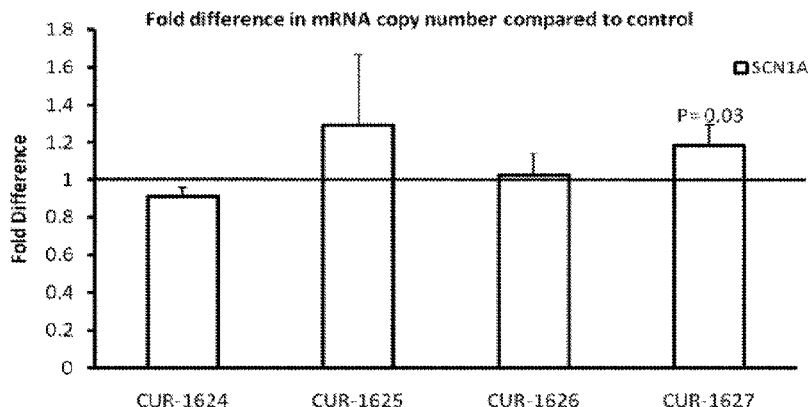




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 (54) Title: TREATMENT OF SODIUM CHANNEL, VOLTAGE-GATED, ALPHA SUBUNIT (SCNA) RELATED DISEASES BY INHIBITION OF NATURAL ANTISENSE TRANSCRIPT TO SCNA



(57) **Abrégé/Abstract:**

The present invention relates to antisense oligonucleotides that modulate the expression of and/or function of Sodium channel, voltage-gated, alpha subunit (SCNA), in particular, by targeting natural antisense polynucleotides of Sodium channel, voltage-gated, alpha subunit (SCNA). The invention also relates to the identification of these antisense oligonucleotides and their use in treating diseases and disorders associated with the expression of SCNA.

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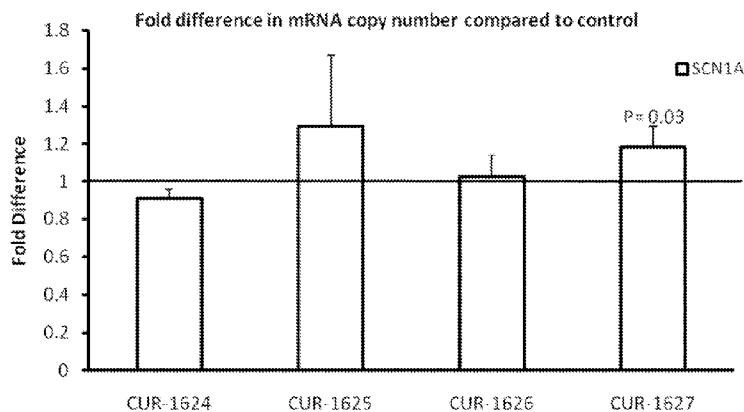
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(54) Title: TREATMENT OF SODIUM CHANNEL, VOLTAGE-GATED, ALPHA SUBUNIT (SCNA) RELATED DISEASES BY INHIBITION OF NATURAL ANTISENSE TRANSCRIPT TO SCNA

FIGURE 1



(57) Abstract: The present invention relates to antisense oligonucleotides that modulate the expression of and/or function of Sodium channel, voltage-gated, alpha subunit (SCNA), in particular, by targeting natural antisense polynucleotides of Sodium channel, voltage-gated, alpha subunit (SCNA). The invention also relates to the identification of these antisense oligonucleotides and their use in treating diseases and disorders associated with the expression of SCNA.

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**TREATMENT OF SODIUM CHANNEL, VOLTAGE-GATED, ALPHA SUBUNIT (SCNA) RELATED  
DISEASES BY INHIBITION OF NATURAL ANTISENSE TRANSCRIPT TO SCNA**

**FIELD OF THE INVENTION**

5 [0001] The present application claims the priority of U.S. provisional patent application No. 61/357,774 filed June 23, 2010.

[0002] Embodiments of the invention comprise oligonucleotides modulating expression and/or function of SCNA and associated molecules.

**BACKGROUND**

10 [0003] DNA-RNA and RNA-RNA hybridization are important to many aspects of nucleic acid function including DNA replication, transcription, and translation. Hybridization is also central to a variety of technologies that either detect a particular nucleic acid or alter its expression. Antisense nucleotides, for example, disrupt gene expression by hybridizing to target RNA, thereby interfering with RNA splicing, transcription, translation, and replication. Antisense DNA has the added feature that DNA-RNA hybrids serve as a substrate for digestion by ribonuclease H, an activity that is present in most cell types. Antisense molecules can be delivered into cells, as is the case for  
15 oligodeoxynucleotides (ODNs), or they can be expressed from endogenous genes as RNA molecules. The FDA recently approved an antisense drug, VITRAVENE<sup>™</sup> (for treatment of cytomegalovirus retinitis), reflecting that antisense has therapeutic utility.

**SUMMARY**

20 [0004] This Summary is provided to present a summary of the invention to briefly indicate the nature and substance of the invention. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims.

[0005] In one aspect, the invention provides methods for inhibiting the action of a natural antisense transcript by using antisense oligonucleotide(s) targeted to any region of the natural antisense transcript resulting in upregulation of the corresponding sense gene wherein said sense gene is selected from at least one member of the SCNA gene family and variants thereof. It is also contemplated herein that inhibition of the natural antisense transcript can be achieved by  
25 siRNA, ribozymes and small molecules, which are considered to be within the scope of the present invention.

[0006] One embodiment provides a method of modulating function and/or expression of an SCNA polynucleotide in patient cells or tissues in vivo or in vitro comprising contacting said cells or tissues with an antisense oligonucleotide 5 to 30 nucleotides in length wherein said oligonucleotide has at least 50% sequence identity to a reverse complement of  
30 a polynucleotide comprising 5 to 30 consecutive nucleotides within nucleotides 1 to 1123 of SEQ ID NO: 12 and 1 to 2352 of SEQ ID NO: 13, 1 to 267 of SEQ ID NO: 14, 1 to 1080 of SEQ ID NO: 15, 1 to 173 of SEQ ID NO: 16, 1 to 618 of SEQ ID NO: 17, 1 to 871 of SEQ ID NO: 18, 1 to 304 of SEQ ID NO: 19, 1 to 293 of SEQ ID NO: 20, 1 to 892 of SEQ ID NO: 21, 1 to 260 of SEQ ID NO: 22, 1 to 982 of SEQ ID NO: 23, 1 to 906 of SEQ ID NO: 24, 1 to 476 of

SEQ ID NO: 25, 1 to 285 of SEQ ID NO: 26, 1 to 162 of SEQ ID NO: 27 and 1 to 94 of SEQ ID NO: 28 thereby modulating function and/or expression of the SCNA polynucleotide in patient cells or tissues *in vivo* or *in vitro*.

[0007] In an embodiment, an oligonucleotide targets a natural antisense sequence of SCNA polynucleotides, for example, nucleotides set forth in SEQ ID NOS: 12 to 28, and any variants, alleles, homologs, mutants, derivatives, fragments and complementary sequences thereto. Examples of antisense oligonucleotides are set forth as SEQ ID NOS: 29 to 94.

[0008] Another embodiment provides a method of modulating function and/or expression of an SCNA polynucleotide in patient cells or tissues *in vivo* or *in vitro* comprising contacting said cells or tissues with an antisense oligonucleotide 5 to 30 nucleotides in length wherein said oligonucleotide has at least 50% sequence identity to a reverse complement of an antisense of the SCNA polynucleotide; thereby modulating function and/or expression of the SCNA polynucleotide in patient cells or tissues *in vivo* or *in vitro*.

[0009] Another embodiment provides a method of modulating function and/or expression of an SCNA polynucleotide in patient cells or tissues *in vivo* or *in vitro* comprising contacting said cells or tissues with an antisense oligonucleotide 5 to 30 nucleotides in length wherein said oligonucleotide has at least 50% sequence complementary to an SCNA natural antisense transcript; thereby modulating function and/or expression of the SCNA polynucleotide in patient cells or tissues *in vivo* or *in vitro*.

[0009.1] A preferred embodiment provides an *ex vivo* method of upregulating a function of and/or an expression of a Sodium channel, voltage-gated, type1, alpha subunit (SCN1A) polynucleotide in a biological system having SEQ ID NO: 1 comprising:

contacting said biological system with at least one single stranded antisense oligonucleotide 13 to 28 nucleotides in length which targets a 13 to 28 nucleotide region of a long non-coding natural antisense polynucleotide selected from the group consisting of SEQ ID NOS: 12 to 28, wherein said at least one single stranded oligonucleotide has 100% sequence identity to a reverse complement of a polynucleotide comprising 13 to 28 consecutive nucleotides within the natural antisense polynucleotide having a nucleic acid sequence as set forth in any one of SEQ ID NOS: 12 to 15 and 17 to 28; thereby upregulating the function of and/or the expression of the SCN1A polynucleotide, and wherein the at least one oligonucleotide comprises at least one oligonucleotide sequence set forth as SEQ ID NOS: 40 to 92.

[0009.2] Another preferred embodiment provides an *ex vivo* method of upregulating a function of and/or an expression of a human Sodium channel, voltage-gated, alpha subunit (SCN1A) polynucleotide in a biological system having SEQ ID NO: 1 comprising:

contacting said biological system with at least one single stranded antisense oligonucleotide of 13 to 30 nucleotides in length that is 100% complementary to and specifically targets a complementary region of a natural antisense polynucleotide of the SCN1A polynucleotide, wherein said natural antisense polynucleotide is selected from the group consisting of nucleotides 1 to 1123 of SEQ ID NO: 12 and 1 to 2352 of SEQ ID NO: 13, 1 to 267 of SEQ ID NO: 14, 1 to 1080 of SEQ ID NO: 15, 1 to 173 of SEQ ID NO: 16, 1 to 618 of SEQ ID NO: 17, 1 to 871 of SEQ ID NO: 18, 1 to 304 of SEQ ID NO: 19, 1 to 293 of SEQ ID NO: 20, 1 to 892 of SEQ ID NO: 21, 1 to 260 of

SEQ ID NO: 22, 1 to 982 of SEQ ID NO: 23, and 1 to 906 of SEQ ID NO: 24; thereby upregulating the function of and/or the expression of the SCN1A polynucleotide, and wherein the at least one oligonucleotide comprises at least one oligonucleotide sequences set forth as SEQ ID NOs: 31, 33, 37, 40 to 92.

[0009.3] Another aspect provides a synthetic, modified oligonucleotide comprising at least one modification which is at least one modified sugar moiety; at least one modified internucleotide linkage; or at least one modified nucleotide, or any combination thereof; wherein said oligonucleotide is an antisense compound which hybridizes to and upregulates a function of and/or expression of a Sodium channel, voltage-gated, type1, alpha subunit (SCN1A) gene *in vivo* or *in vitro* as compared to a normal control, and

wherein said oligonucleotide is 5 to 30 nucleotides in length and has at least 50% sequence identity to the reverse complement of 5-30 consecutive nucleotides within a natural antisense transcript of the SCN1A gene.

[0010] In an embodiment, a composition comprises one or more antisense oligonucleotides which bind to sense and/or antisense SCNA polynucleotides wherein said polynucleotides are selected from the group consisting of SCNA to SCN12A and variants thereof. In a preferred embodiment, the target polynucleotide is selected from SCNA.

[0011] In an embodiment, the oligonucleotides comprise one or more modified or substituted nucleotides.

[0012] In an embodiment, the oligonucleotides comprise one or more modified bonds.

[0013] In yet another embodiment, the modified nucleotides comprise modified bases comprising phosphorothioate, methylphosphonate, peptide nucleic acids, 2'-O-methyl, fluoro- or carbon, methylene or other locked nucleic acid (LNA) molecules. Preferably, the modified nucleotides are locked nucleic acid molecules, including  $\alpha$ -L-LNA.

[0014] In an embodiment, the oligonucleotides are administered to a patient subcutaneously, intramuscularly, intravenously or intraperitoneally.

[0015] In an embodiment, the oligonucleotides are administered in a pharmaceutical composition. A treatment regimen comprises administering the antisense compounds at least once to patient; however, this treatment can be modified to include multiple doses over a period of time. The treatment can be combined with one or more other types of therapies.

[0016] In an embodiment, the oligonucleotides are encapsulated in a liposome or attached to a carrier molecule (e.g. cholesterol, TAT peptide).

[0017] Other aspects are described *infra*.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Figure 1 is a graph of real time PCR results showing the fold change + standard deviation in SCN1A mRNA after treatment of HepG2 cells with phosphorothioate oligonucleotides introduced using Lipofectamine 2000, as compared to control. Real Time PCR results show that levels of SCN1A mRNA in HepG2 cells are significantly increased 48h after treatment with one of the antisense oligonucleotides to SCN1A antisense BG724147. Bars denoted as CUR-1624 to CUR-1627 correspond to samples treated with SEQ ID NOS: 30 to 33 respectively.

[0019] Figure 2 is a graph of real time PCR results showing the fold change + standard deviation in SCN1A mRNA after treatment of HepG2 cells with phosphorothioate oligonucleotides introduced using Lipofectamine 2000, as compared to control. Bars denoted as CUR-1628 to CUR-1631 correspond to samples treated with SEQ ID NOS: 34 to 37 respectively.

[0020] Figure 3 is a graph of real time PCR results showing the fold change + standard deviation in SCN1A mRNA after treatment of HepG2 cells with phosphorothioate oligonucleotides introduced using Lipofectamine 2000, as compared to control. Bars denoted as CUR-1632 to CUR-1636 correspond to samples treated with SEQ ID NOS: 38 to 42 respectively.

