuAAAcGucucuGcAAAdTsdT	UUUGcAGAGACGUUuAGcAdTsdT
Luc	cuuAcGcuGAGuAcuucGAdTsdT	UCGAAGuACUcAGCGuAAGdTsdT

- On Day 0, mice were injected intraperitoneally with 2 mL of 3% thioglycollate broth (Difco Fluid Thioglycollate medium, BD 225650) to induce macrophage migration to the peritoneum. On Day 3, mice were sacrificed and their peritoneal macrophages were collected. Single cell suspensions were generated and analyzed via flow cytometry (Table 22).

- Table 22.** Flow cytometry antibodies used for assays

Color	Target	Clone	Manufacturer
BV421	mCCR2	SA203G11	Biolegend
BV510	Viability	n/a	ThermoFisher
BV605	mTCR-B, mCD19, mNK1.1	H57-597, 6D5, PK136	Biolegend (for all clones)
BV711	mCD45	30-F11	Biolegend
PerCP/Cy5.5	mLy-6C	HK1.4	Biolegend
PE	mCSF1R	AFS98	Biolegend
PE/Dazzle594	mLy-6G	1A8	Biolegend
AF700	mF4/80	CI:A3-1	Bio Rad
APC/Fire750	mCD11b	M1/70	Biolegend

Peritoneal macrophages were gated by singlet, live, mCD45+, mTCR-B-, mCD19-, mNK1.1-, mLy-6G-, mCD11b+, and mF4/80+ criteria. Then, mCSF1R/mCCR2 expression was graphed and quantified (Figure 3). The results demonstrated that silencing of mCSF1R

and mCCR2 were simultaneously achieved in peritoneal macrophages in mice following intraperitoneal administration of siRNA-LNPs. Additionally, Figure 3C demonstrates that using a combination of siRNAs was as at least as effective as, and believed to be more effective than, silencing mCSF1R or mCCR2 using individual siRNAs.

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Example 9: LNP-formulated CSF1R and CCR2 siRNAs administered intravenously in mice

C57BL/7 mice (7-8 weeks old, female, n = 3 per group) were dosed intravenously (1.5 mg/kg by total siRNA) of LNPs on Days -4, -1, and 1. LNPs were synthesized at a composition of 50 : 10 : 38.5 : 1.5 molar ratio of C12-200 : 1,2-distearoyl-*sn*-glycero-3-phosphocholine (DSPC): cholesterol : 1,2-dimyristoyl-*sn*-glycero-3-phosphoethanolamine-N-[methoxy(polyethylene glycol)-2000] (C14 PEG-2000) and a total lipid : total siRNA weight ratio of 9:1. LNPs were formulated with equimolar ratios of either: a) mCSF1R + mCCR2 siRNAs or b) Luc siRNA. Mouse siRNA sequences are listed in Table 21 described above.

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On Day 0, mice were injected intraperitoneally with 2 mL of 3% thioglycollate broth (Difco Fluid Thioglycollate medium, BD 225650) to induce macrophage migration to the peritoneum (*e.g.*, thyglycollate peritonitis model because it was determined that a standard lipopolysaccharide (LPS) peritonitis model did not produce macrophages expressing both CCR2 and CSF1R as CCR2 is quickly downregulated). On Day 3, mice were sacrificed and their blood was collected. Single cell suspensions were generated and analyzed via flow cytometry (Table 22; described above). Blood monocytes were gated by singlet, live, mCD45+, mTCR-B-, mCD19-, mNK1.1-, mCD11b+, mLy-6G- criteria and were then gated separately as Ly-6C^{hi} and Ly-6C^{lo} monocytes (as well-known gating criteria and described, for example, in Leuschner *et al.* (2012) *Nat. Biotechnol.* 29:1005-1010 and Rose *et al.* (2012) *Cytometry A* 81:343-350) since mCCR2 expression is associated with pro-inflammatory Ly-6C^{hi} monocytes but not Ly-6C^{lo} monocytes. Then, mCSF1R/mCCR2 expression was graphed and quantified (Figure 4). The results demonstrated that silencing of mCSF1R on blood monocytes and mCCR2 on Ly-6C^{hi} blood monocytes was simultaneously achieved using the combination of siRNAs in mice following intravenous administration of siRNA-LNPs.

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Example 10: Synergistic silencing of CSF1R and CCR2 in a model *in vitro* reporter system

Regions of CSF1R (NM_005211.3, nucleotide regions: 1030-1108, 2844-2922, 3019-3097, 3887-3965) and CCR2 (NM_001123396.2, nucleotide regions: 465-546, 721-799, 818-896, 982-1060) were cloned into a psiCHECK™-2 (Promega) vector downstream of the *Renilla* luciferase (RLuc) reporter gene. This vector also contains a secondary

5 Firefly luciferase (FLuc) reporter cassette as an internal control. Silencing of either CSF1R or CCR2 in cells expressing this plasmid results in proportional silencing of RLuc and can be normalized for cell count by FLuc. Thus, with this reporter system, both CSF1R and CCR2 silencing can be measured together with a single readout to quantify potential synergistic silencing of the combination of CSF1R and CCR2 siRNAs.

10 CHO cells were plated at 30,000 cells/well in a 96-well plate and transfected with 200 ng of the psiCHECK™-2 plasmid and 0.5 uL of Lipofectamine® 2000. After 24 hr of incubation at 37°C, the media was replaced. LNPs were synthesized at a composition of 50 : 10 : 38.5 : 1.5 molar ratio of C12-200 : 1,2-distearoyl-*sn*-glycero-3-phosphocholine (DSPC): cholesterol : 1,2-dimyristoyl-*sn*-glycero-3-phosphoethanolamine-N-

15 [methoxy(polyethylene glycol)-2000] (C14 PEG-2000) and a total lipid : total siRNA weight ratio of 9:1.; then, LNPs were added to each well with varying individual siRNA concentrations as shown in Figure 5. LNPs contained either CSF1R siRNA (XD-09016), CCR2 siRNA (XD-09098), CSF1R + CCR2 siRNA, or AHA-1 siRNA. AHA-1 siRNA (Table 23), which targets the housekeeping gene AHA-1, was used as a negative control.

20 **Table 23.** AHA-1 siRNA sequence

Target	Sense Sequence	Antisense Sequence
AHA-1	ggAuGAAGuGGAGauuAGudTsdT	ACuAAUCUCcACUUC AUCCdTsdT

After 24 hr, a Dual-Glo® Luciferase Assay (Promega) was performed according to the manufacturer's instructions. The *Renilla* luminescence was normalized by the Firefly

25 luminescence, and this ratio was then normalized to plasmid-transfected untreated cells on the y-axis; the individual (not total) CSF1R or CCR2 siRNA concentration of each LNP was plotted on the x-axis (Figure 5).

The results demonstrated that dose-dependent silencing of CSF1R and CCR2 was achieved with the single and combination siRNA-LNPs. A four-point sigmoidal curve

30 (GraphPad Prism) was fitted to the data to determine IC50s. CSF1R siRNA-LNPs and CCR2 siRNA-LNPs had IC50s of approximately 45 nM and 35 nM, respectively. The combination CSF1R+CCR2 siRNA-LNPs had an IC50 of approximately 20 nM. The IC50

of the combination siRNAs is approximately half of the single siRNAs, thereby demonstrating synergistic silencing of CSF1R and CCR2 in this model *in vitro* reporter system with a single endpoint.

5 **Incorporation by Reference**

All publications, patents, and patent applications mentioned herein are hereby incorporated by reference in their entirety as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated by reference. In case of conflict, the present application, including any definitions herein, will control.

10 Also incorporated by reference in their entirety are any polynucleotide and polypeptide sequences which reference an accession number correlating to an entry in a public database, such as those maintained by The Institute for Genomic Research (TIGR) on the World Wide Web and/or the National Center for Biotechnology Information (NCBI) on the World Wide Web.

15

Equivalents and Scope

The details of one or more embodiments encompassed by the present invention are set forth in the description above. Although the preferred materials and methods have been described above, any materials and methods similar or equivalent to those described herein
20 can be used in the practice or testing of embodiments encompassed by the present invention. Other features, objects and advantages related to the present invention are apparent from the description. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. In the case of conflict, the present description provided
25 above will control.

Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments encompassed by the present invention described herein. The scope of the present invention is not intended to be limited to the description provided herein and such equivalents are intended to be
30 encompassed by the appended claims.

The articles “a” and “an” are used herein to refer to one or to more than one (*i.e.* to at least one) of the grammatical object of the article unless indicated to the contrary or otherwise evident from the context. By way of example, “an element” means one element

or more than one element. Claims or descriptions that include “or” between one or more members of a group are considered satisfied if one, more than one, or all of the group members are present in, employed in, or otherwise relevant to a given product or process unless indicated to the contrary or otherwise evident from the context. The present invention includes embodiments in which exactly one member of the group is present in, employed in, or otherwise relevant to a given product or process. The present invention also includes embodiments in which more than one, or the entire group members are present in, employed in, or otherwise relevant to a given product or process.

It is also noted that the term “comprising” is intended to be open and permits but does not require the inclusion of additional elements or steps. When the term “comprising” is used herein, the term “consisting of” is thus also encompassed and disclosed.

Where ranges are given, endpoints are included. Furthermore, it is to be understood that unless otherwise indicated or otherwise evident from the context and understanding of one of ordinary skill in the art, values that are expressed as ranges can assume any specific value or subrange within the stated ranges in different embodiments encompassed by the present invention, to the tenth of the unit of the lower limit of the range, unless the context clearly dictates otherwise.

In addition, it is to be understood that any particular embodiment of the present invention that falls within the prior art can be explicitly excluded from any one or more of the claims. Since such embodiments are deemed to be known to one of ordinary skill in the art, they can be excluded even if the exclusion is not set forth explicitly herein. Any particular embodiment of the compositions encompassed by the present invention (*e.g.*, any antibiotic, therapeutic or active ingredient; any method of production; any method of use; etc.) can be excluded from any one or more claims, for any reason, whether or not related to the existence of prior art.

It is to be understood that the words which have been used are words of description rather than limitation, and that changes can be made within the purview of the appended claims without departing from the true scope and spirit encompassed by the present invention in its broader aspects.

While the present invention has been described at some length and with some particularity with respect to several described embodiments, it is not intended that it should be limited to any such particulars or embodiments or any particular embodiment, but it is to be construed with references to the appended claims so as to provide the broadest possible

interpretation of such claims in view of the prior art and, therefore, to effectively encompass the intended scope of the present invention.

What is claimed is:

1. A composition comprising a) at least one siRNA molecule that hybridizes to a nucleic acid molecule encoding CCR2, b) at least one siRNA molecule that hybridizes to a nucleic acid molecule encoding CSF1R, or c) a combination of a) and b).
2. The composition of claim 1, wherein the at least one siRNA molecule that hybridizes to the nucleic acid molecule encoding CCR2 comprises a sense strand having a nucleic acid sequence selected from SEQ ID NO: 6 to SEQ ID NO: 67 and an anti-sense strand having a nucleic acid sequence selected from SEQ ID NO: 68 to SEQ ID NO: 129.
3. The composition of claim 1 or 2, wherein the at least one siRNA molecule that hybridizes to the nucleic acid molecule encoding CSF1R comprises a sense strand having a nucleic acid sequence selected from SEQ ID NO: 130 to SEQ ID NO 248 and an anti-sense strand having a nucleic acid sequence selected from SEQ ID NO: 249 to SEQ ID NO: 367.
4. The composition of any one of claims 1-3, wherein the at least one siRNA molecule that hybridizes to the nucleic acid molecule encoding CCR2 or CSF1R further comprise at least one modification.
5. The composition of claim 4, wherein the modification is a modification to the sugar moiety of the nucleic acid sequence, a nucleobase modification, an internucleoside linker modification, an artificial nucleotide, an end cap modification, or any combinations thereof.
6. The composition of claim 4 or 5, wherein the modification locates in the sense strand of the at least one siRNA molecule.
7. The composition of claim 4 or 5, wherein the modification locates in the anti-sense strand of the at least one siRNA molecule.
8. The composition of claim 4 or 5, wherein the modification locates in the sense and anti-sense strands of the at least one siRNA molecule.
9. The composition of claim 4 or 5, wherein the at least one siRNA molecule that hybridizes to the nucleic acid molecule encoding CCR2 comprises a sense strand having a modified nucleic acid sequence selected from SEQ ID NO: 368 to SEQ ID NO: 486 and SEQ ID NO: 883 to SEQ ID NO: 921, and an anti-sense strand having a modified nucleic

acid sequence selected from SEQ ID NO: 487 to SEQ ID NO: 605 and SEQ ID NO: 922 to SEQ ID NO: 960.

