

RNAi Agents for Inhibiting Expression of PNPLA3, Pharmaceutical Compositions Thereof, and Methods of Use

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Appl. No. 63/000,137, filed March 26, 2020, which application is incorporated by reference herein in its entirety.

SEQUENCE LISTING

[0002] This instant application contains a Sequence Listing which has been submitted electronically in ASCII format and is hereby incorporated by reference in its entirety. Said ASCII copy, created on March 25, 2021, is named 103693_002475_PCT_SL.txt and is 248,025 bytes in size.

FIELD OF THE INVENTION

[0003] The present disclosure relates to RNA interference (RNAi) agents, *e.g.*, double stranded RNAi agents, for inhibition of Patatin-like phospholipase domain-containing protein 3 (PNPLA3), pharmaceutical compositions that include PNPLA3 RNAi agents, and methods of use thereof.

BACKGROUND

[0004] Nonalcoholic fatty liver disease (NAFLD) is the most common chronic liver disease in the world and is estimated to affect approximately 20% of the world population. In some individuals the accumulation of ectopic fat in the liver, called steatosis, triggers inflammation and hepatocellular injury leading to a more advanced stage of disease called, nonalcoholic steatohepatitis (NASH). Treatments for NAFLD are often directed towards weight loss and treatment of any secondary conditions, such as insulin resistance or dyslipidemia.

[0005] Patatin-like phospholipase domain-containing 3 (PNPLA3), a type II transmembrane protein is expressed in various cells including in the liver. In hepatocytes, PNPLA3 is expressed on the endoplasmic reticulum and lipid membranes and predominantly exhibits triacylglycerol hydrolase activity.

[0006] The present invention represents a novel approach to reducing PNPLA3 levels and treating hepatologic diseases, such as NAFLD.

SUMMARY

[0007] Disclosed herein are RNAi agents for inhibiting expression of a PNPLA3 gene, comprising an antisense strand comprising at least 17 contiguous nucleotides differing by 0 or 1 nucleotides from any one of the sequences of SEQ ID NOs: 46-60, 176, 181 and 188; and a sense strand comprising a nucleotide sequence that is at least partially complementary to the antisense strand.

[0008] In some embodiments, the antisense strand comprises nucleotides 2-18 of any one of the sequences of SEQ ID NOs: 46-60, 176, 181 and 188.

[0009] In some embodiments, the sense strand comprises a nucleotide sequence of at least 17 contiguous nucleotides differing by 0 or 1 nucleotides from any one of the sense strand sequences of SEQ ID NOs: 2, 3, 4, 9-20, 214, 219 and 220, and wherein the sense strand has a region of at least 85% complementarity over the 17 contiguous nucleotides to the antisense strand.

[0010] In some embodiments, the least one nucleotide of the RNAi agent is a modified nucleotide or includes a modified internucleoside linkage.

[0011] According to some embodiments, all or substantially all of the nucleotides of the sense and/or antisense strand of the RNAi agent are modified nucleotides.

[0012] In some embodiments, the modified nucleotide is selected from the group consisting of: 2'-O-methyl nucleotide, 2'-fluoro nucleotide, 2'-deoxy nucleotide, 2',3'-seco nucleotide mimic, locked nucleotide, 2'-F-arabino nucleotide, 2'-methoxyethyl nucleotide, abasic nucleotide, ribitol, inverted nucleotide, inverted 2'-O-methyl nucleotide, inverted 2'-deoxy nucleotide, 2'-amino-modified nucleotide, 2'-alkyl-modified nucleotide, morpholino nucleotide, vinyl phosphonate containing nucleotide, cyclopropyl phosphonate containing nucleotide, and 3'-O-methyl nucleotide.

[0013] In other embodiments, the all or substantially all of the modified nucleotides are 2'-O-methyl nucleotides, 2'-fluoro nucleotides, or combinations thereof.

[0014] In some embodiments, the antisense strand consists of, consists essentially of, or comprises the nucleotide sequence of any one of the modified antisense strand sequences of SEQ ID NOs: 90, 95 and 102.

[0015] In some embodiments, the sense strand consists of, consists essentially of, or comprises the nucleotide sequence of any of the modified sense strand sequences of SEQ ID NOs: 131, 136 and 137.

[0016] In some embodiments, the antisense strand comprises the nucleotide sequence of any one of the modified sequences of SEQ ID NOs: 90, 95 and 102 and the sense strand comprises the nucleotide sequence of any one of the modified sequences of SEQ ID NOs: 131, 136 and 137.

[0017] In other embodiments, the RNAi agents are linked to a targeting ligand. In some embodiments, the targeting ligand comprises N-acetyl-galactosamine. In yet other embodiments, the targeting ligand comprises the structure of (NAG37) or (NAG37)s. In further embodiments, the targeting ligand is linked to the sense strand. In some embodiments, the targeting ligand is linked to the 5' terminal end of the sense strand.

[0018] In some embodiments, the targeting sense strand is between 18 and 30 nucleotides in length, and the antisense strand is between 18 and 30 nucleotides in length. In other embodiments, the targeting the sense strand and the antisense strand are each between 18 and 27 nucleotides in length. In other embodiments, the targeting the sense strand and the antisense strand are each between 18 and 24 nucleotides in length. In still other embodiments, sense strand and the antisense strand are each 21 nucleotides in length.

[0019] In some embodiments, the RNAi agents have two blunt ends.

[0020] In some embodiments, the sense strand comprises one or two terminal caps. In other embodiments, the sense strand comprises one or two inverted abasic residues.

[0021] In some embodiments, the RNAi agents are comprised of a sense strand and an antisense strand that form a duplex sequence with SEQ ID NOs: (176 and 214); (90 and 131); (181 and 219); (95 and 136); (188 and 220) and/or (102 and 137).

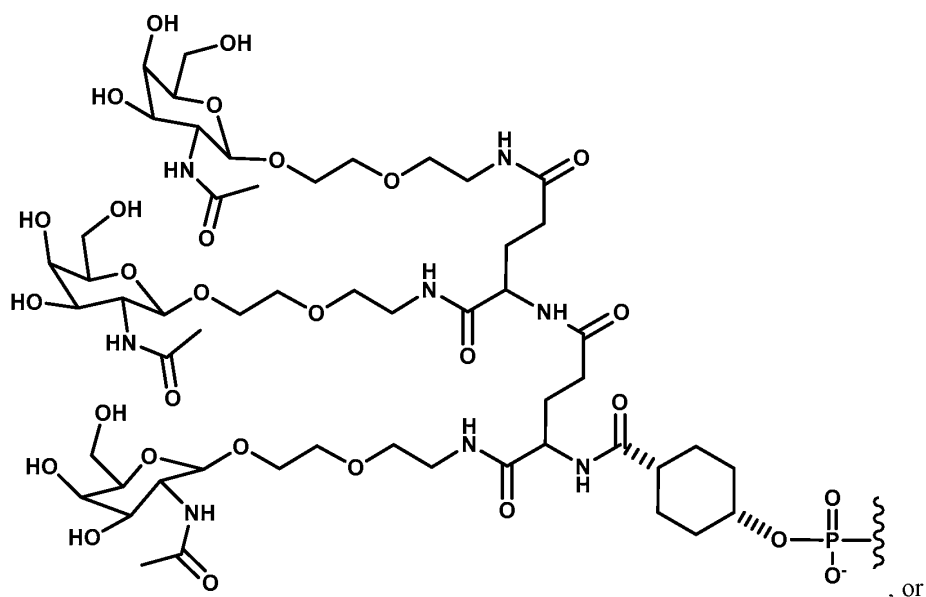
[0022] In some embodiments, the sense strand further includes inverted abasic residues at the 3' terminal end of the nucleotide sequence, at the 5' end of the nucleotide sequence, or at both.

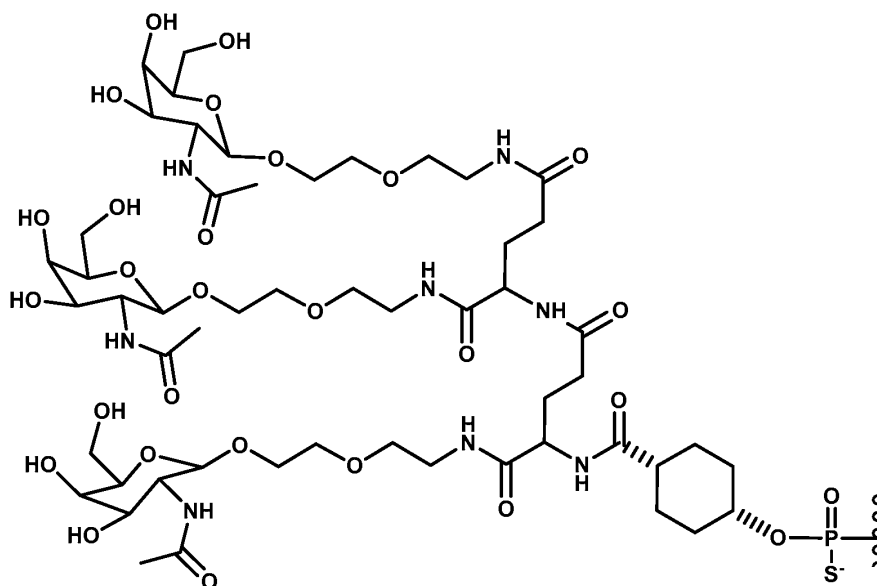
[0023] In some aspects the RNAi agents provided herein comprise an antisense strand that comprises, consists of, or consists essentially of a modified nucleotide sequence that differs by 0 or 1 nucleotides from one of the nucleotide sequences of SEQ ID NOs: 90, 95 and 102; wherein a, c, g, and u represent 2'-O-methyl adenosine, cytidine, guanosine, and uridine, respectively; Af, Cf, Gf, and Uf represent 2'-fluoro adenosine, cytidine, guanosine, and uridine, respectively; s represents a phosphorothioate linkage; and wherein all or substantially all of the nucleotides on the sense strand are modified nucleotides.

[0024] In some embodiments, the disclosed sense strand comprises, consists of, or consists essentially of a modified nucleotide sequence that differs by 0 or 1 nucleotides from one of the nucleotide sequences of SEQ ID NOs: 214, 219 and 256; wherein a, c, g, i, and u represent 2'-O-methyl adenosine, cytidine, guanosine, inosine, and uridine, respectively; Af, Cf, Gf, and Uf represent 2'-fluoro adenosine, cytidine, guanosine, and uridine, respectively; s represents a phosphorothioate linkage; and wherein all or substantially all of the nucleotides on the antisense strand are modified nucleotides. In other embodiments, the sense strand further includes inverted abasic residues at the 3' terminal end of the nucleotide sequence, at the 5' end of the nucleotide sequence, or at both. In other embodiments, the sense strand of the RNAi agents is linked to a targeting ligand.

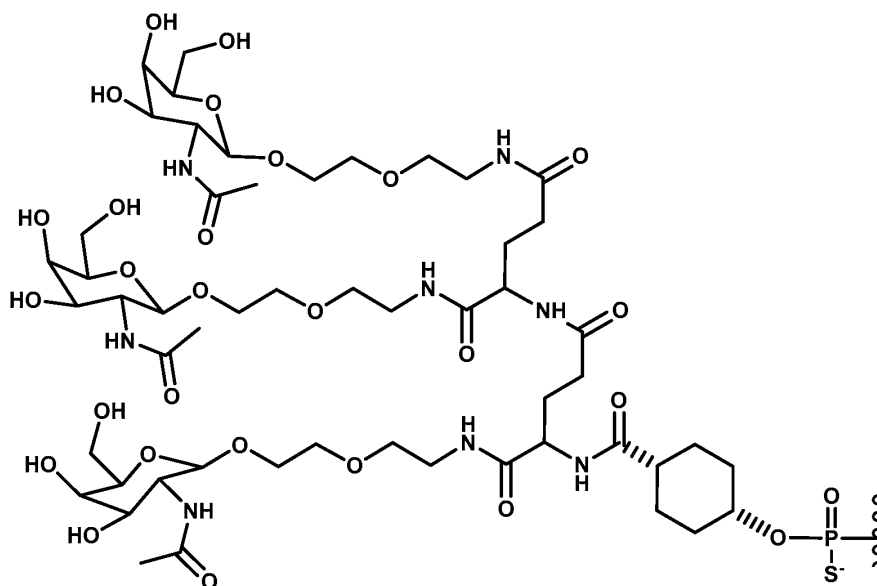
[0025] In some embodiments, the targeting ligand has affinity for the asialoglycoprotein receptor. In some embodiments, the targeting ligand comprises N-acetyl-galactosamine.

[0026] In further embodiments, the targeting ligand comprises:





[0027] In further embodiments, the antisense strand consists of the modified nucleotide sequence of SEQ ID NOs: 90, 95 and 102, and the sense strand consists of the modified nucleotide sequence of SEQ ID NOs: 131, 136 and 137; wherein a, c, g, and u are 2'-O-methyl adenosine, cytidine, guanosine, and uridine, respectively; Af, Cf, Gf, and Uf are 2'-fluoro adenosine, cytidine, guanosine, and uridine, respectively; s is a phosphorothioate linkage; (invAb) is an inverted abasic deoxyribose residue; and (NAG37)s has the following chemical structure:



[0028] Also disclosed herein are compositions comprising the disclosed RNAi agents, wherein the compositions further comprise a pharmaceutically acceptable excipient.

[0029] Also provided herein are methods for inhibiting expression of a PNPLA3 gene in a cell, the methods comprising introducing into a cell an effective amount of the disclosed RNAi agents or the disclosed compositions.

[0030] In some embodiments, the cell is within a subject. In some embodiments, the subject is a human subject.

[0031] In other embodiments, the PNPLA3 gene expression is inhibited by at least about 30%. In some embodiments, the PNPLA3 gene expression is inhibited by at least about 50% in the cytoplasm of hepatocytes.

[0032] Further provided herein are methods of treating a PNPLA3-related disease or disorder, the methods comprising administering to a human subject in need thereof a therapeutically effective amount of the disclosed compositions.

[0033] In some embodiments, the disease is NAFLD, NASH, hepatic fibrosis, alcoholic fatty liver disease, or cirrhosis.

[0034] In some embodiments, the RNAi agents are administered at a dose of about 0.05 mg/kg to about 5.0 mg/kg of body weight of the human subject.

[0035] In other embodiments, the RNAi agent is administered in two or more doses.

[0036] Also provided herein are usages of the disclosed RNAi agents or the disclosed compositions, for the treatment of a disease, disorder, or symptom that is mediated at least in part PNPLA3 gene expression.

[0037] In some embodiments, the symptom is cirrhosis of the liver.

[0038] Further provided herein are usages of the disclosed RNAi agents or the disclosed compositions, for the preparation of a pharmaceutical compositions for treating a disease, disorder, or symptom that is mediated at least in part by PNPLA3 gene expression.

[0039] In some embodiments, the disease is NAFLD, NASH, hepatic fibrosis, or an alcoholic or non-alcoholic liver disease such as cirrhosis. In some embodiments, the RNAi agent is administered at a dose of about 0.05 mg/kg to about 5.0 mg/kg of body weight of the human subject.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] Figure 1 is a graph depicting the baseline-relative whole liver expression of PNPLA3 by PCR from RNAi agent-treated non-human primates (NHPs). Study #1: Data are geometric mean $\pm$ SD (n=4).

[0041] Figure 2 is a graph depicting the average PNPLA3 mRNA knockdown in the cytoplasm of hepatocytes by quantitative ISH between in all animals tested (study #1 and study #2). Study #2: Data are mean $\pm$ SD (n=14).

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0042] The disclosed methods may be understood more readily by reference to the following detailed description taken in connection with the accompanying figures, which form a part of this disclosure. It is to be understood that the disclosed methods are not limited to the specific methods described and/or shown herein, and that the terminology used herein is for the purpose of describing particular embodiments by way of example only and is not intended to be limiting of the claimed methods.

[0043] It is to be appreciated that certain features of the disclosed methods which are, for clarity, described herein in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the disclosed methods that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination.

[0044] *Definitions*

[0045] As used herein, an “RNAi agent” (also referred to as an “RNAi trigger”) means a composition that contains an RNA or RNA-like (e.g., chemically modified RNA) oligonucleotide molecule that is capable of degrading or inhibiting (e.g., degrades or inhibits under appropriate conditions) translation of messenger RNA (mRNA) transcripts of a target mRNA in a sequence specific manner. As used herein, RNAi agents may operate through the RNA interference mechanism (i.e., inducing RNA interference through interaction with the RNA interference pathway machinery (RNA-induced silencing complex or RISC) of mammalian cells), or by any alternative mechanism(s) or pathway(s). While it is believed that RNAi agents, as that term is used herein, operate primarily through the RNA interference mechanism, the disclosed RNAi agents are not bound by or limited to any particular pathway or mechanism of action. RNAi agents disclosed herein are comprised of a sense strand and an antisense strand, and include, but are not limited to: short (or small) interfering RNAs (siRNAs), double stranded RNAs (dsRNA), micro RNAs (miRNAs), short hairpin RNAs (shRNA), and dicer substrates. The antisense strand of the RNAi agents described herein is at least partially complementary to the mRNA being targeted (i.e. PNPLA3 mRNA). RNAi agents can include one or more modified nucleotides and/or one or more non-phosphodiester linkages.

[0046] As used herein, the terms “silence,” “reduce,” “inhibit,” “down-regulate,” or “knockdown” when referring to expression of a given gene, mean that the expression of the gene, as measured by the level of RNA transcribed from the gene or the level of polypeptide, protein, or protein subunit translated from the mRNA in a cell, group of cells, tissue, organ, or subject in which the gene is transcribed, is reduced when the cell, group of cells, tissue, organ, or subject is treated with the RNAi agents described herein as compared to a second cell, group of cells, tissue, organ, or subject that has not or have not been so treated.

[0047] As used herein, the terms “sequence” and “nucleotide sequence” mean a succession or order of nucleobases or nucleotides, described with a succession of letters using standard nomenclature. A nucleic acid molecule can comprise unmodified and/or modified nucleotides. A nucleotide sequence can comprise unmodified and/or modified nucleotides.

[0048] As used herein, a “base,” “nucleotide base,” “nucleotide,” or “nucleobase,” is a heterocyclic pyrimidine or purine compound that is a component of a polynucleotide, and includes the primary purine bases adenine and guanine, and the primary pyrimidine bases cytosine, thymine, and uracil. A nucleotide can be unmodified. A nucleotide may further be modified to include, without limitation, universal bases, hydrophobic bases, promiscuous bases, size-expanded bases, and fluorinated bases. (*See, e.g., Modified Nucleosides in*

Biochemistry, Biotechnology and Medicine, Herdewijn, P. ed. Wiley-VCH, 2008). The synthesis of such modified nucleotides (including phosphoramidite compounds that include modified nucleotides) is known in the art.

[0049] As used herein, and unless otherwise indicated, the term “complementary,” when used to describe a first nucleobase or nucleotide sequence (e.g., RNAi agent sense strand or targeted mRNA) in relation to a second nucleobase or nucleotide sequence (e.g., RNAi agent antisense strand or a single-stranded antisense oligonucleotide), means the ability of an oligonucleotide or polynucleotide including the first nucleotide sequence to hybridize (form base pair hydrogen bonds under mammalian physiological conditions (or otherwise suitable *in vivo* or *in vitro* conditions)) and form a duplex or double helical structure under certain standard conditions with an oligonucleotide that includes the second nucleotide sequence. The person of ordinary skill in the art would be able to select the set of conditions most appropriate for a hybridization test. Complementary sequences include Watson-Crick base pairs or non-Watson-Crick base pairs and include natural or modified nucleotides or nucleotide mimics, at least to the extent that the above hybridization requirements are fulfilled. Sequence identity or complementarity is independent of modification. For example, a and Af, as defined herein, are complementary to U (or T) and identical to A for the purposes of determining identity or complementarity.

[0050] As used herein, “perfectly complementary” or “fully complementary” means that in a hybridized pair of nucleobase or nucleotide sequence molecules, all (100%) of the bases in a contiguous sequence of a first oligonucleotide will hybridize with the same number of bases in a contiguous sequence of a second oligonucleotide. The contiguous sequence may comprise all or a part of a first or second nucleotide sequence.

[0051] As used herein, “partially complementary” means that in a hybridized pair of nucleobase or nucleotide sequence molecules, at least 70%, but not all, of the bases in a contiguous sequence of a first oligonucleotide will hybridize with the same number of bases in a contiguous sequence of a second oligonucleotide. The contiguous sequence may comprise all or a part of a first or second nucleotide sequence.

[0052] As used herein, “substantially complementary” means that in a hybridized pair of nucleobase or nucleotide sequence molecules, at least 85%, but not all, of the bases in a contiguous sequence of a first oligonucleotide will hybridize with the same number of bases in a contiguous sequence of a second oligonucleotide. The contiguous sequence may comprise all or a part of a first or second nucleotide sequence.

[0053] As used herein, the terms “complementary,” “fully complementary,” “partially complementary,” and “substantially complementary” are used with respect to the nucleobase or nucleotide matching between the sense strand and the antisense strand of an RNAi agent, or between the antisense strand of an RNAi agent and a sequence of a PNPLA3 mRNA.

[0054] As used herein, the term “substantially identical” or “substantial identity,” as applied to a nucleic acid sequence means the nucleotide sequence (or a portion of a nucleotide sequence) has at least about 85% sequence identity or more, e.g., at least 90%, at least 95%, or at least 99% identity, compared to a reference sequence. Percentage of sequence identity is determined by comparing two optimally aligned sequences over a comparison window. The percentage is calculated by determining the number of positions at which the same type of nucleic acid base occurs in both sequences to yield the number of matched positions, dividing the number of matched positions by the total number of positions in the window of comparison and multiplying the result by 100 to yield the percentage of sequence identity. The inventions disclosed herein encompass nucleotide sequences substantially identical to those disclosed herein.

[0055] As used herein, the terms “individual”, “patient” and “subject”, are used interchangeably to refer to a member of any animal species including, but not limited to, birds, humans and other primates, and other mammals including commercially relevant mammals or animal models such as mice, rats, monkeys, cattle, pigs, horses, sheep, cats, and dogs. Preferably, the subject is a human.

[0056] As used herein, the terms “treat,” “treatment,” and the like, mean the methods or steps taken to provide relief from or alleviation of the number, severity, and/or frequency of one or more symptoms of a disease in a subject. As used herein, “treat” and “treatment” may include the prevention, management, prophylactic treatment, and/or inhibition or reduction of the number, severity, and/or frequency of one or more symptoms of a disease in a subject.

[0057] As used herein, the phrase “introducing into a cell,” when referring to an RNAi agent, means functionally delivering the RNAi agent into a cell. The phrase “functional delivery,” means delivering the RNAi agent to the cell in a manner that enables the RNAi agent to have the expected biological activity, e.g., sequence-specific inhibition of gene expression.

[0058] Unless stated otherwise, use of the symbol  as used herein means that any group or groups may be linked thereto that is in accordance with the scope of the inventions described herein.

[0059] As used herein, the term “isomers” refers to compounds that have identical molecular formulae, but that differ in the nature or the sequence of bonding of their atoms or in the arrangement of their atoms in space. Isomers that differ in the arrangement of their atoms in space are termed “stereoisomers.” Stereoisomers that are not mirror images of one another are termed “diastereoisomers,” and stereoisomers that are non-superimposable mirror images are termed “enantiomers,” or sometimes optical isomers. A carbon atom bonded to four non-identical substituents is termed a “chiral center.”

[0060] As used herein, unless specifically identified in a structure as having a particular conformation, for each structure in which asymmetric centers are present and thus give rise to enantiomers, diastereomers, or other stereoisomeric configurations, each structure disclosed herein is intended to represent all such possible isomers, including their optically pure and racemic forms. For example, the structures disclosed herein are intended to cover mixtures of diastereomers as well as single stereoisomers.

[0061] As used herein, the terms “comprising,” “including,” “containing” and “characterized by” are exchangeable, inclusive, open-ended and do not exclude additional, unrecited elements or method steps. Any recitation herein of the term “comprising,” particularly in a description of components of a composition or in a description of elements of a device, is understood to encompass those compositions and methods consisting essentially of and consisting of the recited components or elements.

[0062] As used in a claim herein, the phrase “consisting of” excludes any element, step, or ingredient not specified in the claim. When used in a claim herein, the phrase “consisting essentially of” limits the scope of a claim to the specified materials or steps and those that do not materially affect the basic and novel characteristic(s) of the claimed invention.

[0063] The person of ordinary skill in the art would readily understand and appreciate that the compounds and compositions disclosed herein may have certain atoms (e.g., N, O, or S atoms) in a protonated or deprotonated state, depending upon the environment in which the compound or composition is placed. Accordingly, as used herein, the structures disclosed herein envisage that certain functional groups, such as, for example, OH, SH, or NH, may be protonated or deprotonated. The disclosure herein is intended to cover the disclosed compounds and compositions regardless of their state of protonation based on the environment (such as pH), as would be readily understood by the person of ordinary skill in the art. Correspondingly, compounds described herein with labile protons or basic atoms should also be understood to represent salt forms of the corresponding compound. Compounds described herein may be in

a free acid, free base, or salt form. Pharmaceutically acceptable salts of the compounds described herein should be understood to be within the scope of the invention.

[0064] As used herein, the term “linked” or “conjugated” when referring to the connection between two compounds or molecules means that two compounds or molecules are joined by a covalent bond. Unless stated, the terms “linked” and “conjugated” as used herein may refer to the connection between a first compound and a second compound either with or without any intervening atoms or groups of atoms.

[0065] As used herein, the term “including” is used to herein mean, and is used interchangeably with, the phrase “including but not limited to.” The term “or” is used herein to mean, and is used interchangeably with, the term “and/or,” unless the context clearly indicates otherwise.

[0066] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described below. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety. In case of conflict, the present specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

[0067] Other objects, features, aspects, and advantages of the invention will be apparent from the following detailed description, accompanying figures, and from the claims.

Detailed Description

RNAi Agents

[0068] Described herein are RNAi agents for inhibiting expression of a PNPLA3 gene (referred to herein as PNPLA3 RNAi agents or PNPLA3 RNAi triggers). Each PNPLA3 RNAi agent comprises a sense strand and an antisense strand. The sense strand and the antisense strand each can be 16 to 49 nucleotides in length. The sense and antisense strands can be either the same length or they can be different lengths. In some embodiments, the sense and antisense strands are each independently 18 to 27 nucleotides in length. In some embodiments, both the sense and antisense strands are each 21-26 nucleotides in length. In some embodiments, the sense and antisense strands are each 21-24 nucleotides in length. In some embodiments, the sense and antisense strands are each independently 19-21 nucleotides in length. In some embodiments, the sense strand is about 19 nucleotides in length while the antisense strand is

about 21 nucleotides in length. In some embodiments, the sense strand is about 21 nucleotides in length while the antisense strand is about 23 nucleotides in length. In some embodiments, a sense strand is 23 nucleotides in length and an antisense strand is 21 nucleotides in length. In some embodiments, both the sense and antisense strands are each 21 nucleotides in length. In some embodiments, the RNAi agent sense and antisense strands are each independently 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, or 39 nucleotides in length. In some embodiments, a double-stranded RNAi agent has a duplex length of about 16, 17, 18, 19, 20, 21, 22, 23 or 24 nucleotides.

[0069] Examples of nucleotide sequences used in forming PNPLA3 RNAi agents are provided in Tables 2, 3, and 4. Examples of RNAi agent duplexes, that include the sense strand and antisense strand sequences in Tables 2, 3, and 4, are shown in Tables 5A and 5B.

[0070] In some embodiments, the region of perfect, substantial, or partial complementarity between the sense strand and the antisense strand is 16-26 (e.g., 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, or 26) nucleotides in length and occurs at or near the 5' end of the antisense strand (e.g., this region may be separated from the 5' end of the antisense strand by 0, 1, 2, 3, or 4 nucleotides that are not perfectly, substantially, or partially complementary).

[0071] A sense strand of the PNPLA3 RNAi agents described herein includes at least 16 consecutive nucleotides that have at least 85% identity to a core stretch sequence (also referred to herein as a "core stretch" or "core sequence") of the same number of nucleotides in a PNPLA3 mRNA. In some embodiments, a sense strand core stretch sequence is 100% (perfectly) complementary or at least about 85% (substantially) complementary to a core stretch sequence in the antisense strand, and thus the sense strand core stretch sequence is typically perfectly identical or at least about 85% identical to a nucleotide sequence of the same length (sometimes referred to, *e.g.*, as a target sequence) present in the PNPLA3 mRNA target. In some embodiments, this sense strand core stretch is 16, 17, 18, 19, 20, 21, 22, or 23 nucleotides in length. In some embodiments, this sense strand core stretch is 17 nucleotides in length. In some embodiments, this sense strand core stretch is 19 nucleotides in length.

[0072] An antisense strand of a PNPLA3 RNAi agent described herein includes at least 16 consecutive nucleotides that have at least 85% complementarity to a core stretch of the same number of nucleotides in a PNPLA3 mRNA and to a core stretch of the same number of nucleotides in the corresponding sense strand. In some embodiments, an antisense strand core stretch is 100% (perfectly) complementary or at least about 85% (substantially) complementary to a nucleotide sequence (*e.g.*, target sequence) of the same length present in the PNPLA3 mRNA target. In some embodiments, this antisense strand core stretch is 16, 17, 18, 19, 20, 21,

22, or 23 nucleotides in length. In some embodiments, this antisense strand core stretch is 19 nucleotides in length. In some embodiments, this antisense strand core stretch is 17 nucleotides in length. A sense strand core stretch sequence can be the same length as a corresponding antisense core sequence or it can be a different length.

[0073] The PNPLA3 RNAi agent sense and antisense strands anneal to form a duplex. A sense strand and an antisense strand of a PNPLA3 RNAi agent can be partially, substantially, or fully complementary to each other. Within the complementary duplex region, the sense strand core stretch sequence is at least 85% complementary or 100% complementary to the antisense core stretch sequence. In some embodiments, the sense strand core stretch sequence contains a sequence of at least 16, at least 17, at least 18, at least 19, at least 20, at least 21, at least 22, or at least 23 nucleotides that is at least 85% or 100% complementary to a corresponding 16, 17, 18, 19, 20, 21, 22, or 23 nucleotide sequence of the antisense strand core stretch sequence (i.e., the sense and antisense core stretch sequences of a PNPLA3 RNAi agent have a region of at least 16, at least 17, at least 18, at least 19, at least 20, at least 21, at least 22, or at least 23 nucleotides that is at least 85% base paired or 100% base paired.)