[0021] Figure 4 shows dose-dependent upregulation of SCN1A mRNA in primary human skin fibroblasts carrying a Dravet syndrome-associated mutation. CUR-1916, CUR-1740, CUR-1764 and CUR-1770 correspond to samples treated with SEQ ID NOS: 70, 45, 52 and 57 respectively.

[0022] Figure 5 shows dose-dependent upregulation of SCN1A mRNA in SK-N-AS cells. CUR-1916, CUR-1740, CUR-1764 and CUR-1770 correspond to samples treated with SEQ ID NOS: 70, 45, 52 and 57 respectively.

[0023] Figure 6 shows dose-dependent upregulation of SCN1A mRNA in Vero76 cells. CUR-1916, CUR-1740, CUR-1764 and CUR-1770 correspond to samples treated with SEQ ID NOS: 70, 45, 52 and 57 respectively.

[0024] Figure 7 shows that upregulation of SCN1A mRNA is not caused by non-specific toxicity of antisense oligonucleotides. A – upregulation by CUR-1916; B – upregulation by CUR-1770. CUR-1462 is an inactive control oligonucleotide of similar chemistry.

[0025] Figure 8 shows that expression of the SCN8A and SCN9A channels in human fibroblasts carrying a Dravet-associated mutation is not significantly affected by the treatment with antisense oligonucleotides targeted against SCN1A natural antisense transcript. A – treatment with CUR-1770; B – treatment with CUR-1916.

[0026] Figure 9 shows stability of antisense oligonucleotides targeting SCN1A-specific natural antisense transcript. Vero 76 cells were treated as described in Example 2 with two different batches of CUR-1916 synthesized in August 2010 and March 2011. The oligonucleotide synthesized in August 2010 was stored as a 1 mM aqueous solution at 4°C. The oligonucleotide synthesized in March 2011 was shipped in lyophilized form and tested immediately upon arrival.

[0027] Figure 10 shows upregulation of SCN1A protein in fibroblasts carrying a Dravet syndrome mutation treated with antisense oligonucleotides complementary to the SCN1A natural antisense. Fibroblasts were grown in 24 well

plates and treated with antisense oligonucleotides complementary to the SCN1A natural antisense at 20nM (panel c: CUR-1740; d: CUR-1770; e: CUR-1916) and at 0 nM (b). The cells were stained for SCN1A (b-e) by indirect immunohistochemistry using an anti-SCN1A antibody (Abcam cat# ab24820) and a secondary antibody staining/amplification with the avidin/biotin method (Vector Laboratories cat# SP-2001; Vector Laboratories cat# PK-6101; Vector Laboratories cat# SK-4105); panel a - negative control, a rabbit anti-mouse antibody was used as a primary antibody followed by the same staining procedure as in panels b-e.

[0028] Figure 11 shows upregulation of SCN1A protein in SK-N-AS cells treated with antisense oligonucleotides complementary to the SCN1A natural antisense. SK-N-AS cells were grown in 24 well plates and treated with oligonucleotides at 20nM (c: CUR-1740; d: CUR-1764; e: CUR-1770; f: CUR-1916) and at (b: 0 nM). The SK-N-AS cells were stained for SCN1A (b-f) by indirect immunohistochemistry using an anti- SCN1A antibody (Abcam cat# ab24820) and secondary antibody staining/amplification using the avidin/biotin method (Vector Laboratories cat# SP-2001; Vector Laboratories cat# PK-6101; Vector Laboratories cat# SK-4105); as a negative control, a rabbit anti-mouse antibody was used as a primary antibody followed by the same staining procedure as in panels b-f (panel a).

[0029] Figure 12 shows upregulation of SCN1A protein in Vero 76 cells treated with antisense oligonucleotides complementary to the SCN1A natural antisense. Vero 76 cells were grown in 24 well plates and treated with antisense oligonucleotides complementary to the SCN1A natural antisense at 20nM (c: CUR-1740; d: CUR-1945; e: CUR-1770; f: CUR-1916; g: CUR-1924) and at 0 nM (b). The Vero 76 cells were stained for SCN1A (b-f) by indirect immunohistochemistry using an anti- SCN1A antibody (Abcam cat# ab24820) and secondary antibody staining/amplification with the avidin/biotin method (Vector Laboratories cat# SP-2001; Vector Laboratories cat# PK-6101; Vector Laboratories cat# SK-4105); panel a - as a negative control, a rabbit anti-mouse antibody was used as primary antibody followed by the same staining procedure as in panels b-g.

[0030] Figure 13 show that oligonucleotides targeting SCN1A-specific natural antisense transcript that upregulate SCN1A mRNA do not upregulate actin in Vero76 cells. The same antisense oligonucleotides (CUR-1740, CUR-1838, CUR-1924) targeting SCN1A-specific natural antisense transcript that were shown in Examples 5 and 12 to upregulate SCN1A mRNA and protein were tested for their effect on beta-actin mRNA expression in Vero 76 cells. The data confirms that oligonucleotide targeting SCN1A-specific natural antisense transcript do not upregulate a non-related gene such as actin. Bars denoted as CUR-1740, CUR-1838 and CUR-1924 correspond to samples treated with SEQ ID NOS: 45, 62 and 78 respectively.

[0031] Figure 14 shows that oligonucleotide targeting SCN1A-specific natural antisense transcript shown to upregulate SCN1A mRNA and protein do not upregulate actin in fibroblasts carrying a Dravet-associated mutation. The oligonucleotides (CUR-1916, CUR-1945) targeting SCN1A-specific natural antisense transcript that were shown in Examples 2 and 7 to upregulate SCN1A mRNA and protein were tested for their effect on actin mRNA expression in fibroblasts carrying a Dravet-associated mutation. The data below confirms that oligonucleotides targeting SCN1A-



specific natural antisense transcript do not upregulate a non-related gene such as actin. Bars denoted as CUR-1916, and CUR-1945 correspond to samples treated with SEQ ID NOS: 70 and 93 respectively.

[0032] Figure 15 show that oligonucleotides targeting SCN1A-specific natural antisense transcript shown to upregulate SCN1A mRNA and protein do not upregulate actin in SK-N-AS cells. The same antisense oligonucleotides (CUR-1740, CUR-1770, CUR-1916, CUR-1764, CUR-1838) that were shown in Examples to upregulate SCN1A mRNA and protein were tested for their effect on actin mRNA expression in SK-N-AS cells. The data confirms that oligonucleotides targeting SCN1A-specific natural antisense transcript do not upregulate a non-related gene such as actin. Bars denoted as CUR-1740, CUR-1770, CUR-1916, CUR-1764, CUR-1838 correspond to samples treated with SEQ ID NOS: 45, 57, 70, 52 and 62 respectively.

10 [0033] Figure 16 shows staining of actin protein in SK-N-AS cells treated with antisense oligonucleotides complementary to the SCN1A natural antisense. SK-N-AS cells were grown in 24 well plates and treated with oligonucleotides at 20 nM (b: CUR-1740; c: CUR-1764; d: CUR-1770; e: CUR-1916) and at 0 nM (a). The SK-N-AS cells were stained for actin (a-e) by indirect immunohistochemistry using an anti-actin antibody (Abcam cat#ab1801) and secondary antibody staining/amplification using the avidin/biotin method (Vector Laboratories cat# SP-2001; Vector Laboratories cat# PK-6101; Vector Laboratories cat# SK-4105).

[0034] Figure 17 shows staining of actin protein in Vero 76 cells treated with antisense oligonucleotides complementary to the SCN1A natural antisense. Vero 76 cells were grown in 24 well plates and treated with antisense oligonucleotides complementary to the SCN1A natural antisense at 20nM (b: CUR-1740; c: CUR-1770; d: CUR-1916; e: CUR-1924; f: CUR-1945) and at 0 nM (a). The Vero 76 cells were stained for actin (b-f) by indirect immunohistochemistry using an anti-actin antibody (Abcam cat#ab1801) and secondary antibody staining/amplification with the avidin/biotin method (Vector Laboratories cat# SP-2001; Vector Laboratories cat# PK-6101; Vector Laboratories cat# SK-4105); panel a - negative control, a rabbit anti-mouse antibody was used as primary antibody followed by the same staining procedure as in panels b-g.

25 [0035] Figure 18 shows upregulation of actin protein in fibroblasts carrying a Dravet syndrome mutation treated with antisense oligonucleotides complementary to the SCN1A natural antisense. Fibroblasts were grown in 24 well plates and treated with antisense oligonucleotides complementary to the SCN1A natural antisense at 20nM (panel b: CUR-1740; c: CUR-1764; d: CUR-1770; e: CUR-1838 and f: CUR-1916) and at 0 nM (a). The cells were stained for actin (a-f) by indirect immunohistochemistry using an anti-actin antibody (Abcam cat#ab1801) and a secondary antibody staining/amplification with the avidin/biotin method (Vector Laboratories cat# SP-2001; Vector Laboratories cat# PK-6101; Vector Laboratories cat# SK-4105).

30 [0036] Figure 19 shows upregulation of SCN1A protein in fibroblasts carrying a Dravet syndrome mutation treated with antisense oligonucleotides complementary to the SCN1A natural antisense quantified using ELISA. Fibroblasts were treated with oligonucleotides complementary to the SCN1A natural antisense at 0 or 80nM. After 48h, the cells

were transferred to a 96 well plate for 24 h, before being fixed and used for SCN1A and actin ELISAs. The OD readings for SCN1A signal were normalized to actin signal for the same experimental condition. The normalized SCN1A signal in cells dosed with 0 nM of oligonucleotide was used as baseline (100%). Bars denoted as CUR-1740, CUR-1770 and CUR-1916 correspond to samples treated with SEQ ID NOS: 45, 57 and 70 respectively.

5 [0037] Figure 20 shows upregulation of SCN1A protein in Vero76 cells treated with antisense oligonucleotides complementary to the SCN1A natural antisense quantified using ELISA. Vero76 cells were treated with antisense oligonucleotides complementary to the SCN1A natural antisense at 0 or 80nM. After 48h, the cells were transferred to a 96 well plate for 24h before being fixed and used for SCN1A and actin ELISAs. The OD readings for SCN1A signal were normalized to actin signal for the same experimental condition. The normalized SCN1A signal in cells dosed with  
10 0 nM of oligonucleotide was used as baseline (100%). Bars denoted as CUR-1740, CUR-1770, CUR-1916, CUR-1924, CUR-1945 correspond to samples treated with SEQ ID NOS: 45, 57, 70, 78 and 93 respectively.

[0038] Figure 21 shows upregulation of SCN1A protein in SK-N-AS cells treated with oligonucleotides complementary to the SCN1A natural antisense quantified using ELISA. SK-N-AS cells were treated with antisense oligonucleotides complementary to the SCN1A natural antisense at 0 or 20nM. After 48h, the cells were transferred to  
15 a 96 well plate for 24 h, before being fixed and used for SCN1A and actin ELISAs. The OD readings for SCN1A signal were normalized to actin signal for the same experimental condition. The normalized SCN1A signal in cells dosed with 0 nM of oligonucleotide was used as baseline (100%). Bars denoted as CUR-1740, CUR-1770, CUR-1924, CUR-1945 correspond to samples treated with SEQ ID NOS: 45, 57, 78 and 93 respectively.

[0039] Figure 22 shows products from a second PCR round of a 3' RACE of the SCN1A natural antisense transcript  
20 BG724147. A 3' RACE was performed on: a) total RNA from HepG2 cells with adenosine added; b - poly A RNA isolated from HepG2 cells; c - on total RNA from primary human fibroblasts carrying a Dravet syndrome-associated mutation with adenosine added; d - on poly A RNA isolated from primary human fibroblasts carrying a Dravet syndrome-associated mutation. Figure represents a negative of a 1% agarose gel/1xTAE stained with GelRed (GenScript, cat#M00120). Arrow shows a band common for HepG2 cells and primary human fibroblasts carrying a  
25 Dravet syndrome-associated mutation, demonstrating the presence of BG724147 natural antisense transcript in these cells.