10. The composition of claim 4, 5, or 9, wherein the at least one siRNA molecule that hybridizes to the nucleic acid molecule encoding CCR2 comprises a sense strand having a modified nucleic acid sequence selected from SEQ ID NO: 606 to SEQ ID NO: 743 and SEQ ID NO: 961 to SEQ ID NO: 1001, and an anti-sense strand having a modified nucleic acid sequence selected from SEQ ID NO: 744 to SEQ ID NO: 881 and SEQ ID NO: 1002 to SEQ ID NO: 1042.

11. A composition comprising a) at least one siRNA duplex that hybridizes to a nucleic acid molecule encoding CCR2, b) at least one siRNA duplex that hybridizes to a nucleic acid molecule encoding CSF1R, or c) a combination of a) and b),

wherein the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CCR2 comprises a sense strand having a nucleic acid sequence selected from SEQ ID NO: 6 to SEQ ID NO: 67, or a modified nucleic acid sequence selected from SEQ ID NO: 606 to SEQ ID NO: 743, or a modification variant selected from SEQ ID NO: 961 to SEQ ID NO: 1001, and an anti-sense strand having a nucleic acid sequence selected from SEQ ID NO: 68 to SEQ ID NO: 129, or a modified nucleic acid sequence selected from SEQ ID NO: 744 to SEQ ID NO: 881, or a modification variant selected from SEQ ID NO: 1002 to SEQ ID NO: 1042; and/or

wherein the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CSF1R comprises a sense strand having a nucleic acid sequence selected from SEQ ID NO: 130 to SEQ ID NO: 248, or a modified nucleic acid sequence selected from SEQ ID NO: 368 to SEQ ID NO: 486, or a modification variant selected from SEQ ID NO: 883 to SEQ ID NO: 921, and an anti-sense strand having a nucleic acid sequence selected from SEQ ID NO: 249 to SEQ ID NO: 367, or a modified nucleic acid sequence selected from SEQ ID NO: 487 to SEQ ID NO: 605, or a modification variant selected from SEQ ID NO: 922 to SEQ ID NO: 960.

12. The composition of claim 11, wherein the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CCR2 is duplex XD-09048, XD-09050, XD-09098, XD-09117, XD-09127, XD-09043, XD-09045, XD-09060, XD-09062, XD-09086, XD-

09094, XD-09095, XD-09107, XD-09112, XD-09113, XD-09115, XD-09121, XD-09138, XD-09143, or XD-09149, or variants thereof.

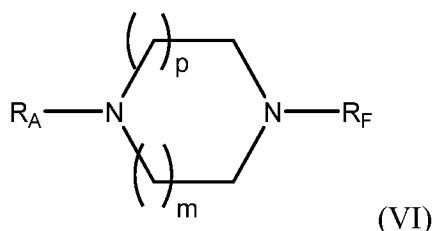
13. The composition of claim 12, wherein the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CCR2 is duplex XD-09048, XD-09050, XD-09098, XD-09117 or XD-09127, or variants thereof.

14. The composition of any one of claims 11-13, wherein the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CSF1R is duplex XD-08944, XD-08947, XD-08988, XD-08993 or XD-08916, XD-08917, XD-08922, XD-08923, XD-08936, XD-08963, XD-08969, XD-08975, XD-08982, XD-08985, XD-08986, XD-08989, XD-09003, XD-09006, XD-09015, or XD-09021, or variants thereof.

15. The composition of claim 14, wherein the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CSF1R is duplex XD-08944, XD-08947, XD-08988, XD-08993 or XD-08916, or variants thereof.

16. The composition of any one of claims 1-15, wherein the composition further comprises a lipid and/or a lipidoid.

17. The composition of claim 16, wherein the lipidoid is of Formula (VI):

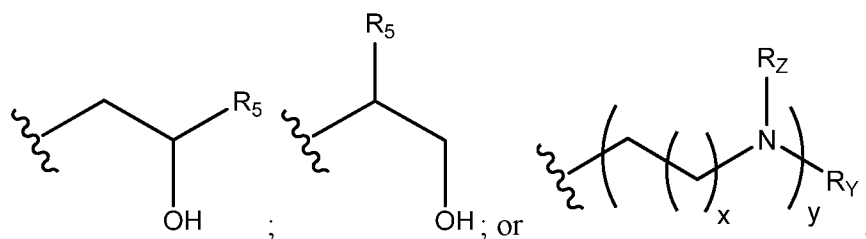


wherein:

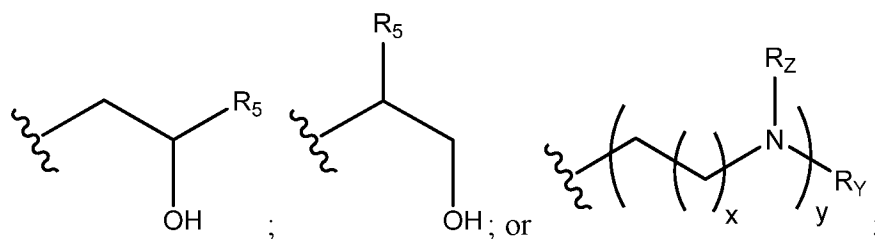
p is an integer between 1 and 3, inclusive;

m is an integer between 1 and 3, inclusive;

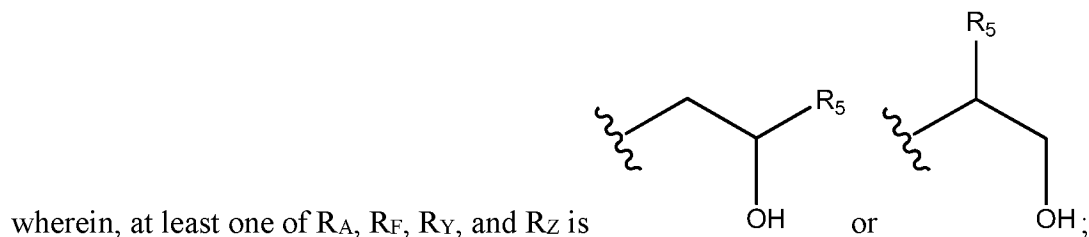
R_A is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C₁₋₂₀ aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C₁₋₂₀ heteroaliphatic; substituted or unsubstituted aryl; substituted or unsubstituted heteroaryl;



R_F is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; substituted or unsubstituted heteroaryl;



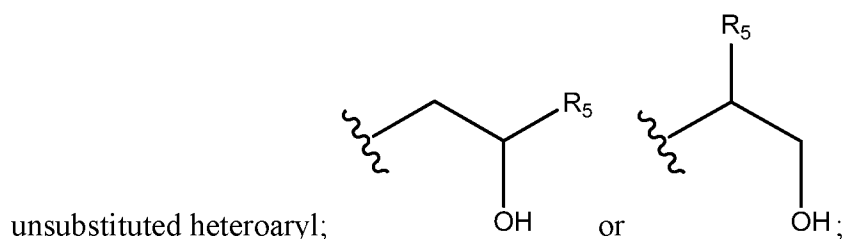
each occurrence of R_5 is independently hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; or substituted or unsubstituted heteroaryl;



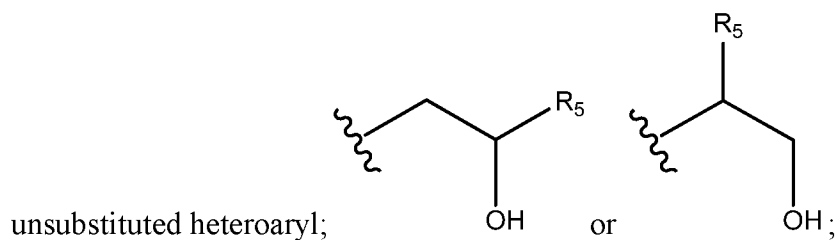
each occurrence of x is an integer between 1 and 10, inclusive;

each occurrence of y is an integer between 1 and 10, inclusive;

each occurrence of R_Y is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; substituted or



each occurrence of R_Z is hydrogen; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} aliphatic; substituted or unsubstituted, cyclic or acyclic, branched or unbranched C_{1-20} heteroaliphatic; substituted or unsubstituted aryl; substituted or



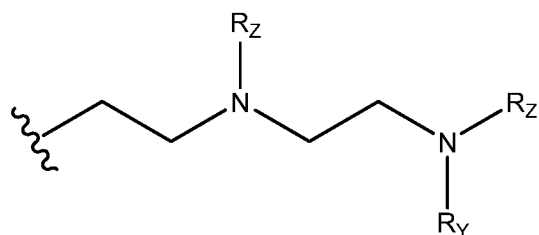
or a pharmaceutically acceptable salt thereof.

18. The composition of claim 17, wherein p is 1.

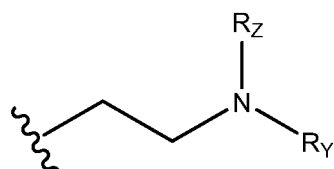
19. The composition of claim 17 or 18, wherein m is 1.

20. The composition of any one of claims 17-19, wherein each of p and m is 1.

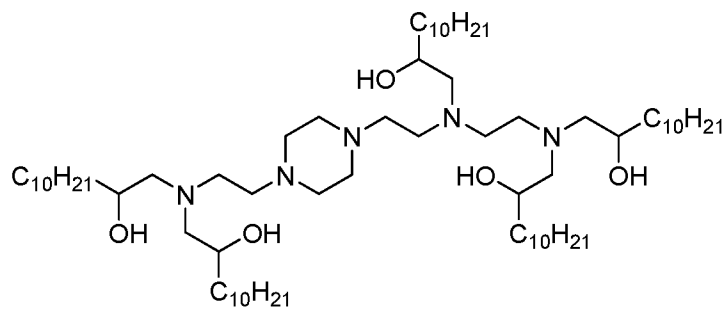
21. The composition of any one of claims 17-20, wherein R_F is



22. The composition of any one of claims 17-21, wherein R_A is



23. The composition of claim 17, wherein the compound of Formula (VI) is of the formula:



(C12-200);

or a salt thereof.

24. The composition of any one of claims 17-23, wherein the composition is in the form a lipid nanoparticle.

25. The composition of claim 24, wherein the lipid nanoparticle comprises about 1.0% to about 60.0% by mole of C12-200.

26. The composition of claim 24 or 25, wherein the lipid nanoparticle further comprises one or more co-lipids.

27. The composition of claim 26, wherein each co-lipid is selected from disteoylphosphatidyl choline (DSPC), cholesterol, and DMG-PEG.