[0074] In some embodiments, the antisense strand of a PNPLA3 RNAi agent disclosed herein differs by 0, 1, 2, or 3 nucleotides from any of the antisense strand sequences in Table 2 or Table 3. In some embodiments, the sense strand of a PNPLA3 RNAi agent disclosed herein differs by 0, 1, 2, or 3 nucleotides from any of the sense strand sequences in Table 2 or Table 4.

[0075] In some embodiments, the sense strand and/or the antisense strand can optionally and independently contain an additional 1, 2, 3, 4, 5, or 6 nucleotides (extension) at the 3' end, the 5' end, or both the 3' and 5' ends of the core stretch sequences. The antisense strand additional nucleotides, if present, may or may not be complementary to the corresponding sequence in the PNPLA3 mRNA. The sense strand additional nucleotides, if present, may or may not be identical to the corresponding sequence in the PNPLA3 mRNA. The antisense strand additional nucleotides, if present, may or may not be complementary to the corresponding sense strand's additional nucleotides, if present.

[0076] As used herein, an extension comprises 1, 2, 3, 4, 5, or 6 nucleotides at the 5' and/or 3' end of the sense strand core stretch sequence and/or antisense strand core stretch sequence. The extension nucleotides on a sense strand may or may not be complementary to nucleotides, either core stretch sequence nucleotides or extension nucleotides, in the corresponding antisense strand. Conversely, the extension nucleotides on an antisense strand may or may not be complementary to nucleotides, either core stretch nucleotides or extension nucleotides, in

the corresponding sense strand. In some embodiments, both the sense strand and the antisense strand of an RNAi agent contain 3' and 5' extensions. In some embodiments, one or more of the 3' extension nucleotides of one strand base pairs with one or more 5' extension nucleotides of the other strand. In other embodiments, one or more of 3' extension nucleotides of one strand do not base pair with one or more 5' extension nucleotides of the other strand. In some embodiments, a PNPLA3 RNAi agent has an antisense strand having a 3' extension and a sense strand having a 5' extension. In some embodiments, the extension nucleotide(s) are unpaired and form an overhang. As used herein, an "overhang" refers to a stretch of one or more unpaired nucleotides located at a terminal end of either the sense strand or the antisense strand that does not form part of the hybridized or duplexed portion of an RNAi agent disclosed herein.

[0077] In some embodiments, a PNPLA3 RNAi agent comprises an antisense strand having a 3' extension of 1, 2, 3, 4, 5, or 6 nucleotides in length. In other embodiments, a PNPLA3 RNAi agent comprises an antisense strand having a 3' extension of 1, 2, or 3 nucleotides in length. In some embodiments, one or more of the antisense strand extension nucleotides comprise nucleotides that are complementary to the corresponding PNPLA3 mRNA sequence. In some embodiments, one or more of the antisense strand extension nucleotides comprise nucleotides that are not complementary to the corresponding PNPLA3 mRNA sequence.

[0078] In some embodiments, a PNPLA3 RNAi agent comprises a sense strand having a 3' extension of 1, 2, 3, 4, or 5 nucleotides in length. In some embodiments, one or more of the sense strand extension nucleotides comprises adenosine, uracil, or thymidine nucleotides, AT dinucleotide, or nucleotides that correspond to or are the identical to nucleotides in the PNPLA3 mRNA sequence. In some embodiments, the 3' sense strand extension includes or consists of one of the following sequences, but is not limited to: T, UT, TT, UU, UUT, TTT, or TTTT (each listed 5' to 3').

[0079] A sense strand can have a 3' extension and/or a 5' extension. In some embodiments, a PNPLA3 RNAi agent comprises a sense strand having a 5' extension of 1, 2, 3, 4, 5, or 6 nucleotides in length. In some embodiments, one or more of the sense strand extension nucleotides comprise nucleotides that correspond to or are identical to nucleotides in the PNPLA3 mRNA sequence.

[0080] Examples of sequences used in forming PNPLA3 RNAi agents are provided in Tables 2, 3, and 4. In some embodiments, a PNPLA3 RNAi agent antisense strand includes a sequence of any of the sequences in Tables 2 or 3. In certain embodiments, a PNPLA3 RNAi

agent antisense strand comprises or consists of any one of the modified sequences in Table 3. In some embodiments, a PNPLA3 RNAi agent antisense strand includes the sequence of nucleotides (from 5' end → 3' end) 1-17, 2-15, 2-17, 1-18, 2-18, 1-19, 2-19, 1-20, 2-20, 1-21, or 2-21, of any of the sequences in Tables 2 or 3. In some embodiments, a PNPLA3 RNAi agent sense strand includes the sequence of any of the sequences in Tables 2 or 4. In some embodiments, a PNPLA3 RNAi agent sense strand includes the sequence of nucleotides (from 5' end → 3' end) 1-18, 1-19, 1-20, 1-21, 2-19, 2-20, 2-21, 3-20, 3-21, or 4-21 of any of the sequences in Tables 2 or 4. In certain embodiments, a PNPLA3 RNAi agent sense strand comprises or consists of a modified sequence of any one of the modified sequences in Table 4.

[0081] In some embodiments, the sense and antisense strands of the RNAi agents described herein contain the same number of nucleotides. In some embodiments, the sense and antisense strands of the RNAi agents described herein contain different numbers of nucleotides. In some embodiments, the sense strand 5' end and the antisense strand 3' end of an RNAi agent form a blunt end. In some embodiments, the sense strand 3' end and the antisense strand 5' end of an RNAi agent form a blunt end. In some embodiments, both ends of an RNAi agent form blunt ends. In some embodiments, neither end of an RNAi agent is blunt-ended. As used herein a "blunt end" refers to an end of a double stranded RNAi agent in which the terminal nucleotides of the two annealed strands are complementary (form a complementary base-pair).

[0082] In some embodiments, the sense strand 5' end and the antisense strand 3' end of an RNAi agent form a frayed end. In some embodiments, the sense strand 3' end and the antisense strand 5' end of an RNAi agent form a frayed end. In some embodiments, both ends of an RNAi agent form a frayed end. In some embodiments, neither end of an RNAi agent is a frayed end. As used herein a frayed end refers to an end of a double stranded RNAi agent in which the terminal nucleotides of the two annealed strands from a pair (i.e., do not form an overhang) but are not complementary (i.e. form a non-complementary pair). In some embodiments, one or more unpaired nucleotides at the end of one strand of a double stranded RNAi agent form an overhang. The unpaired nucleotides may be on the sense strand or the antisense strand, creating either 3' or 5' overhangs. In some embodiments, the RNAi agent contains: a blunt end and a frayed end, a blunt end and 5' overhang end, a blunt end and a 3' overhang end, a frayed end and a 5' overhang end, a frayed end and a 3' overhang end, two 5' overhang ends, two 3' overhang ends, a 5' overhang end and a 3' overhang end, two frayed ends, or two blunt ends. Typically, when present, overhangs are located at the 3' terminal ends of the sense strand, the antisense strand, or both the sense strand and the antisense strand.

[0083] The PNPLA3 RNAi agents disclosed herein may also be comprised of one or more modified nucleotides. In some embodiments, substantially all of the nucleotides of the sense strand and substantially all of the nucleotides of the antisense strand of the PNPLA3 RNAi agent are modified nucleotides. The PNPLA3 RNAi agents disclosed herein may further be comprised of one or more modified internucleoside linkages, e.g., one or more phosphorothioate linkages. In some embodiments, a PNPLA3 RNAi agent contains one or more modified nucleotides and one or more modified internucleoside linkages. In some embodiments, a 2'-modified nucleotide is combined with modified internucleoside linkage.

[0084] In some embodiments, a PNPLA3 RNAi agent is prepared or provided as a salt, mixed salt, or a free-acid. In some embodiments, a PNPLA3 RNAi agent is prepared as a sodium salt. Such forms that are well known in the art are within the scope of the inventions disclosed herein.

Modified Nucleotides

[0085] Modified nucleotides, when used in various oligonucleotide constructs, can preserve activity of the compound in cells while at the same time increasing the serum stability of these compounds, and can also minimize the possibility of activating interferon activity in humans upon administering of the oligonucleotide construct.

[0086] In some embodiments, a PNPLA3 RNAi agent contains one or more modified nucleotides. As used herein, a "modified nucleotide" is a nucleotide other than a ribonucleotide (2'-hydroxyl nucleotide). In some embodiments, at least 50% (e.g., at least 60%, at least 70%, at least 80%, at least 90%, at least 95%, at least 97%, at least 98%, at least 99%, or 100%) of the nucleotides are modified nucleotides. As used herein, modified nucleotides can include, but are not limited to, deoxyribonucleotides, nucleotide mimics, abasic nucleotides, 2'-modified nucleotides, inverted nucleotides, modified nucleobase-comprising nucleotides, bridged nucleotides, peptide nucleic acids (PNAs), 2',3'-seco nucleotide mimics (unlocked nucleobase analogues), locked nucleotides, 3'-O-methoxy (2' internucleoside linked) nucleotides, 2'-F-Arabino nucleotides, 5'-Me, 2'-fluoro nucleotide, morpholino nucleotides, vinyl phosphonate deoxyribonucleotides, vinyl phosphonate containing nucleotides, and cyclopropyl phosphonate containing nucleotides. 2'-modified nucleotides (*i.e.*, a nucleotide with a group other than a hydroxyl group at the 2' position of the five-membered sugar ring) include, but are not limited to, 2'-O-methyl nucleotides, 2'-fluoro nucleotides (also referred to herein as 2'-deoxy-2'-fluoro nucleotides), 2'-deoxy nucleotides, 2'-methoxyethyl (2'-O-2-methoxyethyl) nucleotides (also referred to as 2'-MOE), 2'-amino nucleotides, and 2'-alkyl nucleotides. It is not necessary for

all positions in a given compound to be uniformly modified. Conversely, more than one modification can be incorporated in a single PNPLA3 RNAi agent or even in a single nucleotide thereof. The PNPLA3 RNAi agent sense strands and antisense strands can be synthesized and/or modified by methods known in the art. Modification at one nucleotide is independent of modification at another nucleotide.

[0087] Modified nucleobases include synthetic and natural nucleobases, such as 5-substituted pyrimidines, 6-azapyrimidines and N-2, N-6 and O-6 substituted purines, (e.g., 2-aminopropyladenine, 5-propynyluracil, or 5-propynylcytosine), 5-methylcytosine (5-me-C), 5-hydroxymethyl cytosine, inosine, xanthine, hypoxanthine, 2-aminoadenine, 6-alkyl (e.g., 6-methyl, 6-ethyl, 6-isopropyl, or 6-n-butyl) derivatives of adenine and guanine, 2-alkyl (e.g., 2-methyl, 2-ethyl, 2-isopropyl, or 2-n-butyl) and other alkyl derivatives of adenine and guanine, 2-thiouracil, 2-thiothymine, 2-thiocytosine, 5-halouracil, cytosine, 5-propynyl uracil, 5-propynyl cytosine, 6-azo uracil, 6-azo cytosine, 6-azo thymine, 5-uracil (pseudouracil), 4-thiouracil, 8-halo, 8-amino, 8-sulfhydryl, 8-thioalkyl, 8-hydroxyl and other 8-substituted adenines and guanines, 5-halo (e.g., 5-bromo), 5-trifluoromethyl, and other 5-substituted uracils and cytosines, 7-methylguanine and 7-methyladenine, 8-azaguanine and 8-azaadenine, 7-deazaguanine, 7-deazaadenine, 3-deazaguanine, and 3-deazaadenine.

[0088] In some embodiments, the 5' and/or 3' end of the antisense strand can include abasic residues (Ab), which can also be referred to as an "abasic site" or "abasic nucleotide." An abasic residue (Ab) is a nucleotide or nucleoside that lacks a nucleobase at the 1' position of the sugar moiety. (*See, e.g.*, U.S. Patent No. 5,998,203). In some embodiments, an abasic residue can be placed internally in a nucleotide sequence. In some embodiments, Ab or AbAb can be added to the 3' end of the antisense strand. In some embodiments, the 5' end of the sense strand can include one or more additional abasic residues (e.g., (Ab) or (AbAb)). In some embodiments, UUAb, UAb, or Ab are added to the 3' end of the sense strand. In some embodiments, an abasic (deoxyribose) residue can be replaced with a ribitol (abasic ribose) residue.

[0089] In some embodiments, all or substantially all of the nucleotides of an RNAi agent are modified nucleotides. As used herein, an RNAi agent wherein substantially all of the nucleotides present are modified nucleotides is an RNAi agent having four or fewer (i.e., 0, 1, 2, 3, or 4) nucleotides in both the sense strand and the antisense strand being ribonucleotides (i.e., unmodified). As used herein, a sense strand wherein substantially all of the nucleotides present are modified nucleotides is a sense strand having two or fewer (i.e., 0, 1, or 2) nucleotides in the sense strand being unmodified ribonucleotides. As used herein, an antisense

sense strand wherein substantially all of the nucleotides present are modified nucleotides is an antisense strand having two or fewer (i.e., 0, 1, or 2) nucleotides in the sense strand being unmodified ribonucleotides. In some embodiments, one or more nucleotides of an RNAi agent is an unmodified ribonucleotide.

Modified Internucleoside Linkages

[0090] In some embodiments, one or more nucleotides of a PNPLA3 RNAi agent are linked by non-standard linkages or backbones (i.e., modified internucleoside linkages or modified backbones). Modified internucleoside linkages or backbones include, but are not limited to, phosphorothioate groups (represented herein as a lower case “s”), chiral phosphorothioates, thiophosphates, phosphorodithioates, phosphotriesters, aminoalkyl-phosphotriesters, alkyl phosphonates (e.g., methyl phosphonates or 3'-alkylene phosphonates), chiral phosphonates, phosphinates, phosphoramidates (e.g., 3'-amino phosphoramidate, aminoalkylphosphoramidates, or thionophosphoramidates), thionoalkyl-phosphonates, thionoalkylphosphotriesters, morpholino linkages, boranophosphates having normal 3'-5' linkages, 2'-5' linked analogs of boranophosphates, or boranophosphates having inverted polarity wherein the adjacent pairs of nucleoside units are linked 3'-5' to 5'-3' or 2'-5' to 5'-2'. In some embodiments, a modified internucleoside linkage or backbone lacks a phosphorus atom. Modified internucleoside linkages lacking a phosphorus atom include, but are not limited to, short chain alkyl or cycloalkyl inter-sugar linkages, mixed heteroatom and alkyl or cycloalkyl inter-sugar linkages, or one or more short chain heteroatomic or heterocyclic inter-sugar linkages. In some embodiments, modified internucleoside backbones include, but are not limited to, siloxane backbones, sulfide backbones, sulfoxide backbones, sulfone backbones, formacetyl and thioformacetyl backbones, methylene formacetyl and thioformacetyl backbones, alkene-containing backbones, sulfamate backbones, methyleneimino and methylenehydrazino backbones, sulfonate and sulfonamide backbones, amide backbones, and other backbones having mixed N, O, S, and CH₂ components.

[0091] In some embodiments, a sense strand of a PNPLA3 RNAi agent can contain 1, 2, 3, 4, 5, or 6 phosphorothioate linkages, an antisense strand of a PNPLA3 RNAi agent can contain 1, 2, 3, 4, 5, or 6 phosphorothioate linkages, or both the sense strand and the antisense strand independently can contain 1, 2, 3, 4, 5, or 6 phosphorothioate linkages. In some embodiments, a sense strand of a PNPLA3 RNAi agent can contain 1, 2, 3, or 4 phosphorothioate linkages, an antisense strand of a PNPLA3 RNAi agent can contain 1, 2, 3,

or 4 phosphorothioate linkages, or both the sense strand and the antisense strand independently can contain 1, 2, 3, or 4 phosphorothioate linkages.

[0092] In some embodiments, a PNPLA3 RNAi agent sense strand contains at least two phosphorothioate internucleoside linkages. In some embodiments, the phosphorothioate internucleoside linkages are between the nucleotides at positions 1-3 from the 3' end of the sense strand. In some embodiments, one phosphorothioate internucleoside linkage is at the 5' end of the sense strand nucleotide sequence, and another phosphorothioate linkage is at the 3' end of the sense strand nucleotide sequence. In some embodiments, two phosphorothioate internucleoside linkages are located at the 5' end of the sense strand, and another phosphorothioate linkage is at the 3' end of the sense strand. In some embodiments, the sense strand does not include any phosphorothioate internucleoside linkages between the nucleotides, but contains one, two, or three phosphorothioate linkages between the terminal nucleotides on both the 5' and 3' ends and the optionally present inverted abasic residue terminal caps. In some embodiments, the targeting ligand is linked to the sense strand via a phosphorothioate linkage.

[0093] In some embodiments, a PNPLA3 RNAi agent antisense strand contains four phosphorothioate internucleoside linkages. In some embodiments, the four phosphorothioate internucleoside linkages are between the nucleotides at positions 1-3 from the 5' end of the antisense strand and between the nucleotides at positions 19-21, 20-22, 21-23, 22-24, 23-25, or 24-26 from the 5' end. In some embodiments, three phosphorothioate internucleoside linkages are located between positions 1-4 from the 5' end of the antisense strand, and a fourth phosphorothioate internucleoside linkage is located between positions 20-21 from the 5' end of the antisense strand. In some embodiments, a PNPLA3 RNAi agent contains at least three or four phosphorothioate internucleoside linkages in the antisense strand.

Capping Residues or Moieties

[0094] In some embodiments, the sense strand may include one or more capping residues or moieties, sometimes referred to in the art as a “cap,” a “terminal cap,” or a “capping residue.” As used herein, a “capping residue” is a non-nucleotide compound or other moiety that can be incorporated at one or more termini of a nucleotide sequence of an RNAi agent disclosed herein. A capping residue can provide the RNAi agent, in some instances, with certain beneficial properties, such as, for example, protection against exonuclease degradation. In some embodiments, inverted abasic residues (invAb) (also referred to in the art as “inverted abasic sites”) are added as capping residues. (See, e.g., F. Czauderna, *Nucleic Acids Res.*,

2003, 31(11), 2705-16). Capping residues are generally known in the art, and include, for example, inverted abasic residues as well as carbon chains such as a terminal C₃H₇ (propyl), C₆H₁₃ (hexyl), or C₁₂H₂₅ (dodecyl) groups. In some embodiments, a capping residue is present at either the 5' terminal end, the 3' terminal end, or both the 5' and 3' terminal ends of the sense strand. In some embodiments, the 5' end and/or the 3' end of the sense strand may include more than one inverted abasic deoxyribose moiety as a capping residue.

[0095] In some embodiments, one or more inverted abasic residues (invAb) are added to the 3' end of the sense strand. In some embodiments, one or more inverted abasic residues (invAb) are added to the 5' end of the sense strand. In some embodiments, one or more inverted abasic residues or inverted abasic sites are inserted between the targeting ligand and the nucleotide sequence of the sense strand of the RNAi agent. In some embodiments, the inclusion of one or more inverted abasic residues or inverted abasic sites at or near the terminal end or terminal ends of the sense strand of an RNAi agent allows for enhanced activity or other desired properties of an RNAi agent.

[0096] In some embodiments, one or more inverted abasic residues (invAb) are added to the 5' end of the sense strand. In some embodiments, one or more inverted abasic residues can be inserted between the targeting ligand and the nucleotide sequence of the sense strand of the RNAi agent. The inverted abasic residues may be linked via phosphate, phosphorothioate (e.g., shown herein as (invAb)s)), or other internucleoside linkages. In some embodiments, the inclusion of one or more inverted abasic residues at or near the terminal end or terminal ends of the sense strand of an RNAi agent may allow for enhanced activity or other desired properties of an RNAi agent. In some embodiments, an inverted abasic (deoxyribose) residue can be replaced with an inverted ribitol (abasic ribose) residue. In some embodiments, the 3' end of the antisense strand core stretch sequence, or the 3' end of the antisense strand sequence, may include an inverted abasic residue. The chemical structures for inverted abasic deoxyribose residues are shown in Table 6 below.

PNPLA3 RNAi Agents

[0097] The PNPLA3 RNAi agents disclosed herein are designed to target specific positions on a PNPLA3 gene (e.g., SEQ ID NO: 1).

NM_025225.2 Homo sapiens patatin like phospholipase domain containing 3 (PNPLA3), mRNA (SEQ ID NO: 1):

ATGGTCCGAGGGGGGCGGGGCTGACGTGCGCTGGGAATGCCCTGGCCGAGACA
CTGAGGCAGGGTAGAGAGCGCTTGCGGGCGCCGGGCGGAGCTGCTGCGGATCAG
GACCCGAGCCGATTCCCGATCCCGACCCAGATCCTAACCCGCGCCCCCGCCCCGC
CGCCGCCGCCATGTACGACGCAGAGCGCGGCTGGAGCTTGTCTTCGCGGGCTG
CGGCTTCCTGGGCTTCTACACGTCGGGGCGACCCGCTGCCTGAGCGAGCACGCC
CCGCACCTCCTCCGCGACGCGCGCATGTTGTTTCGGCGCTTCGGCCGGGGCGTTGC
ACTGCGTCGGCGTCCTCTCCGGTATCCCGCTGGAGCAGACTCTGCAGGTCTCTC
AGATCTTGTGCGGAAGGCCAGGAGTCGGAACATTGGCATCTTCCATCCATCCTTC
AACTTAAGCAAGTTCCTCCGACAGGGTCTCTGCAAATGCCTCCCGGCCAATGTCC
ACCAGCTCATCTCCGGCAAAATAGGCATCTCTTTACCAGAGTGTCTGATGGGGA
AAACGTTCTGGTGTCTGACTTTTCGGTCCAAAGACGAAGTCGTGGATGCCTTGTA
TGTTCTGCTTCATCCCTTCTACAGTGGCCTTATCCCTCCTTCCTTCAGAGGCGT
GCGATATGTGGATGGAGGAGTGAGTGACAACGTACCCTTCATTGATGCCAAAAC
AACCATCACCGTGTCCCCCTTCTATGGGGAGTACGACATCTGCCCTAAAGTCAAG
TCCACGAACCTTCTTCATGTGGACATCACCAAGCTCAGTCTACGCTCTGCACAG
GGAACCTCTACCTTCTCTCGAGAGCTTTTGTCCCCCGGATCTCAAGGTGCTGGG
AGAGATATGCCTTCGAGGATATTTGGATGCATTTCAGGTTCTTGGAAGAGAAGGG
CATCTGCAACAGGCCCCAGCCAGGCCTGAAGTCATCCTCAGAAGGGATGGATCC
TGAGGTCGCCATGCCCAGCTGGGCAAACATGAGTCTGGATTCTTCCCCGGAGTCG
GCTGCCTTGGCTGTGAGGCTGGAGGGAGATGAGCTGCTAGACCACCTGCGTCTCA
GCATCCTGCCCTGGGATGAGAGCATCCTGGACACCCTCTCGCCCAGGCTCGCTAC
AGCACTGAGTGAAGAAATGAAAGACAAAGGTGGATACATGAGCAAGATTTGCA
ACTTGCTACCCATTAGGATAATGTCTTATGTAATGCTGCCCTGTACCCTGCCTGTG
GAATCTGCCATTGCGATTGTCCAGAGACTGGTGACATGGCTTCCAGATATGCCCCG
ACGATGTCCTGTGGTTGCAGTGGGTGACCTCACAGGTGTTCACTCGAGTGCTGAT
GTGTCTGCTCCCCGCTCCAGGTCCCAAATGCCAGTGAGCAGCCAACAGGCCTCC
CCATGCACACCTGAGCAGGACTGGCCCTGCTGGACTCCCTGCTCCCCCAAGGGCT
GTCCAGCAGAGACCAAAGCAGAGGCCACCCCGCGGTCCATCCTCAGGTCCAGCC
TGAACCTTCTTCTTGGGCAATAAAGTACCTGCTGGTGTGAGGGGCTCTCCACCTT
TCCCAGTTTTTCTACTAGAGAAGAGTCTGTGAGTCACTTGAGGAGGCGAGTCTAGC
AGATTCTTTCAGAGGTGCTAAAGTTTCCCATCTTTGTGCAGCTACCTCCGCATTGC
TGTGTAGTGACCCCTGCCTGTGACGTGGAGGATCCCAGCCTCTGAGCTGAGTTGG
TTTTATGAAAAGCTAGGAAGCAACCTTTCGCCTGTGCAGCGGTCCAGCACTTAAC
TCTAATACATCAGCATGCGTTAATTCAGCTGGTTGGGAAATGACACCAGGAAGCC

CAGTGCAGAGGGTCCCTTACTGACTGTTTCGTGGCCCTATTAATGGTCAGACTGT
TCCAGCATGAGGTTCTTAGAATGACAGGTGTTTGGATGGGTGGGGCCTTGTGAT
GGGGGGTAGGCTGGCCCATGTGTGATCTTGTGGGGTGGAGGGAAGAGAATAGCA
TGATCCCACCTCCCCATGCTGTGGGAAGGGGTGCAGTTCGTCCCCAAGAACGACA
CTGCCTGTCAGGTGGTCTGCAAAGATGATAACCTTGACTACTAAAAACGTCTCCA
TGGCGGGGGTAACAAGATGATAATCTACTTAATTTTAGAACACCTTTTTTCACCTA
ACTAAAATAATGTTTAAAGAGTTTTGTATAAAAATGTAAGGAAGCGTTGTTACCT
GTTGAATTTTGTATTATGTGAATCAGTGAGATGTTAGTAGAATAAGCCTTAAAAA
AAAAAAAATCGGTTGGGTGCAGTGGCACACGGCTGTAATCCCAGCACTTTGGGA
GGCCAAGGTTGGCAGATCACCTGAGGTCAGGAGTTCAAGACCAGTCTGGCCAAC
ATAGCAAAACCTGTCTCTACTAAAAATACAAAAATTATCTGGGCATGGTGGTGC
ATGCCTGTAATCCCAGCTATTCGGAAGGCTGAGGCAGGAGAATCACTTGAACCC
AGGAGGCGGAGGTTGCGGTGAGCTGAGATTGCACCATTTTCATTCCAGCCTGGGC
AACATGAGTGAAAGTCTGACTCAAAAAAAAAAATTTAAAAAACAAAATAATCT
AGTGTGCAGGGCATTACCTCAGCCCCCAGGCAGGAGCCAAGCACAGCAGGAG
CTTCCGCCTCCTCTCCACTGGAGCACAACTTGAACCTGGCTTATTTTCTGCAGG
GACCAGCCCCACATGGTCAGTGAGTTTCTCCCCATGTGTGGCGATGAGAGAGTGT
AGAAATAAAGAC

[0098] As defined herein, an antisense strand sequence is designed to target a PNPLA3 gene at a given position on the gene when the 5' terminal nucleobase of the antisense strand is aligned with a position that is 19 nucleotides downstream (towards the 3' end) from the position on the gene when base pairing to the gene. For example, as illustrated in Tables 1 and 2 herein, an antisense strand sequence designed to target a PNPLA3 gene at position 2180 requires that when base pairing to the gene, the 5' terminal nucleobase of the antisense strand is aligned with position 2198 of the PNPLA3 gene.

[0099] As provided herein, a PNPLA3 RNAi agent does not require that the nucleobase at position 1 (5' → 3') of the antisense strand be complementary to the gene, provided that there is at least 85% complementarity (e.g., at least 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, or 100% complementarity) of the antisense strand and the gene across a core stretch sequence of at least 16 consecutive nucleotides. For example, for a PNPLA3 RNAi agent disclosed herein that is designed to target position 2180 of a PNPLA3 gene, the 5' terminal nucleobase of the antisense strand of the of the PNPLA3 RNAi agent must be aligned with position 2198 of the gene; however, the 5' terminal nucleobase of the antisense strand may be,

but is not required to be, complementary to position 2200 of a PNPLA3 gene, provided that there is at least 85% complementarity (e.g., at least 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, or 100% complementarity) of the antisense strand and the gene across a core stretch sequence of at least 16 consecutive nucleotides. As shown by, among other things, the various examples disclosed herein, the specific site of binding of the gene by the antisense strand of the PNPLA3 RNAi agent (e.g., whether the PNPLA3 RNAi agent is designed to target a PNPLA3 gene at position 2180, at position 1586, at position 1179, or at some other position) is important to the level of inhibition achieved by the PNPLA3 RNAi agent.

[0100] In some embodiments, the PNPLA3 RNAi agents disclosed herein target a PNPLA3 gene at or near the positions of the PNPLA3 gene sequence shown in Table 1. In some embodiments, the antisense strand of a PNPLA3 RNAi agent disclosed herein includes a core stretch sequence that is fully, substantially, or at least partially complementary to a target PNPLA3 19-mer sequence disclosed in Table 1.

Table 1. PNPLA3 19-mer mRNA Target Sequences (taken from *homo sapiens* patatin like phospholipase domain containing 3 (PNPLA3), mRNA, GenBank NM_025225.2 (SEQ ID NO:1))¹

SEQ ID No.	PNPLA3 19-mer Target Sequences (5' → 3')	Corresponding Positions of Sequence on SEQ ID NO: 1	Targeted Gene Position (as referred to herein)
2	ACCUUUUUCACCUAACUAA	2180-2198	2180
3	CUUUCCCAGUUUUUCACUA	1586-1604	1586
4	GGUGGAUACAUGAGCAAGA	1179-1197	1179
5	GGUCCAAAGACGAAGUCGU	571-589	571
6	AACGUACCCUUCAUUGAUG	687-705	687
7	CUGAGUUGGUUUUAUGAAA	1746-1764	1746
8	AGCAAGAUUUGCAACUUGC	1191-1209	1191

[0101] In some embodiments, a PNPLA3 RNAi agent includes an antisense strand wherein position 19 of the antisense strand (5'→3') is capable of forming a base pair with position 1 of a 19-mer target sequence disclosed in Table 1. In some embodiments, a PNPLA3 RNAi agent includes an antisense strand wherein position 1 of the antisense strand (5'→3') is capable of forming a base pair with position 19 of the 19-mer target sequence disclosed in Table 1.