[0040] *Sequence Listing Description-* SEQ ID NO: 1: Homo sapiens sodium channel, voltage-gated, type I, alpha subunit (SCN1A), transcript variant 1, mRNA (NCBI Accession No.: NM\_001165963); SEQ ID NO: 2: Homo sapiens sodium channel, voltage-gated, type II, alpha subunit (SCN2A), transcript variant 1, mRNA (NCBI Accession No.:  
30 NM\_021007); SEQ ID NO: 3: Homo sapiens sodium channel, voltage-gated, type III, alpha subunit (SCN3A), transcript variant 1, mRNA (NCBI Accession No.: NM\_006922); SEQ ID NO: 4: Homo sapiens sodium channel, voltage-gated, type IV, alpha subunit (SCN4A), mRNA (NCBI Accession No.: NM\_000334); SEQ ID NO: 5: Homo sapiens sodium channel, voltage-gated, type V, alpha subunit (SCN5A), transcript variant 1, mRNA (NCBI Accession

No.: NM\_198056); SEQ ID NO: 6: Homo sapiens sodium channel, voltage-gated, type VII, alpha (SCN7A), mRNA (NCBI Accession No.: NM\_002976); SEQ ID NO: 7: Homo sapiens sodium channel, voltage gated, type VIII, alpha subunit (SCN8A), transcript variant 1, mRNA (NCBI Accession No.: NM\_014191); SEQ ID NO: 8: Homo sapiens sodium channel, voltage-gated, type IX, alpha subunit (SCN9A), mRNA (NCBI Accession No.: NM\_002977); SEQ ID NO: 9: Homo sapiens sodium channel, voltage-gated, type X, alpha subunit (SCN10A), mRNA (NCBI Accession No.: NM\_006514); SEQ ID NO: 10: Homo sapiens sodium channel, voltage-gated, type XI, alpha subunit (SCN11A), mRNA (NCBI Accession No.: NM\_014139); SEQ ID NO: 11: Homo sapiens voltage-gated sodium channel alpha subunit SCN12A (SCN12A) mRNA, complete cds (NCBI Accession No.: AF109737); SEQ ID NO: 12: Natural SCN1A antisense sequence (BG724147 extended); SEQ ID NO: 13: Natural SCN1A antisense sequence (Hs.662210); SEQ ID NO: 14: Natural SCN1A antisense sequence (AA383040); SEQ ID NO: 15: Natural SCN1A antisense sequence (BC029452); SEQ ID NO: 16: Natural SCN1A antisense sequence (AA630035); SEQ ID NO: 17: Natural SCN1A antisense sequence (BE566126); SEQ ID NO: 18: Natural SCN1A antisense sequence (BF673100); SEQ ID NO: 19: Natural SCN1A antisense sequence (BG181807); SEQ ID NO: 20: Natural SCN1A antisense sequence (BG183871); SEQ ID NO: 21: Natural SCN1A antisense sequence (BG215777); SEQ ID NO: 22: Natural SCN1A antisense sequence (BG227970); SEQ ID NO: 23: Natural SCN1A antisense sequence (BM905527); SEQ ID NO: 24: Natural SCN1A antisense sequence (BU180772); SEQ ID NO: 25: Mouse Natural SCN1A antisense sequence (BG724147 ExtMouse); SEQ ID NO: 26: Mouse Natural SCN1A antisense sequence (Hs.662210mouseAS1); SEQ ID NO: 27: Mouse Natural SCN1A antisense sequence (Hs.662210mouseAS2); SEQ ID NO: 28: Mouse Natural SCN1A antisense sequence (Hs.662210mouseAS3); SEQ ID NOs: 29 to 94: Antisense oligonucleotides. SEQ ID NO: 95 and 96 are the reverse complements of the antisense oligonucleotides SEQ ID NO: 58 and 59 respectively. \* indicates a phosphothioate bond, + indicates LNA, 'r' indicates RNA and 'm' indicates a methyl group on the 2' oxygen atom on the designated sugar moiety of the oligonucleotide.

#### DETAILED DESCRIPTION

[0041] Several aspects of the invention are described below with reference to example applications for illustration. It should be understood that numerous specific details, relationships, and methods are set forth to provide a full understanding of the invention. One having ordinary skill in the relevant art, however, will readily recognize that the invention can be practiced without one or more of the specific details or with other methods. The present invention is not limited by the ordering of acts or events, as some acts may occur in different orders and/or concurrently with other acts or events. Furthermore, not all illustrated acts or events are required to implement a methodology in accordance with the present invention.

[0042] All genes, gene names, and gene products disclosed herein are intended to correspond to homologs from any species for which the compositions and methods disclosed herein are applicable. Thus, the terms include, but are not limited to genes and gene products from humans and mice. It is understood that when a gene or gene product from a

particular species is disclosed, this disclosure is intended to be exemplary only, and is not to be interpreted as a limitation unless the context in which it appears clearly indicates. Thus, for example, for the genes disclosed herein, which in some embodiments relate to mammalian nucleic acid and amino acid sequences are intended to encompass homologous and/or orthologous genes and gene products from other animals including, but not limited to other mammals, fish, amphibians, reptiles, and birds. In an embodiment, the genes or nucleic acid sequences are human.

#### *Definitions*

[0043] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Furthermore, to the extent that the terms "including", "includes", "having", "has", "with", or variants thereof are used in either the detailed description and/or the claims, such terms are intended to be inclusive in a manner similar to the term "comprising."

[0044] The term "about" or "approximately" means within an acceptable error range for the particular value as determined by one of ordinary skill in the art, which will depend in part on how the value is measured or determined, i.e., the limitations of the measurement system. For example, "about" can mean within 1 or more than 1 standard deviation, per the practice in the art. Alternatively, "about" can mean a range of up to 20%, preferably up to 10%, more preferably up to 5%, and more preferably still up to 1% of a given value. Alternatively, particularly with respect to biological systems or processes, the term can mean within an order of magnitude, preferably within 5-fold, and more preferably within 2-fold, of a value. Where particular values are described in the application and claims, unless otherwise stated the term "about" meaning within an acceptable error range for the particular value should be assumed.

[0045] As used herein, the term "mRNA" means the presently known mRNA transcript(s) of a targeted gene, and any further transcripts which may be elucidated.

[0046] By "antisense oligonucleotides" or "antisense compound" is meant an RNA or DNA molecule that binds to another RNA or DNA (target RNA, DNA). For example, if it is an RNA oligonucleotide it binds to another RNA target by means of RNA-RNA interactions and alters the activity of the target RNA. An antisense oligonucleotide can upregulate or downregulate expression and/or function of a particular polynucleotide. The definition is meant to include any foreign RNA or DNA molecule which is useful from a therapeutic, diagnostic, or other viewpoint. Such molecules include, for example, antisense RNA or DNA molecules, interference RNA (RNAi), micro RNA, decoy RNA molecules, siRNA, enzymatic RNA, therapeutic editing RNA and agonist and antagonist RNA, antisense oligomeric compounds, antisense oligonucleotides, external guide sequence (EGS) oligonucleotides, alternate splicers, primers, probes, and other oligomeric compounds that hybridize to at least a portion of the target nucleic acid. As such, these compounds may be introduced in the form of single-stranded, double-stranded, partially single-stranded, or circular oligomeric compounds.

[0047] In the context of this invention, the term "oligonucleotide" refers to an oligomer or polymer of ribonucleic acid (RNA) or deoxyribonucleic acid (DNA) or mimetics thereof. The term "oligonucleotide", also includes linear or circular oligomers of natural and/or modified monomers or linkages, including deoxyribonucleosides, ribonucleosides, substituted and alpha-anomeric forms thereof, peptide nucleic acids (PNA), locked nucleic acids (LNA), phosphorothioate, methylphosphonate, and the like. Oligonucleotides are capable of specifically binding to a target polynucleotide by way of a regular pattern of monomer-to-monomer interactions, such as Watson-Crick type of base pairing, Hoogsteen or reverse Hoogsteen types of base pairing, or the like.

[0048] The oligonucleotide may be "chimeric", that is, composed of different regions. In the context of this invention "chimeric" compounds are oligonucleotides, which contain two or more chemical regions, for example, DNA region(s), RNA region(s), PNA region(s) etc. Each chemical region is made up of at least one monomer unit, i.e., a nucleotide in the case of an oligonucleotides compound. These oligonucleotides typically comprise at least one region wherein the oligonucleotide is modified in order to exhibit one or more desired properties. The desired properties of the oligonucleotide include, but are not limited, for example, to increased resistance to nuclease degradation, increased cellular uptake, and/or increased binding affinity for the target nucleic acid. Different regions of the oligonucleotide may therefore have different properties. The chimeric oligonucleotides of the present invention can be formed as mixed structures of two or more oligonucleotides, modified oligonucleotides, oligonucleosides and/or oligonucleotide analogs as described above.

[0049] The oligonucleotide can be composed of regions that can be linked in "register", that is, when the monomers are linked consecutively, as in native DNA, or linked via spacers. The spacers are intended to constitute a covalent "bridge" between the regions and have in preferred cases a length not exceeding about 100 carbon atoms. The spacers may carry different functionalities, for example, having positive or negative charge, carry special nucleic acid binding properties (intercalators, groove binders, toxins, fluorophors etc.), being lipophilic, inducing special secondary structures like, for example, alanine containing peptides that induce alpha-helices.

[0050] As used herein "SCN1A" is inclusive of all family members, mutants, alleles, fragments, species, coding and noncoding sequences, sense and antisense polynucleotide strands, etc. Similarly, SCN2A-SCN12A is inclusive of all mutants, alleles, fragments, etc.

[0051] As used herein, the words 'Sodium channel, voltage-gated, type I, alpha subunit', SCN1A, FEB3, FEB3A, GEFSP2, HBSCI, NAC1, Nav1.1, SCN1, SMEI, Sodium channel protein brain I subunit alpha, Sodium channel protein type I subunit alpha, Sodium channel protein type I subunit alpha and Voltage-gated sodium channel subunit alpha Nav1.1, are considered the same in the literature and are used interchangeably in the present application.

[0052] As used herein, the term "oligonucleotide specific for" or "oligonucleotide which targets" refers to an oligonucleotide having a sequence (i) capable of forming a stable complex with a portion of the targeted gene, or (ii) capable of forming a stable duplex with a portion of a mRNA transcript of the targeted gene. Stability of the complexes

and duplexes can be determined by theoretical calculations and/or in vitro assays. Exemplary assays for determining stability of hybridization complexes and duplexes are described in the Examples below.

[0053] As used herein, the term "target nucleic acid" encompasses DNA, RNA (comprising premRNA and mRNA) transcribed from such DNA, and also cDNA derived from such RNA, coding, noncoding sequences, sense or antisense polynucleotides. The specific hybridization of an oligomeric compound with its target nucleic acid interferes with the normal function of the nucleic acid. This modulation of function of a target nucleic acid by compounds, which specifically hybridize to it, is generally referred to as "antisense". The functions of DNA to be interfered include, for example, replication and transcription. The functions of RNA to be interfered, include all vital functions such as, for example, translocation of the RNA to the site of protein translation, translation of protein from the RNA, splicing of the RNA to yield one or more mRNA species, and catalytic activity which may be engaged in or facilitated by the RNA. The overall effect of such interference with target nucleic acid function is modulation of the expression of an encoded product or oligonucleotides.

[0054] RNA interference "RNAi" is mediated by double stranded RNA (dsRNA) molecules that have sequence-specific homology to their "target" nucleic acid sequences. In certain embodiments of the present invention, the mediators are 5-25 nucleotide "small interfering" RNA duplexes (siRNAs). The siRNAs are derived from the processing of dsRNA by an RNase enzyme known as Dicer. siRNA duplex products are recruited into a multi-protein siRNA complex termed RISC (RNA Induced Silencing Complex). Without wishing to be bound by any particular theory, a RISC is then believed to be guided to a target nucleic acid (suitably mRNA), where the siRNA duplex interacts in a sequence-specific way to mediate cleavage in a catalytic fashion. Small interfering RNAs that can be used in accordance with the present invention can be synthesized and used according to procedures that are well known in the art and that will be familiar to the ordinarily skilled artisan. Small interfering RNAs for use in the methods of the present invention suitably comprise between about 1 to about 50 nucleotides (nt). In examples of non limiting embodiments, siRNAs can comprise about 5 to about 40 nt, about 5 to about 30 nt, about 10 to about 30 nt, about 15 to about 25 nt, or about 20-25 nucleotides.

[0055] Selection of appropriate oligonucleotides is facilitated by using computer programs that automatically align nucleic acid sequences and indicate regions of identity or homology. Such programs are used to compare nucleic acid sequences obtained, for example, by searching databases such as GenBank or by sequencing PCR products. Comparison of nucleic acid sequences from a range of species allows the selection of nucleic acid sequences that display an appropriate degree of identity between species. In the case of genes that have not been sequenced, Southern blots are performed to allow a determination of the degree of identity between genes in target species and other species. By performing Southern blots at varying degrees of stringency, as is well known in the art, it is possible to obtain an approximate measure of identity. These procedures allow the selection of oligonucleotides that exhibit a high degree of complementarity to target nucleic acid sequences in a subject to be controlled and a lower degree of complementarity

to corresponding nucleic acid sequences in other species. One skilled in the art will realize that there is considerable latitude in selecting appropriate regions of genes for use in the present invention.

[0056] By "enzymatic RNA" is meant an RNA molecule with enzymatic activity (Cech, (1988) *J. American. Med. Assoc.* 260, 3030-3035). Enzymatic nucleic acids (ribozymes) act by first binding to a target RNA. Such binding occurs through the target binding portion of an enzymatic nucleic acid which is held in close proximity to an enzymatic portion of the molecule that acts to cleave the target RNA. Thus, the enzymatic nucleic acid first recognizes and then binds a target RNA through base pairing, and once bound to the correct site, acts enzymatically to cut the target RNA.

[0057] By "decoy RNA" is meant an RNA molecule that mimics the natural binding domain for a ligand. The decoy RNA therefore competes with natural binding target for the binding of a specific ligand. For example, it has been shown that over-expression of HIV trans-activation response (TAR) RNA can act as a "decoy" and efficiently binds HIV tat protein, thereby preventing it from binding to TAR sequences encoded in the HIV RNA. This is meant to be a specific example. Those in the art will recognize that this is but one example, and other embodiments can be readily generated using techniques generally known in the art.

[0058] As used herein, the term "monomers" typically indicates monomers linked by phosphodiester bonds or analogs thereof to form oligonucleotides ranging in size from a few monomeric units, e.g., from about 3-4, to about several hundreds of monomeric units. Analogs of phosphodiester linkages include: phosphorothioate, phosphorodithioate, methylphosphonates, phosphoroselenoate, phosphoramidate, and the like, as more fully described below.