28. The composition of claim 27, wherein the concentration of DSPC is about 1.0% to about 20.0% by mole.

29. The composition of claim 27 or 28, wherein the concentration of cholesterol is about 10.0% to about 50.0% by mole.

30. The composition of any one of claims 27-29, wherein the concentration of DMG-PEG is about 0.1% to about 5.0% by mole.

31. The composition of any one of claims 27-30, wherein DSPC is present a concentration of about 1.0% to about 20.0% by mole; cholesterol is present at a concentration of about 10.0% to about 50.0% by mole; and DMG-PEG is present a concentration of about 0.1% to about 5.0% by mole.

32. The composition of claim 31, wherein C12-200, DSPC, cholesterol, and DMG-PEG are present at a ratio of 50%:10%:38.5%:1.5%, respectively.

33. The composition of any one of claims claim 16-32, wherein the lipids and lipidoids of the LNP compared to the siRNA molecules are present at a ratio from about 20:1 to about 5:1 by weight.

34. The composition of claim 33, wherein the lipids and lipidoids of the LNP compared to the siRNA molecules are present at a ratio of 9:1 by weight.

35. The composition of any one of claims 1-34, wherein the composition is in a pharmaceutically acceptable formulation.

36. A method of generating a myeloid-derived cell having an increased inflammatory phenotype after contact with at least one composition of any one of claims 1-35, comprising contacting the myeloid-derived cell with an effective amount of the at least one composition.

37. The method of claim 36, wherein the myeloid-derived cell having an increased inflammatory phenotype exhibits one or more of the following after contact with the at least one composition:

a) increased expression of cluster of differentiation 80 (CD80), CD86, MHCII, MHCI, interleukin 1-beta (IL-1 β), IL-6, CCL3, CCL4, CXCL10, CXCL9, GM-CSF and/or tumor necrosis factor alpha (TNF- α);

b) decreased expression of CD206, CD163, CD16, CD53, VSIG4, PSGL-1, TGFb and/or IL-10;

c) increased secretion of at least one cytokine or chemokine selected from the group consisting of IL-1 β , TNF- α , IL-12, IL-18, GM-CSF, CCL3, CCL4, and IL-23;

d) increased ratio of expression of IL-1 β , IL-6, and/or TNF- α to expression of IL-10;

e) increased CD8⁺ cytotoxic T cell activation;

f) increased recruitment of CD8⁺ cytotoxic T cell activation;

g) increased CD4⁺ helper T cell activity;

h) increased recruitment of CD4⁺ helper T cell activity;

i) increased NK cell activity;

j) increased recruitment of NK cell;

k) increased neutrophil activity;

l) increased macrophage activity; and/or

m) increased spindle-shaped morphology, flatness of appearance, and/or number of dendrites, as assessed by microscopy.

38. The method of claim 36 or 37, wherein the myeloid-derived cell contacted with the at least one composition are comprised within a population of cells and the at least one

composition increases the number of Type 1 and/or M1 macrophages, and/or decreases the number of Type 2 and/or M2 macrophages, in the population of cells.

39. The method of any one of claims 36-38, wherein the myeloid-derived cell contacted with the at least one composition is comprised within a population of cells and the at least one composition increases the ratio of i) to ii), wherein i) is Type 1 and/or M1 macrophages and ii) is Type 2 and/or M2 macrophages in the population of cells.

40. The method of any one of claims 36-39, wherein the myeloid-derived cell is contacted *in vitro* or *ex vivo*.

41. The method of claim 40, wherein the myeloid-derived cell is a primary myeloid-derived cell.

42. The method of any one of claims 36-41, wherein the myeloid-derived cell is purified and/or cultured prior to contact with the at least one composition.

43. The method of any one of claims 36-39, wherein the myeloid-derived cell is contacted *in vivo*.

44. The method of claim 43, wherein the myeloid-derived cell is contacted *in vivo* by systemic, peritumoral, or intratumoral administration of the composition.

45. The method of claim 43 or 44, wherein the myeloid-derived cell is contacted in a subject in need thereof, optionally wherein the contact is in a tissue microenvironment.

46. The method of any one of claims 36-45, further comprising contacting the myeloid-derived cell with at least one additional therapeutic agent.

47. The method of claim 46, wherein the at least one additional therapeutic agent is an antagonist of CCL2 and/or an antagonist of CSF1.

48. The method of claim 46 or 47, wherein the at least one additional therapeutic agent comprises an immunotherapeutic agent that modulates the inflammatory phenotype, optionally wherein the immunotherapeutic agent comprises an immune checkpoint inhibitor, immune-stimulatory agonist, inflammatory agent, cells, a cancer vaccine, and/or a virus.

49. A method of increasing an inflammatory phenotype of myeloid-derived cells in a subject after contact with at least one composition of any one of claims 1-35, comprising administering to the subject an effective amount of the at least one composition that contacts the myeloid-derived cells.

50. The method of claim 49, wherein the myeloid-derived cells having the increased inflammatory phenotype exhibit one or more of the following after contact with the at least one composition:

- a) increased expression of cluster of differentiation 80 (CD80), CD86, MHCII, MHCI, interleukin 1-beta (IL-1 β), IL-6, CCL3, CCL4, CXCL10, CXCL9, GM-CSF and/or tumor necrosis factor alpha (TNF- α);
- b) decreased expression of CD206, CD163, CD16, CD53, VSIG4, PSGL-1 and/or IL-10;
- c) increased secretion of at least one cytokine selected from the group consisting of IL-1 β , TNF- α , IL-12, IL-18, and IL-23;
- d) increased ratio of expression of IL-1 β , IL-6, and/or TNF- α to expression of IL-10;
- e) increased CD8⁺ cytotoxic T cell activation;
- f) increased CD4⁺ helper T cell activity;
- g) increased NK cell activity;
- h) increased neutrophil activity;
- i) increased macrophage activity; and/or
- j) increased spindle-shaped morphology, flatness of appearance, and/or number of dendrites, as assessed by microscopy.

51. The method of claim 49 or 50, wherein the at least one composition increases the number of Type 1 and/or M1 macrophages, decreases the number of Type 2 and/or M2 macrophages, and/or increases the ratio of i) to ii), wherein i) is Type 1 and/or M1 macrophages and ii) is Type 2 and/or M2 macrophages, in the subject.

52. The method of any one of claims 49-51, wherein the number and/or activity of cytotoxic CD8⁺ T cells in the subject is increased after administration of the at least one composition.

53. The method of any one of claims 49-52, wherein the at least one composition is administered systemically, peritumorally, or intratumorally.
54. The method of any one of claims 49-53, wherein the at least one composition contacts the myeloid-derived cells in a tissue microenvironment.
55. The method of any one of claims 49-54, further comprising contacting the myeloid-derived cells with at least one additional therapeutic agent.
56. The method of claim 55, wherein the at least one additional therapeutic agent is an antagonist of CCL2 and/or an antagonist of CSF1.
57. The method of claim 55 or 56, wherein the at least one additional therapeutic agent comprises an immunotherapeutic agent that modulates the inflammatory phenotype, optionally wherein the immunotherapeutic agent comprises an immune checkpoint inhibitor, immune-stimulatory agonist, inflammatory agent, cells, a cancer vaccine, and/or a virus.
58. The method of claim 57, wherein the immune checkpoint is selected from the group consisting of PD-1, PD-L1, PD-L2, and CTLA-4.
59. The method of claim 58, wherein the immune checkpoint is PD-1.
60. The method of any one of claims 55-59, wherein the at least one additional therapeutic agent or regimen is administered before, concurrently with, or after the at least one composition.
61. A method of sensitizing cancer cells in a subject to cytotoxic CD8⁺ T cell-mediated killing and/or immune checkpoint therapy comprising administering to the subject a therapeutically effective amount of at least one composition of any one of claims 1-35 for contacting myeloid-derived cells in the subject.
62. The method of claim 61, wherein the at least one composition is administered systemically, peritumorally, or intratumorally.

63. The method of claim 61 or 62, further comprising treating the cancer in the subject by administering to the subject an effective amount of at least one additional therapeutic agent.
64. The method of claim 63, wherein the at least one additional therapeutic agent is an antagonist of CCL2 and/or an antagonist of CSF1.
65. The method of claims 63 or 64, wherein the at least one additional therapeutic agent comprises an immunotherapeutic agent that modulates the inflammatory phenotype of the myeloid-derived cells, optionally wherein the immunotherapeutic agent comprises an immune checkpoint inhibitor, immune-stimulatory agonist, inflammatory agent, cells, a cancer vaccine, and/or a virus.
66. The method of claim 65, wherein the immune checkpoint is selected from the group consisting of PD-1, PD-L1, PD-L2, and CTLA-4.
67. The method of claim 66, wherein the immune checkpoint is PD-1.
68. The method of claim 67, wherein the at least one additional therapeutic agent or regimen is administered before, concurrently with, or after the at least one composition.
69. The method of any one of claims 61-68, wherein the at least one composition reduces the number of proliferating cells in the cancer and/or reduce the volume or size of a tumor comprising the cancer cells.
70. The method of any one of claims 61-69, wherein the at least one composition increases the amount and/or activity of CD8⁺ T cells infiltrating a tumor comprising the cancer cells.
71. The method of any one of claims 61-70, wherein the at least one composition a) increases the amount and/or activity of M1 macrophages infiltrating a tumor comprising the cancer cells and/or b) decreases the amount and/or activity of M2 macrophages infiltrating a tumor comprising the cancer cells.

72. The method of any one of claims 36-71, wherein the myeloid-derived cells contacted with the at least one composition have a modulated inflammatory phenotype exhibiting one or more of the following:

- a) decreased expression of CCR2 and/or CSF1R receptors by monocytes and/or macrophages;
- b) increased expression of cluster of differentiation 80 (CD80), CD86, MHCII, MHCI, interleukin 1-beta (IL-1 β), IL-6, CCL3, CCL4, CXCL10, CXCL9, GM-CSF and/or tumor necrosis factor alpha (TNF- α) by monocytes and/or macrophages;
- c) decreased expression of CD206, CD163, CD16, CD53, VSIG4, PSGL-1, TGF β and/or IL-10 by monocytes and/or macrophages;
- d) increased secretion of at least one cytokine or chemokine selected from the group consisting of IL-1 β , TNF- α , IL-12, IL-18, GM-CSF, CCL3, CCL4, and IL-2 by monocytes and/or macrophages;
- e) increased ratio of expression of IL-1 β , IL-6, and/or TNF- α to expression of IL-10 by monocytes and/or macrophages;
- f) increased CD8⁺ cytotoxic T cell activation;
- g) increased recruitment of CD8⁺ cytotoxic T cell activation;
- h) increased CD4⁺ helper T cell activity;
- i) increased recruitment of CD4⁺ helper T cell activity;
- j) increased NK cell activity;
- k) increased recruitment of NK cells;
- l) increased neutrophil activity;
- m) increased macrophage activity; and/or
- n) increased spindle-shaped morphology, flatness of appearance, and/or number of dendrites, as assessed by microscopy.

73. The method of any one of claims 36-72, wherein the myeloid-derived cell is a macrophage, a monocyte, a circulating bone marrow derived monocyte, a tissue resident macrophage, a macrophage associated with a clinical condition, a Type 1 macrophage, a M1 macrophage, a Type 2 macrophage, a M2 macrophage, a M2c macrophage, a M2d macrophage, and/or a tumor-associated macrophages (TAM).