¹ When referring to gene positions herein, Applicant uses Genebank NM_025225.2 as the reference gene for human PNPLA3. On or about February 9, 2020, the gene sequence was updated as NM_025225.3. While referencing the updated gene would change the number identified as the "Targeted Gene Position" in Table 1 above, this has no impact on the nucleotide sequences used in the RNAi agents disclosed here.

[0102] In some embodiments, a PNPLA3 RNAi agent includes an antisense strand wherein position 2 of the antisense strand (5' → 3') is capable of forming a base pair with position 18 of the 19-mer target sequence disclosed in Table 1. In some embodiments, a PNPLA3 RNAi agent includes an antisense strand wherein positions 2 through 18 of the antisense strand (5' → 3') are capable of forming base pairs with each of the respective complementary bases located at positions 18 through 2 of the 19-mer target sequence disclosed in Table 1.

[0103] For the RNAi agents disclosed herein, the nucleotide at position 1 of the antisense strand (from 5' end → 3' end) can be perfectly complementary to the PNPLA3 gene, or can be non-complementary to the PNPLA3 gene. In some embodiments, the nucleotide at position 1 of the antisense strand (from 5' end → 3' end) is a U, A, or dT. In some embodiments, the nucleotide at position 1 of the antisense strand (from 5' end → 3' end) forms an A:U or U:A base pair with the sense strand.

[0104] In some embodiments, a PNPLA3 RNAi agent antisense strand comprises the sequence of nucleotides (from 5' end → 3' end) 2-18, 2-19, 2-20, or 2-21 of any of the antisense strand sequences in Table 2 or Table 3. In some embodiments, a PNPLA3 RNAi sense strand comprises the sequence of nucleotides (from 5' end → 3' end) 3-21, 2-21, 1-21, 3-20, 2-20, 1-20, 3-19, 2-19, 1-19, 3-18, 2-18, or 1-18 of any of the sense strand sequences in Table 2 or Table 4.

[0105] In some embodiments, a PNPLA3 RNAi agent antisense strand comprises the sequence of nucleotides (from 5' end → 3' end) 2-18, 2-19, 2-20, or 2-21 of any of the antisense strand sequences of SEQ ID NOs: 46-60, 176, 181 and 188. In some embodiments, a PNPLA3 RNAi sense strand comprises the sequence of nucleotides (from 5' end → 3' end) 3-21, 2-21, 1-21, 3-20, 2-20, 1-20, 3-19, 2-19, 1-19, 3-18, 2-18, or 1-18 of any of the sense strand sequences of SEQ ID NOs: 2, 3, 4, 9-20, 214, 219 and 220.

[0106] In some embodiments, a PNPLA3 RNAi agent is comprised of (i) an antisense strand comprising the sequence of nucleotides (from 5' end → 3' end) 2-18 or 2-19 of any of the antisense strand sequences in Table 2 or Table 3, and (ii) a sense strand comprising the sequence of nucleotides (from 5' end → 3' end) 3-21, 2-21, 1-21, 3-20, 2-20, 1-20, 3-19, 2-19, 1-19, 3-18, 2-18, or 1-18 of any of the sense strand sequences in Table 2 or Table 4.

[0107] In some embodiments, a PNPLA3 RNAi agent is comprised of (i) an antisense strand comprising the sequence of nucleotides (from 5' end → 3' end) 2-18 or 2-19 of any of the antisense strand sequences of SEQ ID NOs: 46-60, 176, 181 and 188, and (ii) a sense strand comprising the sequence of nucleotides (from 5' end → 3' end) 3-21, 2-21, 1-21, 3-20, 2-20, 1-

20, 3-19, 2-19, 1-19, 3-18, 2-18, or 1-18 of any of the sense strand sequences of SEQ ID NOs: 2, 3, 4, 9-20, 214, 219 and 220.

[0108] In some embodiments, the PNPLA3 RNAi agents include core 19-mer nucleotide sequences shown in the following Table 2.

Table 2. PNPLA3 RNAi Agent Antisense Strand and Sense Strand Core Stretch Base Sequences (N=any nucleobase; I = hypoxanthine (inosine nucleotide); (A^{2N}) = 2-aminoadenine nucleotide)

SEQ ID No.	Antisense Strand Base Sequence (5' → 3') (Shown as an Unmodified Nucleotide Sequence)	SEQ ID No.	Sense Strand Base Sequence (5' → 3') (Shown as an Unmodified Nucleotide Sequence)	Corresponding Positions of Identified Sequence on SEQ ID NO: 1	Targeted Gene Position
46	UUAGUUAGGUGAAAAAGGU	2	ACUUUUUACCCUAAACUAA	2180-2198	2180
47	NUAGUUAGGUGAAAAAGGU	9	ACUUUUUACCCUAAACUAN	2180-2198	2180
48	NUAGUUAGGUGAAAAAGGN	10	NCUUUUUACCCUAAACUAN	2180-2198	2180
49	UUAGUUAGGUGAAAAAGGU	11	ACUUUUUACCCUAAACU(A ^{2N})A	2180-2198	2180
50	NUAGUUAGGUGAAAAAGGU	12	ACUUUUUACCCUAAACU(A ^{2N})N	2180-2198	2180
51	NUAGUUAGGUGAAAAAGGN	13	NCUUUUUACCCUAAACU(A ^{2N})N	2180-2198	2180
52	UAGUAAAAACUGGGAAG	3	CUUCCCAAGUUUUUACUA	1586-1604	1586
53	NAGUAAAAACUGGGAAG	14	CUUCCCAAGUUUUUACUN	1586-1604	1586
54	NAGUAAAAACUGGGAAN	15	NUUCCCAAGUUUUUACUN	1586-1604	1586
55	UCUUGCUCAUGAUCCACC	4	GGUGGAUACAUAGCAAGA	1179-1197	1179
56	NCUUGCUCAUGAUCCACC	16	GGUGGAUACAUAGCAAGN	1179-1197	1179
57	NCUUGCUCAUGAUCCACN	17	NGUGGAUACAUAGCAAGN	1179-1197	1179
58	UCUUGCUCAUGAUCCACC	18	GGUGGAUACAUAGCAAGA	1179-1197	1179
59	NCUUGCUCAUGAUCCACC	19	GGUGGAUACAUAGCAAGN	1179-1197	1179
60	NCUUGCUCAUGAUCCACN	20	NGUGGAUACAUAGCAAGN	1179-1197	1179
61	ACGACUUCGUCUUUGGACC	5	GGUCCAAAAGACGAAGUCGU	571-589	571
62	UCGACUUCGUCUUUGGACC	21	GGUCCAAAAGACGAAGUCGA	571-589	571
63	NCGACUUCGUCUUUGGACC	22	GGUCCAAAAGACGAAGUCGN	571-589	571
64	NCGACUUCGUCUUUGGACN	23	NGUCCAAAAGACGAAGUCGN	571-589	571
65	ACGACUUCGUCUUUGGACC	24	GGUCCAAAAGACGAAGUCIU	571-589	571
66	UCGACUUCGUCUUUGGACC	25	GGUCCAAAAGACGAAGUCIA	571-589	571
67	NCGACUUCGUCUUUGGACC	26	GGUCCAAAAGACGAAGUCIN	571-589	571

68	NCGACUUCGUCUUUGGACN	27	NGUCCAAAAGACGAAAGUCIN	571
69	ACGACUUCGUCUUUGGACC	28	GGUCCAAAAGACIAAGUCIU	571
70	UCGACUUCGUCUUUGGACC	29	GGUCCAAAAGACIAAGUCIA	571
71	NCGACUUCGUCUUUGGACC	30	GGUCCAAAAGACIAAGUCIN	571
72	NCGACUUCGUCUUUGGACN	31	NGUCCAAAAGACIAAGUCIN	571
73	ACGACUUCGUCUUUGGACC	32	GGUCCAAAAGACGAAIUCGU	571
74	UCGACUUCGUCUUUGGACC	33	GGUCCAAAAGACGAAIUCGA	571
75	NCGACUUCGUCUUUGGACC	34	GGUCCAAAAGACGAAIUCGN	571
76	NCGACUUCGUCUUUGGACN	35	NGUCCAAAAGACGAAIUCGN	571
257	CAUCAAUAGAGGUACGUU	6	AACGUACCCUUCAUUGAUG	687
78	UAUCAAUAGAGGUACGUU	36	AACGUACCCUUCAUUGAUA	687
77	NAUCAAUAGAGGUACGUU	37	AACGUACCCUUCAUUGAUN	687
79	NAUCAAUAGAGGUACGUN	38	NACGUACCCUUCAUUGAUN	687
258	UUUCAUAAAACCAACUCAG	7	CUGAGUUGGUUUUAUGAAA	1746
80	NUUCAUAAAACCAACUCAG	39	CUGAGUUGGUUUUAUGAAN	1746
81	NUUCAUAAAACCAACUCAN	40	NUGAGUUGGUUUUAUGAAN	1746
82	GCAAGUUGCAAAUCUUGCU	8	AGCAAGAUUUGCAACUUGC	1191
83	UCAAGUUGCAAAUCUUGCU	41	AGCAAGAUUUGCAACUUGA	1191
84	UCAAGUUGCAAAUCUUGCG	42	CGCAAGAUUUGCAACUUGA	1191
85	NCAAGUUGCAAAUCUUGCU	43	AGCAAGAUUUGCAACUUGN	1191
86	NCAAGUUGCAAAUCUUGCG	44	CGCAAGAUUUGCAACUUGN	1191
87	NCAAGUUGCAAAUCUUGCN	45	NGCAAGAUUUGCAACUUGN	1191

[0109] The PNPLA3 RNAi agent sense strands and antisense strands that comprise or consist of the sequences in Table 2 can be modified nucleotides or unmodified nucleotides. In some embodiments, the PNPLA3 RNAi agents having the sense and antisense strand sequences that comprise or consist of the sequences in Table 2 are all or substantially all modified nucleotides.

[0110] In some embodiments, the antisense strand of a PNPLA3 RNAi agent disclosed herein differs by 0, 1, 2, or 3 nucleotides from any of the antisense strand sequences in Table 2. In some embodiments, the antisense strand of a PNPLA3 RNAi agent disclosed herein differs by 0, 1, 2, or 3 nucleotides from any of the antisense strand sequences of SEQ ID NOs: 46-60, 176, 181 and 188. In some embodiments, the sense strand of a PNPLA3 RNAi agent disclosed herein differs by 0, 1, 2, or 3 nucleotides from any of the sense strand sequences in Table 2. In some embodiments, the sense strand of a PNPLA3 RNAi agent disclosed herein differs by 0, 1, 2, or 3 nucleotides from any of the sense strand sequences of SEQ ID NOs: 2, 3, 4, 9-20, 214, 219 and 220.

[0111] As used herein, each N listed in a sequence disclosed in Table 2 may be independently selected from any and all nucleobases (including those found on both modified and unmodified nucleotides). In some embodiments, an N nucleotide listed in a sequence disclosed in Table 2 has a nucleobase that is complementary to the N nucleotide at the corresponding position on the other strand. In some embodiments, an N nucleotide listed in a sequence disclosed in Table 2 has a nucleobase that is not complementary to the N nucleotide at the corresponding position on the other strand. In some embodiments, an N nucleotide listed in a sequence disclosed in Table 2 has a nucleobase that is the same as the N nucleotide at the corresponding position on the other strand. In some embodiments, an N nucleotide listed in a sequence disclosed in Table 2 has a nucleobase that is different from the N nucleotide at the corresponding position on the other strand.

[0112] Certain modified PNPLA3 RNAi agent antisense strands, as well as their underlying unmodified nucleobase sequences, are provided in Table 3. Certain modified PNPLA3 RNAi agent sense strands, as well as their underlying unmodified nucleobase sequences, are provided in Table 4. In forming PNPLA3 RNAi agents, each of the nucleotides in each of the underlying base sequences listed in Tables 3 and 4, as well as in Table 2, above, can be a modified nucleotide.

[0113] The PNPLA3 RNAi agents described herein are formed by annealing an antisense strand with a sense strand. A sense strand containing a sequence listed in Table 2 or Table 4, can be hybridized to any antisense strand containing a sequence listed in Table 2 or Table 3, provided the two sequences have a region of at least 85% complementarity over a contiguous 16, 17, 18, 19, 20, or 21 nucleotide sequence.

[0114] In some embodiments, a PNPLA3 RNAi agent antisense strand comprises a nucleotide sequence of any of the sequences in Table 2 or Table 3.

[0115] In some embodiments, a PNPLA3 RNAi agent comprises or consists of a duplex having the nucleobase sequences of the sense strand and the antisense strand of any of the sequences in Table 2, Table 3 or Table 4. In some embodiments, a PNPLA3 RNAi agent comprises or consists of a duplex sequence with SEQ ID NOs: (176 and 214); (90 and 131); (181 and 219); (95 and 136); (188 and 220) and/or (102 and 137). In some embodiments, the PNPLA3 RNAi agent duplex sequence comprising SEQ ID NOs: (176 and 214); (90 and 131); (181 and 219); (95 and 136); (188 and 220) or (102 and 137) are prepared or provided as a sodium salt, mixed salt, or a free-acid.

[0116] Examples of antisense strands containing modified nucleotides are provided in Table 3. Examples of sense strands containing modified nucleotides are provided in Table 4.

[0117] As used in Tables 3 and 4, the following notations are used to indicate modified nucleotides and linking groups:

A	=	adenosine-3'-phosphate;
C	=	cytidine-3'-phosphate;
G	=	guanosine-3'-phosphate;
U	=	uridine-3'-phosphate
I	=	inosine-3'-phosphate
a	=	2'-O-methyladenosine-3'-phosphate
as	=	2'-O-methyladenosine-3'-phosphorothioate
c	=	2'-O-methylcytidine-3'-phosphate
cs	=	2'-O-methylcytidine-3'-phosphorothioate
g	=	2'-O-methylguanosine-3'-phosphate
gs	=	2'-O-methylguanosine-3'-phosphorothioate
t	=	2'-O-methyl-5-methyluridine-3'-phosphate
ts	=	2'-O-methyl-5-methyluridine-3'-phosphorothioate
u	=	2'-O-methyluridine-3'-phosphate
us	=	2'-O-methyluridine-3'-phosphorothioate

i	=	2'-O-methylinosine-3'-phosphate
is	=	2'-O-methylinosine-3'-phosphorothioate
Af	=	2'-fluoroadenosine-3'-phosphate
Afs	=	2'-fluoroadenosine-3'-phosphorothioate
Cf	=	2'-fluorocytidine-3'-phosphate
Cfs	=	2'-fluorocytidine-3'-phosphorothioate
Gf	=	2'-fluoroguanosine-3'-phosphate
Gfs	=	2'-fluoroguanosine-3'-phosphorothioate
Tf	=	2'-fluoro-5'-methyluridine-3'-phosphate
Tfs	=	2'-fluoro-5'-methyluridine-3'-phosphorothioate
Uf	=	2'-fluorouridine-3'-phosphate
Ufs	=	2'-fluorouridine-3'-phosphorothioate
AUNA	=	2',3'-seco-adenosine-3'-phosphate, see Table 6
AUNAS	=	2',3'-seco-adenosine-3'-phosphorothioate, see Table 6
CUNA	=	2',3'-seco-cytidine-3'-phosphate, see Table 6
CUNAS	=	2',3'-seco-cytidine-3'-phosphorothioate, see Table 6
GUNA	=	2',3'-seco-guanosine-3'-phosphate, see Table 6
GUNAS	=	2',3'-seco-guanosine-3'-phosphorothioate, see Table 6
UUNA	=	2',3'-seco-uridine-3'-phosphate, see Table 6
UUNAS	=	2',3'-seco-uridine-3'-phosphorothioate, see Table 6
a_2N	=	2'-O-methyl-2-aminoadenosine-3'-phosphate, see Table 6
a_2Ns	=	2'-O-methyl-2-aminoadenosine-3'-phosphorothioate, see Table 6
(invAb)	=	inverted abasic deoxyribonucleotide, see Table 6
(invAb)s	=	inverted abasic deoxyribonucleotide-5'-phosphorothioate, see Table 6

[0118] As the person of ordinary skill in the art would readily understand, unless otherwise indicated by the sequence (such as, for example, by a phosphorothioate linkage “s”), when present in an oligonucleotide, the nucleotide monomers are mutually linked by 5'-3'-phosphodiester bonds. As the person of ordinary skill in the art would clearly understand, the inclusion of a phosphorothioate linkage as shown in the modified nucleotide sequences disclosed herein replaces the phosphodiester linkage typically present in oligonucleotides. Further, the person of ordinary skill in the art would readily understand that the terminal nucleotide at the 3' end of a given oligonucleotide sequence would typically have a hydroxyl (-OH) group at the respective 3' position of the given monomer instead of a phosphate moiety *ex vivo*. Additionally, for the embodiments disclosed herein, when viewing the respective strand 5' → 3', the inverted abasic residues are inserted such

that the 3' position of the deoxyribose is linked at the 3' end of the preceding monomer on the respective strand (*see, e.g.*, Table 6). Moreover, as the person of ordinary skill would readily understand and appreciate, while the phosphorothioate chemical structures depicted herein typically show the anion on the sulfur atom, the inventions disclosed herein encompass all phosphorothioate tautomers (e.g., where the sulfur atom has a double-bond and the anion is on an oxygen atom). Unless expressly indicated otherwise herein, such understandings of the person of ordinary skill in the art are used when describing the PNPLA3 RNAi agents and compositions of PNPLA3 RNAi agents disclosed herein.

[0119] Certain examples of targeting ligands, targeting groups, and linking groups used with the PNPLA3 RNAi agents disclosed herein are provided below in Table 6. More specifically, targeting groups and linking groups (which together can form a targeting ligand) include (NAG37) and (NAG37)s, for which their chemical structures are provided below in Table 6. Each sense strand and/or antisense strand can have any targeting ligands, targeting groups, or linking groups listed herein, as well as other groups, conjugated to the 5' and/or 3' end of the sequence.

Table 3. PNPLA3 RNAi Agent Antisense Strand Sequences

Antisense Strand ID:	Modified Antisense Strand (5' → 3')	SEQ ID NO.	Underlying Base Sequence (5' → 3') (Shown as an Unmodified Nucleotide Sequence)	SEQ ID NO.
J1M00002-AS	usCfsasUfcAfaUfgAfaGfgGfuAfcGfuUfsg	88	UCAUCAUGAAGGGUACGUUG	174
J1M00004-AS	usCfsasUfcAfaUfgAfaGfgGfuAfcGfuCfsg	89	UCAUCAUGAAGGGUACGUUG	175
J1M00006-AS	usAfsasUfgAfaAfaAfcUfgGfgAfaAfgGfsu	90	UAGUGAAAACUGGGAAAGGU	176
J1M00008-AS	usAfsasUfgAfaAfaAfcUfgGfgAfaAfgGfsg	91	UAGUGAAAACUGGGAAAGGG	177
J1M00010-AS	asAfsasUfcUfuGfcUfcAfaGfuAfuCfcAfsa	92	AAAUUCUUCUCAUGUAUCCAC	178
J1M00012-AS	usAfsasUfuGfaCfuUfuAfgGfgCfaGfaUfsg	93	UACUUGACUUUAGGGCAGAU	179
J1M00014-AS	usAfsasUfuGfaCfuUfuAfgGfgCfaGfaCfsg	94	UACUUGACUUUAGGGCAGACG	180
J1M00016-AS	usUfsasGfuUfaGfgUfgAfaAfaAfgGfuGfsu	95	UUAGUUAGGUGAAAAAGGUGU	181
J1M00020-AS	usCfsasUfgCfuCfaUfgUfaUfcCfaCfcUfsg	96	UCUUGCUCAUGUAUCCACCUG	182
J1M00023-AS	asCfsasAfcUfuCfcUfgUfuUfgGfaCfcGfsa	97	ACGACUUCGUCUUUGGACCGA	183
J1M00025-AS	usAfsasCfaAfuGfaAfgGfgUfaCfGfuUfgGfsg	98	UAUCAUUGAAGGGUACGUUGG	184
J1M00027-AS	usCfsasAfaAfuAfuCfcUfcGfaAfgGfcAfsa	99	UCCAAAUUCCUCCGAAAGGCAG	185
J1M00029-AS	usUfsasAfaAfaAfcUfgGfgAfaAfgGfuGfsg	100	UUGAAAACUGGGGAAAGGUGG	186
J1M00031-AS	usUfsasAfuAfaAfaCfcAfaCfuCfaGfcUfsc	101	UUCAUAAAACCAACUCAGCUC	187
J1M00032-AS	usCfsasUfgCfuUNA CfaUfgUfaUfcCfaCfcUfsg	102	UCUUGCUCAUGUAUCCACCUG	188
J1M00034-AS	asGfsasAfcGfuUNA UfuUfcCfcCfaUfcAfgAfsa	103	AGAACGUUUUCCCCCAUCAGAC	189
J1M00036-AS	asGfsasAfcGfuUNA UfuUfcCfcCfaUfcAfgAfsu	104	AGAACGUUUUCCCCCAUCAGUU	190
J1M00038-AS	usAfsasAfcCfagaacGfuUfuUfcCfcCfsa	105	UACACCAGAACGUUUUCCCCA	191
J1M00040-AS	usGfsasAfaGfuUNA CfaGfaCfaCfcAfgAfaCfsg	106	UGAAAGUCAGACACCAGAACG	192
J1M00042-AS	usAfsasGfgGfuUNA AfcGfuUfgUfcAfcUfcAfsa	107	UAAAGGUAACGUUGUCACUCAC	193
J1M00046-AS	usAfsasUfuUfagggcAfgAfuGfuCfGfsg	108	UACUUUAGGGCAGAUUCGUG	194
J1M00050-AS	usGfsasAfgCfaAfgUfuGfcAfaAfuCfuCfsg	109	UGUAGCAAGUUGCAAUUCUG	195

Antisense Strand ID:	Modified Antisense Strand (5' → 3')	SEQ ID NO.	Underlying Base Sequence (5' → 3') (Shown as an Unmodified Nucleotide Sequence)	SEQ ID NO.
J1M00052-AS	asCfsgsAfcUfu _{UNA} CfgUfcUfuUfgGfaCfcGfsc	110	ACGACUUCGUCUUUGGACCGA	196
J1M00057-AS	asCfsasAfgAfuCfuGfaGfgAfcCfuGfsc	111	ACAAGAUCUGAGAGGACCUGC	197
J1M00059-AS	usCfsasAfuGfaAfgGfgUfaCfuUfuGfuCfsg	112	UCA AUGAAGGUAUGUUGUGG	198
J1M00063-AS	asAfsusCfuUfgCfuCfaUfgUfaUfcCfaCfsc	113	AAUCUUGCUC AUGUAUCCACC	199
J1M00072-AS	usUfsgsUfcAfuUfuCfcCfaAfcCfaGfcUfsg	114	UUUGUCAUUUCCCCAACACAGCUG	200
J1M00074-AS	usAfsGsUfgAfaAfaAfcUfgGfgAfaAfgGfsc	115	UAGUGAAAAACUGGGGAAAGGC	201
J1M00077-AS	usCfsusUfgCfuCfaUfgUfaUfcCfaCfcUfsu	116	UCUUGCUC AUGUAUCCACCUU	202
J1M00079-AS	usCfsusUfgCfuCfaUfgUfaUfcCfaCfcUfsc	117	UCUUGCUC AUGUAUCCACCUU	203
J1M00082-AS	usUfsasGfuUfaGfgUfgAfaAfaAfgGfuGfsc	118	UUAGUUAGGUGAGAAAAAGGUGC	204
J1M00113-AS	cPrpusUfsasGfuUfaGfgUfgAfaAfaAfgGfuGfsc	119	UUAGUUAGGUGAGAAAAAGGUGU	205
J1M00114-AS	usUfsasGfu _{UNA} aGfgUfgAfaAfaAfgGfuGfsc	120	UUAGUUAGGUGAGAAAAAGGUGU	205
J1M00115-AS	usUfsasGfuUfa _{UNA} GfgUfgAfaAfaAfgGfuGfsc	121	UUAGUUAGGUGAGAAAAAGGUGU	205
J1M00116-AS	usUfsasGfuUfa _{GUNA} gUfgAfaAfaAfgGfuGfsc	122	UUAGUUAGGUGAGAAAAAGGUGU	205
J1M00121-AS	asUfscsCfaAfaUfaUfcCfuCfcAfaGfgCfsc	123	AUCCAAAUAUCCUCGAAAGGCA	206
J1M00123-AS	usCfsasUfgUfaUfcCfaCfcUfuUfgUfcUfsu	124	UCAUGUAUCCACCUUUUGUCUU	207
J1M00125-AS	usGfscsAfaAfuCfuUfgCfuCfaUfgUfaUfsc	125	UGCAAAUCUUGCUC AUGUAUC	208
J1M00127-AS	usCfsasAfgUfuGfcAfaAfuCfuUfgCfuCfsc	126	UCAAGUUGCAAAUCUUGCUCA	209
J1M00129-AS	usCfsasAfgUfuGfcAfaAfuCfuUfgCfuCfsg	127	UCAAGUUGCAAAUCUUGCUUG	210
J1M00133-AS	usUfsusCfaUfaAfaAfcCfaAfcUfcAfgCfsc	128	UUUCAUAAAACCAACUCAGCU	211

Table 4. PNPLA3 RNAi Agent Sense Strand Sequences

Sense Strand ID:	Modified Sense Strand (5' → 3')	SEQ ID NO.	Underlying Base Sequence (5' → 3') (Shown as an Unmodified Nucleotide Sequence)	SEQ ID NO.
J1M00001-SS	(NAG37)S(invAb)scaacguacCfCfUfucuaugaugas(invAb)	129	CAACGUACCCUUCAUUGAUGA	212
J1M00003-SS	(NAG37)S(invAb)scgacguacCfCfUfucuaugaugas(invAb)	130	CGACGUACCCUUCAUUGAUGA	213
J1M00005-SS	(NAG37)S(invAb)saccuuuccCfAfGfuuuuuacuas(invAb)	131	ACCUUCCCCAGUUUUUUCACUA	214
J1M00007-SS	(NAG37)S(invAb)scuuuuuccCfAfGfuuuuuacuas(invAb)	132	CCUUUCCCCAGUUUUUUCACUA	215
J1M00009-SS	(NAG37)S(invAb)sguggauacAfUfGfagcaaguuuS(invAb)	133	GUGGAUACAUGAGCAAGAUUU	216
J1M00011-SS	(NAG37)S(invAb)scaucugccCfUfAfaagucuaaguas(invAb)	134	CAUCUGCCCUAAAGUCAAGUA	217
J1M00013-SS	(NAG37)S(invAb)scgucugccCfUfAfaagucuaaguas(invAb)	135	CGUCUGCCCUAAAGUCAAGUA	218
J1M00015-SS	(NAG37)S(invAb)sacaccuuUfUfCfaccuaacuaas(invAb)	136	ACACCUUUUUCACCUAAACUAA	219
J1M00019-SS	(NAG37)S(invAb)scagguggaUfAfCfaugagcaagas(invAb)	137	CAGGUGGAUACAUGAGCAAGA	220
J1M00021-SS	(NAG37)S(invAb)scagguggaUfAfCfaugaicaagas(invAb)	138	CAGGUGGAUACAUGAICAAGA	221
J1M00022-SS	(NAG37)S(invAb)sucgguccaAfAfGfagcaagucius(invAb)	139	UCGGUCCAAAGACGAAAGUCIU	222
J1M00024-SS	(NAG37)S(invAb)sccaacguaCfCfCfuucaugauas(invAb)	140	CCAACGUACCCUUCAUUGAUA	223
J1M00026-SS	(NAG37)S(invAb)scugccuucGfAfGfgauuuuigias(invAb)	141	CUGCCUUCGAGGAUAUUUIGA	224
J1M00028-SS	(NAG37)S(invAb)scaccuuUfCfCfaguuuuuacaas(invAb)	142	CCACCUUCCCCAGUUUUUUCAA	225
J1M00030-SS	(NAG37)S(invAb)sgagcugagUfUfGfguuuuuagaas(invAb)	143	GAGCUGAGUUGGUUUUUAUGAA	226
J1M00033-SS	(NAG37)S(invAb)sgucugaugGfGfGfaaacguucius(invAb)	144	GUCUGAUGGGGAAAACGUUCU	227
J1M00035-SS	(NAG37)S(invAb)scugaugGfGfGfaaacguucius(invAb)	145	CUGAUGGGGAAAACGUUCUUU	228
J1M00037-SS	(NAG37)S(invAb)sugggaaaAfCfGfucugiuigas(invAb)	146	UGGGGAAAACGUUCUGIUGUA	229
J1M00039-SS	(NAG37)S(invAb)scguucuggUfGfUfucgacuuucas(invAb)	147	CGUUCUGGUGUCUGACUUUCA	230

Sense Strand ID:	Modified Sense Strand (5' → 3')	SEQ ID NO.	Underlying Base Sequence (5' → 3') (Shown as an Unmodified Nucleotide Sequence)	SEQ ID NO.
J1M00041-SS	(NAG37)s(invAb)sgugagugaCfAfAfcguaccuuas(invAb)	148	GUGAGUGACAACGUACCCUUA	231
J1M00045-SS	(NAG37)s(invAb)scacgacauCfUfGfccuaaaguas(invAb)	149	CACGACAUCUGCCCUAAAAGUA	232
J1M00049-SS	(NAG37)s(invAb)scgagauuuGfCfAfacuuiucuas(invAb)	150	CGAGAUUUUGCAACUUIUCACA	233
J1M00051-SS	(NAG37)s(invAb)sucggguccaAfAfGfaggaugugus(invAb)	151	UCGGUCCAAAAGACGAAAGUCGU	234
J1M00053-SS	(NAG37)s(invAb)sucggguccaAfAfGfaggauiucgus(invAb)	152	UCGGUCCAAAAGACGAAIUCGU	235
J1M00054-SS	(NAG37)s(invAb)scacccuuUfUfCfaccuaacua_2Nas(invAb)	153	CCACCUUUUUUACCCUAAACU(A ^{2N})A	236
J1M00056-SS	(NAG37)s(invAb)scgagiuccUfCfUfaggaucuuugus(invAb)	154	GCAGIUCUUCUCAGAUUUUGU	237
J1M00058-SS	(NAG37)s(invAb)scgacaagUfAfCfcccuaugus(invAb)	155	CGACAACGUACCCUUCAUUGA	238
J1M00062-SS	(NAG37)s(invAb)sgguggauaCfAfUfagcaagaauus(invAb)	156	GGUGGAUACAUGAGCAAGAUU	239
J1M00071-SS	(NAG37)s(invAb)scagcugguUfGfGfagaugacaas(invAb)	157	CAGCUGGUUGGGAAAUGACAA	240
J1M00073-SS	(NAG37)s(invAb)sgccuuuccCfAfGfuuuuuacuas(invAb)	158	GCCUUUCCCAGUUUUUUCACUA	241
J1M00076-SS	(NAG37)s(invAb)saagguggaUfAfCfagaicaagas(invAb)	159	AAGGUGGAUACAUGAICAAGA	242
J1M00078-SS	(NAG37)s(invAb)sgagguggaUfAfCfagaicaagas(invAb)	160	GAGGUGGAUACAUGAICAAGA	243
J1M00080-SS	(NAG37)s(invAb)sa_2NagguggaUfAfCfagaicaagas(invAb)	161	(A ^{2N})AGGUGGAUACAUGAICAAGA	244
J1M00081-SS	(NAG37)s(invAb)sgcaccuuUfUfCfaccuaacuas(invAb)	162	GCACCUUUUUUACCCUAAACUAA	245
J1M00083-SS	(NAG37)s(invAb)sgcaccuuUfUfCfaccuaacua_2Nas(invAb)	163	GCACCUUUUUUACCCUAAACUAA	246
J1M00084-SS	(NAG37)s(invAb)sa_2NcaccuuUfUfCfaccuaacuas(invAb)	164	(A ^{2N})CACCUUUUUUACCCUAAACUAA	247
J1M00117-SS	(NAG37)s(invAb)sacaccuuUfUfCfaccuaacua_2Nas(invAb)	165	ACACCUUUUUUACCCUAAACU(A ^{2N})A	248
J1M00118-SS	(NAG37)s(invAb)sa_2NcaccuuUfUfCfaccuaacua_2Nas(invAb)	166	(A ^{2N})CACCUUUUUUACCCUAAACUAA	249
J1M00119-SS	(NAG37)s(invAb)sacAfCfUfUfUfCfaccuaacuas(invAb)	167	ACACCUUUUUUACCCUAAACUAA	250
J1M00120-SS	(NAG37)s(invAb)sugccuuccGfGfauuuuugaus(invAb)	168	UGCCUUCGAGGAUAUUUGGAU	251

Sense Strand ID:	Modified Sense Strand (5' → 3')	SEQ ID NO.	Underlying Base Sequence (5' → 3') (Shown as an Unmodified Nucleotide Sequence)	SEQ ID NO.
J1M00122-SS	(NAG37)s(invAb)sa_2NagacaaaGfGfUfggauacaugas(invAb)	169	(A ^{2N})AGACAAAGGUGGAUACAUGA	252
J1M00124-SS	(NAG37)s(invAb)sga_2NuacaugAfGfCfaagauugcas(invAb)	170	G(A ^{2N})UACAUGAGCAAAGAUUUGCA	253
J1M00126-SS	(NAG37)s(invAb)sugagcaagAfUfUfugcaacuugas(invAb)	171	UGAGCAAAGAUUUGCAACUUGA	254
J1M00128-SS	(NAG37)s(invAb)scgagcaagAfUfUfugcaacuugas(invAb)	172	CGAGCAAAGAUUUGCAACUUGA	255
J1M00132-SS	(NAG37)s(invAb)sagcugaguUfGfGfuuuuugaas(invAb)	173	AGCUGAGUUGGUUUUAUGAAA	256

(A^{2N}) = 2-aminoadenine nucleotide; I = hypoxanthine (inosine) nucleotide

[0120] The PNPLA3 RNAi agents described herein are formed by annealing an antisense strand with a sense strand. A sense strand containing a sequence listed in Table 2 or Table 4 can be hybridized to any antisense strand containing a sequence listed in Table 2 or Table 3, provided the two sequences have a region of at least 85% complementarity over a contiguous 16, 17, 18, 19, 20, or 21 nucleotide sequence.