[0059] The term "nucleotide" covers naturally occurring nucleotides as well as nonnaturally occurring nucleotides. It should be clear to the person skilled in the art that various nucleotides which previously have been considered "non-naturally occurring" have subsequently been found in nature. Thus, "nucleotides" includes not only the known purine and pyrimidine heterocycles-containing molecules, but also heterocyclic analogues and tautomers thereof. Illustrative examples of other types of nucleotides are molecules containing adenine, guanine, thymine, cytosine, uracil, purine, xanthine, diaminopurine, 8-oxo- N6-methyladenine, 7-deazaxanthine, 7-deazaguanine, N4,N4-ethanocytosin, N6,N6-ethano-2,6- diaminopurine, 5-methylcytosine, 5-(C3-C6)-alkynyleytosine, 5-fluorouracil, 5-bromouracil, pseudoisocytosine, 2-hydroxy-5-methyl-4-triazolopyridin, isocytosine, isoguanin, inosine and the "non-naturally occurring" nucleotides described in Benner *et al.*, U.S. Pat No. 5,432,272. The term "nucleotide" is intended to cover every and all of these examples as well as analogues and tautomers thereof. Especially interesting nucleotides are those containing adenine, guanine, thymine, cytosine, and uracil, which are considered as the naturally occurring nucleotides in relation to therapeutic and diagnostic application in humans. Nucleotides include the natural 2'-deoxy and 2'-hydroxyl sugars, e.g., as described in Kornberg and Baker, *DNA Replication*, 2nd Ed. (Freeman, San Francisco, 1992) as well as their analogs.

[0060] "Analog" in reference to nucleotides includes synthetic nucleotides having modified base moieties and/or modified sugar moieties (see e.g., described generally by Scheit, *Nucleotide Analogs*, John Wiley, New York, 1980;

Freier & Altmann, (1997) *Nucl. Acid. Res.*, 25(22), 4429- 4443, Toulmé, J.J., (2001) *Nature Biotechnology* 19:17-18; Manoharan M., (1999) *Biochemica et Biophysica Acta* 1489:117-139; Freier S. M., (1997) *Nucleic Acid Research*, 25:4429-4443, Uhlman, E., (2000) *Drug Discovery & Development*, 3: 203-213, Herdewin P., (2000) *Antisense & Nucleic Acid Drug Dev.*, 10:297-310); 2'-O, 3'-C-linked [3.2.0] bicycloarabinonucleosides. Such analogs include  
5 synthetic nucleotides designed to enhance binding properties, e.g., duplex or triplex stability, specificity, or the like.

[0061] As used herein, "hybridization" means the pairing of substantially complementary strands of oligomeric compounds. One mechanism of pairing involves hydrogen bonding, which may be Watson-Crick, Hoögsteen or reversed Hoögsteen hydrogen bonding, between complementary nucleoside or nucleotide bases (nucleotides) of the strands of oligomeric compounds. For example, adenine and thymine are complementary nucleotides which pair  
10 through the formation of hydrogen bonds. Hybridization can occur under varying circumstances.

[0062] An antisense compound is "specifically hybridizable" when binding of the compound to the target nucleic acid interferes with the normal function of the target nucleic acid to cause a modulation of function and/or activity, and there is a sufficient degree of complementarity to avoid non-specific binding of the antisense compound to non-target nucleic acid sequences under conditions in which specific binding is desired, i.e., under physiological conditions in the case of  
15 in vivo assays or therapeutic treatment, and under conditions in which assays are performed in the case of in vitro assays.

[0063] As used herein, the phrase "stringent hybridization conditions" or "stringent conditions" refers to conditions under which a compound of the invention will hybridize to its target sequence, but to a minimal number of other sequences. Stringent conditions are sequence-dependent and will be different in different circumstances and in the  
20 context of this invention, "stringent conditions" under which oligomeric compounds hybridize to a target sequence are determined by the nature and composition of the oligomeric compounds and the assays in which they are being investigated. In general, stringent hybridization conditions comprise low concentrations (<0.15M) of salts with inorganic cations such as Na<sup>++</sup> or K<sup>++</sup> (i.e., low ionic strength), temperature higher than 20°C - 25° C. below the T<sub>m</sub> of the oligomeric compound:target sequence complex, and the presence of denaturants such as formamide,  
25 dimethylformamide, dimethyl sulfoxide, or the detergent sodium dodecyl sulfate (SDS). For example, the hybridization rate decreases 1.1% for each 1% formamide. An example of a high stringency hybridization condition is 0.1X sodium chloride-sodium citrate buffer (SSC)/0.1% (w/v) SDS at 60° C. for 30 minutes.

[0064] "Complementary," as used herein, refers to the capacity for precise pairing between two nucleotides on one or two oligomeric strands. For example, if a nucleobase at a certain position of an antisense compound is capable of  
30 hydrogen bonding with a nucleobase at a certain position of a target nucleic acid, said target nucleic acid being a DNA, RNA, or oligonucleotide molecule, then the position of hydrogen bonding between the oligonucleotide and the target nucleic acid is considered to be a complementary position. The oligomeric compound and the further DNA, RNA, or oligonucleotide molecule are complementary to each other when a sufficient number of complementary positions in



each molecule are occupied by nucleotides which can hydrogen bond with each other. Thus, "specifically hybridizable" and "complementary" are terms which are used to indicate a sufficient degree of precise pairing or complementarity over a sufficient number of nucleotides such that stable and specific binding occurs between the oligomeric compound and a target nucleic acid.

5 [0065] It is understood in the art that the sequence of an oligomeric compound need not be 100% complementary to that of its target nucleic acid to be specifically hybridizable. Moreover, an oligonucleotide may hybridize over one or more segments such that intervening or adjacent segments are not involved in the hybridization event (e.g., a loop structure, mismatch or hairpin structure). The oligomeric compounds of the present invention comprise at least about 70%, or at least about 75%, or at least about 80%, or at least about 85%, or at least about 90%, or at least about 95%, or  
10 at least about 99% sequence complementarity to a target region within the target nucleic acid sequence to which they are targeted. For example, an antisense compound in which 18 of 20 nucleotides of the antisense compound are complementary to a target region, and would therefore specifically hybridize, would represent 90 percent complementarity. In this example, the remaining non-complementary nucleotides may be clustered or interspersed with complementary nucleotides and need not be contiguous to each other or to complementary nucleotides. As such, an  
15 antisense compound which is 18 nucleotides in length having 4 (four) non-complementary nucleotides which are flanked by two regions of complete complementarity with the target nucleic acid would have 77.8% overall complementarity with the target nucleic acid and would thus fall within the scope of the present invention. Percent complementarity of an antisense compound with a region of a target nucleic acid can be determined routinely using BLAST programs (basic local alignment search tools) and PowerBLAST programs known in the art. Percent  
20 homology, sequence identity or complementarity, can be determined by, for example, the Gap program (Wisconsin Sequence Analysis Package, Version 8 for Unix, Genetics Computer Group, University Research Park, Madison Wis.), using default settings, which uses the algorithm of Smith and Waterman (*Adv. Appl. Math.*, (1981) 2, 482-489).

[0066] As used herein, the term "Thermal Melting Point (T<sub>m</sub>)" refers to the temperature, under defined ionic strength, pH, and nucleic acid concentration, at which 50% of the oligonucleotides complementary to the target sequence  
25 hybridize to the target sequence at equilibrium. Typically, stringent conditions will be those in which the salt concentration is at least about 0.01 to 1.0 M Na ion concentration (or other salts) at pH 7.0 to 8.3 and the temperature is at least about 30°C for short oligonucleotides (e.g., 10 to 50 nucleotide). Stringent conditions may also be achieved with the addition of destabilizing agents such as formamide.

[0067] As used herein, "modulation" means either an increase (stimulation) or a decrease (inhibition) in the expression  
30 of a gene.

[0068] The term "variant", when used in the context of a polynucleotide sequence, may encompass a polynucleotide sequence related to a wild type gene. This definition may also include, for example, "allelic," "splice," "species," or "polymorphic" variants. A splice variant may have significant identity to a reference molecule, but will generally have

a greater or lesser number of polynucleotides due to alternate splicing of exons during mRNA processing. The corresponding polypeptide may possess additional functional domains or an absence of domains. Species variants are polynucleotide sequences that vary from one species to another. Of particular utility in the invention are variants of wild type gene products. Variants may result from at least one mutation in the nucleic acid sequence and may result in altered mRNAs or in polypeptides whose structure or function may or may not be altered. Any given natural or recombinant gene may have none, one, or many allelic forms. Common mutational changes that give rise to variants are generally ascribed to natural deletions, additions, or substitutions of nucleotides. Each of these types of changes may occur alone, or in combination with the others, one or more times in a given sequence.

[0069] The resulting polypeptides generally will have significant amino acid identity relative to each other. A polymorphic variant is a variation in the polynucleotide sequence of a particular gene between individuals of a given species. Polymorphic variants also may encompass "single nucleotide polymorphisms" (SNPs,) or single base mutations in which the polynucleotide sequence varies by one base. The presence of SNPs may be indicative of, for example, a certain population with a propensity for a disease state, that is susceptibility versus resistance.

[0070] Derivative polynucleotides include nucleic acids subjected to chemical modification, for example, replacement of hydrogen by an alkyl, acyl, or amino group. Derivatives, e.g., derivative oligonucleotides, may comprise non-naturally-occurring portions, such as altered sugar moieties or inter-sugar linkages. Exemplary among these are phosphorothioate and other sulfur containing species which are known in the art. Derivative nucleic acids may also contain labels, including radionucleotides, enzymes, fluorescent agents, chemiluminescent agents, chromogenic agents, substrates, cofactors, inhibitors, magnetic particles, and the like.

[0071] A "derivative" polypeptide or peptide is one that is modified, for example, by glycosylation, pegylation, phosphorylation, sulfation, reduction/alkylation, acylation, chemical coupling, or mild formalin treatment. A derivative may also be modified to contain a detectable label, either directly or indirectly, including, but not limited to, a radioisotope, fluorescent, and enzyme label.

[0072] As used herein, the term "animal" or "patient" is meant to include, for example, humans, sheep, elks, deer, mule deer, minks, mammals, monkeys, horses, cattle, pigs, goats, dogs, cats, rats, mice, birds, chicken, reptiles, fish, insects and arachnids.

[0073] "Mammal" covers warm blooded mammals that are typically under medical care (e.g., humans and domesticated animals). Examples include feline, canine, equine, bovine, and human, as well as just human.

[0074] "Treating" or "treatment" covers the treatment of a disease-state in a mammal, and includes: (a) preventing the disease-state from occurring in a mammal, in particular, when such mammal is predisposed to the disease-state but has not yet been diagnosed as having it; (b) inhibiting the disease-state, e.g., arresting its development; and/or (c) relieving the disease-state, e.g., causing regression of the disease state until a desired endpoint is reached. Treating also includes

the amelioration of a symptom of a disease (e.g., lessen the pain or discomfort), wherein such amelioration may or may not be directly affecting the disease (e.g., cause, transmission, expression, etc.).

[0075] As used herein a "Neurological disease or disorder" refers to any disease or disorder of the nervous system and/or visual system. "Neurological disease or disorder" include disease or disorders that involve the central nervous system (brain, brainstem and cerebellum), the peripheral nervous system (including cranial nerves), and the autonomic nervous system (parts of which are located in both central and peripheral nervous system). A Neurological disease or disorder includes but is not limited to acquired epileptiform aphasia; acute disseminated encephalomyelitis; adrenoleukodystrophy; age-related macular degeneration; agenesis of the corpus callosum; agnosia; Aicardi syndrome; Alexander disease; Alpers' disease; alternating hemiplegia; Alzheimer's disease; Vascular dementia; amyotrophic lateral sclerosis; anencephaly; Angelman syndrome; angiomatosis; anoxia; aphasia; apraxia; arachnoid cysts; arachnoiditis; Arnold-Chiari malformation; arteriovenous malformation; Asperger syndrome; ataxia telangiectasia; attention deficit hyperactivity disorder; autism; autonomic dysfunction; back pain; Batten disease; Behcet's disease; Bell's palsy; benign essential blepharospasm; benign focal; amyotrophy; benign intracranial hypertension; Binswanger's disease; blepharospasm; Bloch Sulzberger syndrome; brachial plexus injury; brain abscess; brain injury; brain tumors (including glioblastoma multiforme); spinal tumor; Brown-Sequard syndrome; Canavan disease; carpal tunnel syndrome; causalgia; central pain syndrome; central pontine myelinolysis; cephalic disorder; cerebral aneurysm; cerebral arteriosclerosis; cerebral atrophy; cerebral gigantism; cerebral palsy; Charcot-Marie-Tooth disease; chemotherapy-induced neuropathy and neuropathic pain; Chiari malformation; chorea; chronic inflammatory demyelinating polyneuropathy; chronic pain; chronic regional pain syndrome; Coffin Lowry syndrome; coma, including persistent vegetative state; congenital facial diplegia; corticobasal degeneration; cranial arteritis; craniostyosis; Creutzfeldt-Jakob disease; cumulative trauma disorders; Cushing's syndrome; cytomegalic inclusion body disease; cytomegalovirus infection; dancing eyes-dancing feet syndrome; DandyWalker syndrome; Dawson disease; De Morsier's syndrome; Dejerine-Klumpke palsy; dementia; dermatomyositis; diabetic neuropathy; diffuse sclerosis; Dravet's, dysautonomia; dysgraphia; dyslexia; dystonias; early infantile epileptic encephalopathy; empty sella syndrome; encephalitis; encephaloceles; encephalotrigeminal angiomatosis; epilepsy; Erb's palsy; essential tremor; Fabry's disease; Fahr's syndrome; fainting; familial spastic paralysis; febrile seizures; Fisher syndrome; Friedreich's ataxia; fronto-temporal dementia and other "tauopathies"; Gaucher's disease; Gerstmann's syndrome; giant cell arteritis; giant cell inclusion disease; globoid cell leukodystrophy; Guillain-Barre syndrome; HTLV-1-associated myelopathy; Hallervorden-Spatz disease; head injury; headache; hemifacial spasm; hereditary spastic paraplegia; heredopathia atactica polyneuritiformis; herpes zoster ophthalmicus; herpes zoster; Hirayama syndrome; HIV-associated dementia and neuropathy (also neurological manifestations of AIDS); holoprosencephaly; Huntington's disease and other polyglutamine repeat diseases; hydranencephaly; hydrocephalus; hypercortisolism; hypoxia; immune-mediated encephalomyelitis; inclusion body myositis; incontinentia pigmenti; infantile phytanic acid storage disease; infantile