74. The method of any one of claims 36-73, wherein the cancer is selected from the group consisting of mesothelioma, kidney renal clear cell carcinoma, glioblastoma, lung

adenocarcinoma, lung squamous cell carcinoma, pancreatic adenocarcinoma, breast invasive carcinoma, acute myeloid leukemia, adrenocortical carcinoma, bladder urothelial carcinoma, brain lower grade glioma, breast invasive carcinoma, cervical squamous cell carcinoma and endocervical adenocarcinoma, cholangiocarcinoma, colon adenocarcinoma, esophageal carcinoma, glioblastoma multiforme, head and neck squamous cell carcinoma, kidney chromophobe, kidney renal clear cell carcinoma, kidney renal papillary cell carcinoma, liver hepatocellular carcinoma, lung adenocarcinoma, lung squamous cell carcinoma, lymphoid neoplasm diffuse large B-cell lymphoma, mesothelioma, ovarian serous, cystadenocarcinoma, pancreatic adenocarcinoma, pheochromocytoma, paraganglioma, prostate adenocarcinoma, rectum adenocarcinoma, sarcoma, skin cutaneous melanoma, stomach adenocarcinoma, testicular germ cell tumors, thymoma, thyroid carcinoma, uterine carcinosarcoma, uterine corpus endometrial carcinoma, and uveal melanoma.

75. The method of any one of claims 36-74, wherein the myeloid-derived cells are comprised within a human tumor model, an animal model of cancer, and/or a thyglycollate peritonitis model.