[0121] In some embodiments, the antisense strand of a PNPLA3 RNAi agent disclosed herein differs by 0, 1, 2, or 3 nucleotides from any of the antisense strand sequences in Table 3. In some embodiments, the sense strand of a PNPLA3 RNAi agent disclosed herein differs by 0, 1, 2, or 3 nucleotides from any of the sense strand sequences in Table 4.

[0122] In some embodiments, a PNPLA3 RNAi agent antisense strand comprises a nucleotide sequence of any of the sequences in Table 2 or Table 3. In some embodiments, a PNPLA3 RNAi agent antisense strand comprises the sequence of nucleotides (from 5' end → 3' end) 1-17, 2-17, 1-18, 2-18, 1-19, 2-19, 1-20, 2-20, 1-21, or 2-21, of any of the sequences in Table 2 or Table 3. In certain embodiments, a PNPLA3 RNAi agent antisense strand comprises or consists of a modified sequence of any one of the modified sequences in Table 3.

[0123] In some embodiments, a PNPLA3 RNAi agent sense strand comprises the nucleotide sequence of any of the sequences in Table 2 or Table 4. In some embodiments, a PNPLA3 RNAi agent sense strand comprises the sequence of nucleotides (from 5' end → 3' end) 1-17, 2-17, 3-17, 4-17, 1-18, 2-18, 3-18, 4-18, 1-19, 2-19, 3-19, 4-19, 1-20, 2-20, 3-20, 4-20, 1-21, 2-21, 3-21, or 4-21, of any of the sequences in Table 2 or Table 4. In certain embodiments, a PNPLA3 RNAi agent sense strand comprises or consists of a modified sequence of any one of the modified sequences in Table 4.

[0124] For the PNPLA3 RNAi agents disclosed herein, the nucleotide at position 1 of the antisense strand (from 5' end → 3' end) can be perfectly complementary to a PNPLA3 gene, or can be non-complementary to a PNPLA3 gene. In some embodiments, the nucleotide at position 1 of the antisense strand (from 5' end → 3' end) is a U, A, or dT (or a modified version thereof). In some embodiments, the nucleotide at position 1 of the antisense strand (from 5' end → 3' end) forms an A:U or U:A base pair with the sense strand.

[0125] A sense strand containing a sequence listed in Table 2 or Table 4 can be hybridized to any antisense strand containing a sequence listed in Table 2 or Table 3, provided the two sequences have a region of at least 85% complementarity over a contiguous 16, 17, 18, 19, 20, or 21 nucleotide sequence. In some embodiments, the

PNPLA3 RNAi agent has a sense strand consisting of the modified sequence of any of the modified sequences in Table 4, and an antisense strand consisting of the modified sequence of any of the modified sequences in Table 3. Certain representative sequence pairings are exemplified by the Duplex ID Nos. shown in Tables 5A and 5B.

[0126] In some embodiments, a PNPLA3 RNAi agent comprises, consists of, or consists essentially of a duplex represented by any one of the Duplex ID Nos. presented herein. In some embodiments, a PNPLA3 RNAi agent comprises the sense strand and antisense strand nucleotide sequences of any of the duplexes represented by any of the Duplex ID Nos. presented herein. In some embodiments, a PNPLA3 RNAi agent comprises the sense strand and antisense strand nucleotide sequences of any of the duplexes represented by any of the Duplex ID Nos. presented herein and a targeting group and/or linking group wherein the targeting group and/or linking group is covalently linked (*i.e.*, conjugated) to the sense strand or the antisense strand. In some embodiments, a PNPLA3 RNAi agent includes the sense strand and antisense strand modified nucleotide sequences of any of the Duplex ID Nos. presented herein. In some embodiments, a PNPLA3 RNAi agent comprises the sense strand and antisense strand modified nucleotide sequences of any of the Duplex ID Nos. presented herein and a targeting group and/or linking group, wherein the targeting group and/or linking group is covalently linked to the sense strand or the antisense strand.

[0127] In some embodiments, a PNPLA3 RNAi agent comprises an antisense strand and a sense strand having the nucleotide sequences of any of the antisense strand/sense strand duplexes of Table 2 or Tables 5A and 5B, and further comprises a targeting group or targeting ligand. In some embodiments, a PNPLA3 RNAi agent comprises an antisense strand and a sense strand having the nucleotide sequences of any of the antisense strand/sense strand duplexes of Table 2 or Tables 5A and 5B, and further comprises an asialoglycoprotein receptor ligand targeting group.

[0128] A targeting group, with or without a linker, can be linked to the 5' or 3' end of any of the sense and/or antisense strands disclosed in Tables 2, 3, and 4. A linker, with or without a targeting group, can be attached to the 5' or 3' end of any of the sense and/or antisense strands disclosed in Tables 2, 3, and 4.

[0129] In some embodiments, a PNPLA3 RNAi agent comprises an antisense strand and a sense strand having the nucleotide sequences of any of the antisense strand/sense strand duplexes of Table 2 or Tables 5A and 5B, and further comprises a targeting ligand selected from the group consisting of: (NAG37) and (NAG37)s, each as defined in Table 6.

[0130] In some embodiments, a PNPLA3 RNAi agent comprises an antisense strand and a sense strand having the modified nucleotide sequence of any of the antisense strand and/or sense strand nucleotide sequences in Table 3 or Table 4.

[0131] In some embodiments, a PNPLA3 RNAi agent comprises an antisense strand and a sense strand having a modified nucleotide sequence of any of the antisense strand and/or sense strand nucleotide sequences of any of the duplexes Tables 5A and 5B, and further comprises an asialoglycoprotein receptor ligand targeting group.

[0132] In some embodiments, a PNPLA3 RNAi agent comprises, consists of, or consists essentially of any of the duplexes of Tables 5A and 5B.

Table 5A. PNPLA3 RNAi Agents Duplexes with Corresponding Sense and Antisense Strand ID Numbers

Duplex ID	Antisense Strand ID	Sense Strand ID	Duplex ID	Antisense Strand ID	Sense Strand ID
J1D00001	J1M00002-AS	J1M00001-SS	J1D00041	J1M00074-AS	J1M00073-SS
J1D00002	J1M00004-AS	J1M00003-SS	J1D00043	J1M00077-AS	J1M00076-SS
J1D00003	J1M00006-AS	J1M00005-SS	J1D00044	J1M00079-AS	J1M00078-SS
J1D00004	J1M00008-AS	J1M00007-SS	J1D00045	J1M00077-AS	J1M00080-SS
J1D00005	J1M00010-AS	J1M00009-SS	J1D00046	J1M00082-AS	J1M00081-SS
J1D00006	J1M00012-AS	J1M00011-SS	J1D00047	J1M00082-AS	J1M00083-SS
J1D00007	J1M00014-AS	J1M00013-SS	J1D00048	J1M00016-AS	J1M00084-SS
J1D00008	J1M00016-AS	J1M00015-SS	J1D00074	J1M00113-AS	J1M00015-SS
J1D00010	J1M00020-AS	J1M00019-SS	J1D00075	J1M00114-AS	J1M00015-SS
J1D00011	J1M00020-AS	J1M00021-SS	J1D00076	J1M00115-AS	J1M00015-SS
J1D00012	J1M00023-AS	J1M00022-SS	J1D00077	J1M00116-AS	J1M00015-SS
J1D00013	J1M00025-AS	J1M00024-SS	J1D00078	J1M00016-AS	J1M00117-SS
J1D00014	J1M00027-AS	J1M00026-SS	J1D00079	J1M00016-AS	J1M00118-SS
J1D00015	J1M00029-AS	J1M00028-SS	J1D00080	J1M00016-AS	J1M00119-SS
J1D00016	J1M00031-AS	J1M00030-SS	J1D00081	J1M00121-AS	J1M00120-SS
J1D00017	J1M00032-AS	J1M00019-SS	J1D00082	J1M00123-AS	J1M00122-SS
J1D00018	J1M00034-AS	J1M00033-SS	J1D00083	J1M00125-AS	J1M00124-SS
J1D00019	J1M00036-AS	J1M00035-SS	J1D00084	J1M00127-AS	J1M00126-SS
J1D00020	J1M00038-AS	J1M00037-SS	J1D00085	J1M00129-AS	J1M00128-SS
J1D00021	J1M00040-AS	J1M00039-SS	J1D00087	J1M00133-AS	J1M00132-SS
J1D00022	J1M00042-AS	J1M00041-SS			
J1D00024	J1M00046-AS	J1M00045-SS			
J1D00026	J1M00050-AS	J1M00049-SS			
J1D00027	J1M00052-AS	J1M00051-SS			
J1D00028	J1M00052-AS	J1M00022-SS			
J1D00029	J1M00023-AS	J1M00053-SS			
J1D00032	J1M00057-AS	J1M00056-SS			
J1D00033	J1M00059-AS	J1M00058-SS			
J1D00035	J1M00063-AS	J1M00062-SS			
J1D00040	J1M00072-AS	J1M00071-SS			

Table 5B. PNPLA3 RNAi Agents Duplexes with Corresponding Sense and Antisense Strand ID Numbers and Sequence ID numbers for the modified and unmodified nucleotide sequences.

Duplex	AS ID	AS modified SEQ ID NO:	AS unmodified SEQ ID NO:	SS ID	SS modified SEQ ID NO:	SS unmodified SEQ ID NO:
J1D00001	J1M00002-AS	88	174	J1M00001-SS	129	212
J1D00002	J1M00004-AS	89	175	J1M00003-SS	130	213
J1D00003	J1M00006-AS	90	176	J1M00005-SS	131	214
J1D00004	J1M00008-AS	91	177	J1M00007-SS	132	215
J1D00005	J1M00010-AS	92	178	J1M00009-SS	133	216
J1D00006	J1M00012-AS	93	179	J1M00011-SS	134	217
J1D00007	J1M00014-AS	94	180	J1M00013-SS	135	218
J1D00008	J1M00016-AS	95	181	J1M00015-SS	136	219
J1D00010	J1M00020-AS	96	182	J1M00019-SS	137	220
J1D00011	J1M00020-AS	96	183	J1M00021-SS	138	221
J1D00012	J1M00023-AS	97	184	J1M00022-SS	139	222
J1D00013	J1M00025-AS	98	185	J1M00024-SS	140	223
J1D00014	J1M00027-AS	99	186	J1M00026-SS	141	224
J1D00015	J1M00029-AS	100	187	J1M00028-SS	142	225
J1D00016	J1M00031-AS	101	188	J1M00030-SS	143	226
J1D00017	J1M00032-AS	102	189	J1M00019-SS	137	220
J1D00018	J1M00034-AS	103	190	J1M00033-SS	144	227
J1D00019	J1M00036-AS	104	191	J1M00035-SS	145	228
J1D00020	J1M00038-AS	105	192	J1M00037-SS	146	229
J1D00021	J1M00040-AS	106	193	J1M00039-SS	147	230
J1D00022	J1M00042-AS	107	194	J1M00041-SS	148	231
J1D00024	J1M00046-AS	108	195	J1M00045-SS	149	232
J1D00026	J1M00050-AS	109	196	J1M00049-SS	150	233
J1D00027	J1M00052-AS	110	197	J1M00051-SS	151	234
J1D00028	J1M00052-AS	110	198	J1M00022-SS	152	222
J1D00029	J1M00023-AS	97	183	J1M00053-SS	153	235
J1D00032	J1M00057-AS	111	199	J1M00056-SS	154	237
J1D00033	J1M00059-AS	112	200	J1M00058-SS	155	238
J1D00035	J1M00063-AS	113	201	J1M00062-SS	156	239
J1D00040	J1M00072-AS	114	202	J1M00071-SS	157	240
J1D00041	J1M00074-AS	115	203	J1M00073-SS	158	241
J1D00043	J1M00077-AS	116	204	J1M00076-SS	159	242
J1D00044	J1M00079-AS	117	205	J1M00078-SS	160	243
J1D00045	J1M00077-AS	116	206	J1M00080-SS	161	244

J1D00046	J1M00082-AS	118	207	J1M00081-SS	162	245
J1D00047	J1M00082-AS	118	207	J1M00083-SS	163	246
J1D00048	J1M00016-AS	95	181	J1M00084-SS	164	247
J1D00074	J1M00113-AS	119	210	J1M00015-SS	136	219
J1D00075	J1M00114-AS	120	211	J1M00015-SS	136	219
J1D00076	J1M00115-AS	121	212	J1M00015-SS	136	219
J1D00077	J1M00116-AS	122	213	J1M00015-SS	136	219
J1D00078	J1M00016-AS	95	181	J1M00117-SS	165	248
J1D00079	J1M00016-AS	95	181	J1M00118-SS	166	249
J1D00080	J1M00016-AS	95	181	J1M00119-SS	167	250
J1D00081	J1M00121-AS	123	206	J1M00120-SS	168	251
J1D00082	J1M00123-AS	124	207	J1M00122-SS	169	252
J1D00083	J1M00125-AS	125	208	J1M00124-SS	170	253
J1D00084	J1M00127-AS	126	209	J1M00126-SS	171	254
J1D00085	J1M00129-AS	127	210	J1M00128-SS	172	255
J1D00087	J1M00133-AS	128	211	J1M00132-SS	173	256

[0133] In some embodiments, a PNPLA3 RNAi agent is prepared or provided as a salt, mixed salt, or a free-acid. The RNAi agents described herein, upon delivery to a cell expressing a PNPLA3 gene, inhibit or knockdown expression of one or more PNPLA3 genes *in vivo* and/or *in vitro*.

Targeting Ligands or Groups, Linking Groups, and Delivery Vehicles

[0134] In some embodiments, a PNPLA3 RNAi agent is conjugated to one or more non-nucleotide groups including, but not limited to, a targeting group, a linking group, a targeting ligand, a delivery polymer, or a delivery vehicle. The non-nucleotide group can enhance targeting, delivery or attachment of the RNAi agent. Examples of targeting groups and linking groups are provided in Table 6. The non-nucleotide group can be covalently linked to the 3' and/or 5' end of either the sense strand and/or the antisense strand. In some embodiments, a PNPLA3 RNAi agent contains a non-nucleotide group linked to the 3' and/or 5' end of the sense strand. In some embodiments, a non-nucleotide group is linked to the 5' end of a PNPLA3 RNAi agent sense strand. A non-nucleotide group may be linked directly or indirectly to the RNAi agent via a linker/linking group. In some embodiments, a non-nucleotide group is linked to the RNAi agent via a labile, cleavable, or reversible bond or linker.

[0135] In some embodiments, a non-nucleotide group enhances the pharmacokinetic or biodistribution properties of an RNAi agent or conjugate to which it is attached to improve cell- or tissue-specific distribution and cell-specific uptake of the RNAi agent or conjugate. In some embodiments, a non-nucleotide group enhances endocytosis of the RNAi agent.

[0136] Targeting groups or targeting moieties enhance the pharmacokinetic or biodistribution properties of a conjugate or RNAi agent to which they are attached to improve cell-specific (including, in some cases, organ specific) distribution and cell-specific (or organ specific) uptake of the conjugate or RNAi agent. A targeting group can be monovalent, divalent, trivalent, tetravalent, or have higher valency for the target to which it is directed. Representative targeting groups include, without limitation, compounds with affinity to cell surface molecules, cell receptor ligands, haptens, antibodies, monoclonal antibodies, antibody fragments, and antibody mimics with affinity to cell surface molecules.

[0137] In some embodiments, a targeting group is linked to an RNAi agent using a linker, such as a PEG linker or one, two, or three abasic and/or ribitol (abasic ribose) residues, which can in some instances serve as linkers. In some embodiments, a targeting ligand comprises a galactose-derivative cluster.

[0138] The PNPLA3 RNAi agents described herein can be synthesized having a reactive group, such as an amino group (also referred to herein as an amine), at the 5'-terminus and/or the 3'-terminus. The reactive group can be used subsequently to attach a targeting moiety using methods typical in the art.

[0139] In some embodiments, a targeting group comprises an asialoglycoprotein receptor ligand. As used herein, an asialoglycoprotein receptor ligand is a ligand that contains a moiety having affinity for the asialoglycoprotein receptor. As noted herein, the asialoglycoprotein receptor is highly expressed on hepatocytes. In some embodiments, an asialoglycoprotein receptor ligand includes or consists of one or more galactose derivatives. As used herein, the term galactose derivative includes both galactose and derivatives of galactose having affinity for the asialoglycoprotein receptor that is equal to or greater than that of galactose. Galactose derivatives include, but are not limited to: galactose, galactosamine, N-formylgalactosamine, N-acetyl-galactosamine, N-propionyl-galactosamine, N-n-butanoyl-galactosamine, and N-iso-butanoylgalactos-amine (see for example: S.T. Iobst and K. Drickamer, J.B.C., 1996, 271, 6686). Galactose derivatives, and clusters of galactose derivatives, that are useful for *in vivo* targeting of oligonucleotides and

other molecules to the liver are known in the art (see, for example, Baenziger and Fiete, 1980, *Cell*, 22, 611-620; Connolly et al., 1982, *J. Biol. Chem.*, 257, 939-945).

[0140] Galactose derivatives have been used to target molecules to hepatocytes *in vivo* through their binding to the asialoglycoprotein receptor expressed on the surface of hepatocytes. Binding of asialoglycoprotein receptor ligands to the asialoglycoprotein receptor(s) facilitates cell-specific targeting to hepatocytes and endocytosis of the molecule into hepatocytes. Asialoglycoprotein receptor ligands can be monomeric (*e.g.*, having a single galactose derivative, also referred to as monovalent or monodentate) or multimeric (*e.g.*, having multiple galactose derivatives). The galactose derivative or galactose derivative cluster can be attached to the 3' or 5' end of the sense or antisense strand of the RNAi agent using methods known in the art. The preparation of targeting ligands, such as galactose derivative clusters, is described in, for example, International Patent Application Publication No. WO 2018/044350 to Arrowhead Pharmaceuticals, Inc., and International Patent Application Publication No. WO 2017/156012 to Arrowhead Pharmaceuticals, Inc., the contents of both of which are incorporated by reference herein in their entirety.

[0141] As used herein, a galactose derivative cluster comprises a molecule having two to four terminal galactose derivatives. A terminal galactose derivative is attached to a molecule through its C-1 carbon. In some embodiments, the galactose derivative cluster is a galactose derivative trimer (also referred to as tri-antennary galactose derivative or tri-valent galactose derivative). In some embodiments, the galactose derivative cluster comprises N-acetyl-galactosamines. In some embodiments, the galactose derivative cluster comprises three N-acetyl-galactosamines. In some embodiments, the galactose derivative cluster is a galactose derivative tetramer (also referred to as tetra-antennary galactose derivative or tetra-valent galactose derivative). In some embodiments, the galactose derivative cluster comprises four N-acetyl-galactosamines.

[0142] As used herein, a galactose derivative trimer contains three galactose derivatives, each linked to a central branch point. As used herein, a galactose derivative tetramer contains four galactose derivatives, each linked to a central branch point. The galactose derivatives can be attached to the central branch point through the C-1 carbons of the saccharides. In some embodiments, the galactose derivatives are linked to the branch point via linkers or spacers. In some embodiments, the linker or spacer is a flexible hydrophilic spacer, such as a PEG group (*see, e.g.*, U.S. Patent No. 5,885,968; Biessen et al. *J. Med. Chem.* 1995 Vol. 39 p. 1538-1546). In some embodiments, the PEG spacer is a PEG₃ spacer.

The branch point can be any small molecule which permits attachment of three galactose derivatives and further permits attachment of the branch point to the RNAi agent. An example of branch point group is a di-lysine or di-glutamate. Attachment of the branch point to the RNAi agent can occur through a linker or spacer. In some embodiments, the linker or spacer comprises a flexible hydrophilic spacer, such as, but not limited to, a PEG spacer. In some embodiments, the linker comprises a rigid linker, such as a cyclic group. In some embodiments, a galactose derivative comprises or consists of N-acetyl-galactosamine. In some embodiments, the galactose derivative cluster is comprised of a galactose derivative tetramer, which can be, for example, an N-acetyl-galactosamine tetramer.

[0143] Embodiments of the present disclosure include pharmaceutical compositions for delivering a PNPLA3 RNAi agent to a liver cell *in vivo*. Such pharmaceutical compositions can include, for example, a PNPLA3 RNAi agent conjugated to a galactose derivative cluster. In some embodiments, the galactose derivative cluster is comprised of a galactose derivative trimer, which can be, for example, an N-acetyl-galactosamine trimer, or galactose derivative tetramer, which can be, for example, an N-acetyl-galactosamine tetramer.

[0144] A targeting ligand or targeting group can be linked to the 3' or 5' end of a sense strand or an antisense strand of a PNPLA3 RNAi agent disclosed herein.

[0145] Targeting ligands include, but are not limited to (NAG37) and (NAG37)s as defined in Table 6. Other targeting groups and targeting ligands, including galactose cluster targeting ligands, are known in the art.

[0146] In some embodiments, a linking group is conjugated to the RNAi agent. The linking group facilitates covalent linkage of the agent to a targeting group, delivery polymer, or delivery vehicle. The linking group can be linked to the 3' and/or the 5' end of the RNAi agent sense strand or antisense strand. In some embodiments, the linking group is linked to the RNAi agent sense strand. In some embodiments, the linking group is conjugated to the 5' or 3' end of an RNAi agent sense strand. In some embodiments, a linking group is conjugated to the 5' end of an RNAi agent sense strand. Examples of linking groups, can include, but are not limited to: reactive groups such a primary amines and alkynes, alkyl groups, abasic nucleotides, ribitol (abasic ribose), and/or PEG groups.

[0147] In some embodiments, a targeting group is linked internally to a nucleotide on the sense strand and/or the antisense strand of the RNAi agent. In some embodiments, a targeting group is linked to the RNAi agent via a linker.

[0148] A linker or linking group is a connection between two atoms that links one chemical group (such as an RNAi agent) or segment of interest to another chemical group (such as a targeting group or delivery polymer) or segment of interest via one or more covalent bonds. A labile linkage contains a labile bond. A linkage can optionally include a spacer that increases the distance between the two joined atoms. A spacer can further add flexibility and/or length to the linkage. Spacers include, but are not be limited to, alkyl groups, alkenyl groups, alkynyl groups, aryl groups, aralkyl groups, aralkenyl groups, and aralkynyl groups; each of which can contain one or more heteroatoms, heterocycles, amino acids, nucleotides, and saccharides. Spacer groups are well known in the art and the preceding list is not meant to limit the scope of the description.

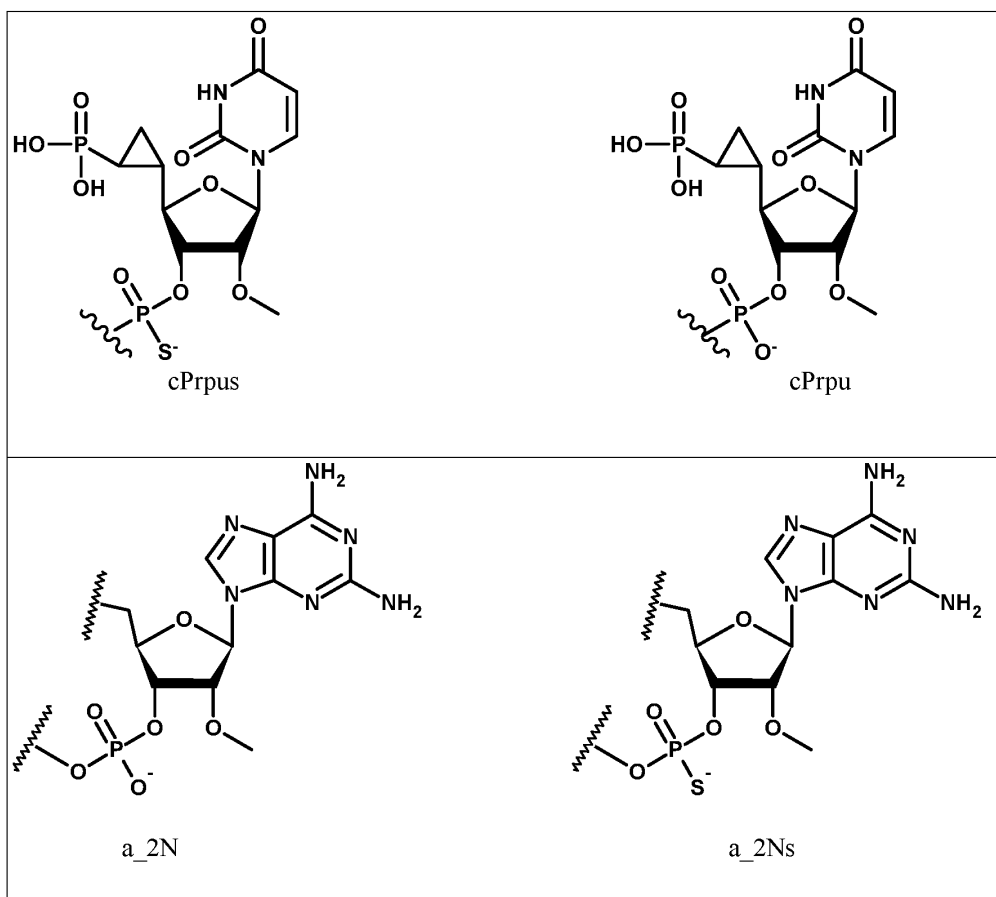
[0149] In some embodiments, when two or more RNAi agents are included in a single composition, each of the RNAi agents may be linked to the same targeting group or two a different targeting groups (i.e., targeting groups having different chemical structure). In some embodiments, targeting groups are linked to the PNPLA3 RNAi agents disclosed herein without the use of an additional linker. In some embodiments, the targeting group itself is designed having a linker or other site to facilitate conjugation readily present. In some embodiments, when two or more PNPLA3 RNAi agents are included in a single molecule, each of the RNAi agents may utilize the same linker or different linkers (*i.e.*, linkers having different chemical structures).