refsum disease; infantile spasms; inflammatory myopathy; intracranial cyst; intracranial hypertension; Joubert syndrome; Keams-Sayre syndrome; Kennedy disease Kinsbourne syndrome; Klippel Feil syndrome; Krabbe disease; Kugelberg-Welander disease; kuru; Lafora disease; Lambert-Eaton myasthenic syndrome; Landau-Kleffner syndrome; lateral medullary (Wallenberg) syndrome; learning disabilities; Leigh's disease; Lennox-Gustaut syndrome; Lesch-Nyhan syndrome; leukodystrophy; Lewy body dementia; Lissencephaly; locked-in syndrome; Lou Gehrig's disease (i.e., motor neuron disease or amyotrophic lateral sclerosis); lumbar disc disease; Lyme disease--neurological sequelae; Machado-Joseph disease; macrencephaly; megalencephaly; Melkersson-Rosenthal syndrome; Menieres disease; meningitis; Menkes disease; metachromatic leukodystrophy; microcephaly; migraine; Miller Fisher syndrome; mini-strokes; mitochondrial myopathies; Mobius syndrome; monomelic amyotrophy; motor neuron disease; Moyamoya disease; mucopolysaccharidoses; multi-infarct dementia; multifocal motor neuropathy; multiple sclerosis and other demyelinating disorders; multiple system atrophy with postural hypotension; muscular dystrophy; myasthenia gravis; myelinoclastic diffuse sclerosis; myoclonic encephalopathy of infants; myoclonus; myopathy; myotonia congenital; narcolepsy; neurofibromatosis; neuroleptic malignant syndrome; neurological manifestations of AIDS; neurological sequelae of lupus; neuromyotonia; neuronal ceroid lipofuscinosis; neuronal migration disorders; Niemann-Pick disease; O'Sullivan-McLeod syndrome; occipital neuralgia; occult spinal dysraphism sequence; Ohtahara syndrome; olivopontocerebellar atrophy; opsoclonus myoclonus; optic neuritis; orthostatic hypotension; overuse syndrome; paresthesia; a neurodegenerative disease or disorder (Parkinson's disease, Huntington's disease, Alzheimer's disease, amyotrophic lateral sclerosis (ALS), dementia, multiple sclerosis and other diseases and disorders associated with neuronal cell death); paramyotonia congenital; paraneoplastic diseases; paroxysmal attacks; Parry Romberg syndrome; Pelizaeus-Merzbacher disease; periodic paralyses; peripheral neuropathy; painful neuropathy and neuropathic pain; persistent vegetative state; pervasive developmental disorders; photic sneeze reflex; phytanic acid storage disease; Pick's disease; pinched nerve; pituitary tumors; polymyositis; porencephaly; post-polio syndrome; postherpetic neuralgia; postinfectious encephalomyelitis; postural hypotension; Prader- Willi syndrome; primary lateral sclerosis; prion diseases; progressive hemifacial atrophy; progressive multifocalleukoencephalopathy; progressive sclerosing poliodystrophy; progressive supranuclear palsy; pseudotumor cerebri; Ramsay-Hunt syndrome (types I and II); Rasmussen's encephalitis; reflex sympathetic dystrophy syndrome; Refsum disease; repetitive motion disorders; repetitive stress injuries; restless legs syndrome; retrovirus-associated myelopathy; Rett syndrome; Reye's syndrome; Saint Vitus dance; Sandhoff disease; Schilder's disease; schizencephaly; septo-optic dysplasia; shaken baby syndrome; shingles; Shy-Drager syndrome; Sjogren's syndrome; sleep apnea; Soto's syndrome; spasticity; spina bifida; spinal cord injury; spinal cord tumors; spinal muscular atrophy; Stiff-Person syndrome; stroke; Sturge-Weber syndrome; subacute sclerosing panencephalitis; subcortical arteriosclerotic encephalopathy; Sydenham chorea; syncope; syringomyelia; tardive dyskinesia; Tay-Sachs disease; temporal arteritis; tethered spinal cord syndrome; Thomsen disease; thoracic outlet syndrome; Tic Douloureux; Todd's paralysis; Tourette syndrome; transient ischemic attack; transmissible

spongiform encephalopathies; transverse myelitis; traumatic brain injury; tremor; trigeminal neuralgia; tropical spastic paraparesis; tuberculous sclerosis; vascular dementia (multi-infarct dementia); vasculitis including temporal arteritis; Von Hippel-Lindau disease; Wallenberg's syndrome; Werdnig-Hoffman disease; West syndrome; whiplash; Williams syndrome; Wildon's disease; and Zellweger syndrome and other neurological disorders recited herein.

5 [0076] A cardiovascular disease or disorder includes those disorders that can either cause ischemia or are caused by reperfusion of the heart. Examples include, but are not limited to, atherosclerosis, coronary artery disease, granulomatous myocarditis, chronic myocarditis (non-granulomatous), primary hypertrophic cardiomyopathy, peripheral artery disease (PAD), peripheral vascular disease, venous thromboembolism, pulmonary embolism, stroke, angina pectoris, myocardial infarction, cardiovascular tissue damage caused by cardiac arrest, cardiovascular tissue  
10 damage caused by cardiac bypass, cardiogenic shock, and related conditions that would be known by those of ordinary skill in the art or which involve dysfunction of or tissue damage to the heart or vasculature, especially, but not limited to, tissue damage related to SCNA activation. CVS diseases include, but are not limited to, atherosclerosis, granulomatous myocarditis, myocardial infarction, myocardial fibrosis secondary to valvular heart disease, myocardial fibrosis without infarction, primary hypertrophic cardiomyopathy, and chronic myocarditis (non-granulomatous).

15 [0077] Examples of diseases or disorders associated with sodium channel dysfunction include, but are not restricted to, malignant hyperthermia, myasthenia, episodic ataxia, neuropathic and inflammatory pain, Alzheimer's disease, Parkinson's disease, schizophrenia, hyperekplexia, myotonias such as hypo- and hyperkalaemic periodic paralysis, paramyotonia congenita and potassium aggravated myotonia as well as cardiac arrhythmias such as long QT syndrome.  
*Polynucleotide and Oligonucleotide Compositions and Molecules*

20 [0078] *Targets:* In one embodiment, the targets comprise nucleic acid sequences of Sodium channel, voltage-gated, alpha subunit (SCNA), including without limitation sense and/or antisense noncoding and/or coding sequences associated with SCNA.

[0079] Voltage-sensitive ion channels are a class of transmembrane proteins that provide a basis for cellular excitability and the ability to transmit information via ion-generated membrane potentials. In response to changes in  
25 membrane potentials, these molecules mediate rapid ion flux through selective channels in a cell membrane. If channel density is high enough, a regenerative depolarization results, which is called an action potential.

[0080] The voltage-gated sodium channel is responsible for the generation and propagation of action potentials in most electrically excitable cells, including neurons, heart cells, and muscle. Electrical activity is triggered by depolarization of the membrane, which opens channels through the membrane that are highly selective for sodium ions.  
30 Ions are then driven intracellularly through open channels by an electrochemical gradient. Although sodium-based action potentials in different tissues are similar, electrophysiological studies have demonstrated that multiple structurally and functionally distinct sodium channels exist, and numerous genes encoding sodium channels have been cloned. The SCNA gene belongs to a gene family of voltage-gated sodium channels.

[0081] Voltage-gated sodium channels can be named according to a standardized form of nomenclature outlined in Goldin, et al. (2000) *Neuron* 28:365-368. According to that system, voltage-gated sodium channels are grouped into one family from which nine mammalian isoforms and have been identified and expressed. These nine isoforms are given the names Nav1.1 through Nav1.9. Also, splice variants of the various isoforms are distinguished by the use of lower case letters following the numbers (e.g., "Nav1.1a").

[0082] Voltage-gated sodium channels play an important role in the generation of action potential in nerve cells and muscle. The alpha subunit (SCNA) is the main component of the channel, and would be sufficient to generate an efficient channel when expressed in cells in vitro. In turn, the beta-1 and 2 subunits need an alpha subunit to give an effective channel. The role of these subunits would be to modify the kinetic properties of the channel, mainly by fast inactivation of the sodium currents. The mutation found in the GEFS syndrome on the SCN1B gene is shown to reduce the fast inactivation of the sodium channels as compared to a normal SCN1B, when co-expressed with an alpha subunit.

[0083] In an embodiment, antisense oligonucleotides are used to prevent or treat diseases or disorders associated with SCNA family members. Exemplary Sodium channel, voltage-gated, alpha subunit (SCNA) mediated diseases and disorders which can be treated with cell/tissues regenerated from stem cells obtained using the antisense compounds comprise: a disease or disorder associated with abnormal function and/or expression of SCNA, a neurological disease or disorder, convulsion, pain (including chronic pain), impaired electrical excitability involving sodium channel dysfunction, a disease or disorder associated with sodium channel dysfunction, a disease or disorder associated with misregulation of voltage-gated sodium channel alpha subunit activity (e.g., paralysis, hyperkalemic periodic paralysis, paramyotonia congenita, potassium-aggravated myotonia, long Q-T syndrome 3, motor endplate disease, ataxia etc.), a gastrointestinal tract disease due to dysfunction of the enteric nervous system (e.g., colitis, ileitis, inflammatory bowel syndrome etc.), a cardiovascular disease or disorder (e.g., hypertension, congestive heart failure etc.); a disease or disorder of the genitourinary tract involving sympathetic and parasympathetic innervation (e.g., benign prostrate hyperplasia, impotence); a disease or disorder associated with neuromuscular system (e.g., muscular dystrophy, multiple sclerosis, epilepsy, autism, migraine (e.g., Sporadic and familial hemiplegic migraines etc.), Severe myoclonic epilepsy of infancy (SMEI or Dravet's syndrome), Generalised epilepsy with febrile seizure plus (GEFS+) etc.) and SCNA-related seizure disorders.

[0084] The present invention further relates to a pharmaceutical composition comprising at least one of an oligonucleotide that targets a natural antisense transcript to at least one or more of a target selected from the group consisting of SCN1A to SCN12A genes or mRNAs or isoforms or variants thereof. The present invention further relates to a method of treating a neurological disease or disorder comprising administering an oligonucleotide that targets a natural antisense transcript of at least one or more of a target selected from the group consisting of mRNA SCN1A, SCN2A, SCN3A, SCN4A, SCN5A, SCN6A, SCN7A, SCN8A, SCN9A, SCN10A, SCN11A and SCN12A

or variant thereof. In a preferred embodiment, oligos are selected to upregulate the expression of a fully functional expression product of said SCNA family. In a preferred embodiment, the oligos of the invention upregulate transcription and/or translation of any one of the mRNAs of an SCNXA family of genes to provide fully functional sodium channels in a patient in need of treatment thereof. In patients having a disease or disorder associated with a mutated version of a voltage gated sodium channel, in a preferred embodiment administration or treatment with a pharmaceutical composition comprising an oligonucleotide that targets a natural antisense transcript of a voltage gated sodium channel alpha gene or mRNA of such a gene upregulates a fully functional expression product in a ratio that is greater than the upregulation of an expression product derived from a mutated form of the gene. In another embodiment, the present invention relates to a combination of oligonucleotides that target at least one natural antisense transcript of at least two SCNXA family members wherein X is selected from 1-12. For example, in the treatment of Dravett's Syndrome, a combination of oligonucleotides may be used to upregulate the expression products of, for example, SCN1A and SCN9A. In another embodiment, at least one oligonucleotide may be selected to target a natural antisense transcript of at least two genes selected from any one of SCN1A to SCN12A. Preferred oligonucleotides of the invention are between about 5 to about 30 nucleotides in length and are at least 50% complementary to a 5 to about 30 nucleotide segment of an NAT. Preferred NATs of any one of the SCNA genes or transcription products thereof are those which, when targeted by an oligonucleotide of the invention, interfere with and modulate the expression of mRNA and/or the translation product of said mRNA. In a preferred embodiment, the oligonucleotides upregulate the expression of the functional protein of the target to treat or mitigate an SCNA associated disease. In a preferred embodiment, this "upregulation" is not associated with a cause or promotion of a disease such as cancer.

[0085] Alterations in an SCNA gene may include or encompass many or all forms of gene mutations including insertions, deletions, rearrangements and/or point mutations in the coding and/or non-coding regions of a gene. Deletions may be of the entire gene or a portion of the gene. Point mutations may result in amino acid substitutions, frame shifts or stop codons. Point mutations may also occur in a regulatory region of an SCNA gene, such as a promoter, resulting in a loss or a decrease of expression of an mRNA or may result in improper processing of such mRNA leading to a decrease in stability or translation efficiency. Such alterations in humans may lead to various forms of disease and there are many publications which describe the association of an alteration in an SCNA gene with, for example, epilepsy or SMEI. Such alterations may be "de novo" or may be inherited. The present invention is not limited to treating diseases associated with alterations in an SCNA gene and also includes treatment of an SCNA associated disease or condition wherein a patient does not have or necessarily have an alteration or mutation in the SCNA gene. It is believed that any modulation or upregulation of functional voltage gated sodium channel expression products will result in mitigation or treatment of an associated SCNA disease or condition in a patient in need of treatment thereof. Such mitigation also may include at least one measurable indicia of clinical improvement including

fewer seizures, less frequent seizures, less severe seizures, development of fewer seizure types, improvement in neurological development or any other treatment benefit.