76. The method of any one of claims 36-75, wherein the subject is a mammal.

77. The method of claim 76, wherein the mammal is a human.

78. The method of claim 77, wherein the human is afflicted with a cancer.

Figure 1A CSF1R siRNAs

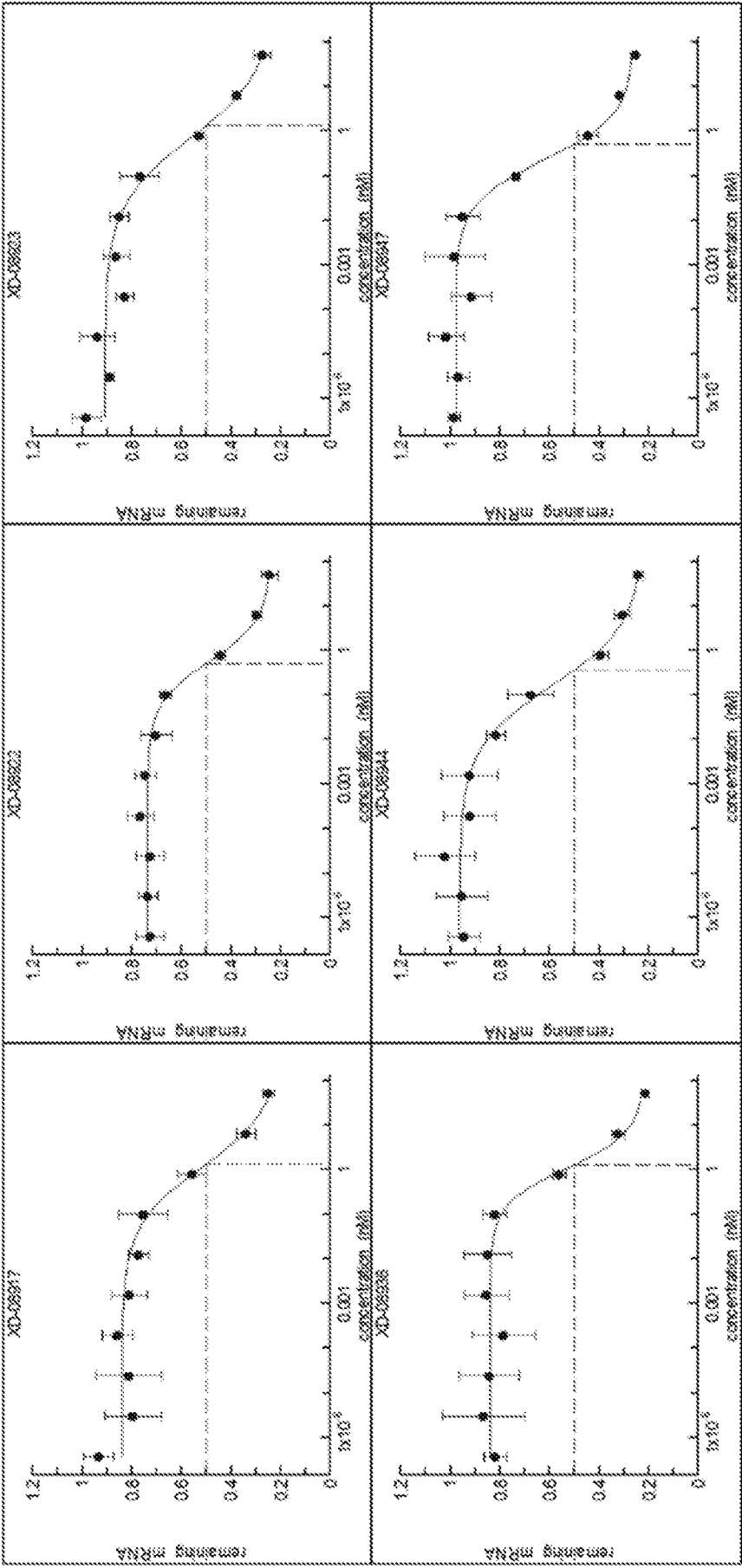


Figure 1A (cont.) CSFIR siRNAs

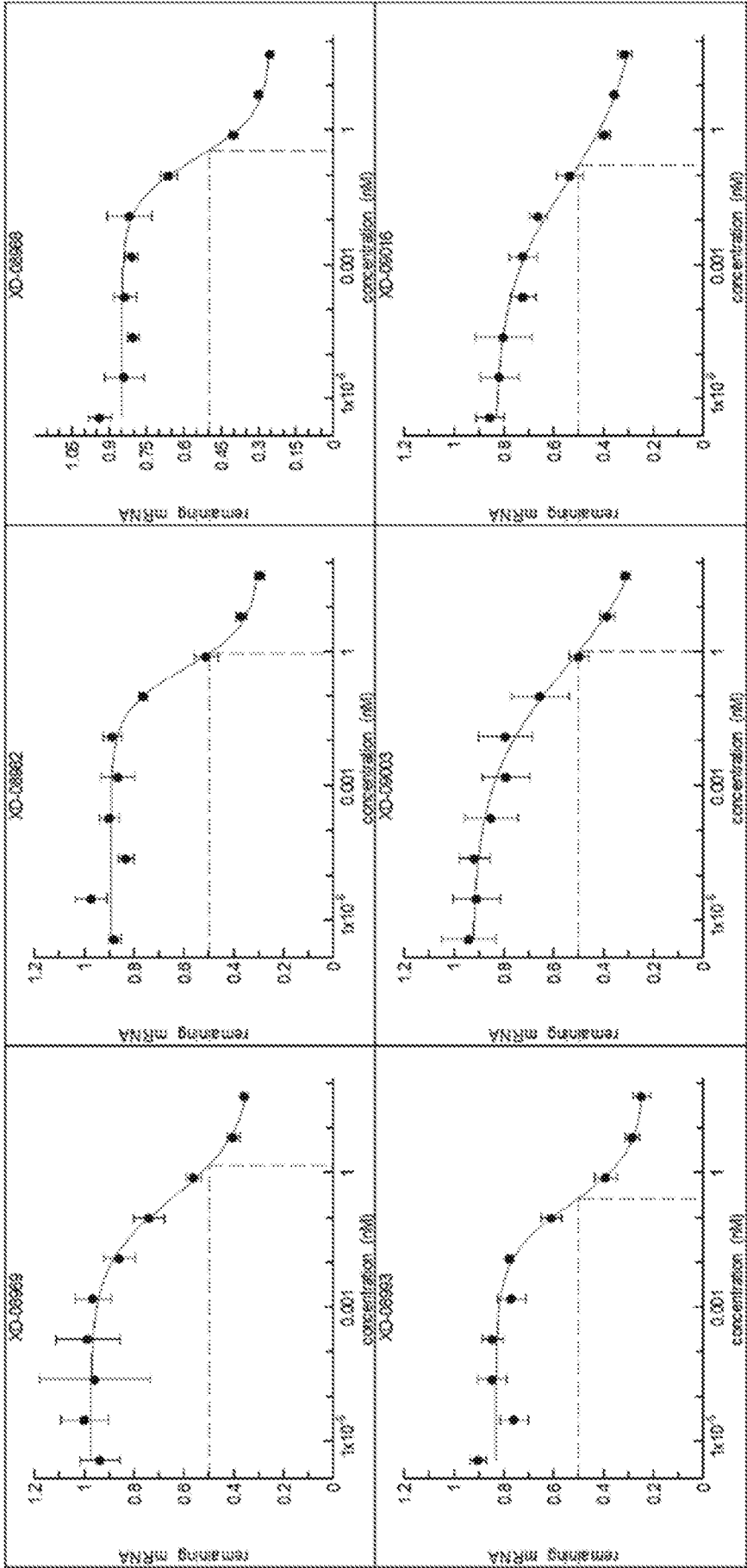


Figure 1B CCR2 siRNAs