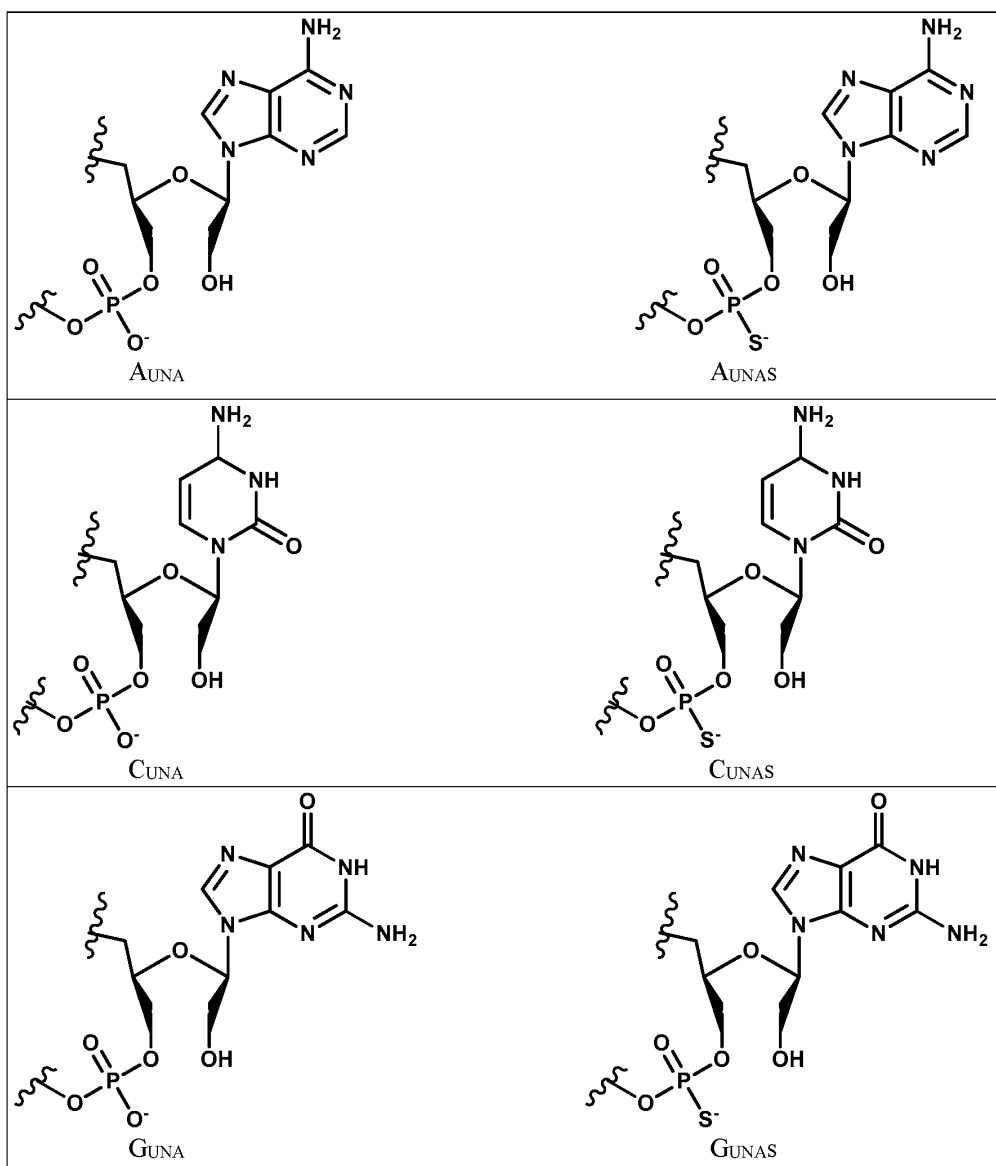
[0150] Any of the PNPLA3 RNAi agent nucleotide sequences listed in Tables 2, 3, or 4, whether modified or unmodified, can contain 3' and/or 5' targeting group(s) or linking group(s). Any of the PNPLA3 RNAi agent sequences listed in Table 3 or 4, or are otherwise described herein, which contain a 3' or 5' targeting group or linking group, can alternatively contain no 3' or 5' targeting group or linking group, or can contain a different 3' or 5' targeting group or linking group including, but not limited to, those depicted in Table 6. Any of the PNPLA3 RNAi agent duplexes listed in Tables 5A and 5B, whether modified or unmodified, can further comprise a targeting group or linking group, including, but not limited to, those depicted in Table 6, and the targeting group or linking group can be attached to the 3' or 5' terminus of either the sense strand or the antisense strand of the PNPLA3 RNAi agent duplex.

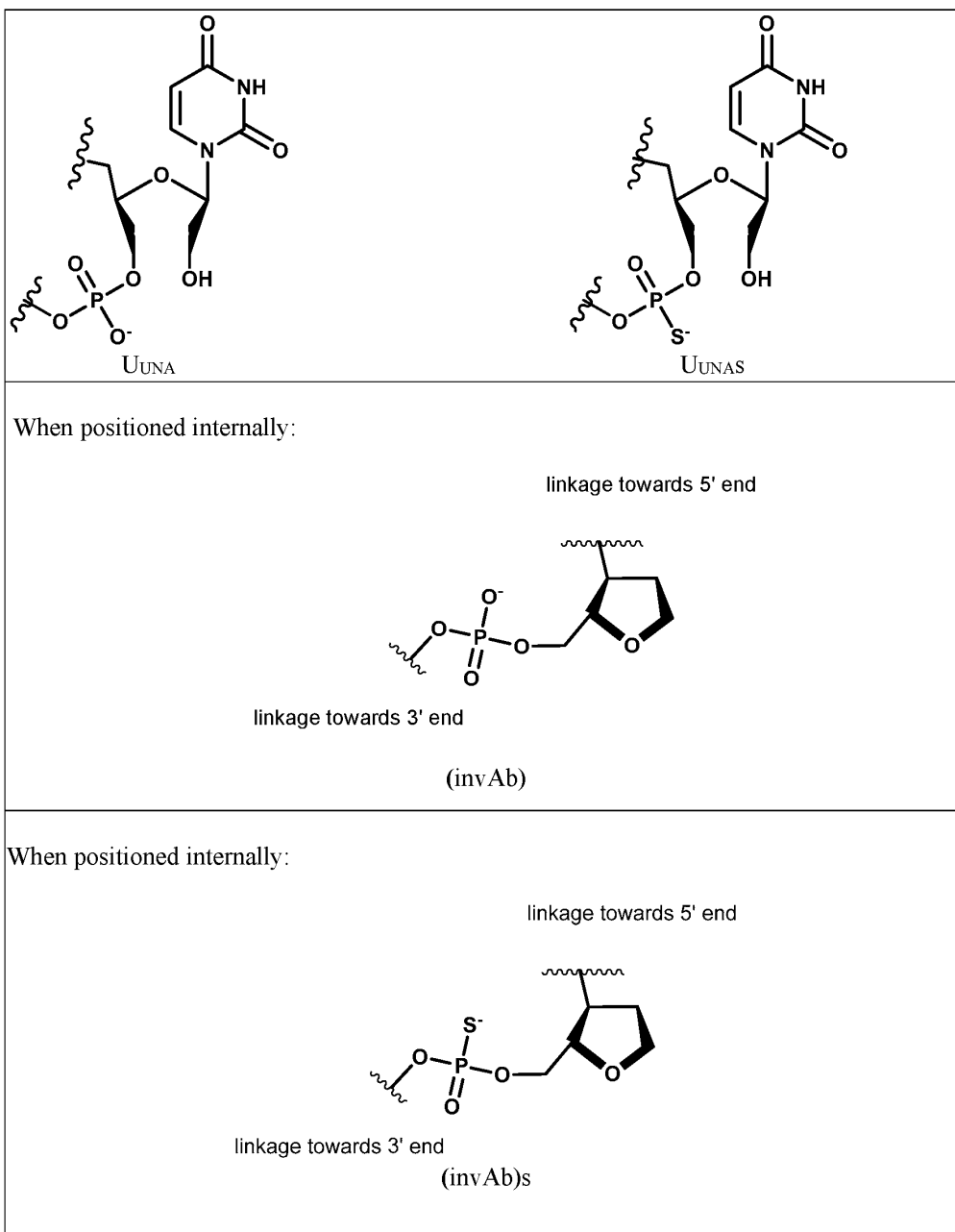
[0151] Examples of targeting groups and linking groups (which when combined can form targeting ligands) are provided in Table 6. Table 4 provides several embodiments of

PNPLA3 RNAi agent sense strands having a targeting group or linking group linked to the 5' or 3' end.

Table 6. Structures Representing Various Modified Nucleotides, Targeting Ligands or Targeting Groups, Capping Residues, and Linking Groups

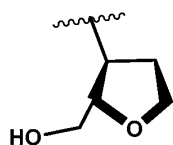




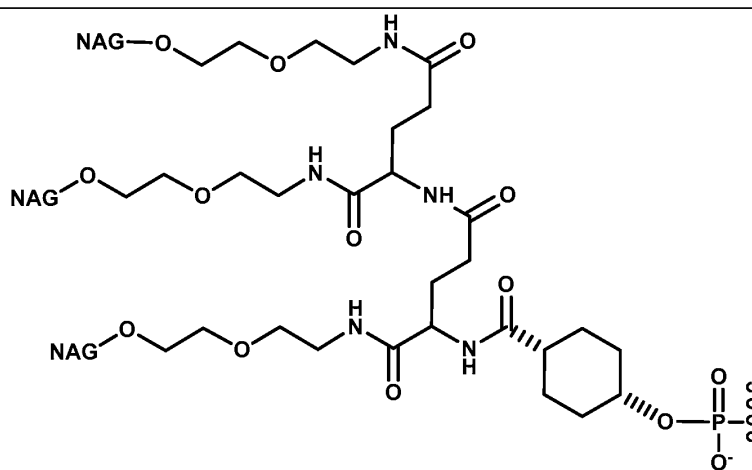


When positioned at the 3' terminal end:

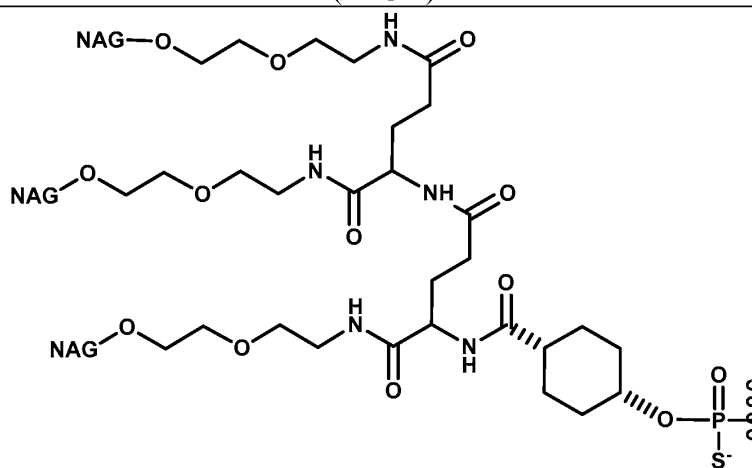
linkage towards 5' end



(invAb)



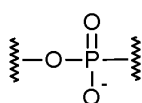
(NAG37)



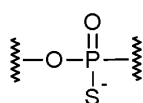
(NAG37)s

[0152] In each of the above structures in Table 6, NAG comprises an N-acetyl-galactosamine or another galactose derivative, as would be understood by a person of ordinary skill in the art to be attached in view of the structures above and description provided herein.

[0153] Each (NAG_x) may be attached to a PNPLA3 RNAi agent via a phosphate group (as in (NAG37)), or a phosphorothioate group, (as is (NAG37)s), or another linking group.



Phosphate group



Phosphorothioate group

Other linking groups known in the art may be used.

[0154] In some embodiments, a delivery vehicle can be used to deliver an RNAi agent to a cell or tissue. A delivery vehicle is a compound that improves delivery of the RNAi agent to a cell or tissue. A delivery vehicle can include, or consist of, but is not limited to: a polymer, such as an amphipathic polymer, a membrane active polymer, a peptide, a melittin peptide, a melittin-like peptide (MLP), a lipid, a reversibly modified polymer or peptide, or a reversibly modified membrane active polyamine. In some embodiments, the RNAi agents can be combined with lipids, nanoparticles, polymers, liposomes, micelles, DPCs or other delivery systems available in the art. The RNAi agents can also be chemically conjugated to targeting groups, lipids (including, but not limited to cholesterol and cholesteryl derivatives), nanoparticles, polymers, liposomes, micelles, DPCs (see, for example WO 2000/053722, WO 2008/0022309, WO 2011/104169, and WO 2012/083185, WO 2013/032829, WO 2013/158141, each of which is incorporated herein by reference), hydrogels, cyclodextrins, biodegradable nanocapsules, and bioadhesive microspheres, proteinaceous vectors, or other delivery systems suitable for nucleic acid or oligonucleotide delivery as known and available in the art.

Pharmaceutical Compositions and Formulations

[0155] The PNPLA3 RNAi agents disclosed herein can be prepared as pharmaceutical compositions or formulations (also referred to herein as “medicaments”). In some embodiments, pharmaceutical compositions include at least one PNPLA3 RNAi agent.

These pharmaceutical compositions are particularly useful in the inhibition of the expression of the target mRNA in a target cell, a group of cells, a tissue, or an organism.

[0156] The pharmaceutical compositions can be used to treat a subject having a disease, disorder, or condition that would benefit from reduction in the level of the target PNPLA3 mRNA, or inhibition in expression of the target gene. The pharmaceutical compositions can be used to treat a subject at risk of developing a disease, disorder, or condition that would benefit from reduction of the level of the target mRNA or an inhibition in expression the target gene. In one embodiment, the method includes administering a PNPLA3 RNAi agent linked to a targeting ligand as described herein, to a subject to be treated. In some embodiments, one or more pharmaceutically acceptable excipients (including vehicles, carriers, diluents, and/or delivery polymers) are added to the pharmaceutical compositions that include a PNPLA3 RNAi agent, thereby forming a pharmaceutical formulation or medicament suitable for *in vivo* delivery to a subject, including a human.

[0157] The pharmaceutical compositions that include a PNPLA3 RNAi agent and methods disclosed herein decrease the level of the target mRNA in a cell, group of cells, group of cells, tissue, organ, or subject, including by administering to the subject a therapeutically effective amount of a herein described PNPLA3 RNAi agent, thereby inhibiting the expression of PNPLA3 mRNA in the subject. In some embodiments, the subject has been previously identified or diagnosed as having a pathogenic upregulation of the target gene in the targeted cell or tissue. In some embodiments, the subject has been previously identified or diagnosed as having NAFLD, NASH, hepatic fibrosis, and/or alcoholic or non-alcoholic liver disease, such as cirrhosis. In some embodiments, the subject has been suffering from symptoms associated with NAFLD, NASH, hepatic fibrosis, and/or alcoholic or non-alcoholic liver disease, such as cirrhosis.

[0158] In some embodiments, the described pharmaceutical compositions including a PNPLA3 RNAi agent are used for treating or managing clinical presentations associated with NAFLD, NASH, hepatic fibrosis, alcoholic or non-alcoholic liver diseases, including cirrhosis, and/or over-expression of PNPLA3 in a subject. In some embodiments, a therapeutically (including prophylactically) effective amount of one or more of pharmaceutical compositions is administered to a subject in need of such treatment. In some embodiments, administration of any of the disclosed PNPLA3 RNAi agents can be used to decrease the number, severity, and/or frequency of symptoms of a disease in a subject.

[0159] The described pharmaceutical compositions that include a PNPLA3 RNAi agent can be used to treat at least one symptom in a subject having a disease or disorder that would benefit from reduction or inhibition in expression of PNPLA3 mRNA. In some embodiments, the subject is administered a therapeutically effective amount of one or more pharmaceutical compositions that include a PNPLA3 RNAi agent thereby treating the symptom. In other embodiments, the subject is administered a prophylactically effective amount of one or more PNPLA3 RNAi agents, thereby preventing or inhibiting the at least one symptom.

[0160] The route of administration is the path by which a PNPLA3 RNAi agent is brought into contact with the body. In general, methods of administering drugs and oligonucleotides and nucleic acids for treatment of a mammal are well known in the art and can be applied to administration of the compositions described herein. The PNPLA3 RNAi agents disclosed herein can be administered via any suitable route in a preparation appropriately tailored to the particular route. Thus, herein described pharmaceutical compositions can be administered by injection, for example, intravenously, intramuscularly, intracutaneously, subcutaneously, intraarticularly, or intraperitoneally. In some embodiments, the herein described pharmaceutical compositions are administered via subcutaneous injection.

[0161] The pharmaceutical compositions including a PNPLA3 RNAi agent described herein can be delivered to a cell, group of cells, tissue, or subject using oligonucleotide delivery technologies known in the art. In general, any suitable method recognized in the art for delivering a nucleic acid molecule (*in vitro* or *in vivo*) can be adapted for use with the compositions described herein. For example, delivery can be by local administration, (*e.g.*, direct injection, implantation, or topical administering), systemic administration, or subcutaneous, intravenous, intraperitoneal, or parenteral routes, including intracranial (*e.g.*, intraventricular, intraparenchymal and intrathecal), intramuscular, transdermal, airway (aerosol), nasal, oral, rectal, or topical (including buccal and sublingual) administration. In certain embodiments, the compositions are administered by subcutaneous or intravenous infusion or injection.

[0162] In some embodiments, the pharmaceutical compositions described herein comprise one or more pharmaceutically acceptable excipients. The pharmaceutical compositions described herein are formulated for administration to a subject.

[0163] As used herein, a pharmaceutical composition or medicament includes a pharmacologically effective amount of at least one of the described therapeutic compounds and one or more pharmaceutically acceptable excipients. Pharmaceutically acceptable excipients (excipients) are substances other than the Active Pharmaceutical Ingredient (API, therapeutic product, *e.g.*, PNPLA3 RNAi agent) that are intentionally included in the drug delivery system. Excipients do not exert or are not intended to exert a therapeutic effect at the intended dosage. Excipients can act to a) aid in processing of the drug delivery system during manufacture, b) protect, support or enhance stability, bioavailability or patient acceptability of the API, c) assist in product identification, and/or d) enhance any other attribute of the overall safety, effectiveness, of delivery of the API during storage or use. A pharmaceutically acceptable excipient may or may not be an inert substance.

[0164] Excipients include, but are not limited to: absorption enhancers, anti-adherents, anti-foaming agents, anti-oxidants, binders, buffering agents, carriers, coating agents, colors, delivery enhancers, delivery polymers, detergents, dextran, dextrose, diluents, disintegrants, emulsifiers, extenders, fillers, flavors, glidants, humectants, lubricants, oils, polymers, preservatives, saline, salts, solvents, sugars, surfactants, suspending agents, sustained release matrices, sweeteners, thickening agents, tonicity agents, vehicles, water-repelling agents, and wetting agents.

[0165] Pharmaceutical compositions suitable for injectable use include sterile aqueous solutions (where water-soluble) or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersion. For intravenous administration, suitable carriers include physiological saline, bacteriostatic water, Cremophor® ELTM (BASF, Parsippany, NJ) or phosphate buffered saline (PBS). Suitable carriers should be stable under the conditions of manufacture and storage and should be preserved against the contaminating action of microorganisms such as bacteria and fungi. The carrier can be a solvent or dispersion medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyethylene glycol), and suitable mixtures thereof. The proper fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. In many cases, it will be preferable to include isotonic agents, for example, sugars, polyalcohols such as mannitol, sorbitol, and sodium chloride in the composition. Prolonged absorption of the injectable compositions can be brought about by including in

the composition an agent which delays absorption, for example, aluminum monostearate and gelatin.

[0166] Sterile injectable solutions can be prepared by incorporating the active compound in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by filter sterilization. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle, which contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, methods of preparation include vacuum drying and freeze-drying which yields a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof.

[0167] In some embodiments, pharmaceutical formulations that include the PNPLA3 RNAi agents disclosed herein suitable for subcutaneous administration can be prepared in an aqueous sodium phosphate buffer (e.g., the PNPLA3 RNAi agent formulated in 0.5 mM sodium phosphate monobasic, 0.5 mM sodium phosphate dibasic, in water)

[0168] Formulations suitable for intra-articular administration can be in the form of a sterile aqueous preparation of the drug that can be in microcrystalline form, for example, in the form of an aqueous microcrystalline suspension. Liposomal formulations or biodegradable polymer systems can also be used to present the drug for both intra-articular and ophthalmic administration.

[0169] Formulations suitable for oral administration of the PNPLA3 RNAi agents disclosed herein can also be prepared. In some embodiments, the PNPLA3 RNAi agents disclosed herein are administered orally. In some embodiments, the PNPLA3 RNAi agents disclosed herein are formulated in a capsule for oral administration.

[0170] The active compounds can be prepared with carriers that will protect the compound against rapid elimination from the body, such as a controlled release formulation, including implants and microencapsulated delivery systems. Biodegradable, biocompatible polymers can be used, such as ethylene vinyl acetate, polyanhydrides, polyglycolic acid, collagen, polyorthoesters, and polylactic acid. Methods for preparation of such formulations will be apparent to those skilled in the art. Liposomal suspensions can also be used as pharmaceutically acceptable carriers. These can be prepared according to methods known to those skilled in the art, for example, as described in U.S. Patent No. 4,522,811.

[0171] The PNPLA3 RNAi agents can be formulated in compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form refers to physically discrete units suited as unitary dosages for the subject to be treated; each unit containing a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the dosage unit forms of the disclosure are dictated by and directly dependent on the unique characteristics of the active compound and the therapeutic effect to be achieved, and the limitations inherent in the art of compounding such an active compound for the treatment of individuals.

[0172] A pharmaceutical composition can contain other additional components commonly found in pharmaceutical compositions. Such additional components include, but are not limited to: anti-pruritics, astringents, local anesthetics, analgesics, antihistamines, or anti-inflammatory agents (e.g., acetaminophen, NSAIDs, diphenhydramine, etc.). It is also envisioned that cells, tissues, or isolated organs that express or comprise the herein defined RNAi agents may be used as “pharmaceutical compositions.” As used herein, “pharmacologically effective amount,” “therapeutically effective amount,” or simply “effective amount” refers to that amount of an RNAi agent to produce a pharmacological, therapeutic, or preventive result.

[0173] In some embodiments, the methods disclosed herein further comprise the step of administering a second therapeutic or treatment in addition to administering an RNAi agent disclosed herein. In some embodiments, the second therapeutic is another PNPLA3 RNAi agent (e.g., a PNPLA3 RNAi agent that targets a different sequence within the PNPLA3 target). In other embodiments, the second therapeutic can be a small molecule drug, an antibody, an antibody fragment, or an aptamer.

[0174] In some embodiments, the described PNPLA3 RNAi agent(s) are optionally combined with one or more additional therapeutics. The PNPLA3 RNAi agent and additional therapeutic(s) can be administered in a single composition or they can be administered separately. In some embodiments, the one or more additional therapeutics is administered separately in separate dosage forms from the RNAi agent (e.g., the PNPLA3 RNAi agent is administered by subcutaneous injection, while the additional therapeutic involved in the method of treatment dosing regimen is administered orally). In some embodiments, the described PNPLA3 RNAi agent(s) are administered to a subject in need thereof via subcutaneous injection, and the one or more optional additional therapeutics are

administered orally, which together provide for a treatment regimen for diseases and conditions associated with NAFLD, NASH, hepatic fibrosis, and/or alcoholic or non-alcoholic liver diseases, including cirrhosis. In some embodiments, the described PNPLA3 RNAi agent(s) are administered to a subject in need thereof via subcutaneous injection, and the one or more optional additional therapeutics are administered via a separate subcutaneous injection. In some embodiments, the PNPLA3 RNAi agent and one or more additional therapeutics are combined into a single dosage form (e.g., a “cocktail” formulated into a single composition for subcutaneous injection). The PNPLA3 RNAi agents, with or without the one or more additional therapeutics, can be combined with one or more excipients to form pharmaceutical compositions.

[0175] Generally, an effective amount of a PNPLA3 RNAi agent will be in the range of from about 0.1 to about 100 mg/kg of body weight/dose, e.g., from about 1.0 to about 50 mg/kg of body weight/dose. In some embodiments, an effective amount of an active compound will be in the range of from about 0.25 to about 5 mg/kg of body weight per dose. In some embodiments, an effective amount of an active ingredient will be in the range of from about 0.5 to about 4 mg/kg of body weight per dose. Dosing may be weekly, bi-weekly, monthly, or at any other interval depending on the dose of PNPLA3 RNAi agent administered, the activity level of the particular PNPLA3 RNAi agent, and the desired level of inhibition for the particular subject. The Examples herein show suitable levels for inhibition in certain animal species. The amount administered will depend on such variables as the overall health status of the patient, the relative biological efficacy of the compound delivered, the formulation of the drug, the presence and types of excipients in the formulation, and the route of administration. Also, it is to be understood that the initial dosage administered can be increased beyond the above upper level to rapidly achieve the desired blood-level or tissue level, or the initial dosage can be smaller than the optimum.

[0176] For treatment of disease or for formation of a medicament or composition for treatment of a disease, the pharmaceutical compositions described herein including a PNPLA3 RNAi agent can be combined with an excipient or with a second therapeutic agent or treatment including, but not limited to: a second or other RNAi agent, a small molecule drug, an antibody, an antibody fragment, peptide and/or an aptamer.

[0177] The described PNPLA3 RNAi agents, when added to pharmaceutically acceptable excipients or adjuvants, can be packaged into kits, containers, packs, or

dispensers. The pharmaceutical compositions described herein may be packaged in pre-filled syringes, pen injectors, autoinjectors, infusion bags/devices, or vials.

Methods of Treatment and Inhibition of Expression

[0178] The PNPLA3 RNAi agents disclosed herein can be used to treat a subject (e.g., a human or other mammal) having a disease or disorder that would benefit from administration of the RNAi agent. In some embodiments, the RNAi agents disclosed herein can be used to treat a subject (e.g., a human) that would benefit from reduction and/or inhibition in expression of PNPLA3 mRNA and/or PNPLA3 protein levels, for example, a subject that has been diagnosed with or is suffering from symptoms related to NAFLD, NASH, hepatic fibrosis, or alcoholic or non-alcoholic liver diseases, including cirrhosis.

[0179] In some embodiments, the subject is administered a therapeutically effective amount of any one or more PNPLA3 RNAi agents. Treatment of a subject can include therapeutic and/or prophylactic treatment. The subject is administered a therapeutically effective amount of any one or more PNPLA3 RNAi agents described herein. The subject can be a human, patient, or human patient. The subject may be an adult, adolescent, child, or infant. Administration of a pharmaceutical composition described herein can be to a human being or animal.

[0180] The PNPLA3 RNAi agents described herein can be used to treat at least one symptom in a subject having a PNPLA3-related disease or disorder, or having a disease or disorder that is mediated at least in part by PNPLA3 gene expression. In some embodiments, the PNPLA3 RNAi agents are used to treat or manage a clinical presentation of a subject with a disease or disorder that would benefit from or be mediated at least in part by a reduction in PNPLA3 mRNA. The subject is administered a therapeutically effective amount of one or more of the PNPLA3 RNAi agents or PNPLA3 RNAi agent-containing compositions described herein. In some embodiments, the methods disclosed herein comprise administering a composition comprising a PNPLA3 RNAi agent described herein to a subject to be treated. In some embodiments, the subject is administered a prophylactically effective amount of any one or more of the described PNPLA3 RNAi agents, thereby treating the subject by preventing or inhibiting the at least one symptom.

[0181] In certain embodiments, the present disclosure provides methods for treatment of diseases, disorders, conditions, or pathological states mediated at least in part by PNPLA3

gene expression, in a patient in need thereof, wherein the methods include administering to the patient any of the PNPLA3 RNAi agents described herein.

[0182] In some embodiments, the gene expression level and/or mRNA level of a PNPLA3 gene in a subject to whom a described PNPLA3 RNAi agent is administered is reduced by at least about 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 95%, 96%, 97%, 98%, 99%, or greater than 99% relative to the subject prior to being administered the PNPLA3 RNAi agent or to a subject not receiving the PNPLA3 RNAi agent. The gene expression level and/or mRNA level in the subject may be reduced in a cell, group of cells, and/or tissue of the subject. In some embodiments, the PNPLA3 gene expression is inhibited by at least about 50%, 55%, 60%, 65%, 66%, 67%, 68%, 69%, 70%, or greater than 70% in the cytoplasm of hepatocytes relative to the subject prior to being administered the PNPLA3 RNAi agent or to a subject not receiving the PNPLA3 RNAi agent.

[0183] In some embodiments, the PNPLA3 protein level in a subject to whom a described PNPLA3 RNAi agent has been administered is reduced by at least about 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, 99%, or greater than 99% relative to the subject prior to being administered the PNPLA3 RNAi agent or to a subject not receiving the PNPLA3 RNAi agent. The protein level in the subject may be reduced in a cell, group of cells, tissue, blood, and/or other fluid of the subject.

[0184] A reduction in PNPLA3 mRNA levels and PNPLA3 protein levels can be assessed by any methods known in the art. As used herein, a reduction or decrease in PNPLA3 mRNA level and/or protein level are collectively referred to herein as a reduction or decrease in PNPLA3 or inhibiting or reducing the expression of PNPLA3. The Examples set forth herein illustrate known methods for assessing inhibition of PNPLA3 gene expression. The person of ordinary skill in the art would further know suitable methods for assessing inhibition of PNPLA3 gene expression *in vivo* and/or *in vitro*.

[0185] In some embodiments, disclosed herein are methods of treatment (including prophylactic or preventative treatment) of diseases, disorders, or symptoms caused by caused by NAFLD, NASH, hepatic fibrosis, and/or alcoholic or non-alcoholic liver diseases, including cirrhosis, wherein the methods include administering to a subject in need thereof a therapeutically effective amount of a PNPLA3 RNAi agent that includes an antisense strand that is at least partially complementary to the portion of the PNPLA3 mRNA having

the sequence in Table 1. In some embodiments, disclosed herein are methods of treatment (including prophylactic or preventative treatment) of diseases or symptoms caused by caused by NAFLD, NASH, hepatic fibrosis, and/or alcoholic or non-alcoholic liver diseases, including cirrhosis, wherein the methods include administering to a subject in need thereof a therapeutically effective amount of a PNPLA3 RNAi agent that includes an antisense strand comprising the sequence of any of the sequences in Tables 2 or 3, and a sense strand that comprises any of the sequences in Tables 2 or 4 that is at least partially complementary to the antisense strand. In some embodiments, disclosed herein are methods of treatment (including prophylactic or preventative treatment) of diseases or symptoms caused by caused by NAFLD, NASH, hepatic fibrosis, and/or alcoholic or non-alcoholic liver diseases, including cirrhosis, wherein the methods include administering to a subject in need thereof a therapeutically effective amount of a PNPLA3 RNAi agent that includes a sense strand that comprises any of the sequences in Tables 2 or 4, and an antisense strand comprising the sequence of any of the sequences in Tables 2 or 3 that is at least partially complementary to the sense strand.