[0086] In an embodiment, modulation of SCNA by one or more antisense oligonucleotides is administered to a patient in need thereof, to prevent or treat any disease or disorder related to SCNA abnormal expression, function, activity as compared to a normal control.

[0087] In an embodiment, the oligonucleotides are specific for polynucleotides of SCNA, which includes, without limitation noncoding regions. The SCNA targets comprise variants of SCNA; mutants of SCNA, including SNPs; noncoding sequences of SCNA; alleles, fragments and the like. Preferably the oligonucleotide is an antisense RNA molecule.

[0088] In accordance with embodiments of the invention, the target nucleic acid molecule is not limited to SCNA polynucleotides alone but extends to any of the isoforms, receptors, homologs, non-coding regions and the like of SCNA.

[0089] In an embodiment, an oligonucleotide targets a natural antisense sequence (natural antisense to the coding and non-coding regions) of SCNA targets, including, without limitation, variants, alleles, homologs, mutants, derivatives, fragments and complementary sequences thereto. Preferably the oligonucleotide is an antisense RNA or DNA molecule.

[0090] In an embodiment, the oligomeric compounds of the present invention also include variants in which a different base is present at one or more of the nucleotide positions in the compound. For example, if the first nucleotide is an adenine, variants may be produced which contain thymidine, guanosine, cytidine or other natural or unnatural nucleotides at this position. This may be done at any of the positions of the antisense compound. These compounds are then tested using the methods described herein to determine their ability to inhibit expression of a target nucleic acid.

[0091] In some embodiments, homology, sequence identity or complementarity, between the antisense compound and target is from about 50% to about 60%. In some embodiments, homology, sequence identity or complementarity, is from about 60% to about 70%. In some embodiments, homology, sequence identity or complementarity, is from about 70% to about 80%. In some embodiments, homology, sequence identity or complementarity, is from about 80% to about 90%. In some embodiments, homology, sequence identity or complementarity, is about 90%, about 92%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99% or about 100%.

[0092] An antisense compound is specifically hybridizable when binding of the compound to the target nucleic acid interferes with the normal function of the target nucleic acid to cause a loss of activity, and there is a sufficient degree of complementarity to avoid non-specific binding of the antisense compound to non-target nucleic acid sequences under conditions in which specific binding is desired. Such conditions include, i.e., physiological conditions in the case of in vivo assays or therapeutic treatment, and conditions in which assays are performed in the case of in vitro assays.



[0093] An antisense compound, whether DNA, RNA, chimeric, substituted etc, is specifically hybridizable when binding of the compound to the target DNA or RNA molecule interferes with the normal function of the target DNA or RNA to cause a loss of utility, and there is a sufficient degree of complementarity to avoid non-specific binding of the antisense compound to non-target sequences under conditions in which specific binding is desired, i.e., under physiological conditions in the case of in vivo assays or therapeutic treatment, and in the case of in vitro assays, under conditions in which the assays are performed.

[0094] In an embodiment, targeting of SCNA including without limitation, antisense sequences which are identified and expanded, using for example, PCR, hybridization etc., one or more of the sequences set forth as SEQ ID NOS: 12 to 28, and the like, modulate the expression or function of SCNA. In one embodiment, expression or function is upregulated as compared to a control. In an embodiment, expression or function is down-regulated as compared to a control.

[0095] In an embodiment, oligonucleotides comprise nucleic acid sequences set forth as SEQ ID NOS: 29 to 94 including antisense sequences which are identified and expanded, using for example, PCR, hybridization etc. These oligonucleotides can comprise one or more modified nucleotides, shorter or longer fragments, modified bonds and the like. Examples of modified bonds or internucleotide linkages comprise phosphorothioate, phosphorodithioate or the like. In an embodiment, the nucleotides comprise a phosphorus derivative. The phosphorus derivative (or modified phosphate group) which may be attached to the sugar or sugar analog moiety in the modified oligonucleotides of the present invention may be a monophosphate, diphosphate, triphosphate, alkylphosphate, alkanephosphate, phosphorothioate and the like. The preparation of the above-noted phosphate analogs, and their incorporation into nucleotides, modified nucleotides and oligonucleotides, per se, is also known and need not be described here.

[0096] The specificity and sensitivity of antisense is also harnessed by those of skill in the art for therapeutic uses. Antisense oligonucleotides have been employed as therapeutic moieties in the treatment of disease states in animals and man. Antisense oligonucleotides have been safely and effectively administered to humans and numerous clinical trials are presently underway. It is thus established that oligonucleotides can be useful therapeutic modalities that can be configured to be useful in treatment regimes for treatment of cells, tissues and animals, especially humans.

[0097] In embodiments of the present invention oligomeric antisense compounds, particularly oligonucleotides, bind to target nucleic acid molecules and modulate the expression and/or function of molecules encoded by a target gene. The functions of DNA to be interfered comprise, for example, replication and transcription. The functions of RNA to be interfered comprise all vital functions such as, for example, translocation of the RNA to the site of protein translation, translation of protein from the RNA, splicing of the RNA to yield one or more mRNA species, and catalytic activity which may be engaged in or facilitated by the RNA. The functions may be upregulated or inhibited depending on the functions desired.

[0098] The antisense compounds, include, antisense oligomeric compounds, antisense oligonucleotides, external guide sequence (EGS) oligonucleotides, alternate splicers, primers, probes, and other oligomeric compounds that hybridize to at least a portion of the target nucleic acid. As such, these compounds may be introduced in the form of single-stranded, double-stranded, partially single-stranded, or circular oligomeric compounds.

5 [0099] Targeting an antisense compound to a particular nucleic acid molecule, in the context of this invention, can be a multistep process. The process usually begins with the identification of a target nucleic acid whose function is to be modulated. This target nucleic acid may be, for example, a cellular gene (or mRNA transcribed from the gene) whose expression is associated with a particular disorder or disease state, or a nucleic acid molecule from an infectious agent. In the present invention, the target nucleic acid encodes Sodium channel, voltage-gated, alpha subunit (SCNA).

10 [00100] The targeting process usually also includes determination of at least one target region, segment, or site within the target nucleic acid for the antisense interaction to occur such that the desired effect, e.g., modulation of expression, will result. Within the context of the present invention, the term "region" is defined as a portion of the target nucleic acid having at least one identifiable structure, function, or characteristic. Within regions of target nucleic acids are segments. "Segments" are defined as smaller or sub-portions of regions within a target nucleic acid. "Sites," as used in  
15 the present invention, are defined as positions within a target nucleic acid.

[00101] In an embodiment, the antisense oligonucleotides bind to the natural antisense sequences of Sodium channel, voltage-gated, alpha subunit (SCNA) and modulate the expression and/or function of SCNA (SEQ ID NO: 1 to 11). Examples of natural antisense sequences include SEQ ID NOS: 12 to 28. Examples of antisense oligonucleotides include SEQ ID NOS: 29 to 94.

20 [00102] In an embodiment, the antisense oligonucleotides bind to one or more segments of Sodium channel, voltage-gated, alpha subunit (SCNA) polynucleotides and modulate the expression and/or function of SCNA. The segments comprise at least five consecutive nucleotides of the SCNA sense or antisense polynucleotides.

[00103] In an embodiment, the antisense oligonucleotides are specific for natural antisense sequences of SCNA wherein binding of the oligonucleotides to the natural antisense sequences of SCNA modulate expression and/or  
25 function of SCNA.

[00104] In an embodiment, oligonucleotide compounds comprise sequences set forth as SEQ ID NOS: 29 to 94 including antisense sequences which are identified and expanded, using for example, PCR, hybridization etc These oligonucleotides can comprise one or more modified nucleotides, shorter or longer fragments, modified bonds and the like. Examples of modified bonds or internucleotide linkages comprise phosphorothioate, phosphorodithioate or the like. In an embodiment, the nucleotides comprise a phosphorus derivative. The phosphorus derivative (or modified  
30 phosphate group) which may be attached to the sugar or sugar analog moiety in the modified oligonucleotides of the present invention may be a monophosphate, diphosphate, triphosphate, alkylphosphate, alkanephosphate,

phosphorothioate and the like. The preparation of the above-noted phosphate analogs, and their incorporation into nucleotides, modified nucleotides and oligonucleotides, per se, is also known and need not be described here.

[00105] Since, as is known in the art, the translation initiation codon is typically 5'-AUG (in transcribed mRNA molecules; 5'-ATG in the corresponding DNA molecule), the translation initiation codon is also referred to as the "AUG codon," the "start codon" or the "AUG start codon". A minority of genes has a translation initiation codon having the RNA sequence 5'-GUG, 5'-UUG or 5'-CUG; and 5'-AUA, 5'-ACG and 5'-CUG have been shown to function in vivo. Thus, the terms "translation initiation codon" and "start codon" can encompass many codon sequences, even though the initiator amino acid in each instance is typically methionine (in eukaryotes) or formylmethionine (in prokaryotes). Eukaryotic and prokaryotic genes may have two or more alternative start codons, any one of which may be preferentially utilized for translation initiation in a particular cell type or tissue, or under a particular set of conditions. In the context of the invention, "start codon" and "translation initiation codon" refer to the codon or codons that are used in vivo to initiate translation of an mRNA transcribed from a gene encoding Sodium channel, voltage-gated, alpha subunit (SCNA), regardless of the sequence(s) of such codons. A translation termination codon (or "stop codon") of a gene may have one of three sequences, i.e., 5'-UAA, 5'-UAG and 5'-UGA (the corresponding DNA sequences are 5'-TAA, 5'-TAG and 5'-TGA, respectively).

[00106] The terms "start codon region" and "translation initiation codon region" refer to a portion of such an mRNA or gene that encompasses from about 25 to about 50 contiguous nucleotides in either direction (i.e., 5' or 3') from a translation initiation codon. Similarly, the terms "stop codon region" and "translation termination codon region" refer to a portion of such an mRNA or gene that encompasses from about 25 to about 50 contiguous nucleotides in either direction (i.e., 5' or 3') from a translation termination codon. Consequently, the "start codon region" (or "translation initiation codon region") and the "stop codon region" (or "translation termination codon region") are all regions that may be targeted effectively with the antisense compounds of the present invention.

[00107] The open reading frame (ORF) or "coding region," which is known in the art to refer to the region between the translation initiation codon and the translation termination codon, is also a region which may be targeted effectively. Within the context of the present invention, a targeted region is the intragenic region encompassing the translation initiation or termination codon of the open reading frame (ORF) of a gene.

[00108] Another target region includes the 5' untranslated region (5'UTR), known in the art to refer to the portion of an mRNA in the 5' direction from the translation initiation codon, and thus including nucleotides between the 5' cap site and the translation initiation codon of an mRNA (or corresponding nucleotides on the gene). Still another target region includes the 3' untranslated region (3'UTR), known in the art to refer to the portion of an mRNA in the 3' direction from the translation termination codon, and thus including nucleotides between the translation termination codon and 3' end of an mRNA (or corresponding nucleotides on the gene). The 5' cap site of an mRNA comprises an N7-methylated guanosine residue joined to the 5'-most residue of the mRNA via a 5'-5' triphosphate linkage. The 5' cap region of an

mRNA is considered to include the 5' cap structure itself as well as the first 50 nucleotides adjacent to the cap site. Another target region for this invention is the 5' cap region.

[00109] Although some eukaryotic mRNA transcripts are directly translated, many contain one or more regions, known as "introns," which are excised from a transcript before it is translated. The remaining (and therefore translated) regions are known as "exons" and are spliced together to form a continuous mRNA sequence. In one embodiment, targeting splice sites, i.e., intron-exon junctions or exon-intron junctions, is particularly useful in situations where aberrant splicing is implicated in disease, or where an overproduction of a particular splice product is implicated in disease. An aberrant fusion junction due to rearrangement or deletion is another embodiment of a target site. mRNA transcripts produced via the process of splicing of two (or more) mRNAs from different gene sources are known as "fusion transcripts". Introns can be effectively targeted using antisense compounds targeted to, for example, DNA or pre-mRNA.

[00110] In an embodiment, the antisense oligonucleotides bind to coding and/or non-coding regions of a target polynucleotide and modulate the expression and/or function of the target molecule.

[00111] In an embodiment, the antisense oligonucleotides bind to natural antisense polynucleotides and modulate the expression and/or function of the target molecule.

[00112] In an embodiment, the antisense oligonucleotides bind to sense polynucleotides and modulate the expression and/or function of the target molecule.

[00113] Alternative RNA transcripts can be produced from the same genomic region of DNA. These alternative transcripts are generally known as "variants". More specifically, "pre-mRNA variants" are transcripts produced from the same genomic DNA that differ from other transcripts produced from the same genomic DNA in either their start or stop position and contain both intronic and exonic sequence.

[00114] Upon excision of one or more exon or intron regions, or portions thereof during splicing, pre-mRNA variants produce smaller "mRNA variants". Consequently, mRNA variants are processed pre-mRNA variants and each unique pre-mRNA variant must always produce a unique mRNA variant as a result of splicing. These mRNA variants are also known as "alternative splice variants". If no splicing of the pre-mRNA variant occurs then the pre-mRNA variant is identical to the mRNA variant.