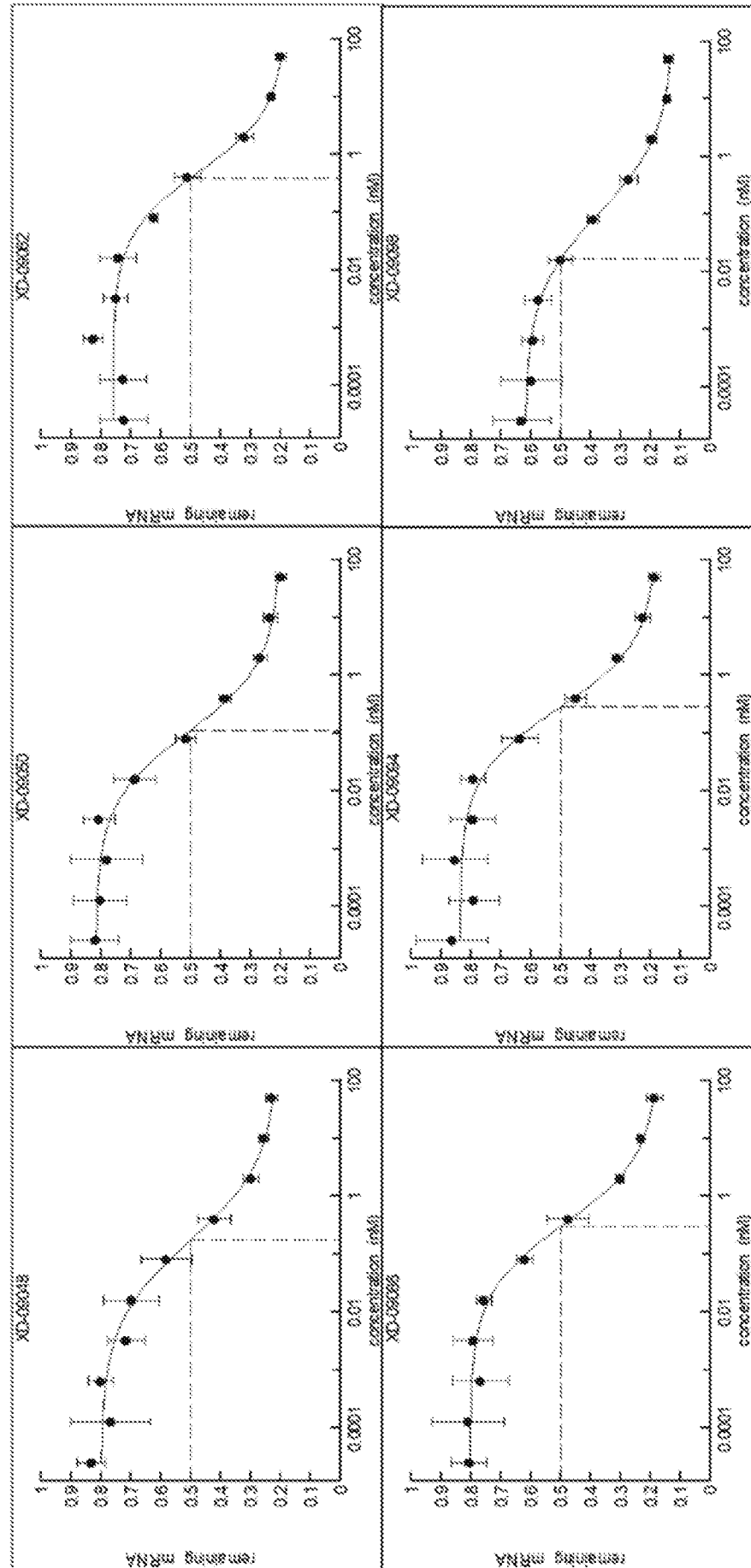


Figure 1B (cont.) CCR2 siRNAs

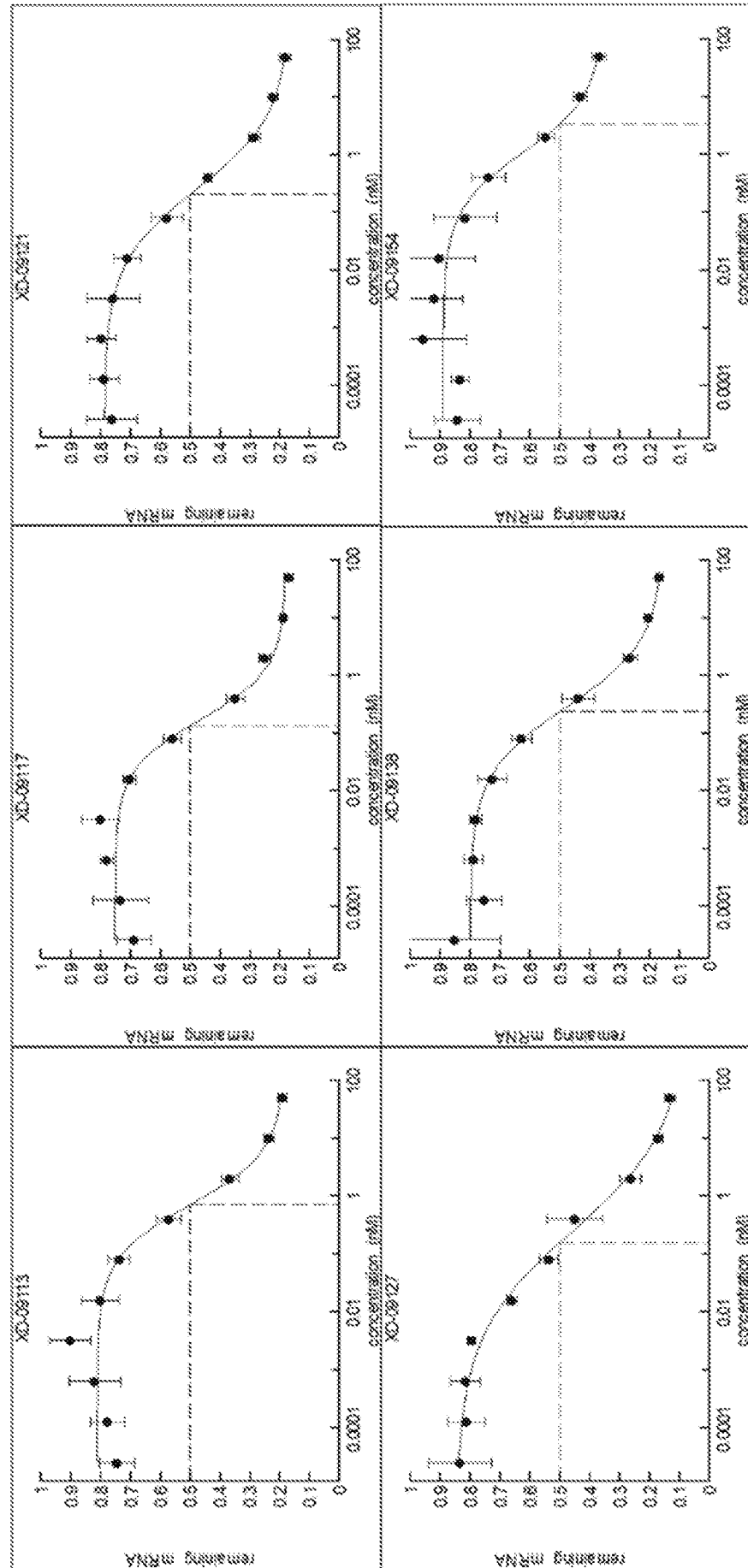


Figure 1C Selected CSF1R siRNA duplexes and variants

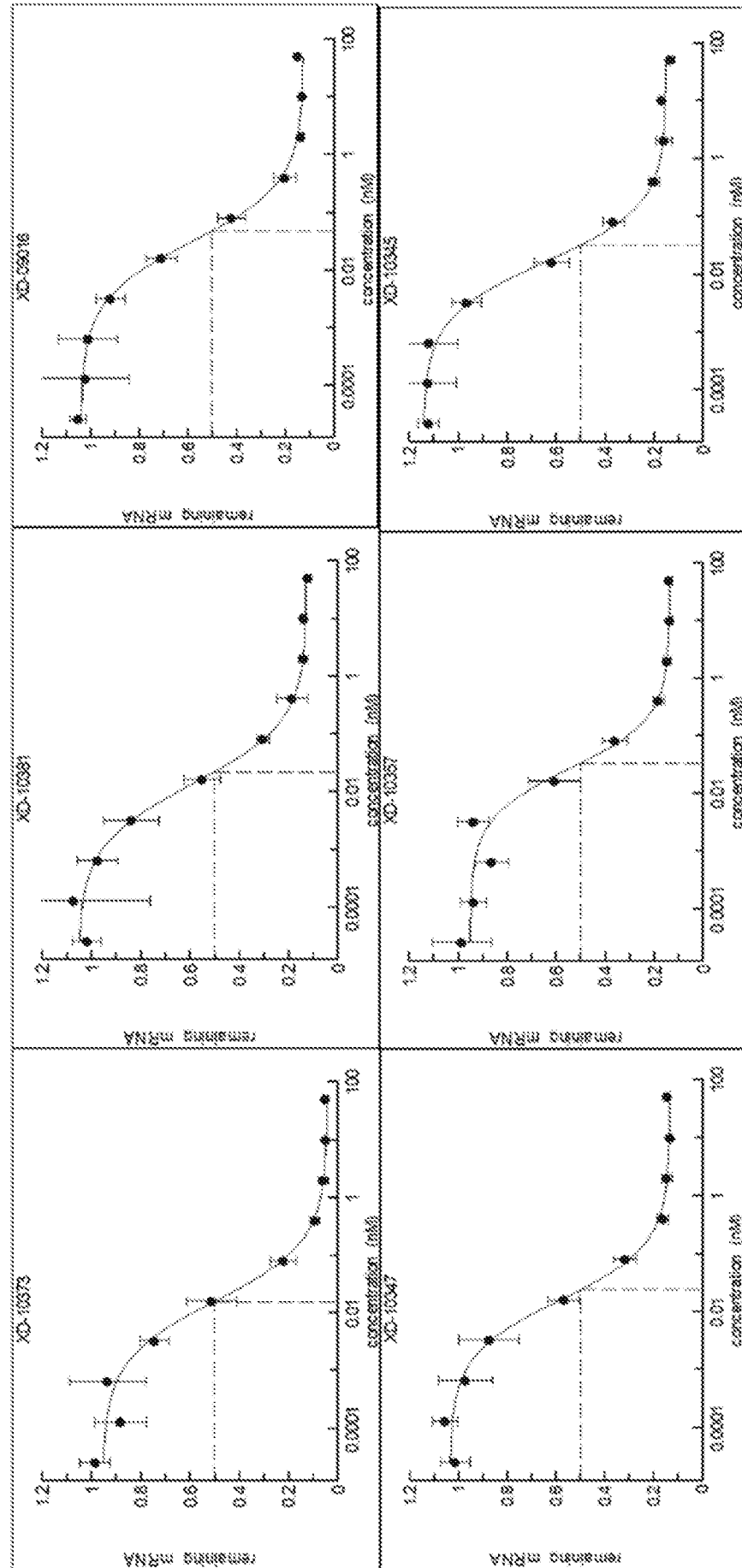


Figure 1C (cont.) Selected CSF1R siRNA duplexes and variants

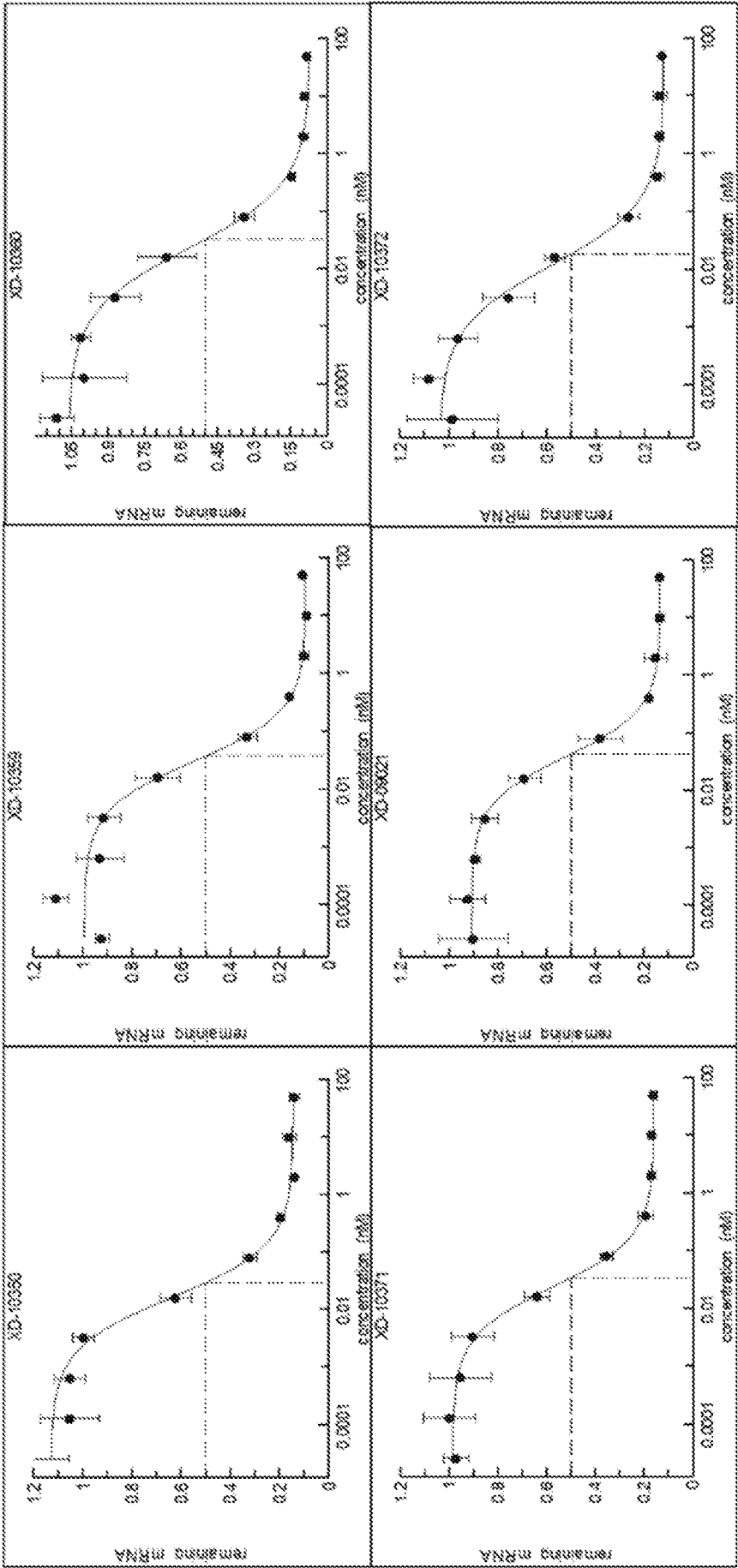


Figure 1D Selected CCR2 siRNA duplexes and variants