[0186] In some embodiments, disclosed herein are methods for inhibiting expression of a PNPLA3 gene in a cell, wherein the methods include administering to the cell a PNPLA3 RNAi agent that includes an antisense strand that is at least partially complementary to the portion of the PNPLA3 mRNA having the sequence in Table 1. In some embodiments, disclosed herein are methods of inhibiting expression of a PNPLA3 gene in a cell, wherein the methods include administering to a cell a PNPLA3 RNAi agent that includes an antisense strand comprising the sequence of any of the sequences in Tables 2 or 3, and a sense strand that comprises any of the sequences in Tables 2 or 4 that is at least partially complementary to the antisense strand. In some embodiments, disclosed herein are methods of inhibiting expression of a PNPLA3 gene in a cell, wherein the methods include administering a PNPLA3 RNAi agent that includes a sense strand that comprises any of the sequences in Tables 2 or 4, and an antisense strand that includes the sequence of any of the sequences in Tables 2 or 3 that is at least partially complementary to the sense strand.

[0187] The use of PNPLA3 RNAi agents provides methods for therapeutic (including prophylactic) treatment of diseases/disorders associated with NAFLD, NASH, hepatic fibrosis, alcoholic or non-alcoholic liver diseases, including cirrhosis, and/or enhanced or elevated PNPLA3 expression. The described PNPLA3 RNAi agents mediate RNA interference to inhibit the expression of one or more genes necessary for production of

PNPLA3 protein. PNPLA3 RNAi agents can also be used to treat or prevent various diseases, disorders, or conditions, including NAFLD, NASH, hepatic fibrosis, and/or alcoholic or non-alcoholic liver diseases, including cirrhosis. Furthermore, compositions for delivery of PNPLA3 RNAi agents to liver cells *in vivo* are described.

Cells, Tissues, Organs, and Non-Human Organisms

[0188] Cells, tissues, organs, and non-human organisms that include at least one of the PNPLA3 RNAi agents described herein are contemplated. The cell, tissue, organ, or non-human organism is made by delivering the RNAi agent to the cell, tissue, organ or non-human organism.

ILLUSTRATIVE EMBODIMENTS

[0189] Provided here are illustrative embodiments of the disclosed technology. These embodiments are illustrative only and do not limit the scope of the present disclosure or of the claims attached hereto.

[0190] Embodiment 1. An RNAi agent for inhibiting expression of a PNPLA3 gene, comprising:

an antisense strand comprising at least 17 contiguous nucleotides differing by 0 or 1 nucleotides from any one of the sequences of SEQ ID NOs: 46-87, 174-211, and 257-258; and a sense strand comprising a nucleotide sequence that is at least partially complementary to the antisense strand.

[0191] Embodiment 2. The RNAi agent of embodiment 1, wherein the antisense strand comprises nucleotides 2-18 of any one of the sequences of SEQ ID NOs: 46-87, 174-211, and 257-258.

[0192] Embodiment 3. The RNAi agent of embodiment 1 or embodiment 2, wherein the sense strand comprises a nucleotide sequence of at least 17 contiguous nucleotides differing by 0 or 1 nucleotides from any one of the sense strand sequences of SEQ ID NOs: 2-45 and 212-256, and wherein the sense strand has a region of at least 85% complementarity over the 17 contiguous nucleotides to the antisense strand.

[0193] Embodiment 4. The RNAi agent of any one of embodiments 1-3, wherein at least one nucleotide of the RNAi agent is a modified nucleotide or includes a modified internucleoside linkage.

[0194] Embodiment 5. The RNAi agent of any one of embodiments 1-3, wherein all or substantially all of the nucleotides of the sense and/or antisense strand of the RNAi agent are modified nucleotides.

[0195] Embodiment 6. The RNAi agent of any one of embodiments 4-5, wherein the modified nucleotide is selected from the group consisting of: 2'-O-methyl nucleotide, 2'-fluoro nucleotide, 2'-deoxy nucleotide, 2',3'-seco nucleotide mimic, locked nucleotide, 2'-F-arabino nucleotide, 2'-methoxyethyl nucleotide, abasic nucleotide, ribitol, inverted nucleotide, inverted 2'-O-methyl nucleotide, inverted 2'-deoxy nucleotide, 2'-amino-modified nucleotide, 2'-alkyl-modified nucleotide, morpholino nucleotide, vinyl phosphonate containing nucleotide, cyclopropyl phosphonate containing nucleotide, and 3'-O-methyl nucleotide.

[0196] Embodiment 7. The RNAi agent of embodiment 5, wherein all or substantially all of the modified nucleotides are 2'-O-methyl nucleotides, 2'-fluoro nucleotides, or combinations thereof.

[0197] Embodiment 8. The RNAi agent of any one of embodiments 1-7, wherein the antisense strand comprises the nucleotide sequence of any one of the modified antisense strand sequences of SEQ ID NOs: 88-128.

[0198] Embodiment 9. The RNAi agent of any one of embodiments 1-8, wherein the sense strand comprises the nucleotide sequence of any of the modified sense strand sequences of SEQ ID NOs: 129-173.

[0199] Embodiment 10. The RNAi agent of embodiment 1, wherein the antisense strand comprises the nucleotide sequence of any one of the modified sequences of SEQ ID NOs: 88-128 and the sense strand comprises the nucleotide sequence of any one of the modified sequences of SEQ ID NOs: 129-173.

[0200] Embodiment 11. The RNAi agent of any one of embodiments 1-10, wherein the RNAi agent is linked to a targeting ligand.

[0201] Embodiment 12. The RNAi agent of embodiment 11, wherein the targeting ligand comprises n-acetyl-galactosamine.

[0202] Embodiment 13. The RNAi agent of embodiment 11 or 12, wherein the targeting ligand comprises the structure of (NAG37) or (NAG37)s.

[0203] Embodiment 14. The RNAi agent of any one of embodiments 11-14, wherein the targeting ligand is linked to the sense strand.

[0204] Embodiment 15. The RNAi agent of embodiment 15, wherein the targeting ligand is linked to the 5' terminal end of the sense strand.

[0205] Embodiment 16. The RNAi agent of any one of embodiments 1-16, wherein the sense strand is between 18 and 30 nucleotides in length, and the antisense strand is between 18 and 30 nucleotides in length.

[0206] Embodiment 17. The RNAi agent of embodiment 17, wherein the sense strand and the antisense strand are each between 18 and 27 nucleotides in length.

[0207] Embodiment 18. The RNAi agent of embodiment 18, wherein the sense strand and the antisense strand are each between 18 and 24 nucleotides in length.

[0208] Embodiment 19. The RNAi agent of embodiment 19, wherein the sense strand and the antisense strand are each 21 nucleotides in length.

[0209] Embodiment 20. The RNAi agent of any one of embodiments 17-20, wherein the RNAi agent has two blunt ends.

[0210] Embodiment 21. The RNAi agent of any one of embodiments 1-21, wherein the sense strand comprises one or two terminal caps.

[0211] Embodiment 22. The RNAi agent of any one of embodiments 1-22, wherein the sense strand comprises one or two inverted abasic residues.

[0212] Embodiment 23. The RNAi agent of embodiment 1, wherein the RNAi agent is comprised of a sense strand and an antisense strand that form a duplex sequence of any one of the duplexes with SEQ ID NOs as listed in Table 5B.

[0213] Embodiment 24. The RNAi agent of any one of embodiments 1-23, wherein the sense strand further includes inverted abasic residues at the 3' terminal end of the nucleotide sequence, at the 5' end of the nucleotide sequence, or at both.

[0214] Embodiment 25. The RNAi agent of embodiment 1, comprising an antisense strand that comprises, consists of, or consists essentially of a modified nucleotide sequence that differs by 0 or 1 nucleotides from one of the nucleotide sequences of SEQ ID NOs: 88-128, wherein a, c, g, and u represent 2'-O-methyl adenosine, cytidine, guanosine, and uridine, respectively; Af, Cf, Gf, and Uf represent 2'-fluoro adenosine, cytidine, guanosine, and uridine, respectively; s represents a phosphorothioate linkage; and wherein all or substantially all of the nucleotides on the sense strand are modified nucleotides.

[0215] Embodiment 26. The RNAi agent of embodiment 1, wherein the sense strand comprises, consists of, or consists essentially of a modified nucleotide sequence that differs by 0 or 1 nucleotides from one of the nucleotide sequences of SEQ ID NOs: 129-173, wherein a, c, g, i, and u represent 2'-O-methyl adenosine, cytidine, guanosine, inosine, and uridine, respectively; Af, Cf, Gf, and Uf represent 2'-fluoro adenosine, cytidine, guanosine, and uridine, respectively; s represents a phosphorothioate linkage; and wherein all or substantially all of the nucleotides on the antisense strand are modified nucleotides.

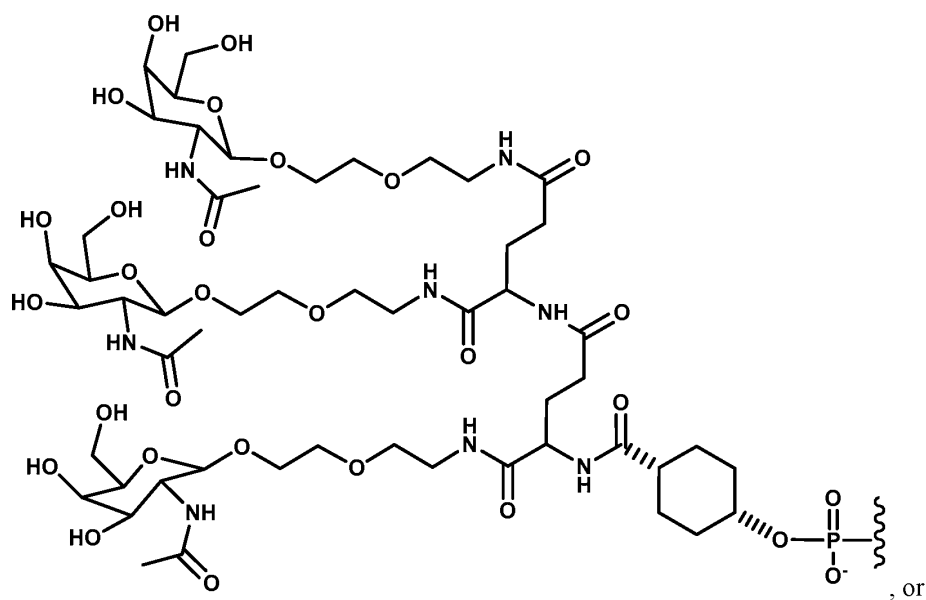
[0216] Embodiment 27. The RNAi agent of any one of embodiments 24-26, wherein the sense strand further includes inverted abasic residues at the 3' terminal end of the nucleotide sequence, at the 5' end of the nucleotide sequence, or at both.

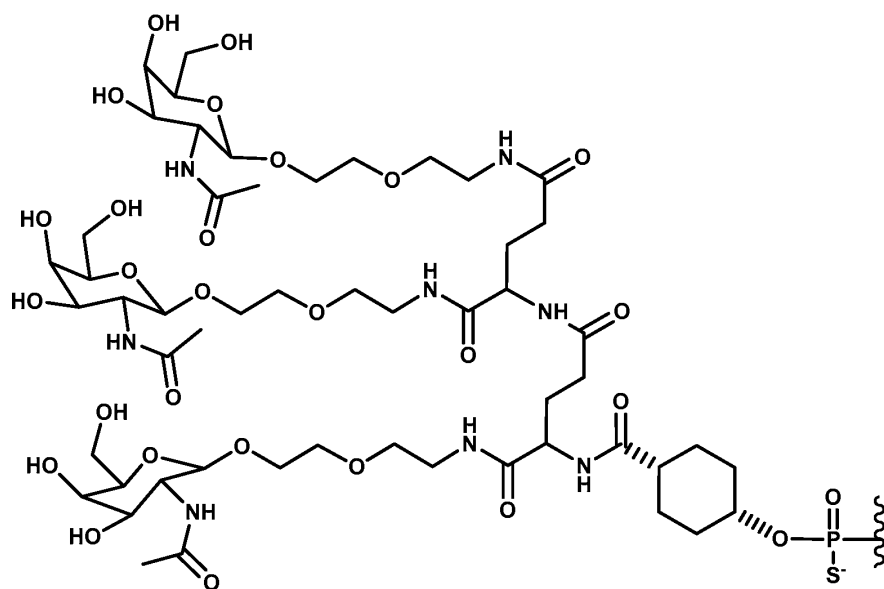
[0217] Embodiment 28. The RNAi agent of any one of embodiments 24-27, wherein the sense strand of the RNAi agent is linked to a targeting ligand.

[0218] Embodiment 29. The RNAi agent of embodiment 28, wherein the targeting ligand has affinity for the asialoglycoprotein receptor.

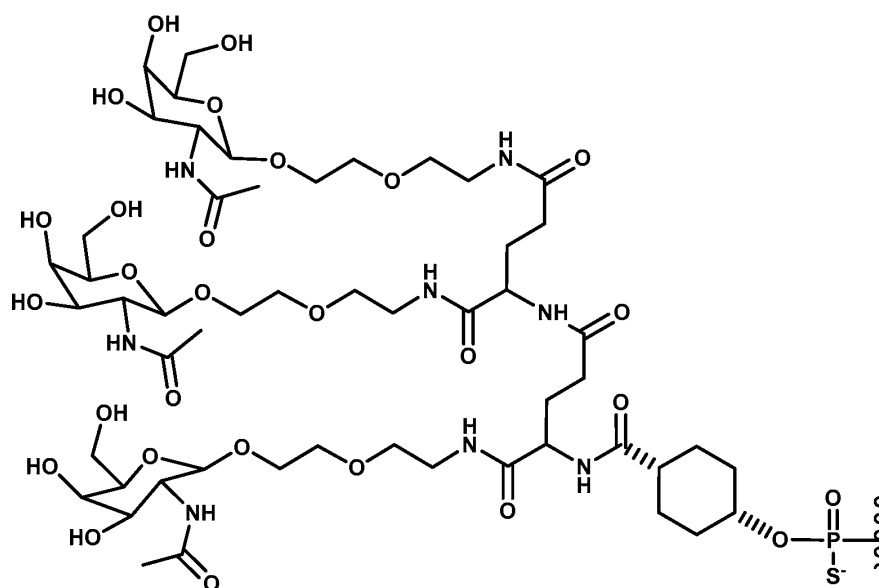
[0219] Embodiment 30. The RNAi agent of embodiment 29, wherein the targeting ligand comprises N-acetyl-galactosamine.

[0220] Embodiment 31. The RNAi agent of embodiment 1, wherein the targeting ligand comprises:





[0221] Embodiment 32. The RNAi agent of embodiment 1, wherein the antisense strand consists of the modified nucleotide sequence of SEQ ID NO: 88-128 and the sense strand consists of the modified nucleotide sequence of SEQ ID NO: 129-173, wherein a, c, g, and u are 2'-O-methyl adenosine, cytidine, guanosine, and uridine, respectively; Af, Cf, Gf, and Uf are 2'-fluoro adenosine, cytidine, guanosine, and uridine, respectively; s is a phosphorothioate linkage; (invAb) is an inverted abasic deoxyribose residue; and (NAG37)s has the following chemical structure:



[0222] Embodiment 33. A composition comprising the RNAi agent of any one of embodiments 1-32, wherein the composition further comprises a pharmaceutically acceptable excipient.

[0223] Embodiment 34. A method for inhibiting expression of a PNPLA3 gene in a cell, the method comprising introducing into a cell an effective amount of an RNAi agent of any one of embodiments 1-32 or the composition of any one of embodiments 33.

[0224] Embodiment 35. The method of embodiment 34, wherein the cell is within a subject.

[0225] Embodiment 36. The method of embodiment 35, wherein the subject is a human subject.

[0226] Embodiment 37. The method of any one of embodiments 34-36, wherein the PNPLA3 gene expression is inhibited by at least about 30%.

[0227] Embodiment 38. A method of treating a PNPLA3-related disease or disorder, the method comprising administering to a human subject in need thereof a therapeutically effective amount of the composition of embodiment 33.

[0228] Embodiment 39. The method of embodiment 38, wherein the disease is NAFLD, NASH, hepatic fibrosis, alcoholic fatty liver disease, or cirrhosis.

[0229] Embodiment 40. The method of any one of embodiments 34-39, wherein the RNAi agent is administered at a dose of about 0.05 mg/kg to about 5.0 mg/kg of body weight of the human subject.

[0230] Embodiment 41. The method of any one of embodiments 34-40, wherein the RNAi agent is administered in two or more doses.

[0231] Embodiment 42. Use of the RNAi agent of any one of embodiments 1-32 or the composition according to embodiment 33, for the treatment of a disease, disorder, or symptom that is mediated at least in part PNPLA3 gene expression.

[0232] Embodiment 43. Use according to embodiment 42, wherein the symptom is cirrhosis of the liver.

[0233] Embodiment 44. Use of the RNAi agent of any one of embodiments 1-32 or the composition according to embodiment 33, for the preparation of a pharmaceutical compositions for treating a disease, disorder, or symptom that is mediated at least in part by PNPLA3 gene expression.

[0234] Embodiment 45. Use of the RNAi agent according to any one of embodiments 42 to 44, wherein the disease is NAFLD, NASH, hepatic fibrosis, or an alcoholic or non-alcoholic liver disease such as cirrhosis.

[0235] Embodiment 46. Use of the composition of embodiment 33, wherein the RNAi agent is administered at a dose of about 0.05 mg/kg to about 5.0 mg/kg of body weight of the human subject.

[0236] The above provided embodiments and items are now illustrated with the following, non-limiting examples.

EXAMPLES

Example 1. Synthesis of PNPLA3 RNAi Agents.

[0237] PNPLA3 RNAi agent duplexes shown in Tables 5A and 5B, above, were synthesized in accordance with the following general procedures:

A. *Synthesis.*

[0238] The sense and antisense strands of the RNAi agents were synthesized according to phosphoramidite technology on solid phase used in oligonucleotide synthesis. Such standard synthesis is generally known in the art. Depending on the scale, either a

MerMade96E® (Bioautomation), a MerMade12® (Bioautomation), or an OP Pilot 100 (GE Healthcare) was used. Syntheses were performed on a solid support made of controlled pore glass (CPG, 500 Å or 600 Å, obtained from Prime Synthesis, Aston, PA, USA). The monomer positioned at the 3' end of the respective strand was attached to the solid support as a starting point for synthesis. All RNA and 2'-modified RNA phosphoramidites were purchased from Thermo Fisher Scientific (Milwaukee, WI, USA) or Hongene Biotech (Shanghai, PRC). The 2'-O-methyl phosphoramidites included the following: (5'-O-dimethoxytrityl-N⁶-(benzoyl)-2'-O-methyl-adenosine-3'-O-(2-cyanoethyl-N,N-diisopropylamino) phosphoramidite, 5'-O-dimethoxy-trityl-N⁴-(acetyl)-2'-O-methyl-cytidine-3'-O-(2-cyanoethyl-N,N-diisopropyl-amino) phosphoramidite, (5'-O-dimethoxytrityl-N²-(isobutyryl)-2'-O-methyl-guanosine-3'-O-(2-cyanoethyl-N,N-diisopropylamino) phosphoramidite, and 5'-O-dimethoxytrityl-2'-O-methyl-uridine-3'-O-(2-cyanoethyl-N,N-diisopropylamino) phosphoramidite. The 2'-deoxy-2'-fluoro-phosphoramidites carried the same protecting groups as the 2'-O-methyl amidites. 5'-(4,4'-Dimethoxytrityl)-2',3'-seco-uridine, 2'-benzoyl-3'-[(2-cyanoethyl)-(N,N-diisopropyl)]-phosphoramidite was also purchased from Thermo Fisher Scientific or Hongene Biotech. 5'-dimethoxytrityl-2'-O-methyl-inosine-3'-O-(2-cyanoethyl-N,N-diisopropylamino) phosphoramidites were purchased from Glen Research (Virginia) or Hongene Biotech. The inverted abasic (3'-O-dimethoxytrityl-2'-deoxyribose-5'-O-(2-cyanoethyl-N,N-diisopropylamino) phosphoramidites were purchased from ChemGenes (Wilmington, MA, USA) or SAFC (St Louis, MO, USA). 5'-O-dimethoxytrityl-N²,N⁶-(phenoxyacetate)-2'-O-methyl-diaminopurine-3'-O-(2-cyanoethyl-N,N-diisopropylamino) phosphoramidites were obtained from ChemGenes or Hongene Biotech.

[0239] Targeting ligand-containing phosphoramidites were dissolved in anhydrous dichloromethane or anhydrous acetonitrile (50 mM), while all other amidites were dissolved in anhydrous acetonitrile (50 mM), or anhydrous dimethylformamide and molecular sieves (3 Å) were added. 5-Benzylthio-1H-tetrazole (BTT, 250 mM in acetonitrile) or 5-Ethylthio-1H-tetrazole (ETT, 250 mM in acetonitrile) was used as activator solution. Coupling times were 12 min (RNA), 15 min (targeting ligand), 90 sec (2'OMe), and 60 sec (2'F). In order to introduce phosphorothioate linkages, a 100 mM solution of 3-phenyl 1,2,4-dithiazoline-5-one (POS, obtained from PolyOrg, Inc., Leominster, MA, USA) in anhydrous Acetonitrile was employed. Unless specifically identified as a “naked” RNAi agent having no targeting ligand present, each of the

PNPLA3 RNAi agent duplexes synthesized and tested in the following Examples utilized N-acetyl-galactosamine as “NAG” in the targeting ligand chemical structures represented in Table 6.

B. Cleavage and deprotection of support bound oligomer.

[0240] After finalization of the solid phase synthesis, the dried solid support was treated with a 1:1 volume solution of 40 wt. % methylamine in water and 28% ammonium hydroxide solution (Aldrich) for 1.5 hours at 30°C. The solution was evaporated and the solid residue was reconstituted in water (see below).

C. Purification.

[0241] Crude oligomers were purified by anionic exchange HPLC using a TSKgel SuperQ-5PW 13µm column and Shimadzu LC-8 system. Buffer A was 20 mM Tris, 5 mM EDTA, pH 9.0 and contained 20% Acetonitrile and buffer B was the same as buffer A with the addition of 1.5 M sodium chloride. UV traces at 260 nm were recorded. Appropriate fractions were pooled then run on size exclusion HPLC using a GE Healthcare XK 26/40 column packed with Sephadex G-25 fine with a running buffer of filtered DI water or 100mM ammonium bicarbonate, pH 6.7 and 20% Acetonitrile.

D. Annealing.

[0242] Complementary strands were mixed by combining equimolar RNA solutions (sense and antisense) in 1×Phosphate-Buffered Saline (Coming, Cellgro) to form the RNAi agents. Some RNAi agents were lyophilized and stored at −15 to −25°C. Duplex concentration was determined by measuring the solution absorbance on a UV-Vis spectrometer in 1× Phosphate-Buffered Saline. The solution absorbance at 260 nm was then multiplied by a conversion factor and the dilution factor to determine the duplex concentration. The conversion factor used was either 0.050 mg/(mL·cm) or was calculated from an experimentally determined extinction coefficient.

Example 2. PNPLA3-SEAP Mouse Model.

[0243] To evaluate certain PNPLA3 RNAi agents, a PNPLA3-SEAP mouse model was used. Six- to eight-week-old female C57BL/6 albino mice or ICR mice, depending on availability, were transiently transfected *in vivo* with plasmid by hydrodynamic tail vein injection, administered at least 29 days prior to administration of a PNPLA3 RNAi agent or control. Two types of SEAP plasmids were prepared. The first plasmid contains the human PNPLA3 cDNA sequence (GenBank NM_025225.2 (SEQ ID NO:1)) inserted into the 3'

UTR of the SEAP (secreted human placental alkaline phosphatase) reporter gene. Due to perceived instability of the full length transcript over time, a second plasmid was synthesized that included a truncated version of the human PNPLA3 cDNA sequence (specifically nucleotides 501-2210 of GenBank NM_025225.2). One of the two plasmids were selected to transfect into mice. 50 µg of the respective plasmid in Ringer's Solution in a total volume of 10% of the animal's body weight was injected into mice via the tail vein to create PNPLA3-SEAP model mice. The solution was injected through a 27-gauge needle in 5-7 seconds as previously described (Zhang G et al., "High levels of foreign gene expression in hepatocytes after tail vein injection of naked plasmid DNA." Human Gene Therapy 1999 Vol. 10, p1735-1737.). Inhibition of expression of PNPLA3 by a PNPLA3 RNAi agent results in concomitant inhibition of SEAP expression, which is measured. Prior to administration of a treatment (between day -7 and day 1 pre-dose), SEAP expression levels in serum were measured by the Phospha-Light™ SEAP Reporter Gene Assay System (Invitrogen), and the mice were grouped according to average SEAP levels.

[0244] Mice were anesthetized with 2-3% isoflurane and blood samples were collected from the submandibular area into serum separation tubes (Sarstedt AG & Co., Nümbrecht, Germany). Blood was allowed to coagulate at ambient temperature for 20 min. The tubes were centrifuged at 8,000 ×g for 3 min to separate the serum and stored at 4°C. Serum was collected and measured by the Phospha-Light™ SEAP Reporter Gene Assay System (Invitrogen) according to the manufacturer's instructions. Serum SEAP levels for each animal can be normalized to the control group of mice injected with vehicle control in order to account for the non-treatment related decline in PNPLA3 expression with this model. To do so, first, the SEAP level for each animal at a time point was divided by the pre-treatment level of expression in that animal (Day -1) in order to determine the ratio of expression "normalized to pre-treatment". Expression at a specific time point was then normalized to the control group by dividing the "normalized to pre-treatment" ratio for an individual animal by the average "normalized to pre-treatment" ratio of all mice in the normal vehicle control group. Alternatively, the serum SEAP levels for each animal was assessed by normalizing to pre-treatment levels only.

Example 3. *In Vivo* Testing of PNPLA3 RNAi Agents in PNPLA3-SEAP Mice.

[0245] The PNPLA3-SEAP mouse model described in Example 2, above, using the plasmid containing the full length human PNPLA3 transcript was used. At day 1, each

mouse was given a single subcutaneous administration of 200 μ l/ 20 g animal weight containing either 3.0 mg/kg (mpk) of a PNPLA3 RNAi agent formulated in saline, or vehicle control (saline with no RNAi agent), according to the following Table 7.

Table 7. Targeted Positions and Dosing Groups of Example 3

Group	Targeted Gene Position (within SEQ ID NO: 1)	RNAi Agent and Dose	Dosing Regimen
1	N/A	Saline (no RNAi agent)	Single injection on day 1
2	688	3.0 mg/kg J1D00001	Single injection on day 1
3	688	3.0 mg/kg J1D00002	Single injection on day 1
4	1586	3.0 mg/kg J1D00004	Single injection on day 1
5	2180	3.0 mg/kg J1D00008	Single injection on day 1
6	1179	3.0 mg/kg J1D00010	Single injection on day 1
7	1179	3.0 mg/kg J1D00011	Single injection on day 1
8	571	3.0 mg/kg J1D00012	Single injection on day 1
9	1745	3.0 mg/kg J1D00016	Single injection on day 1

[0246] Each of the PNPLA3 RNAi agents included modified nucleotides that were conjugated at the 5' terminal end of the sense strand to a targeting ligand that included three N-acetyl-galactosamine groups (tridentate ligand) having the modified sequences as set forth in the duplex structures herein. (See Tables 3-5 for specific modifications and structure information related to the PNPLA3 RNAi agents, including (NAG37)s ligand). The PNPLA3 RNAi agents J1D00001 (Group 2) and J1D00002 (Group 3) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 688 of the gene; the PNPLA3 RNAi agent J1D00004 (Group 4) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1586 of the gene; the PNPLA3 RNAi agent J1D00008 (Group 5) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 2180 of the gene; the PNPLA3 RNAi agents J1D00010 (Group 6) and J1D00011 (Group 7) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1179 of the gene; the PNPLA3 RNAi agent J1D00012 (Group 8) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 571 of the gene; the PNPLA3 RNAi agent J1D00016 (Group 9) included nucleotide sequences that were designed to

inhibit expression of a PNPLA3 gene at position 1745 of the gene. (*See, e.g.*, SEQ ID NO:1 and Table 2 for the PNPLA3 gene referenced).

[0247] The injections were performed between the skin and muscle (i.e. subcutaneous injections) into the loose skin over the neck and shoulder area. Four (4) mice in each group were tested (n=4). Serum was collected on day -1 (pre-treatment), day 8, day 15, day 22, and day 29, and SEAP expression levels were determined pursuant to the procedure set forth in Example 2, above. Data from the experiment are shown in the following Tables 8 and 9:

Table 8. Average SEAP Normalized to Pre-Treatment (Day -1) in full length transcript PNPLA3-SEAP Mice from Example 3

Group ID	Day 8		Day 15		Day 22	
	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)
Group 1 (Saline vehicle)	0.402	0.136	0.398	0.097	0.285	0.159
Group 2 (3.0 mg/kg JID00001)	0.325	0.120	0.260	0.129	0.144	0.068
Group 3 (3.0 mg/kg JID00002)	0.279	0.076	0.237	0.114	0.174	0.019
Group 4 (3.0 mg/kg JID00004)	0.186	0.055	0.145	0.065	0.073	0.038
Group 5 (3.0 mg/kg JID00008)	0.160	0.027	0.115	0.034	0.073	0.026
Group 6 (3.0 mg/kg JID00010)	0.298	0.054	0.299	0.104	0.203	0.084
Group 7 (3.0 mg/kg JID00011)	0.264	0.052	0.194	0.077	0.095	0.054
Group 8 (3.0 mg/kg JID00012)	0.170	0.047	0.159	0.053	0.113	0.045
Group 9 (3.0 mg/kg JID00016)	0.302	0.108	0.246	0.079	0.162	0.054

* As noted in Example 2, above, the gradual reduction in SEAP in the vehicle control group (Group 1) over time is due to the loss of the SEAP reporter gene in the cells of the mice due to natural cell replication in the animals, and is not the result of any inhibitory compound.