[00115] Variants can be produced through the use of alternative signals to start or stop transcription. Pre-mRNAs and mRNAs can possess more than one start codon or stop codon. Variants that originate from a pre-mRNA or mRNA that use alternative start codons are known as "alternative start variants" of that pre-mRNA or mRNA. Those transcripts that use an alternative stop codon are known as "alternative stop variants" of that pre-mRNA or mRNA. One specific type of alternative stop variant is the "polyA variant" in which the multiple transcripts produced result from the alternative selection of one of the "polyA stop signals" by the transcription machinery, thereby producing transcripts that terminate

at unique polyA sites. Within the context of the invention, the types of variants described herein are also embodiments of target nucleic acids.

[00116] The locations on the target nucleic acid to which the antisense compounds hybridize are defined as at least a 5-nucleotide long portion of a target region to which an active antisense compound is targeted.

5 [00117] While the specific sequences of certain exemplary target segments are set forth herein, one of skill in the art will recognize that these serve to illustrate and describe particular embodiments within the scope of the present invention. Additional target segments are readily identifiable by one having ordinary skill in the art in view of this disclosure.

10 [00118] Target segments 5-100 nucleotides in length comprising a stretch of at least five (5) consecutive nucleotides selected from within the illustrative preferred target segments are considered to be suitable for targeting as well.

[00119] Target segments can include DNA or RNA sequences that comprise at least the 5 consecutive nucleotides from the 5'-terminus of one of the illustrative preferred target segments (the remaining nucleotides being a consecutive stretch of the same DNA or RNA beginning immediately upstream of the 5'-terminus of the target segment and continuing until the DNA or RNA contains about 5 to about 100 nucleotides). Similarly preferred target segments are represented by DNA or RNA sequences that comprise at least the 5 consecutive nucleotides from the 3'-terminus of one of the illustrative preferred target segments (the remaining nucleotides being a consecutive stretch of the same DNA or RNA beginning immediately downstream of the 3'-terminus of the target segment and continuing until the DNA or RNA contains about 5 to about 100 nucleotides). One having skill in the art armed with the target segments illustrated herein will be able, without undue experimentation, to identify further preferred target segments.

20 [00120] Once one or more target regions, segments or sites have been identified, antisense compounds are chosen which are sufficiently complementary to the target, i.e., hybridize sufficiently well and with sufficient specificity, to give the desired effect.

[00121] In embodiments of the invention the oligonucleotides bind to an antisense strand of a particular target. The oligonucleotides are at least 5 nucleotides in length and can be synthesized so each oligonucleotide targets overlapping sequences such that oligonucleotides are synthesized to cover the entire length of the target polynucleotide. The targets also include coding as well as non coding regions.

25 [00122] In one embodiment, it is preferred to target specific nucleic acids by antisense oligonucleotides. Targeting an antisense compound to a particular nucleic acid is a multistep process. The process usually begins with the identification of a nucleic acid sequence whose function is to be modulated. This may be, for example, a cellular gene (or mRNA transcribed from the gene) whose expression is associated with a particular disorder or disease state, or a non coding polynucleotide such as for example, non coding RNA (ncRNA).

30 [00123] RNAs can be classified into (1) messenger RNAs (mRNAs), which are translated into proteins, and (2) non-protein-coding RNAs (ncRNAs). ncRNAs comprise microRNAs, antisense transcripts and other Transcriptional Units

(TU) containing a high density of stop codons and lacking any extensive "Open Reading Frame". Many ncRNAs appear to start from initiation sites in 3' untranslated regions (3'UTRs) of protein-coding loci. ncRNAs are often rare and at least half of the ncRNAs that have been sequenced by the FANTOM consortium seem not to be polyadenylated. Most researchers have for obvious reasons focused on polyadenylated mRNAs that are processed and exported to the cytoplasm. Recently, it was shown that the set of non-polyadenylated nuclear RNAs may be very large, and that many such transcripts arise from so-called intergenic regions. The mechanism by which ncRNAs may regulate gene expression is by base pairing with target transcripts. The RNAs that function by base pairing can be grouped into (1) cis encoded RNAs that are encoded at the same genetic location, but on the opposite strand to the RNAs they act upon and therefore display perfect complementarity to their target, and (2) trans-encoded RNAs that are encoded at a chromosomal location distinct from the RNAs they act upon and generally do not exhibit perfect base-pairing potential with their targets.

[00124] Without wishing to be bound by theory, perturbation of an antisense polynucleotide by the antisense oligonucleotides described herein can alter the expression of the corresponding sense messenger RNAs. However, this regulation can either be discordant (antisense knockdown results in messenger RNA elevation) or concordant (antisense knockdown results in concomitant messenger RNA reduction). In these cases, antisense oligonucleotides can be targeted to overlapping or non-overlapping parts of the antisense transcript resulting in its knockdown or sequestration. Coding as well as non-coding antisense can be targeted in an identical manner and that either category is capable of regulating the corresponding sense transcripts -- either in a concordant or discordant manner. The strategies that are employed in identifying new oligonucleotides for use against a target can be based on the knockdown of antisense RNA transcripts by antisense oligonucleotides or any other means of modulating the desired target.

[00125] *Strategy 1:* In the case of discordant regulation, knocking down the antisense transcript elevates the expression of the conventional (sense) gene. Should that latter gene encode for a known or putative drug target, then knockdown of its antisense counterpart could conceivably mimic the action of a receptor agonist or an enzyme stimulant.

[00126] *Strategy 2:* In the case of concordant regulation, one could concomitantly knock down both antisense and sense transcripts and thereby achieve synergistic reduction of the conventional (sense) gene expression. If, for example, an antisense oligonucleotide is used to achieve knockdown, then this strategy can be used to apply one antisense oligonucleotide targeted to the sense transcript and another antisense oligonucleotide to the corresponding antisense transcript, or a single energetically symmetric antisense oligonucleotide that simultaneously targets overlapping sense and antisense transcripts.

[00127] According to the present invention, antisense compounds include antisense oligonucleotides, ribozymes, external guide sequence (EGS) oligonucleotides, siRNA compounds, single- or double-stranded RNA interference (RNAi) compounds such as siRNA compounds, and other oligomeric compounds which hybridize to at least a portion

of the target nucleic acid and modulate its function. As such, they may be DNA, RNA, DNA-like, RNA-like, or mixtures thereof, or may be mimetics of one or more of these. These compounds may be single-stranded, double-stranded, circular or hairpin oligomeric compounds and may contain structural elements such as internal or terminal bulges, mismatches or loops. Antisense compounds are routinely prepared linearly but can be joined or otherwise prepared to be circular and/or branched. Antisense compounds can include constructs such as, for example, two strands hybridized to form a wholly or partially double-stranded compound or a single strand with sufficient self-complementarity to allow for hybridization and formation of a fully or partially double-stranded compound. The two strands can be linked internally leaving free 3' or 5' termini or can be linked to form a continuous hairpin structure or loop. The hairpin structure may contain an overhang on either the 5' or 3' terminus producing an extension of single stranded character. The double-stranded compounds optionally can include overhangs on the ends. Further modifications can include conjugate groups attached to one of the termini, selected nucleotide positions, sugar positions or to one of the internucleoside linkages. Alternatively, the two strands can be linked via a non-nucleic acid moiety or linker group. When formed from only one strand, dsRNA can take the form of a self-complementary hairpin-type molecule that doubles back on itself to form a duplex. Thus, the dsRNAs can be fully or partially double stranded. Specific modulation of gene expression can be achieved by stable expression of dsRNA hairpins in transgenic cell lines, however, in some embodiments, the gene expression or function is up regulated. When formed from two strands, or a single strand that takes the form of a self-complementary hairpin-type molecule doubled back on itself to form a duplex, the two strands (or duplex-forming regions of a single strand) are complementary RNA strands that base pair in Watson-Crick fashion.

[00128] Once introduced to a system, the compounds of the invention may elicit the action of one or more enzymes or structural proteins to effect cleavage or other modification of the target nucleic acid or may work via occupancy-based mechanisms. In general, nucleic acids (including oligonucleotides) may be described as "DNA-like" (i.e., generally having one or more 2'-deoxy sugars and, generally, T rather than U bases) or "RNA-like" (i.e., generally having one or more 2'-hydroxyl or 2'-modified sugars and, generally U rather than T bases). Nucleic acid helices can adopt more than one type of structure, most commonly the A- and B-forms. It is believed that, in general, oligonucleotides which have B-form-like structure are "DNA-like" and those which have A-formlike structure are "RNA-like." In some (chimeric) embodiments, an antisense compound may contain both A- and B-form regions.

[00129] In an embodiment, the desired oligonucleotides or antisense compounds, comprise at least one of: antisense RNA, antisense DNA, chimeric antisense oligonucleotides, antisense oligonucleotides comprising modified linkages, interference RNA (RNAi), short interfering RNA (siRNA); a micro, interfering RNA (miRNA); a small, temporal RNA (stRNA); or a short, hairpin RNA (shRNA); small RNA-induced gene activation (RNAa); small activating RNAs (saRNAs), or combinations thereof.

[00130] dsRNA can also activate gene expression, a mechanism that has been termed "small RNA-induced gene activation" or RNAa. dsRNAs targeting gene promoters induce potent transcriptional activation of associated genes. RNAa was demonstrated in human cells using synthetic dsRNAs, termed "small activating RNAs" (saRNAs). It is currently not known whether RNAa is conserved in other organisms.

5 [00131] Small double-stranded RNA (dsRNA), such as small interfering RNA (siRNA) and microRNA (miRNA), have been found to be the trigger of an evolutionary conserved mechanism known as RNA interference (RNAi). RNAi invariably leads to gene silencing via remodeling chromatin to thereby suppress transcription, degrading complementary mRNA, or blocking protein translation. However, in instances described in detail in the examples section which follows, oligonucleotides are shown to increase the expression and/or function of the Sodium channel, voltage-gated, alpha subunit (SCNA) polynucleotides and encoded products thereof. dsRNAs may also act as small  
10 activating RNAs (saRNA). Without wishing to be bound by theory, by targeting sequences in gene promoters, saRNAs would induce target gene expression in a phenomenon referred to as dsRNA-induced transcriptional activation (RNAa).

[00132] In a further embodiment, the "preferred target segments" identified herein may be employed in a screen for  
15 additional compounds that modulate the expression of Sodium channel, voltage-gated, alpha subunit (SCNA) polynucleotides. "Modulators" are those compounds that decrease or increase the expression of a nucleic acid molecule encoding SCNA and which comprise at least a 5-nucleotide portion that is complementary to a preferred target segment. The screening method comprises the steps of contacting a preferred target segment of a nucleic acid molecule encoding sense or natural antisense polynucleotides of SCNA with one or more candidate modulators, and selecting for  
20 one or more candidate modulators which decrease or increase the expression of a nucleic acid molecule encoding SCNA polynucleotides, e.g. SEQ ID NOS: 29 to 94. Once it is shown that the candidate modulator or modulators are capable of modulating (e.g. either decreasing or increasing) the expression of a nucleic acid molecule encoding SCNA polynucleotides, the modulator may then be employed in further investigative studies of the function of SCNA polynucleotides, or for use as a research, diagnostic, or therapeutic agent in accordance with the present invention.

25 [00133] Targeting the natural antisense sequence preferably modulates the function of the target gene. For example, the SCNA gene (e.g. accession number NM\_001165963, NM\_021007, NM\_006922, NM\_000334, NM\_198056, NM\_002976, NM\_014191, NM\_002977, NM\_006514, NM\_014139, AF109737). In an embodiment, the target is an antisense polynucleotide of the SCNA gene. In an embodiment, an antisense oligonucleotide targets sense and/or natural antisense sequences of SCNA polynucleotides (e.g. accession number NM\_001165963, NM\_021007,  
30 NM\_006922, NM\_000334, NM\_198056, NM\_002976, NM\_014191, NM\_002977, NM\_006514, NM\_014139, AF109737), variants, alleles, isoforms, homologs, mutants, derivatives, fragments and complementary sequences thereto. Preferably the oligonucleotide is an antisense molecule and the targets include coding and noncoding regions of antisense and/or sense SCNA polynucleotides.



[00134] The preferred target segments of the present invention may be also be combined with their respective complementary antisense compounds of the present invention to form stabilized double-stranded (duplexed) oligonucleotides.

[00135] Such double stranded oligonucleotide moieties have been shown in the art to modulate target expression and regulate translation as well as RNA processing via an antisense mechanism. Moreover, the double-stranded moieties may be subject to chemical modifications. For example, such double-stranded moieties have been shown to inhibit the target by the classical hybridization of antisense strand of the duplex to the target, thereby triggering enzymatic degradation of the target.

[00136] In an embodiment, an antisense oligonucleotide targets Sodium channel, voltage-gated, alpha subunit (SCNA) polynucleotides (e.g. accession number NM\_001165963, NM\_021007, NM\_006922, NM\_000334, NM\_198056, NM\_002976, NM\_014191, NM\_002977, NM\_006514, NM\_014139, AF109737), variants, alleles, isoforms, homologs, mutants, derivatives, fragments and complementary sequences thereto. Preferably the oligonucleotide is an antisense molecule.

[00137] In accordance with embodiments of the invention, the target nucleic acid molecule is not limited to SCNA alone but extends to any of the isoforms, receptors, homologs and the like of SCNA molecules.