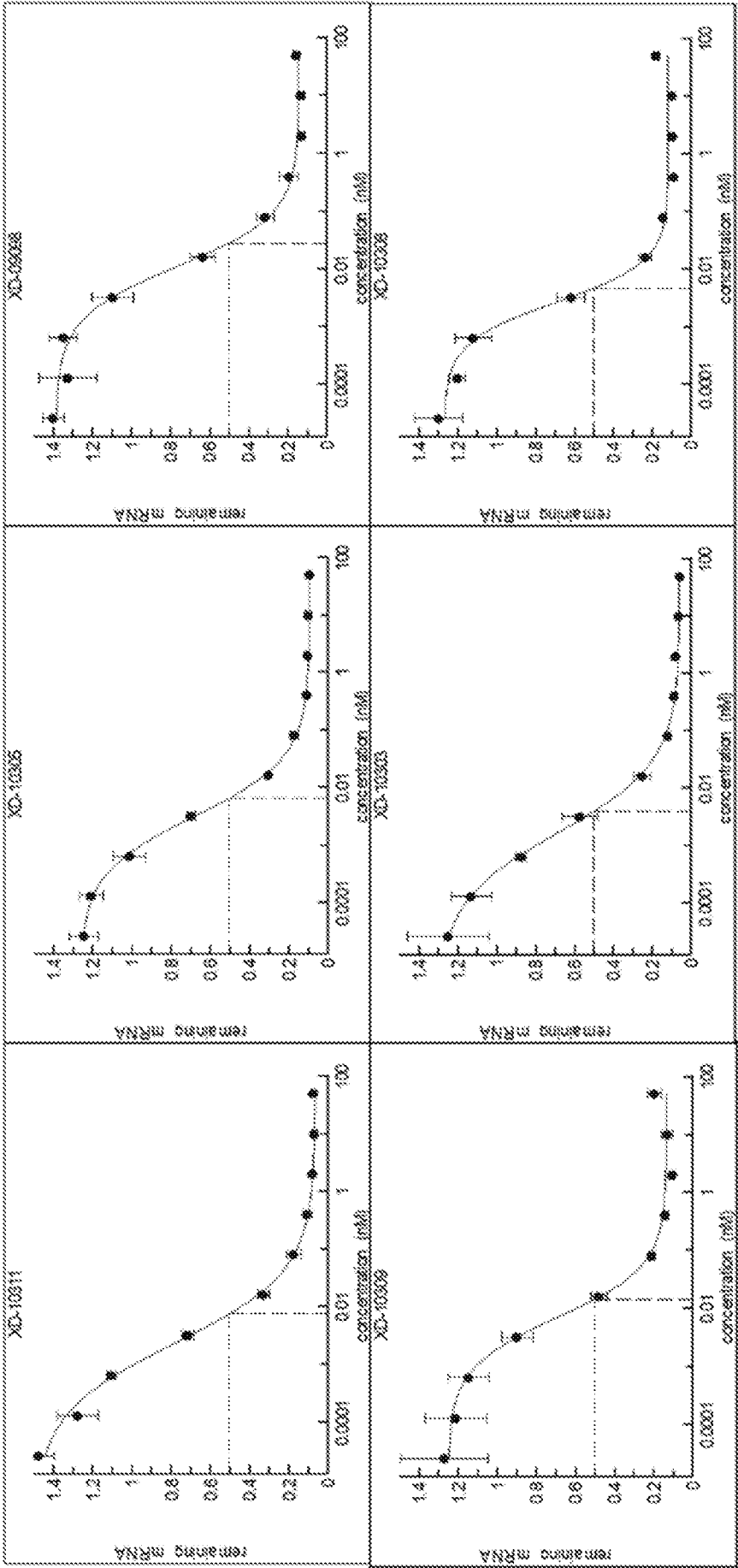


Figure 1D (cont.) Selected CCR2 siRNA duplexes and variants

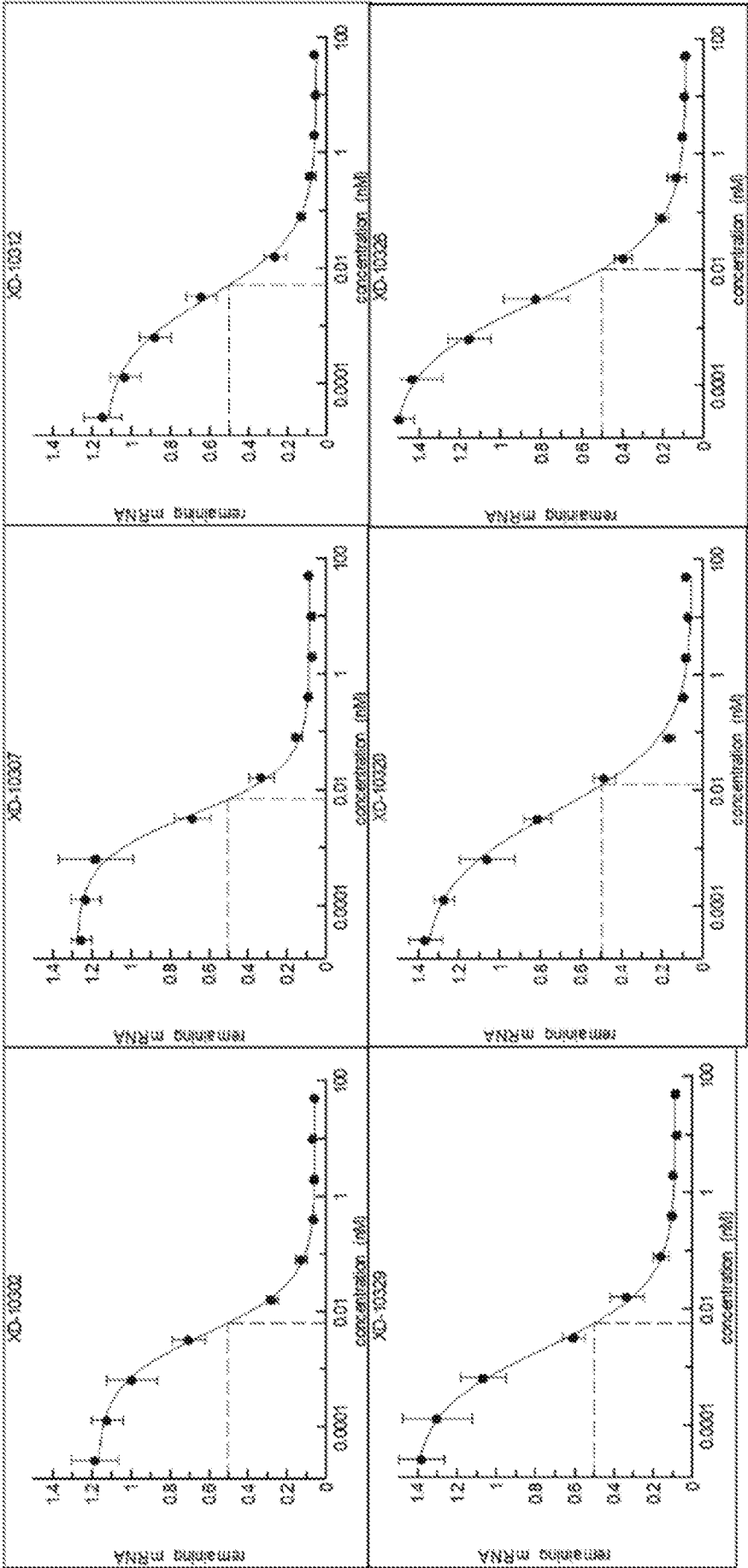


Figure 2

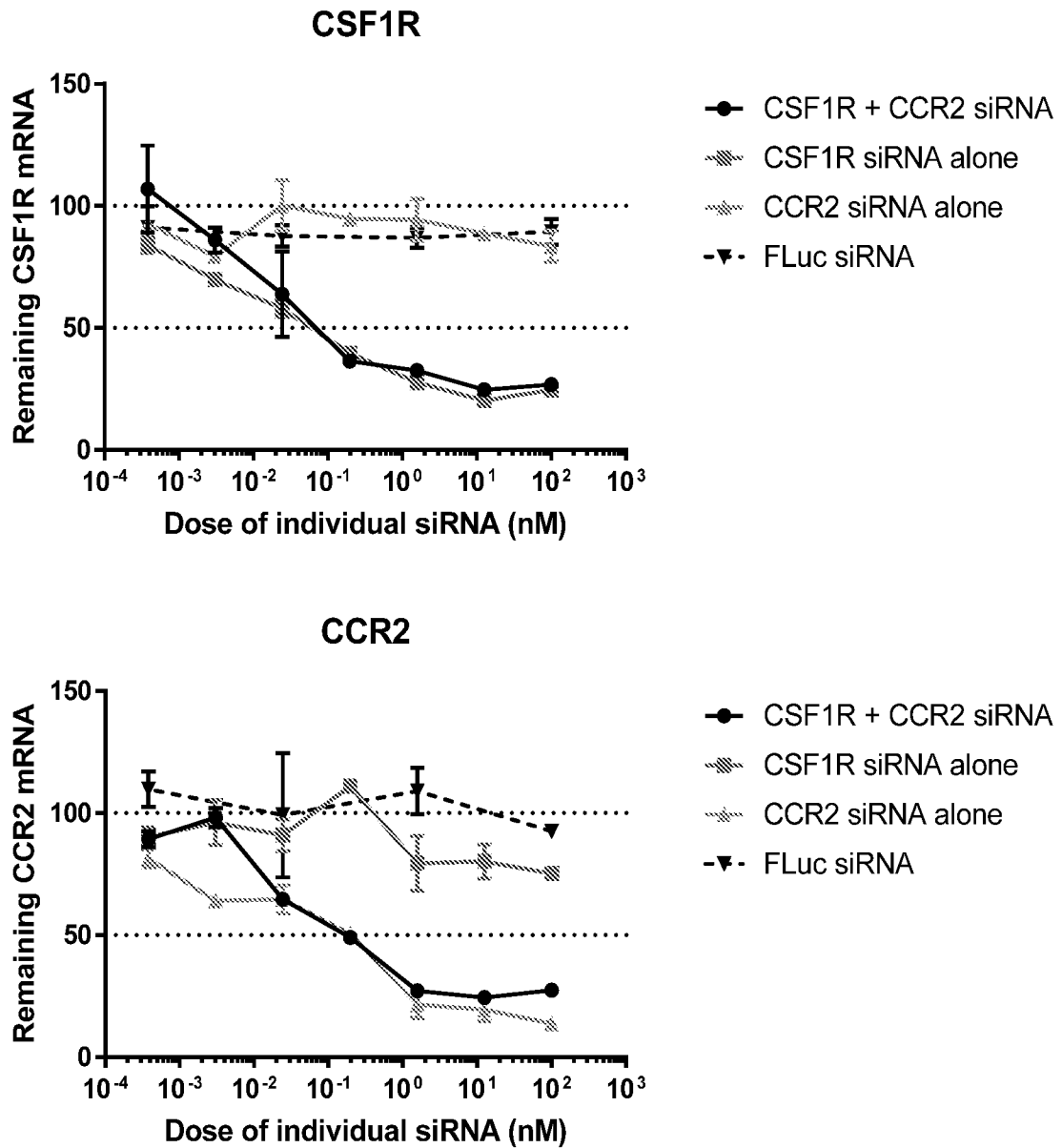
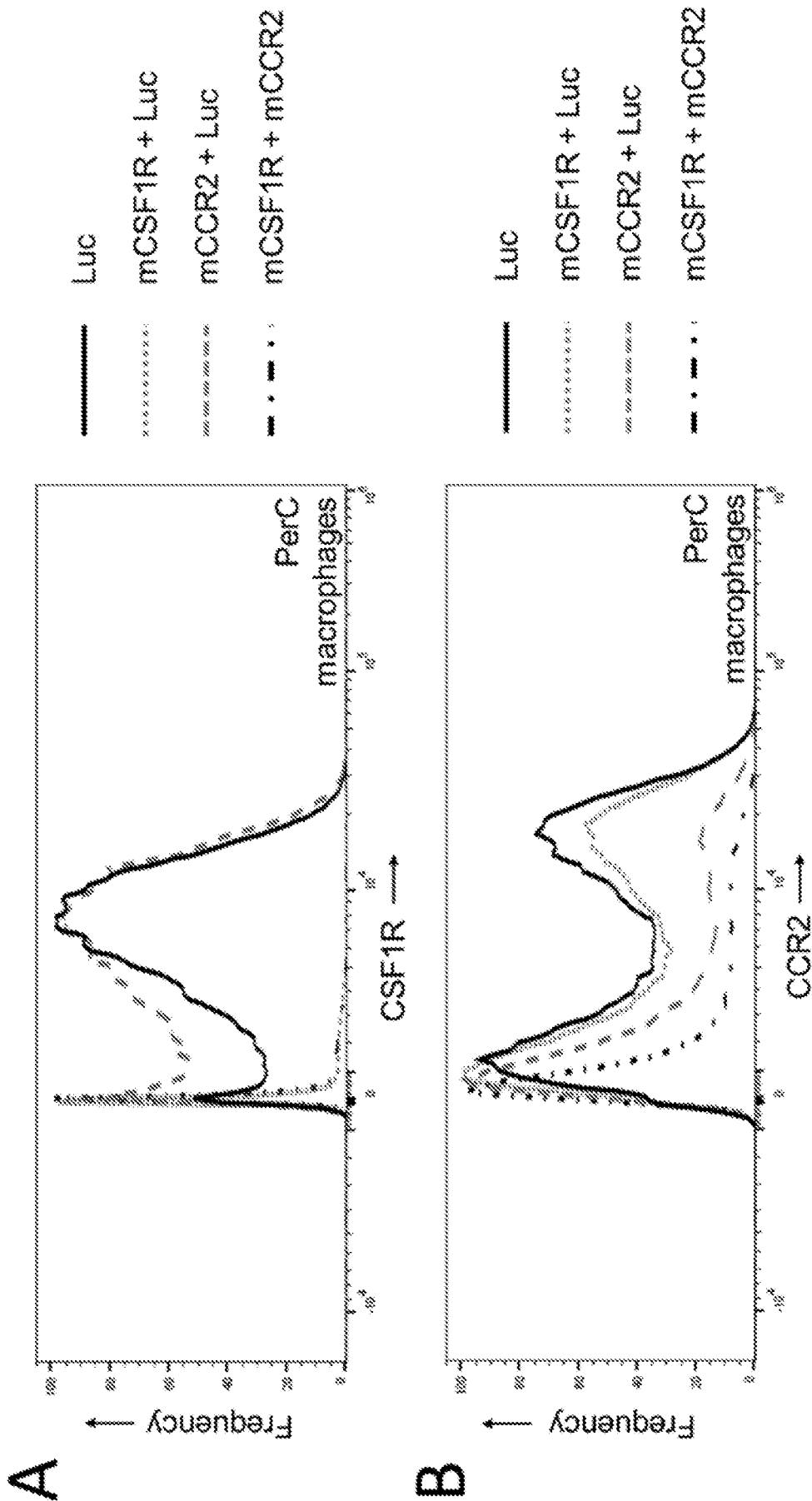


Figure 3



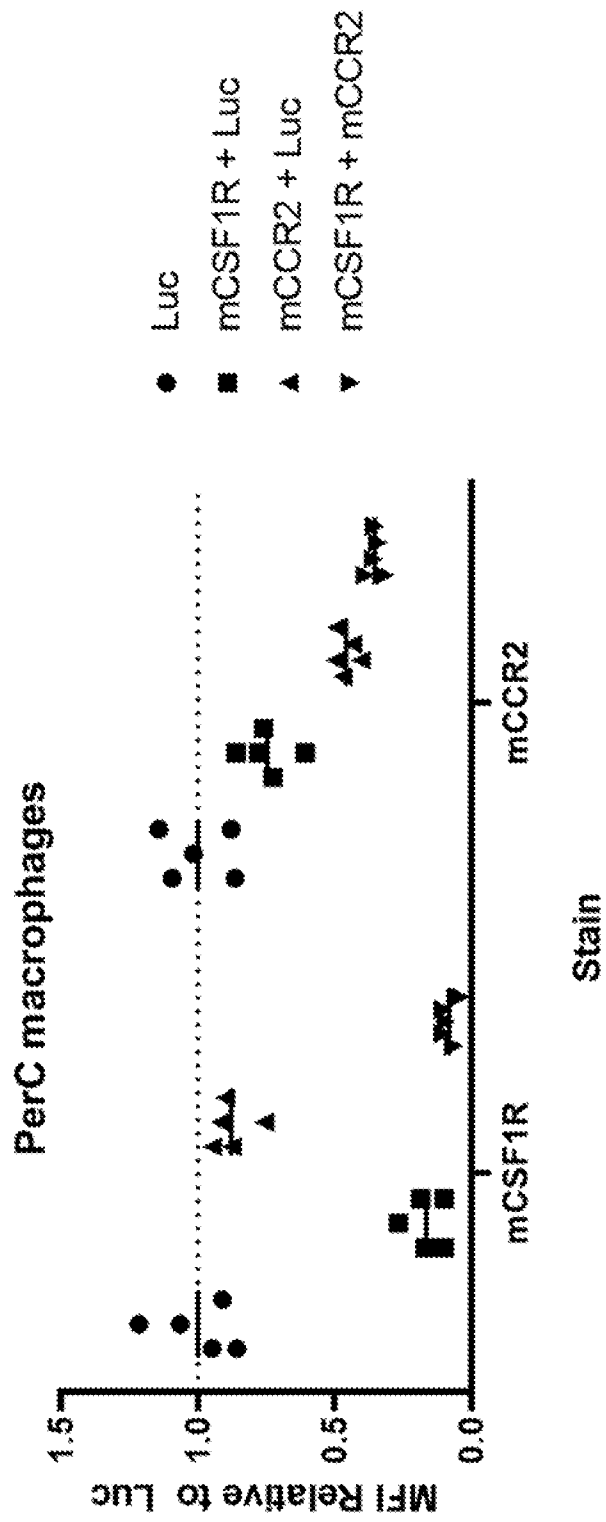


Figure 4

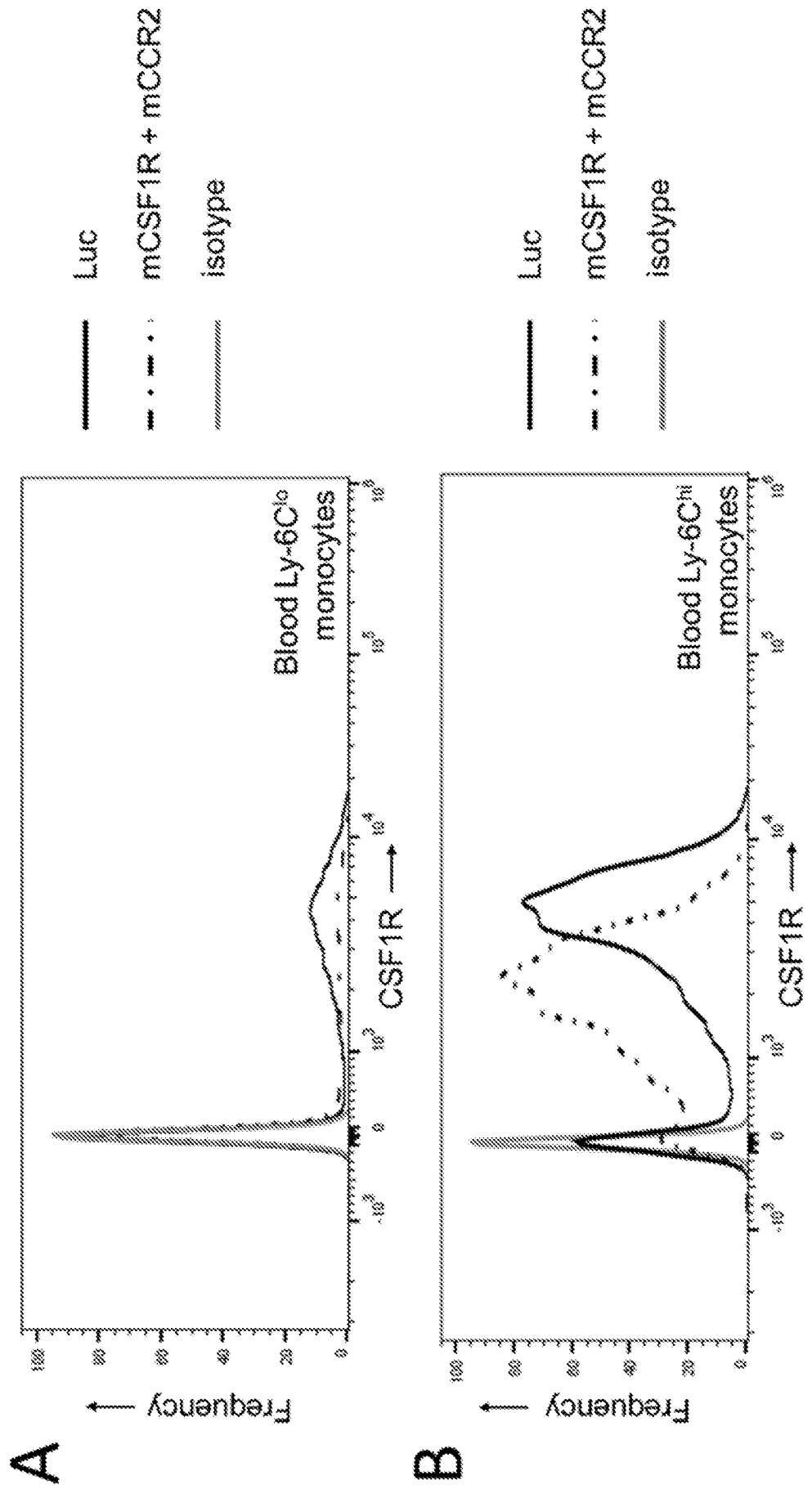


Figure 4 (cont.)