Table 9. Average SEAP Normalized to Pre-Treatment (Day -1) and Vehicle Control in full length transcript PNPLA3-SEAP Mice from Example 3

Group ID	Day 8		Day 15		Day 22	
	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)
Group 1 (Saline vehicle)	1.000	0.339	1.000	0.244	1.000	0.558
Group 2 (3.0 mg/kg JID00001)	0.809	0.298	0.655	0.325	0.505	0.240
Group 3 (3.0 mg/kg JID00002)	0.693	0.190	0.597	0.288	0.610	0.067
Group 4 (3.0 mg/kg JID00004)	0.462	0.136	0.365	0.163	0.258	0.132
Group 5 (3.0 mg/kg JID00008)	0.399	0.066	0.289	0.085	0.257	0.092
Group 6 (3.0 mg/kg JID00010)	0.742	0.133	0.751	0.262	0.715	0.296
Group 7 (3.0 mg/kg JID00011)	0.657	0.130	0.487	0.194	0.332	0.189
Group 8 (3.0 mg/kg JID00012)	0.422	0.117	0.399	0.133	0.397	0.157
Group 9 (3.0 mg/kg JID00016)	0.752	0.270	0.619	0.198	0.567	0.188

Example 4. *In Vivo* Testing of PNPLA3 RNAi Agents in PNPLA3-SEAP Mice.

[0248] The PNPLA3-SEAP mouse model described in Example 2, above, using the plasmid containing the full length human PNPLA3 transcript was used. At day 1, each mouse was given a single subcutaneous administration of 200 μ l/ 20 g animal weight containing either 3.0 mg/kg (mpk) of a PNPLA3 RNAi agent formulated in saline, or vehicle control (saline with no RNAi agent), according to the following Table 10.

Table 10. Targeted Positions and Dosing Groups of Example 4

Group	Targeted Gene Position (within SEQ ID NO: 1)	RNAi Agent and Dose	Dosing Regimen
1	N/A	Saline (no RNAi agent)	Single injection on day 1
2	2180	3.0 mg/kg J1D00008	Single injection on day 1
3	886	3.0 mg/kg J1D00014	Single injection on day 1
4	1584	3.0 mg/kg J1D00015	Single injection on day 1
5	553	3.0 mg/kg J1D00021	Single injection on day 1
6	680	3.0 mg/kg J1D00022	Single injection on day 1
7	1182	3.0 mg/kg J1D00005	Single injection on day 1
8	746	3.0 mg/kg J1D00024	Single injection on day 1

[0249] Each of the PNPLA3 RNAi agents included modified nucleotides that were conjugated at the 5' terminal end of the sense strand to a targeting ligand that included three N-acetyl-galactosamine groups (tridentate ligand) having the modified sequences as set forth in the duplex structures herein. (See Tables 3-5 for specific modifications and structure information related to the PNPLA3 RNAi agents, including (NAG37)s ligand). The PNPLA3 RNAi agent J1D00008 (Group 2) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 2180 of the gene; the PNPLA3 RNAi agent J1D00014 (Group 3) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 886 of the gene; the PNPLA3 RNAi agent J1D00015 (Group 4) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1584 of the gene; the PNPLA3 RNAi agent J1D00021 (Group 5) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 553 of the gene; the PNPLA3 RNAi agent J1D00022 (Group 6) included

nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 680 of the gene; the PNPLA3 RNAi agent J1D00005 (Group 7) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1182 of the gene; and the PNPLA3 RNAi agent J1D00024 (Group 8) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 746 of the gene. (*See, e.g.,* SEQ ID NO:1 and Table 2 for the PNPLA3 gene referenced).

[0250] The injections were performed between the skin and muscle (i.e. subcutaneous injections) into the loose skin over the neck and shoulder area. Four (4) mice in each group were tested (n=4). Serum was collected on day -1 (pre-treatment), day 8, day 15, day 22, and day 29, and SEAP expression levels were determined pursuant to the procedure set forth in Example 2, above. Data from the experiment are shown in the following Tables 11 and 12:

Table 11. Average SEAP Normalized to Pre-Treatment (Day -1) in full length transcript PNPLA3-SEAP Mice from Example 4

Group ID	Day 8		Day 15		Day 22	
	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)
Group 1 (Saline vehicle)	0.857	0.471	1.737	0.769	0.260	0.148
Group 2 (3.0 mg/kg JID00008)	0.344	0.128	0.679	0.375	0.095	0.044
Group 3 (3.0 mg/kg JID00014)	1.221	0.267	2.307	0.878	0.363	0.192
Group 4 (3.0 mg/kg JID00015)	0.424	0.078	0.885	0.279	0.130	0.030
Group 5 (3.0 mg/kg JID00021)	0.832	0.299	1.891	0.903	0.320	0.141
Group 6 (3.0 mg/kg JID00022)	0.527	0.259	1.223	0.547	0.190	0.097
Group 7 (3.0 mg/kg JID00005)	0.817	0.323	1.291	0.618	0.235	0.149
Group 8 (3.0 mg/kg JID00024)	0.700	0.143	2.079	0.821	0.470	0.207

* As noted in Example 2, above, the gradual reduction in SEAP in the vehicle control group (Group 1) over time is due to the loss of the SEAP reporter gene in the cells of the mice due to natural cell replication in the animals, and is not the result of any inhibitory compound.

Table 12. Average SEAP Normalized to Pre-Treatment (Day -1) and Vehicle Control in full length transcript PNPLA3-SEAP Mice from Example 4

Group ID	Day 8		Day 15		Day 22	
	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)
Group 1 (Saline vehicle)	1.000	0.550	1.000	0.443	1.000	0.568
Group 2 (3.0 mg/kg JID00008)	0.401	0.149	0.391	0.216	0.367	0.170
Group 3 (3.0 mg/kg JID00014)	1.426	0.312	1.328	0.505	1.397	0.737
Group 4 (3.0 mg/kg JID00015)	0.495	0.091	0.510	0.160	0.500	0.117
Group 5 (3.0 mg/kg JID00021)	0.971	0.349	1.089	0.520	1.231	0.541
Group 6 (3.0 mg/kg JID00022)	0.615	0.302	0.704	0.315	0.732	0.371
Group 7 (3.0 mg/kg JID00005)	0.954	0.377	0.743	0.356	0.905	0.574
Group 8 (3.0 mg/kg JID00024)	0.817	0.167	1.197	0.473	1.808	0.796

Example 5. *In Vivo* Testing of PNPLA3 RNAi Agents in PNPLA3-SEAP Mice.

[0251] The PNPLA3-SEAP mouse model was used as described in Example 2, above, using the plasmid containing the truncated version of the human PNPLA3 transcript. At day 1, each mouse was given a single subcutaneous administration of 200 μ l/ 20 g animal weight containing either 3.0 mg/kg (mpk) of a PNPLA3 RNAi agent formulated in saline, or vehicle control (saline with no RNAi agent), according to the following Table 13.

Table 13. Targeted Positions and Dosing Groups of Example 5

Group	Targeted Gene Position (within SEQ ID NO: 1)	RNAi Agent and Dose	Dosing Regimen
1	N/A	Saline (no RNAi agent)	Single injection on day 1
2	571	3.0 mg/kg J1D00012	Single injection on day 1
3	571	3.0 mg/kg J1D00027	Single injection on day 1
4	571	3.0 mg/kg J1D00028	Single injection on day 1
5	571	3.0 mg/kg J1D00029	Single injection on day 1
6	1179	3.0 mg/kg J1D00011	Single injection on day 1
7	1179	3.0 mg/kg J1D00017	Single injection on day 1
8	1586	3.0 mg/kg J1D00004	Single injection on day 1
9	1586	3.0 mg/kg J1D00003	Single injection on day 1
10	1586	3.0 mg/kg J1D00041	Single injection on day 1
11	2180	3.0 mg/kg J1D00008	Single injection on day 1

[0252] Each of the PNPLA3 RNAi agents included modified nucleotides that were conjugated at the 5' terminal end of the sense strand to a targeting ligand that included three N-acetyl-galactosamine groups (tridentate ligand) having the modified sequences as set forth in the duplex structures herein. (See Tables 3-5 for specific modifications and structure information related to the PNPLA3 RNAi agents, including (NAG37)s ligand). The PNPLA3 RNAi agents J1D00012 (Group 2), J1D00027 (Group 3), J1D00028 (Group 4), J1D00029 (Group 5) each included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 571 of the gene; the PNPLA3 RNAi agents J1D00011 (Group 6) and J1D00017 (Group 7) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1179 of the gene; the PNPLA3 RNAi agents J1D00004 (Group 8), J1D00003 (Group 9), and J1D00041 (Group 10)

included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1586 of the gene; and the PNPLA3 RNAi agent J1D00008 (Group 11) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 2180 of the gene. (*See, e.g.*, SEQ ID NO:1 and Table 2 for the PNPLA3 gene referenced).

[0253] The injections were performed between the skin and muscle (i.e. subcutaneous injections) into the loose skin over the neck and shoulder area. Four (4) mice in each group were tested (n=4). Serum was collected on day -1 (pre-treatment), day 8, day 15, day 22, and day 29, and SEAP expression levels were determined pursuant to the procedure set forth in Example 2, above. Data from the experiment are shown in the following Tables 14 and 15:

Table 14. Average SEAP Normalized to Pre-Treatment (Day -1) in truncated transcript PNPLA3-SEAP Mice from Example 5

Group ID	Day 8			Day 15			Day 22			Day 29		
	Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)	
Group 1 (Saline vehicle)	0.772	0.173		0.746	0.164		0.446	0.258		0.677	0.725	
Group 2 (3.0 mg/kg JID00012)	0.150	0.073		0.109	0.056		0.130	0.063		0.235	0.151	
Group 3 (3.0 mg/kg JID00027)	0.132	0.104		0.132	0.084		0.199	0.126		0.249	0.190	
Group 4 (3.0 mg/kg JID00028)	0.190	0.078		0.194	0.083		0.294	0.074		0.328	0.089	
Group 5 (3.0 mg/kg JID00029)	0.173	0.090		0.108	0.035		0.090	0.033		0.161	0.107	
Group 6 (3.0 mg/kg JID00011)	0.296	0.138		0.192	0.138		0.175	0.061		0.279	0.069	
Group 7 (3.0 mg/kg JID00017)	0.204	0.113		0.085	0.049		0.151	0.054		0.317	0.088	
Group 8 (3.0 mg/kg JID00004)	0.073	0.058		0.066	0.094		0.083	0.120		0.141	0.198	
Group 9 (3.0 mg/kg JID00003)	0.065	0.018		0.026	0.007		0.024	0.007		0.039	0.008	
Group 10 (3.0 mg/kg JID00041)	0.079	0.034		0.037	0.029		0.060	0.039		0.073	0.018	
Group 11 (3.0 mg/kg JID00008)	0.142	0.048		0.091	0.071		0.216	0.235		0.285	0.219	

* As noted in Example 2, above, the gradual reduction in SEAP in the vehicle control group (Group 1) over time is due to the loss of the SEAP reporter gene in the cells of the mice due to natural cell replication in the animals, and is not the result of any inhibitory compound.

Table 15. Average SEAP Normalized to Pre-Treatment (Day -1) and Vehicle Control in truncated transcript PNPLA3-SEAP Mice from Example 5

Group ID	Day 8		Day 15		Day 22		Day 29	
	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)
Group 1 (Saline vehicle)	1.000	0.224	1.000	0.220	1.000	0.578	1.000	1.071
Group 2 (3.0 mg/kg JID00012)	0.194	0.094	0.146	0.075	0.290	0.142	0.346	0.222
Group 3 (3.0 mg/kg JID00027)	0.172	0.134	0.177	0.113	0.445	0.283	0.368	0.280
Group 4 (3.0 mg/kg JID00028)	0.246	0.101	0.260	0.112	0.659	0.167	0.484	0.131
Group 5 (3.0 mg/kg JID00029)	0.225	0.117	0.145	0.047	0.203	0.074	0.237	0.158
Group 6 (3.0 mg/kg JID00011)	0.383	0.179	0.257	0.185	0.391	0.136	0.412	0.101
Group 7 (3.0 mg/kg JID00017)	0.265	0.147	0.114	0.066	0.339	0.120	0.467	0.129
Group 8 (3.0 mg/kg JID00004)	0.095	0.075	0.089	0.126	0.186	0.268	0.208	0.293
Group 9 (3.0 mg/kg JID00003)	0.084	0.023	0.035	0.010	0.054	0.015	0.057	0.012
Group 10 (3.0 mg/kg JID00041)	0.094	0.041	0.048	0.037	0.126	0.081	0.102	0.025
Group 11 (3.0 mg/kg JID00008)	0.169	0.057	0.119	0.092	0.451	0.491	0.397	0.305

[0254] Each of the PNPLA3 RNAi agents in each of the dosing groups (i.e., Groups 2 through 11) showed reduction in SEAP as compared to the vehicle control (Group 1) at all measured timepoints.

Example 6. *In Vivo* Testing of PNPLA3 RNAi Agents in PNPLA3-SEAP Mice.

[0255] The PNPLA3-SEAP mouse model was used as described in Example 2, above, using the plasmid containing the truncated version of the human PNPLA3 transcript. At day 1, each mouse was given a single subcutaneous administration of 200 μ l/ 20 g animal weight containing either 3.0 mg/kg (mpk) of a PNPLA3 RNAi agent formulated in saline, or vehicle control (saline with no RNAi agent), according to the following Table 16.

Table 16. Targeted Positions and Dosing Groups of Example 6

Group	Targeted Gene Position (within SEQ ID NO: 1)	RNAi Agent and Dose	Dosing Regimen
1	N/A	Saline (no RNAi agent)	Single injection on day 1
2	2180	3.0 mg/kg J1D00008	Single injection on day 1
3	2180	3.0 mg/kg J1D00046	Single injection on day 1
4	2180	3.0 mg/kg J1D00047	Single injection on day 1
5	2180	3.0 mg/kg J1D00048	Single injection on day 1
6	1179	3.0 mg/kg J1D00011	Single injection on day 1
7	1179	3.0 mg/kg J1D00043	Single injection on day 1
8	1179	3.0 mg/kg J1D00044	Single injection on day 1
9	1179	3.0 mg/kg J1D00045	Single injection on day 1
10	544	3.0 mg/kg J1D00020	Single injection on day 1
11	1195	3.0 mg/kg J1D00026	Single injection on day 1

[0256] Each of the PNPLA3 RNAi agents included modified nucleotides that were conjugated at the 5' terminal end of the sense strand to a targeting ligand that included three N-acetyl-galactosamine groups (tridentate ligand) having the modified sequences as set forth in the duplex structures herein. (See Tables 3-5 for specific modifications and structure information related to the PNPLA3 RNAi agents, including (NAG37)s ligand). The PNPLA3 RNAi agents J1D00008 (Group 2), J1D00046 (Group 3), J1D00047 (Group 4), and J1D00048 (Group 5) each included nucleotide sequences that were designed to inhibit

expression of a PNPLA3 gene at position 2180 of the gene; the PNPLA3 RNAi agents J1D00011 (Group 6), J1D00043 (Group 7), J1D00044 (Group 8), and J1D00045 (Group 9) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1179 of the gene; the PNPLA3 RNAi agent J1D00020 (Group 10) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 544 of the gene; and the PNPLA3 RNAi agent J1D00026 (Group 11) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1195 of the gene. (*See, e.g.*, SEQ ID NO:1 and Table 2 for the PNPLA3 gene referenced).

[0257] The injections were performed between the skin and muscle (i.e. subcutaneous injections) into the loose skin over the neck and shoulder area. Four (4) mice in each group were tested (n=4). Serum was collected on day -1 (pre-treatment), day 8, day 15, day 22, and day 29, and SEAP expression levels were determined pursuant to the procedure set forth in Example 2, above. Data from the experiment are shown in the following Tables 17 and 18:

Table 17. Average SEAP Normalized to Pre-Treatment (Day -1) in truncated transcript PNPLA3-SEAP Mice from Example 6

Group ID	Day 8			Day 15			Day 22			Day 29		
	Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)	
Group 1 (Saline vehicle)	1.434	0.237		1.189	0.385		0.616	0.022		1.323	0.693	
Group 2 (3.0 mg/kg JID00008)	0.328	0.215		0.356	0.186		0.329	0.129		1.342	0.529	
Group 3 (3.0 mg/kg JID00046)	0.254	0.240		0.356	0.478		0.303	0.338		0.370	0.210	
Group 4 (3.0 mg/kg JID00047)	0.219	0.080		0.127	0.042		0.106	0.017		0.488	0.072	
Group 5 (3.0 mg/kg JID00048)	0.153	0.055		0.158	0.064		0.175	0.078		0.463	0.126	
Group 6 (3.0 mg/kg JID00011)	0.782	0.468		0.874	0.597		0.461	0.361		0.714	0.582	
Group 7 (3.0 mg/kg JID00043)	0.713	0.539		0.981	0.784		0.939	0.725		1.364	0.975	
Group 8 (3.0 mg/kg JID00044)	0.683	0.113		0.539	0.143		0.355	0.096		0.891	0.217	
Group 9 (3.0 mg/kg JID00045)	0.479	0.309		0.547	0.101		0.383	0.201		0.935	0.361	
Group 10 (3.0 mg/kg JID00020)	0.726	0.575		0.906	0.856		0.506	0.376		1.255	1.244	
Group 11 (3.0 mg/kg JID00026)	0.590	0.431		0.395	0.434		0.351	0.322		0.703	0.293	

* As noted in Example 2, above, the gradual reduction in SEAP in the vehicle control group (Group 1) over time is due to the loss of the SEAP reporter gene in the cells of the mice due to natural cell replication in the animals, and is not the result of any inhibitory compound.

Table 18. Average SEAP Normalized to Pre-Treatment (Day -1) and Vehicle Control in truncated transcript PNPLA3-SEAP Mice from Example 6

Group ID	Day 8		Day 15		Day 22		Day 29	
	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)
Group 1 (Saline vehicle)	1.000	0.165	1.000	0.323	1.000	0.035	1.000	0.524
Group 2 (3.0 mg/kg JID00008)	0.229	0.150	0.299	0.156	0.535	0.209	1.014	0.400
Group 3 (3.0 mg/kg JID00046)	0.177	0.167	0.299	0.402	0.492	0.549	0.280	0.159
Group 4 (3.0 mg/kg JID00047)	0.153	0.056	0.107	0.035	0.173	0.028	0.369	0.055
Group 5 (3.0 mg/kg JID00048)	0.107	0.038	0.133	0.054	0.283	0.127	0.350	0.095
Group 6 (3.0 mg/kg JID00011)	0.545	0.326	0.735	0.502	0.749	0.586	0.540	0.440
Group 7 (3.0 mg/kg JID00043)	0.497	0.375	0.825	0.660	1.524	1.177	1.031	0.737
Group 8 (3.0 mg/kg JID00044)	0.476	0.079	0.453	0.120	0.576	0.157	0.674	0.164
Group 9 (3.0 mg/kg JID00045)	0.334	0.215	0.460	0.085	0.621	0.327	0.706	0.272
Group 10 (3.0 mg/kg JID00020)	0.506	0.401	0.762	0.720	0.822	0.611	0.949	0.940
Group 11 (3.0 mg/kg JID00026)	0.411	0.300	0.333	0.365	0.569	0.523	0.531	0.222

Example 7. *In Vivo* Testing of PNPLA3 RNAi Agents in PNPLA3-SEAP Mice.

[0258] The PNPLA3-SEAP mouse model was used as described in Example 2, above, using the plasmid containing the truncated version of the human PNPLA3 transcript. At day 1, each mouse was given a single subcutaneous administration of 200 μ l/ 20 g animal weight containing either 1.5 mg/kg (mpk) of a PNPLA3 RNAi agent formulated in saline, or vehicle control (saline with no RNAi agent), according to the following Table 19.

Table 19. Targeted Positions and Dosing Groups of Example 7

Group	Targeted Gene Position (within SEQ ID NO: 1)	RNAi Agent and Dose	Dosing Regimen
1	N/A	Saline (no RNAi agent)	Single injection on day 1
2	2180	1.5 mg/kg J1D00008	Single injection on day 1
3	538	1.5 mg/kg J1D00018	Single injection on day 1
4	538	1.5 mg/kg J1D00019	Single injection on day 1
5	687	1.5 mg/kg J1D00013	Single injection on day 1
6	751	1.5 mg/kg J1D00006	Single injection on day 1
7	751	1.5 mg/kg J1D00007	Single injection on day 1
8	1181	1.5 mg/kg J1D00035	Single injection on day 1
9	685	1.5 mg/kg J1D00033	Single injection on day 1
10	373	1.5 mg/kg J1D00032	Single injection on day 1
11	1837	1.5 mg/kg J1D00040	Single injection on day 1

[0259] Each of the PNPLA3 RNAi agents included modified nucleotides that were conjugated at the 5' terminal end of the sense strand to a targeting ligand that included three N-acetyl-galactosamine groups (tridentate ligand) having the modified sequences as set forth in the duplex structures herein. (See Tables 3-5 for specific modifications and structure information related to the PNPLA3 RNAi agents, including (NAG37)s ligand). The PNPLA3 RNAi agent J1D00008 (Group 2) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 2180 of the gene; the PNPLA3 RNAi agents J1D00018 (Group 3) and J1D00019 (Group 4) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 538 of the gene; the PNPLA3 RNAi agent J1D00013 (Group 5) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 687 of the gene; the PNPLA3

RNAi agents J1D000006 (Group 6) and J1D000007 (Group 7) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 751 of the gene; the PNPLA3 RNAi agent J1D000035 (Group 8) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1181 of the gene; the PNPLA3 RNAi agent J1D000033 (Group 9) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 685 of the gene; the PNPLA3 RNAi agent J1D000032 (Group 10) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 373 of the gene; and the PNPLA3 RNAi agent J1D000040 (Group 11) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1837 of the gene. (*See, e.g.*, SEQ ID NO:1 and Table 2 for the PNPLA3 gene referenced).

[0260] The injections were performed between the skin and muscle (i.e. subcutaneous injections) into the loose skin over the neck and shoulder area. Four (4) mice in each group were tested (n=4). Serum was collected on day -1 (pre-treatment), day 8, day 15, day 22, and day 29, and SEAP expression levels were determined pursuant to the procedure set forth in Example 2, above. Data from the experiment are shown in the following Tables 20 and 21:

Table 20. Average SEAP Normalized to Pre-Treatment (Day -1) in truncated transcript PNPLA3-SEAP Mice from Example 7

Group ID	Day 8			Day 15			Day 22			Day 29		
	Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)	
Group 1 (Saline vehicle)	0.302	0.188		0.192	0.105		0.209	0.194		0.167	0.145	
Group 2 (1.5 mg/kg JID00008)	0.083	0.035		0.113	0.105		0.127	0.105		0.148	0.119	
Group 3 (1.5 mg/kg JID00018)	0.505	0.344		0.561	0.425		0.455	0.295		0.424	0.283	
Group 4 (1.5 mg/kg JID00019)	0.293	0.152		0.329	0.169		0.337	0.215		0.291	0.203	
Group 5 (1.5 mg/kg JID00013)	0.101	0.099		0.084	0.065		0.076	0.061		0.110	0.115	
Group 6 (1.5 mg/kg JID00006)	0.221	0.140		0.265	0.265		0.218	0.232		0.126	0.191	
Group 7 (1.5 mg/kg JID00007)	0.257	0.102		0.237	0.172		0.162	0.082		0.177	0.088	
Group 8 (1.5 mg/kg JID00035)	0.548	0.504		0.344	0.278		0.406	0.361		0.413	0.395	
Group 9 (1.5 mg/kg JID00033)	0.481	0.154		0.270	0.126		0.204	0.114		0.258	0.115	
Group 10 (1.5 mg/kg JID00032)	0.687	0.145		0.831	0.243		0.639	0.270		0.464	0.093	
Group 11 (1.5 mg/kg JID00040)	0.237	0.101		0.190	0.085		0.182	0.100		0.162	0.137	

* As noted in Example 2, above, the gradual reduction in SEAP in the vehicle control group (Group 1) over time is due to the loss of the SEAP reporter gene in the cells of the mice due to natural cell replication in the animals, and is not the result of any inhibitory compound.

Table 21. Average SEAP Normalized to Pre-Treatment (Day -1) and Vehicle Control in truncated transcript PNPLA3-SEAP Mice from Example 7

Group ID	Day 8		Day 15		Day 22		Day 29	
	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)
Group 1 (Saline vehicle)	1.000	0.621	1.000	0.549	1.000	0.927	1.000	0.868
Group 2 (1.5 mg/kg JID000008)	0.275	0.117	0.588	0.547	0.606	0.503	0.887	0.710
Group 3 (1.5 mg/kg JID000018)	1.673	1.139	2.924	2.217	2.175	1.408	2.536	1.691
Group 4 (1.5 mg/kg JID000019)	0.969	0.502	1.713	0.879	1.611	1.028	1.737	1.214
Group 5 (1.5 mg/kg JID000013)	0.335	0.327	0.440	0.341	0.364	0.293	0.657	0.686
Group 6 (1.5 mg/kg JID000006)	0.730	0.462	1.383	1.379	1.043	1.108	0.753	1.144
Group 7 (1.5 mg/kg JID000007)	0.850	0.339	1.234	0.894	0.772	0.393	1.057	0.527
Group 8 (1.5 mg/kg JID000035)	1.814	1.669	1.794	1.451	1.939	1.724	2.471	2.365
Group 9 (1.5 mg/kg JID000033)	1.592	0.509	1.409	0.658	0.974	0.545	1.541	0.685
Group 10 (1.5 mg/kg JID000032)	2.274	0.479	4.330	1.265	3.050	1.292	2.772	0.559
Group 11 (1.5 mg/kg JID000040)	0.784	0.335	0.991	0.445	0.870	0.476	0.967	0.817

Example 8. *In Vivo* Testing of PNPLA3 RNAi Agents in PNPLA3-SEAP Mice.

[0261] The PNPLA3-SEAP mouse model was used as described in Example 2, above, using the plasmid containing the truncated version of the human PNPLA3 transcript. At day 1, each mouse was given a single subcutaneous administration of 200 μ l/ 20 g animal weight containing either 1.5 mg/kg (mpk) of a PNPLA3 RNAi agent formulated in saline, or vehicle control (saline with no RNAi agent), according to the following Table 22.

Table 22. Targeted Positions and Dosing Groups of Example 8

Group	Targeted Gene Position (within SEQ ID NO: 1)	RNAi Agent and Dose	Dosing Regimen
1	N/A	Saline (no RNAi agent)	Single injection on day 1
2	2180	1.5 mg/kg J1D00008	Single injection on day 1
3	2180	1.5 mg/kg J1D00074	Single injection on day 1
4	2180	1.5 mg/kg J1D00075	Single injection on day 1
5	2180	1.5 mg/kg J1D00076	Single injection on day 1
6	2180	1.5 mg/kg J1D00077	Single injection on day 1
7	2180	1.5 mg/kg J1D00078	Single injection on day 1
8	2180	1.5 mg/kg J1D00048	Single injection on day 1
9	2180	1.5 mg/kg J1D00079	Single injection on day 1
10	2180	1.5 mg/kg J1D00080	Single injection on day 1

[0262] Each of the PNPLA3 RNAi agents included modified nucleotides that were conjugated at the 5' terminal end of the sense strand to a targeting ligand that included three N-acetyl-galactosamine groups (tridentate ligand) having the modified sequences as set forth in the duplex structures herein. (See Tables 3-5 for specific modifications and structure information related to the PNPLA3 RNAi agents, including (NAG37)s ligand). The PNPLA3 RNAi agents in each Group (i.e., Groups 2-10) each included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 2180 of the gene. (See, e.g., SEQ ID NO:1 and Table 2 for the PNPLA3 gene referenced).

[0263] The injections were performed between the skin and muscle (i.e. subcutaneous injections) into the loose skin over the neck and shoulder area. Four (4) mice in each group were tested (n=4). Serum was collected on day -1 (pre-treatment), day 8, day 15, day 22, and day 29, and SEAP expression levels were determined pursuant to the procedure set forth

in Example 2, above. Data from the experiment are shown in the following Tables 23 and 24:

Table 23. Average SEAP Normalized to Pre-Treatment (Day -1) in truncated transcript PNPLA3-SEAP Mice from Example 8

Group ID	Day 8			Day 15			Day 22			Day 29		
	Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)	
Group 1 (Saline vehicle)	1.134	0.219		0.851	0.295		0.826	0.637		0.759	0.471	
Group 2 (1.5 mg/kg JID00008)	0.367	0.080		0.267	0.138		0.374	0.202		0.410	0.309	
Group 3 (1.5 mg/kg JID00074)	0.205	0.063		0.211	0.072		0.276	0.108		0.396	0.182	
Group 4 (1.5 mg/kg JID00075)	0.705	0.202		0.673	0.370		0.634	0.415		0.571	0.427	
Group 5 (1.5 mg/kg JID00076)	0.484	0.312		0.307	0.200		0.315	0.301		0.260	0.189	
Group 6 (1.5 mg/kg JID00077)	0.445	0.293		0.290	0.186		0.400	0.329		0.310	0.207	
Group 7 (1.5 mg/kg JID00078)	0.190	0.099		0.153	0.122		0.289	0.292		0.291	0.255	
Group 8 (1.5 mg/kg JID00048)	0.341	0.194		0.389	0.306		0.345	0.089		0.418	0.232	
Group 9 (1.5 mg/kg JID00079)	0.213	0.105		0.174	0.189		0.285	0.249		0.311	0.248	
Group 10 (1.5 mg/kg JID00080)	0.270	0.143		0.277	0.159		0.439	0.309		0.525	0.411	

* As noted in Example 2, above, the gradual reduction in SEAP in the vehicle control group (Group 1) over time is due to the loss of the SEAP reporter gene in the cells of the mice due to natural cell replication in the animals, and is not the result of any inhibitory compound.