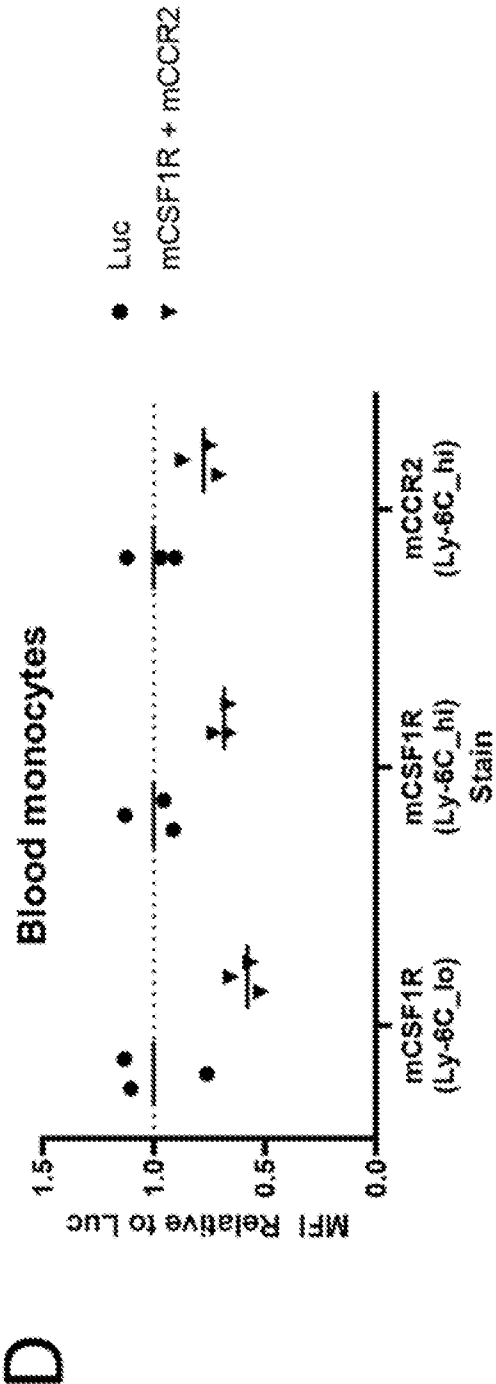
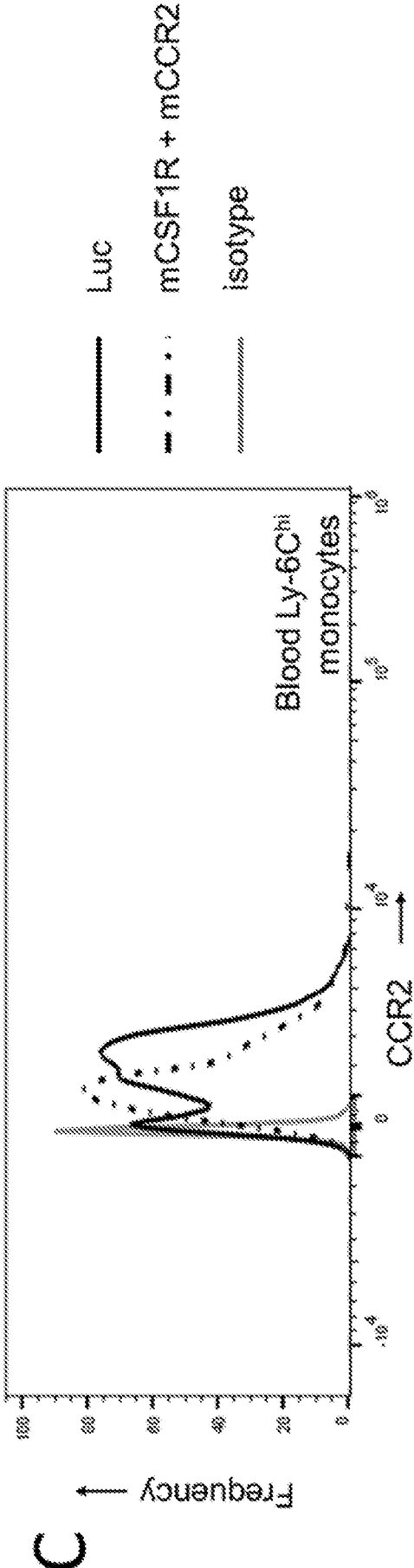
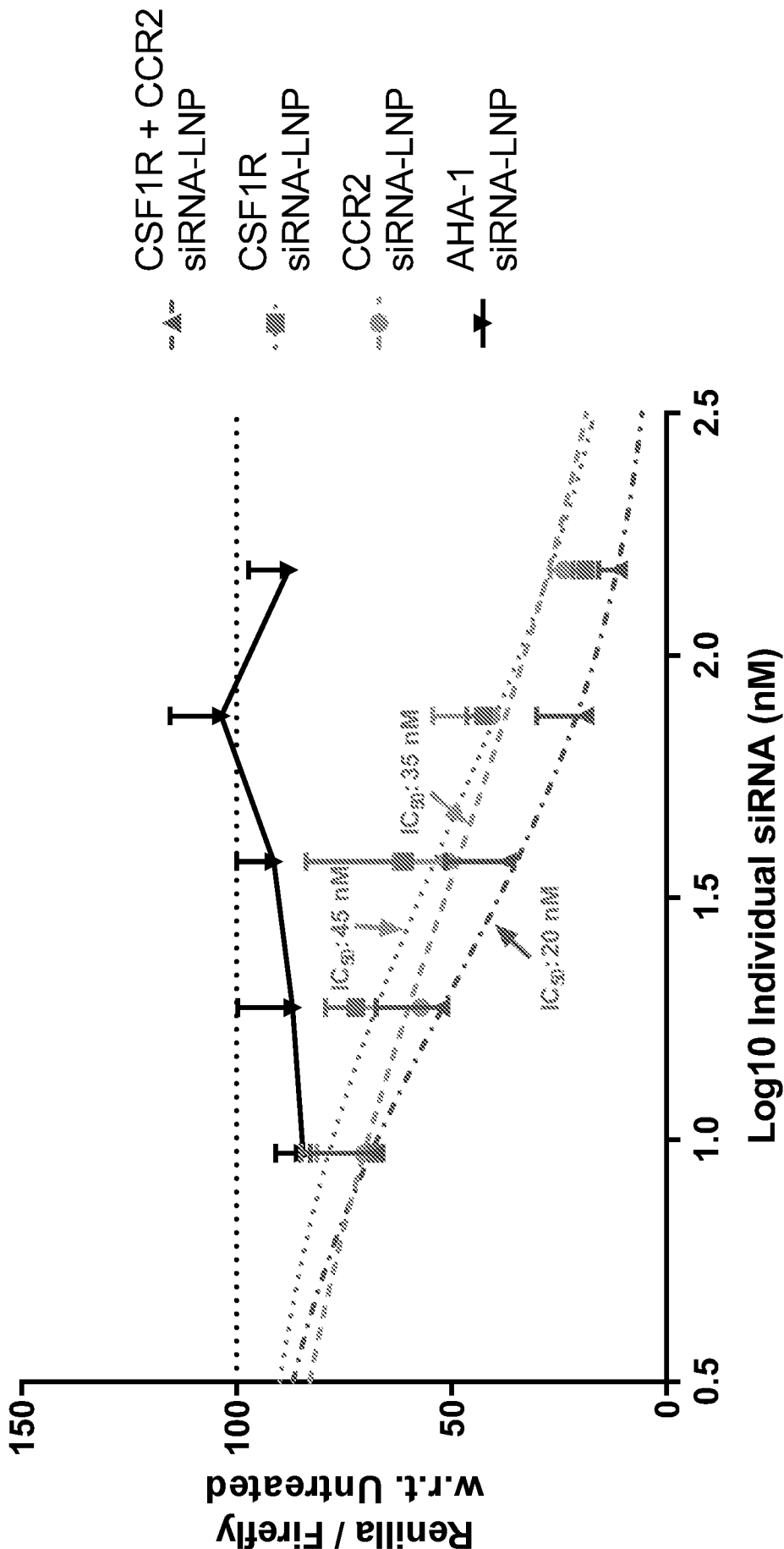


Figure 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/45841

A. CLASSIFICATION OF SUBJECT MATTER

IPC - C12N 15/113, A61K 48/00, C07H 21/04 (2019.01)

CPC - C12N 15/1138, C12N 15/113

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/0038871 A1 (VISWANATH et al.) 17 February 2011 (17.02.2011) abstract; claims 4 and 7	1
-----		-----
Y		2, 11
Y	WO 2005/101002 A1 (BAYER HEALTHCARE AG) 27 October 2005 (27.10.2005) p. 1, para 1; Fig. 4; SEQ ID NO: 4	2, 11

☐ 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

16 December 2019

Date of mailing of the international search report

10 JAN 2020

Name and mailing address of the ISA/US

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Authorized officer

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Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/45841

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 4-10, 16-78
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:
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.

--continued on next extra sheet--

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.:
1, 2, 11 limited to CCR2 siRNA SEQ ID Nos: 6 and 68 (duplex XD-09033)

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.

--continued from Box III: Observations where unity of invention is lacking--

Group I+, claims 1-3 and 11-15, directed to a composition comprising a) at least one siRNA molecule that hybridizes to a nucleic acid molecule encoding CCR2, and/or b) at least one siRNA molecule that hybridizes to a nucleic acid molecule encoding CSF1R. The composition will be searched to the extent that the siRNA molecule encompasses a siRNA molecule that hybridizes to CCR2, comprising sense strand SEQ ID NO: 6, anti-sense strand SEQ ID NO: 68, and duplex XD-09033 (note, applicant specification p. 68, Table 2 and p. 195, Table 12, duplex XD-09033 corresponds to SEQ ID Nos: 6 and 68). It is believed that claims 1, 2 and 11 encompass this first named invention, and thus these claims will be searched without fee to the extent that the siRNA molecule encompasses CCR2 siRNA SEQ ID Nos: 6 and 68 (duplex XD-09033). Additional siRNA molecule(s) will be searched upon the payment of additional fees. Applicants must specify the claims that encompass any additionally elected siRNA molecule(s). Applicants must further indicate, if applicable, the claims which encompass 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. An exemplary election would be siRNA molecule comprising sense strand SEQ ID NO: 7, anti-sense strand SEQ ID NO: 69, and duplex XD-09034, (claims 1, 2, 11).

The inventions listed as Group I+ do not relate to a single special technical feature 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

The inventions of Group I+ each include the special technical feature of a unique nucleic acid sequence, and is considered a distinct technical feature.

No technical features are shared between the CCR2 or CSF1R siRNA nucleic acid sequences of Group I+ and, accordingly, these groups lack unity a priori.

Additionally, even if Group I+ were considered to share the technical features of including: a composition comprising a) at least one siRNA molecule that hybridizes to a nucleic acid molecule encoding CCR2, and/or b) at least one siRNA molecule that hybridizes to a nucleic acid molecule encoding CSF1R, wherein the at least one siRNA duplex that hybridizes to the nucleic acid molecule encoding CCR2 or CSF1R comprises a sense strand and an anti-sense strand, these shared technical features are previously taught by US 2011/0038871 A1 to Viswanth et al., (hereinafter Viswanth).

Viswanth teaches a composition comprising an siRNA molecule that hybridizes to a nucleic acid molecule encoding CCR2, wherein the siRNA duplex that hybridizes to the nucleic acid molecule encoding CCR2 comprises a sense strand and an anti-sense strand (abstract "compositions and methods for treating conditions of the eye using CCR2"; claim 4 "A double stranded short interfering nucleic acid (siNA) molecule that directs cleavage of CCR2 RNA...wherein one strand of the siNA molecule comprises a nucleotide sequence having sufficient complementarity to the CCR2 RNA for the siNA molecule to direct cleavage of the CCR2 RNA via RNA interference."; claim 7).

As the technical features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups.

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

NOTE, continuation of item 4 above: claims 4-10, 16-78 are held unsearchable because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).