Table 24. Average SEAP Normalized to Pre-Treatment (Day -1) and Vehicle Control in truncated transcript PNPLA3-SEAP Mice from Example 8

Group ID	Day 8		Day 15		Day 22		Day 29	
	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)
Group 1 (Saline vehicle)	1.000	0.193	1.000	0.347	1.000	0.771	1.000	0.620
Group 2 (1.5 mg/kg JID00008)	0.324	0.071	0.314	0.162	0.453	0.245	0.540	0.408
Group 3 (1.5 mg/kg JID00074)	0.181	0.056	0.248	0.085	0.334	0.131	0.522	0.240
Group 4 (1.5 mg/kg JID00075)	0.621	0.178	0.791	0.435	0.768	0.503	0.752	0.563
Group 5 (1.5 mg/kg JID00076)	0.426	0.275	0.361	0.235	0.382	0.365	0.343	0.250
Group 6 (1.5 mg/kg JID00077)	0.393	0.258	0.341	0.219	0.484	0.398	0.409	0.273
Group 7 (1.5 mg/kg JID00078)	0.168	0.087	0.180	0.144	0.350	0.353	0.384	0.337
Group 8 (1.5 mg/kg JID00048)	0.300	0.171	0.457	0.359	0.418	0.108	0.551	0.306
Group 9 (1.5 mg/kg JID00079)	0.188	0.093	0.204	0.222	0.345	0.301	0.410	0.327
Group 10 (1.5 mg/kg JID00080)	0.238	0.126	0.326	0.187	0.531	0.374	0.692	0.542

Each of the PNPLA3 RNAi agents in each of the dosing groups (i.e., Groups 2 through 10) showed reduction in SEAP as compared to the vehicle control (Group 1) at all measured timepoints.

Example 9. *In Vivo* Testing of PNPLA3 RNAi Agents in PNPLA3-SEAP Mice.

[0264] The PNPLA3-SEAP mouse model was used as described in Example 2, above, using the plasmid containing the truncated version of the human PNPLA3 transcript. At day 1, each mouse was given a single subcutaneous administration of 200 μ l/ 20 g animal weight containing 1.5 mg/kg (mpk) of a PNPLA3 RNAi agent formulated in saline, or vehicle control (saline with no RNAi agent), which included the dosing groups according to the following Table 25.

Table 25. Targeted Positions and Dosing Groups of Example 9

Group	Targeted Gene Position (within SEQ ID NO: 1)	RNAi Agent and Dose	Dosing Regimen
1	N/A	Saline (no RNAi agent)	Single injection on day 1
2	2180	1.5 mg/kg J1D00008	Single injection on day 1
3	887	1.5 mg/kg J1D00081	Single injection on day 1
4	1185	1.5 mg/kg J1D00083	Single injection on day 1
5	1191	1.5 mg/kg J1D00084	Single injection on day 1
6	1191	1.5 mg/kg J1D00085	Single injection on day 1
7	1746	1.5 mg/kg J1D00087	Single injection on day 1
8	1173	1.5 mg/kg J1D00082	Single injection on day 1

[0265] Each of the PNPLA3 RNAi agents included modified nucleotides that were conjugated at the 5' terminal end of the sense strand to a targeting ligand that included three N-acetyl-galactosamine groups (tridentate ligand) having the modified sequences as set forth in the duplex structures herein. (See Tables 3-5 for specific modifications and structure information related to the PNPLA3 RNAi agents, including (NAG37)s ligand). The PNPLA3 RNAi agent J1D00008 (Group 2) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 2180 of the gene; the PNPLA3 RNAi agent J1D00081 (Group 3) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 887 of the gene; the PNPLA3 RNAi agent

J1D00083 (Group 4) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1185 of the gene; the PNPLA3 RNAi agents J1D00084 (Group 5) and J1D00085 (Group 6) each included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1191 of the gene; the PNPLA3 RNAi agent J1D00087 (Group 7) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1746 of the gene; and the PNPLA3 RNAi agent J1D00082 (Group 8) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1173 of the gene. (*See, e.g.*, SEQ ID NO:1 and Table 2 for the PNPLA3 gene referenced).

[0266] The injections were performed between the skin and muscle (i.e. subcutaneous injections) into the loose skin over the neck and shoulder area. Four (4) mice in each group were tested (n=4). Serum was collected on day -1 (pre-treatment), day 8, day 15, day 22, and day 29, and SEAP expression levels were determined pursuant to the procedure set forth in Example 2, above. Data from the experiment are shown in the following Tables 26 and 27:

Table 26. Average SEAP Normalized to Pre-Treatment (Day -1) in truncated transcript PNPLA3-SEAP Mice from Example 9

Group ID	Day 8			Day 15			Day 22			Day 29		
	Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)		Avg SEAP	Std Dev (+/-)	
Group 1 (Saline vehicle)	0.668	0.265		0.578	0.386		0.522	0.289		1.227	1.269	
Group 2 (1.5 mg/kg JID00008)	0.236	0.177		0.149	0.116		0.448	0.343		0.822	0.725	
Group 3 (1.5 mg/kg JID00081)	0.339	0.160		0.254	0.179		0.320	0.192		0.529	0.330	
Group 4 (1.5 mg/kg JID00083)	0.524	0.404		0.332	0.304		0.375	0.227		0.564	0.517	
Group 5 (1.5 mg/kg JID00084)	0.304	0.200		0.158	0.142		0.185	0.167		0.343	0.364	
Group 6 (1.5 mg/kg JID00085)	0.506	0.241		0.320	0.241		0.355	0.220		0.718	0.497	
Group 7 (1.5 mg/kg JID00087)	0.170	0.069		0.122	0.092		0.252	0.102		0.549	0.028	
Group 8 (1.5 mg/kg JID00082)	0.508	0.302		0.454	0.308		0.488	0.361		0.914	0.661	

* As noted in Example 2, above, the gradual reduction in SEAP in the vehicle control group (Group 1) over time is due to the loss of the SEAP reporter gene in the cells of the mice due to natural cell replication in the animals, and is not the result of any inhibitory compound.

Table 27. Average SEAP Normalized to Pre-Treatment (Day -1) and Vehicle Control in truncated transcript PNPLA3-SEAP Mice from Example 9

Group ID	Day 8		Day 15		Day 22		Day 29	
	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)	Avg SEAP	Std Dev (+/-)
Group 1 (Saline vehicle)	1.000	0.397	1.000	0.668	1.000	0.553	1.000	1.034
Group 2 (1.5 mg/kg JID00008)	0.353	0.265	0.259	0.201	0.860	0.658	0.669	0.591
Group 3 (1.5 mg/kg JID00081)	0.507	0.240	0.440	0.310	0.613	0.369	0.431	0.269
Group 4 (1.5 mg/kg JID00083)	0.784	0.604	0.574	0.526	0.719	0.435	0.459	0.421
Group 5 (1.5 mg/kg JID00084)	0.455	0.300	0.273	0.246	0.355	0.320	0.279	0.297
Group 6 (1.5 mg/kg JID00085)	0.757	0.360	0.555	0.418	0.681	0.421	0.585	0.405
Group 7 (1.5 mg/kg JID00087)	0.255	0.103	0.211	0.160	0.483	0.195	0.448	0.022
Group 8 (1.5 mg/kg JID00082)	0.759	0.452	0.786	0.534	0.935	0.693	0.745	0.539

Example 10. *In Vivo* Testing of PNPLA3 RNAi Agents in Cynomolgus Monkeys.

[0267] PNPLA3 RNAi agents J1D00003, J1D00008, and J1D00017 were evaluated in cynomolgus monkeys (cynos). On days 1 and 43, four cynos for each group (n=4) were administered a subcutaneous injection of 0.4 mL/kg (approximately 1.5 mL volume, depending on animal mass) containing 4.0 mg/kg (10 mg/mL) of the respective PNPLA3 RNAi agent, formulated in saline, or the saline vehicle alone with no RNAi agent to serve as a control (See Table 28 below).

Table 28. Targeted Positions and Dosing Groups of Example 10

Group	Targeted Gene Position (within SEQ ID NO: 1)	RNAi Agent and Dose	Dosing Regimen (on days 1 and 43)
1	N/A	Saline (no RNAi agent)	Single subcutaneous injection
2	1586	4.0 mg/kg J1D00003	Single subcutaneous injection
3	2180	4.0 mg/kg J1D00008	Single subcutaneous injection
4	1179	4.0 mg/kg J1D00017	Single subcutaneous injection

[0268] The PNPLA3 RNAi agents included modified nucleotides and a tridentate N-acetyl-galactosamine-containing targeting ligand ((NAG37)s) conjugated to the 5'-terminal end of the sense strand, as shown in Tables 3-6. PNPLA3 RNAi agent J1D00003 (Group 2) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1586 of the gene; PNPLA3 RNAi agent J1D00008 (Group 3) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 2180 of the gene; and PNPLA3 RNAi agent J1D00017 (Group 4) included nucleotide sequences that were designed to inhibit expression of a PNPLA3 gene at position 1179 of the gene.

[0269] On days -13 (pre-dose), 15, 29, 57, and 76, liver biopsies were taken. On the date of each biopsy collection, cynos were anesthetized and laparoscopy was used to extract two liver tissue samples approximately 80 mg to 120 mg each. The biopsy samples were then homogenized, and levels of PNPLA3 mRNA in the cyno livers were measured by RT-qPCR. Resulting values were then normalized to the pre-dose (in this case, at day -13) PNPLA3 mRNA measurements. The resulting mRNA data are reflected in the following Table 29:

Table 29. PNPLA3 mRNA Levels Normalized to Pre-Dose (Day -13) from Example 10 for Each Group (n=4)

	Day 15			Day 29		
	Relative PNPLA3 mRNA Expression	Low Error	High Error	Relative PNPLA3 mRNA Expression	Low Error	High Error
Group 1: Saline	0.768	0.144	0.178	0.616	0.138	0.178
Group 2: J1D00003	0.624	0.222	0.345	0.468	0.178	0.287
Group 3: J1D00008	0.486	0.065	0.074	0.455	0.120	0.164
Group 4: J1D00017	0.671	0.211	0.307	0.517	0.088	0.105
	Day 57			Day 76		
	Relative PNPLA3 mRNA Expression	Low Error	High Error	Relative PNPLA3 mRNA Expression	Low Error	High Error
Group 1: Saline	1.037	0.313	0.448	0.569	0.121	0.153
Group 2: J1D00003	0.449	0.176	0.290	0.649	0.321	0.636
Group 3: J1D00008	0.526	0.062	0.070	0.631	0.085	0.099
Group 4: J1D00017	0.795	0.217	0.298	0.824	0.221	0.301

Example 11. *In Vivo* Testing of PNPLA3 RNAi Agent J1D00008 in Cynomolgus Monkeys

[0270] The objective of this study was to evaluate RNAi agent J1D00008 for both depth and duration of knockdown of WT PNPLA3 mRNA in the liver of cynomolgus monkeys (cynos). Knockdown was normalized per animal to baseline measures obtained from liver biopsies performed prior to dosing.

[0271] Materials and Methods

[0272] Study 1: Cynos were grouped by body weight (2-5kg) into a saline- (group 1) or RNA-treated group (groups 2-4), n=4 per group. Cynos were dosed twice on days 1 and 43 subcutaneously at 4 mg/kg in 0.4 ml/kg saline. Cynos were fasted overnight for at least 12 hours prior to biopsy and blood draw. Liver biopsy samples were collected from all animals pre-dose and on test days 15, 29, 57, and 76. For each animal, liver biopsy samples (2x, approximately 100 mg each) were collected for PNPLA3 mRNA quantification by qPCR and *in situ* hybridization (ISH). Blood was collected from a femoral vein from each animal pre-dose and post-dose on Days 15, 29, 57, and 76. For all animals, groups, and timepoints, RNA was isolated from the left lateral liver lobe to perform qRT-PCR, data were normalized

to a house-keeping gene (ARFGAP2), and relative expression was compared to baseline/pre-dose biopsy. At the end of the study, PNPLA3 expression was measured in left and right lateral and median liver lobes from groups 1 and 3 to confirm that expression did not vary from lobe to lobe, and that the left lateral lobe was representative. RNAscope®-based *in situ* hybridization assay (ACDbio, Newark, CA) of cynomolgus monkey liver biopsy was performed. Image-based quantitative software analysis (HALO™ software system, Indica Labs, Albuquerque, NM) was utilized to quantify total PNPLA3 mRNA copies in given liver cell populations.

[0273] Study 2: A second non-human primate study was performed as described in Study 1, with the follow modifications or additions. Cynos were grouped by body weight (2-5kg) into two RNAi-treated groups, n=10 per group. Animals were dosed on days 1 and 29 subcutaneously at 4 mg/kg in saline and followed for 57 days.

[0274] **Results**

[0275] From Study 1, measurement of PNPLA3 expression by PCR is shown in Figure 1 for RNAi agent J1D00008. PNPLA3 mRNA was reduced by 51%, 55%, 47%, and 37% at the respective timepoints normalized to baseline and a housekeeping gene. Subsequent to these results, an *in situ* hybridization (ISH) was performed to evaluate the intracellular (cytoplasmic vs nuclear) distribution of PNPLA3 mRNA. Approximately 50% of the whole cell PNPLA3 mRNA was observed to be partitioned within the nucleus. This suggests that the RNAi agent J1D00008 was significantly reducing PNPLA3 mRNA at the site of protein translation (i.e. the hepatocyte cytoplasm), but that the knockdown at the whole cell-level was underestimated by qPCR due to the confounding residual nuclear PNPLA3 mRNA pool. Cytoplasmic PNPLA3 mRNA knockdown was thus quantified.

[0276] ISH performed on liver biopsies from cynos treated with RNAi agent J1D00008 revealed that significant residual PNPLA3 mRNA was retained in the nucleus of cells supporting the assertion that this pool was confounding knockdown results in whole liver as assessed by qPCR.

[0277] Quantification of the ISH images showed that, with RNAi agent J1D00008 treatment, PNPLA3 mRNA was reduced in the cytoplasm by 44-63% over all 76 days (Table 30). Since GalNAc-RNAi agents such as RNAi agent J1D00008 mediate degradation of target mRNA specifically in the cytoplasm of hepatocytes, whole liver quantification of PNPLA3 knockdown is diluted by the relative contribution of PNPLA3 mRNA from non-targeted cell types (e.g. stellate and Kupffer cells). Therefore, a model-based analysis was

performed to estimate the reduction of PNPLA3 mRNA specifically in the cytoplasm of hepatocytes, with correction for extra-hepatocyte PNPLA3 mRNA expression. Table 31 lists the relevant assumptions to liver physiology employed in the modeling.

[0278] Table 30. Quantification of ISH images for whole liver cytoplasm and nuclear PNPLA3 expression relative to baseline (day -13) in study #1.

Time (day)	Nuclear PNPLA3 mRNA (avg. transcript per cell)	Relative expression	Relative knockdown	Cytoplasm PNPLA3 mRNA (avg. transcript per cell)	Relative expression	Relative knockdown
-13	0.52 ± 0.21	n/a	n/a	0.62 ± 0.27	n/a	n/a
15	0.43 ± 0.15	0.84	0.16	0.20 ± 0.04	0.37	0.63
29	0.40 ± 0.13	0.85	0.15	0.21 ± 0.05	0.38	0.62
57	0.53 ± 0.24	1.08	-0.08	0.29 ± 0.11	0.50	0.50
76	0.70 ± 0.28	1.45	-0.45	0.33 ± 0.10	0.56	0.44

Data are means relative to baseline $\pm$ SD (n=4)

[0279] Table 31. Parameters relevant to liver physiology employed in the modeling.

Cell type	Liver composition (%)
Hepatocyte	85
Stellate cell (HSC)	8
Kupffer (others...)	7
Cell type	Relative PNPLA3 mRNA
Hepatocyte	1x
Stellate cell (HSC)	2x
Kupffer (others...)	1x

[0280] Using this model, PNPLA3 mRNA was reduced by 81% on day 15 and 78% on day 29 in the cytoplasm of hepatocytes after administering a single 4 mg/kg SC dose of RNAi agent J1D00008. When this modeling was repeated in Study 2, a 66% and 65% reduction in PNPLA3 mRNA at days 15 and 29 respectively was achieved. On average

across all NHPs tested (n=14) with RNAi agent J1D00008, PNPLA3 mRNA was reduced by 70% in the cytoplasm of hepatocytes on day 15 and day 29 (Figure 2).

Example 12. Safety

[0281] The nonclinical safety of RNAi agent J1D00008 administration for up to 3 months was evaluated in rats and monkeys at doses of up to 500 mg/kg and 300 mg/kg, respectively. In both species, RNAi agent J1D00008 was well tolerated and no adverse signs of toxicity were observed up to the highest doses evaluated.

OTHER EMBODIMENTS

[0282] It is to be understood that while the invention has been described in conjunction with the detailed description thereof, the foregoing description is intended to illustrate and not limit the scope of the invention, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the scope of the following claims.

CLAIMS:

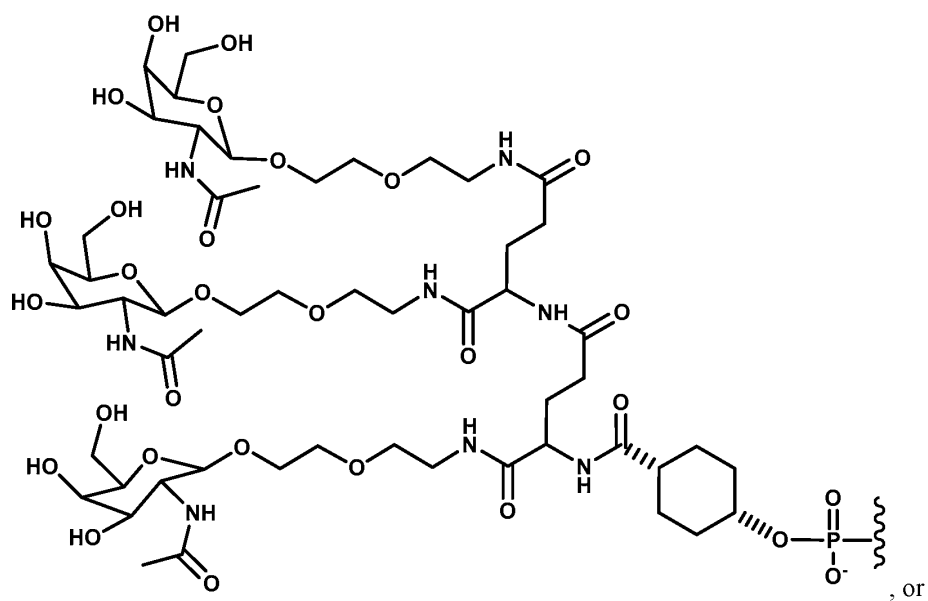
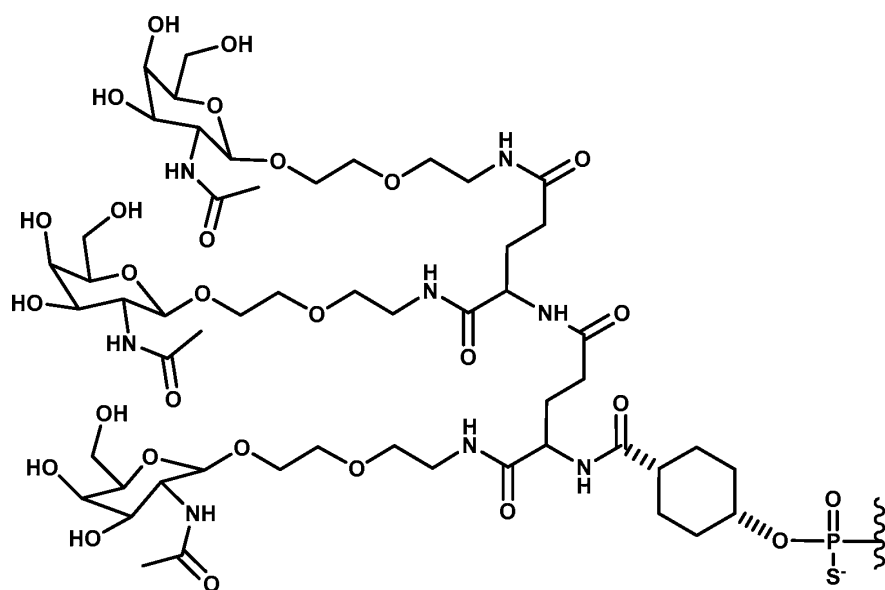
1. An RNAi agent for inhibiting expression of a PNPLA3 gene, comprising:
an antisense strand comprising at least 17 contiguous nucleotides differing by 0 or 1 nucleotides from any one of the sequences of SEQ ID NOs: 46-60, 176, 181 and 188 ; and
a sense strand comprising a nucleotide sequence that is at least partially complementary to the antisense strand.
2. The RNAi agent of claim 1, wherein the antisense strand comprises nucleotides 2-18 of any one of the sequences of SEQ ID NOs: 46-60, 176, 181 and 188.
3. The RNAi agent of claim 1 or claim 2, wherein the sense strand comprises a nucleotide sequence of at least 17 contiguous nucleotides differing by 0 or 1 nucleotides from any one of the sense strand sequences of SEQ ID NOs: 2, 3, 4, 9-20, 214, 219 and 220, and wherein the sense strand has a region of at least 85% complementarity over the 17 contiguous nucleotides to the antisense strand.
4. The RNAi agent of any one of claims 1-3, wherein at least one nucleotide of the RNAi agent is a modified nucleotide or includes a modified internucleoside linkage.
5. The RNAi agent of any one of claims 1-3, wherein all or substantially all of the nucleotides of the sense and/or antisense strand of the RNAi agent are modified nucleotides.
6. The RNAi agent of any one of claims 4-5, wherein the modified nucleotide is selected from the group consisting of: 2'-O-methyl nucleotide, 2'-fluoro nucleotide, 2'-deoxy nucleotide, 2',3'-seco nucleotide mimic, locked nucleotide, 2'-F-arabino nucleotide, 2'-methoxyethyl nucleotide, abasic nucleotide, ribitol, inverted nucleotide, inverted 2'-O-methyl nucleotide, inverted 2'-deoxy nucleotide, 2'-amino-modified nucleotide, 2'-alkyl-modified nucleotide, morpholino nucleotide, vinyl phosphonate containing nucleotide, cyclopropyl phosphonate containing nucleotide, and 3'-O-methyl nucleotide.

7. The RNAi agent of claim 5, wherein all or substantially all of the modified nucleotides are 2'-O-methyl nucleotides, 2'-fluoro nucleotides, or combinations thereof.
8. The RNAi agent of any one of claims 1-7, wherein the antisense strand consists of, consists essentially of, or comprises the nucleotide sequence of any one of the modified antisense strand sequences of SEQ ID NOs: 90, 95 and 102.
9. The RNAi agent of any one of claims 1-8, wherein the sense strand consists of, consists essentially of, or comprises the nucleotide sequence of any of the modified sense strand sequences of SEQ ID NOs: 131, 136 and 137.
10. The RNAi agent of claim 1, wherein the antisense strand comprises the nucleotide sequence of any one of the modified sequences of SEQ ID NOs: 90, 95 and 102 and the sense strand comprises the nucleotide sequence of any one of the modified sequences of SEQ ID NOs: 131, 136 and 137.
11. The RNAi agent of any one of claims 1-10, wherein the RNAi agent is linked to a targeting ligand.
12. The RNAi agent of claim 11, wherein the targeting ligand comprises N-acetyl-galactosamine.
13. The RNAi agent of claim 11 or 12, wherein the targeting ligand comprises the structure of (NAG37) or (NAG37)s.
14. The RNAi agent of any one of claims 11-13, wherein the targeting ligand is linked to the sense strand.
15. The RNAi agent of claim 14, wherein the targeting ligand is linked to the 5' terminal end of the sense strand.

16. The RNAi agent of any one of claims 1-15, wherein the sense strand is between 18 and 30 nucleotides in length, and the antisense strand is between 18 and 30 nucleotides in length.
17. The RNAi agent of claim 16, wherein the sense strand and the antisense strand are each between 18 and 27 nucleotides in length.
18. The RNAi agent of claim 17, wherein the sense strand and the antisense strand are each between 18 and 24 nucleotides in length.
19. The RNAi agent of claim 18, wherein the sense strand and the antisense strand are each 21 nucleotides in length.
20. The RNAi agent of any one of claims 16-19, wherein the RNAi agent has two blunt ends.
21. The RNAi agent of any one of claims 1-20, wherein the sense strand comprises one or two terminal caps.
22. The RNAi agent of any one of claims 1-22, wherein the sense strand comprises one or two inverted abasic residues.
23. The RNAi agent of claim 1, wherein the RNAi agent is comprised of a sense strand and an antisense strand that form a duplex sequence with SEQ ID NOs: (176 and 214); (90 and 131); (181 and 219); (95 and 136); (188 and 220) and/or (102 and 137).
24. The RNAi agent of any one of claims 1-23, wherein the sense strand further includes inverted abasic residues at the 3' terminal end of the nucleotide sequence, at the 5' end of the nucleotide sequence, or at both.
25. The RNAi agent of claim 1, comprising an antisense strand that comprises, consists of, or consists essentially of a modified nucleotide sequence that differs by 0 or 1 nucleotides from one of the nucleotide sequences of SEQ ID NOs: 90, 95 and 102;

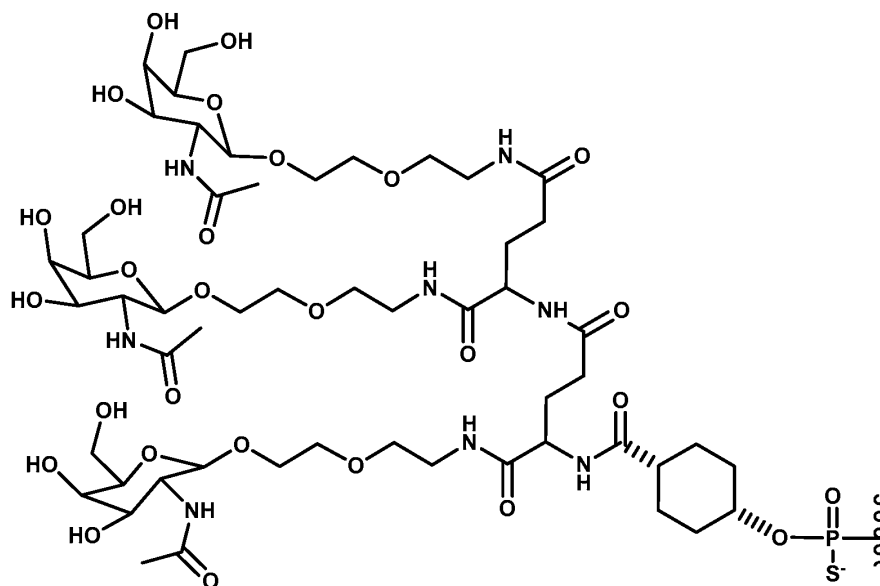
wherein a, c, g, and u represent 2'-O-methyl adenosine, cytidine, guanosine, and uridine, respectively; Af, Cf, Gf, and Uf represent 2'-fluoro adenosine, cytidine, guanosine, and uridine, respectively; s represents a phosphorothioate linkage; and wherein all or substantially all of the nucleotides on the sense strand are modified nucleotides.

26. The RNAi agent of claim 1, wherein the sense strand comprises, consists of, or consists essentially of a modified nucleotide sequence that differs by 0 or 1 nucleotides from one of the nucleotide sequences of SEQ ID NOs: 214, 219 and 256; wherein a, c, g, i, and u represent 2'-O-methyl adenosine, cytidine, guanosine, inosine, and uridine, respectively; Af, Cf, Gf, and Uf represent 2'-fluoro adenosine, cytidine, guanosine, and uridine, respectively; s represents a phosphorothioate linkage; and wherein all or substantially all of the nucleotides on the antisense strand are modified nucleotides.
27. The RNAi agent of any one of claims 24-26, wherein the sense strand further includes inverted abasic residues at the 3' terminal end of the nucleotide sequence, at the 5' end of the nucleotide sequence, or at both.
28. The RNAi agent of any one of claims 24-27, wherein the sense strand of the RNAi agent is linked to a targeting ligand.
29. The RNAi agent of claim 28, wherein the targeting ligand has affinity for the asialoglycoprotein receptor.
30. The RNAi agent of claim 29, wherein the targeting ligand comprises N-acetyl-galactosamine.
31. The RNAi agent of claim 1, wherein the targeting ligand comprises:



32. The RNAi agent of claim 1, wherein the antisense strand consists of the modified nucleotide sequence of SEQ ID NOs: 90, 95 and 102, and the sense strand consists of the modified nucleotide sequence of SEQ ID NOs: 131, 136 and 137;

wherein a, c, g, and u are 2'-O-methyl adenosine, cytidine, guanosine, and uridine, respectively; Af, Cf, Gf, and Uf are 2'-fluoro adenosine, cytidine, guanosine, and uridine, respectively; s is a phosphorothioate linkage; (invAb) is an inverted abasic deoxyribose residue; and (NAG37)s has the following chemical structure:



33. A composition comprising the RNAi agent of any one of claims 1-32, wherein the composition further comprises a pharmaceutically acceptable excipient.
34. A method for inhibiting expression of a PNPLA3 gene in a cell, the method comprising introducing into a cell an effective amount of an RNAi agent of any one of claims 1-32 or the composition of claim 33.
35. The method of claim 34, wherein the cell is within a subject.
36. The method of claim 35, wherein the subject is a human subject.
37. The method of any one of claims 34-36, wherein the PNPLA3 gene expression is inhibited by at least about 30%.

38. A method of treating a PNPLA3-related disease or disorder, the method comprising administering to a human subject in need thereof a therapeutically effective amount of the composition of claim 33.
39. The method of claim 38, wherein the disease is NAFLD, NASH, hepatic fibrosis, alcoholic fatty liver disease, or cirrhosis.
40. The method of any one of claims 34-39, wherein the RNAi agent is administered at a dose of about 0.05 mg/kg to about 5.0 mg/kg of body weight of the human subject.
41. The method of any one of claims 34-40, wherein the RNAi agent is administered in two or more doses.
42. Use of the RNAi agent of any one of claims 1-32 or the composition according to claim 33, for the treatment of a disease, disorder, or symptom that is mediated at least in part PNPLA3 gene expression.
43. Use according to claim 42, wherein the symptom is cirrhosis of the liver.
44. Use of the RNAi agent of any one of claims 1-32 or the composition according to claim 33, for the preparation of a pharmaceutical compositions for treating a disease, disorder, or symptom that is mediated at least in part by PNPLA3 gene expression.
45. Use according to any one of claims 42 to 44, wherein the disease is NAFLD, NASH, hepatic fibrosis, or an alcoholic or non-alcoholic liver disease such as cirrhosis.
46. Use according to any one of claims 42 to 45, wherein the RNAi agent is administered at a dose of about 0.05 mg/kg to about 5.0 mg/kg of body weight of the human subject.