[00138] In an embodiment, an oligonucleotide targets a natural antisense sequence of SCNA polynucleotides, for example, polynucleotides set forth as SEQ ID NOS: 12 to 28, and any variants, alleles, homologs, mutants, derivatives, fragments and complementary sequences thereto. Examples of antisense oligonucleotides are set forth as SEQ ID NOS: 29 to 94.

[00139] In one embodiment, the oligonucleotides are complementary to or bind to nucleic acid sequences of SCNA antisense, including without limitation noncoding sense and/or antisense sequences associated with SCNA polynucleotides and modulate expression and/or function of SCNA molecules.

[00140] In an embodiment, the oligonucleotides are complementary to or bind to nucleic acid sequences of SCNA natural antisense, set forth as SEQ ID NOS: 12 to 28, and modulate expression and/or function of SCNA molecules.

[00141] In an embodiment, oligonucleotides comprise sequences of at least 5 consecutive nucleotides of SEQ ID NOS: 29 to 94 and modulate expression and/or function of SCNA molecules.

[00142] The polynucleotide targets comprise SCNA, including family members thereof, variants of SCNA; mutants of SCNA, including SNPs; noncoding sequences of SCNA; alleles of SCNA; species variants, fragments and the like. Preferably the oligonucleotide is an antisense molecule.

[00143] In an embodiment, the oligonucleotide targeting SCNA polynucleotides, comprise: antisense RNA, interference RNA (RNAi), short interfering RNA (siRNA); micro interfering RNA (miRNA); a small, temporal RNA (stRNA); or a short, hairpin RNA (shRNA); small RNA-induced gene activation (RNAa); or, small activating RNA (saRNA).

[00144] In an embodiment, targeting of Sodium channel, voltage-gated, alpha subunit (SCNA) polymucleotides, e.g. SEQ ID NOS: 1 to 11, modulate the expression or function of these targets. In one embodiment, expression or function is upregulated as compared to a control. In an embodiment, expression or function is down-regulated as compared to a control. In a further embodiment, targeting of the natural antisense transcripts (e.g. SEQ ID NOS. 12 to 28) as well as any other target NATs of such target polymucleotides results in the upregulation of said target mRNA and corresponding protein.

[00145] In an embodiment, antisense compounds comprise sequences set forth as SEQ ID NOS: 29 to 94. These oligonucleotides can comprise one or more modified nucleotides, shorter or longer fragments, modified bonds and the like.

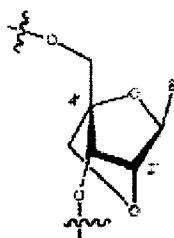
10 [00146] In an embodiment, SEQ ID NOS: 29 to 94 comprise one or more LNA nucleotides. Table 1 shows exemplary antisense oligonucleotides useful in the methods of the invention.

Table 1:

Sequence ID	Antisense Sequence Name	Sequence
Seq_29	CUR-1462	mC*mC*mU*mA*mU*mC*T*T*T*C*C*C*C*C*C*T*mA*mC*mC*mU*mU*mU
Seq_30	CUR-1624	T*C*G*G*T*G*T*C*C*A*C*T*C*T*G*G*C*A*G*T
Seq_31	CUR-1625	T*G*C*A*C*T*G*T*G*G*G*A*G*C*C*T*G*T*C*T
Seq_32	CUR-1626	G*T*A*G*C*A*C*T*G*T*G*G*A*C*A*T*C*G*G*C
Seq_33	CUR-1627	G*T*A*G*A*A*G*A*A*C*A*G*C*C*C*G*T*A*G*T*G
Seq_34	CUR-1628	G*T*G*G*T*C*T*C*T*G*C*A*T*T*C*T*G*T*C*A
Seq_35	CUR-1629	G*T*G*G*T*A*T*A*G*G*A*A*C*T*G*G*C*A*G*C*A
Seq_36	CUR-1630	G*T*C*C*A*A*T*C*A*T*A*C*A*G*C*A*G*A*A
Seq_37	CUR-1631	G*T*G*A*C*T*G*T*A*C*C*A*A*T*T*G*C*T*G*T
Seq_38	CUR-1632	A*C*T*T*C*T*T*C*C*A*C*T*C*C*T*T*C*C*T
Seq_39	CUR-1633	G*A*T*G*T*C*C*C*T*T*C*C*T*G*C*G*T*T*G*T
Seq_40	CUR-1634	T*G*T*G*G*A*T*G*C*T*G*G*G*T*G*T*C*T*C*T*C
Seq_41	CUR-1635	T*C*C*C*A*G*T*G*A*C*T*C*C*C*G*A*T*G*C*T
Seq_42	CUR-1636	A*G*T*C*T*C*A*G*T*T*G*T*C*A*G*T*A*C*C*T*C
Seq_43	CUR-1738	G*T*T*A*T*T*G*A*A*T*G*C*C*C*T*G*G*T*G*T
Seq_44	CUR-1739	T*C*G*G*A*T*C*A*T*C*A*G*G*G*T*T*G*T*A*G*T
Seq_45	CUR-1740	G*T*G*G*T*A*T*A*G*G*A*A*C*T*G*G*C*A*G*C*A
Seq_46	CUR-1741	T*C*T*G*C*T*C*T*T*C*C*C*T*A*C*A*T*T*G*G
Seq_47	CUR-1742	G*T*A*A*T*C*T*G*C*T*C*T*T*C*C*C*T*A*C
Seq_48	CUR-1743	G*G*G*A*G*A*A*C*T*T*G*A*G*A*G*C*A*A*C*A*G
Seq_49	CUR-1744	G*C*C*A*G*T*C*A*C*A*A*A*T*T*C*A*G*A*T*C*A
Seq_50	CUR-1762	+G*+T*A*T*A*G*G*A*A*C*T*G*+G*+C*+A
Seq_51	CUR-1763	+G*+T*G*G*T*A*+T*A*G*G*A*A*+C*+T*+G
Seq_52	CUR-1764	mG*mU*mG*G*mU*A*mU*A*G*G*A*A*mC*T*G*G*mC*A*mG*mC*mA
Seq_53	CUR-1766	+A*+G*A*A*C*T*T*G*A*G*A*G*+C*+A*+A
Seq_54	CUR-1767	mG*mG*mG*A*G*A*A*mC*T*mU*G*A*G*A*G*mC*A*A*mC*mA*mG
Seq_55	CUR-1768	+G*+C*C*A*G*+T*C*A*+C*A*A*A*+T*+T*+C
Seq_56	CUR-1769	+C*+A*C*A*A*A*T*T*C*A*G*A*+T*+C*+A

Seq_57	CUR-1770	mG*mC*mC*A*G*T*mC*A*C*A*A*A*mU*T*mC*A*G*A*mU*mC*mA
Seq_58	CUR-1798	rArUrUrUrArArArArCrArCrGrGrArArGrArCrUrUrUrArGrUrArGrUrG
Seq_59	CUR-1799	rUrCrArCrArArArUrUrCrArGrArUrCrArCrCrArUrCrUrUrCrUrA
Seq_60	CUR-1836	+G*+T*GGTA+T*AGGAA+C*+T*+G
Seq_61	CUR-1837	mG*mU*mG*GmU*AmU*AGGAAmC*TGmC*AmG*mC*mA
Seq_62	CUR-1838	+G*+C*CAGT*C*A+C*AAA+T*+T*+C
Seq_63	CUR-1839	+C*+A*CAAATTCAGA+T*+C*+A
Seq_64	CUR-1891	mG*mG*mU*A*mU*A*G*G*mA*A*A*C*mU*G*G*mC*A*G*mC*A*G*mU*G*mU*mU*mG
Seq_65	CUR-1892	mU*mG*mG*T*A*mU*A*G*mG*A*A*mC*T*G*G*mC*A*G*C*mA*mG*mU
Seq_66	CUR-1895	mG*G*T*A*mU*A*G*G*A*A*mC*T*G*G*mC*A*G*mC*A*G*T*G*T*T*mG
Seq_67	CUR-1896	mA*mA*G*mC*G*G*mU*A*T*A*G*G*A*A*mC*T*G*G*mC*A*G*mC*A*mG
Seq_68	CUR-1900	G*T*G*G*C*A*T*A*G*G*G*A*C*G*G*G*C*A*G*C*A
Seq_69	CUR-1901	mG*mU*mG*G*mC*A*mU*A*G*mG*G*A*mC*G*G*G*mC*A*mG*mC*mA
Seq_70	CUR-1916	mG*mA*mG*C*C*A*G*mU*C*A*mC*A*A*A*mU*T*C*A*G*mA*T*C*A*mC*mC*mC
Seq_71	CUR-1917	mA*A*mU*G*G*G*A*G*A*A*mC*mU*mU*G*A*G*A*G*mC*mA*mA
Seq_72	CUR-1918	mA*mC*mA*mA*mG*mU*G*G*C*A*T*A*G*G*G*A*C*G*G*mG*mC*mA*mG*mC*mA
Seq_73	CUR-1919	mA*mC*A*A*G*mU*G*G*mC*A*T*A*mG*G*G*A*mC*G*G*G*mC*A*G*mC*mA
Seq_74	CUR-1920	mA*A*G*mU*G*G*mC*A*mU*A*G*mG*G*A*mC*G*G*G*mC*A*G*mC*A*G*mU
Seq_75	CUR-1921	mA*mA*mG*mU*mG*G*C*A*T*A*G*G*G*A*C*G*G*G*C*A*mG*mC*mA*mG*mU
Seq_76	CUR-1922	G*T*G*ACTGTGCCCATTTG*C*T*G
Seq_77	CUR-1923	G*C*C*ACTT*GATGAT*CTA*A*A*A*C
Seq_78	CUR-1924	G*T*G*GAC*AGGAT*GCAC*AAAGG*A
Seq_79	CUR-1925	mG*TGACmU*GTGCCmC*ATTGCTmG
Seq_80	CUR-1926	mG*TGACTGTGCCCATTTGCTmG
Seq_81	CUR-1927	mC*CTCmU*TTCmU*GGCmC*TTGmC*TTmC
Seq_82	CUR-1928	mG*ACAAmC*CTTGmC*AGCCAmC*TGAmU*GATGmA
Seq_83	CUR-1929	T*G*G*T*A*T*A*G*G*A*A*A*C*T*G*G*C*A*G*C*A
Seq_84	CUR-1930	mU*mG*G*mU*A*mU*A*G*G*A*A*mC*T*G*G*mC*A*mG*mC*mA
Seq_85	CUR-1931	mC*mC*A*G*T*mC*A*C*A*A*A*mU*T*mC*A*G*A*mU*mC*mA
Seq_86	CUR-1932	mU*mG*GmU*AmU*AGGAAmC*TGmC*AmG*mC*mA
Seq_87	CUR-1933	mA*mG*C*C*A*G*mU*C*A*mC*A*A*A*mU*T*C*A*G*mA*T*C*A*mC*mC*mC
Seq_88	CUR-1940	mG*mC*C*A*G*mU*C*A*mC*A*A*A*mU*T*C*mA*mG
Seq_89	CUR-1941	mG*mC*C*A*G*mU*C*A*mC*A*A*A*mU*mU*mC
Seq_90	CUR-1942	+G*+C*C*A*G*mU*C*A*mC*A*A*A*mU*+T*+C
Seq_91	CUR-1943	+G*C*C*A*G*+T*C*A*+C*A*A*A*T*+T*+C
Seq_92	CUR-1944	+G*+C*mC*A*G*mU*C*A*mC*A*mA*+A*+T
Seq_93	CUR-1945	+G*+C*C*A*G*T*C*A*C*A*+A*+A*+T
Seq_94	CUR-1946	+G*C*C*A*G*T*C*A*+C*+A*+A

[00147] \* indicates a phosphothioate bond, + indicates LNA, 'r' indicates RNA and 'm' indicates a methyl group on the 2' oxygen atom on the designated sugar moiety of the oligonucleotide. To avoid ambiguity, this LNA has the formula:



wherein B is the particular designated base.

[00148] Table 2: Relative expression of SCN1A mRNA in cells treated with antisense oligonucleotides targeting SCN1A- specific natural antisense transcript Avg - average fold difference in SCN1A expression compared to mock transfected control; Std - standard deviation, P - probability that the treated samples are not different from mock control. N - total number of replicates

Table2:

ID#	SCN1A fibroblasts			SK-N-AS			Vero76			3T3			HepG2			CHP-212		
	Avg	Std	N	Avg	Std	N	Avg	Std	N	Avg	Std	N	Avg	Std	N	Avg	Std	N
CUR-1462				1.0	0.2	4	1.2	0.3	8	0.8	0.1	5						
CUR-1624							2.9	1.1	5				0.9	0.0	5			
CUR-1625	0.7	0.7	4										1.3	0.4	4			
CUR-1626													1.0	0.1	5			
CUR-1627													1.2	0.1	4			
CUR-1628													0.9	0.1	5			
CUR-1629				12.6	1.5	5							0.9	0.1	4			
CUR-1630													1.0	0.1	5			
CUR-1631	4.0	2.8	1							1.3	0.1	14	1.1	0.1	3			
CUR-1632							1.2	0.7	4				1.0	0.1	5			
CUR-1633													1.0	0.2	4			
CUR-1634							2.9	1.1	5				1.2	0.1	4			
CUR-1635													1.1	0.3	4			
CUR-1636													1.1	0.1	4			
CUR-1719							1.2	0.3	4									
CUR-1738	0.8	0.6	7															
CUR-1739	0.9	0.4	7															
CUR-1740	8.2	2.0	27	18.2	2.0	16	4.3	1.1	12	1.7	0.5	10	1.1	0.3	9	8.8	1.7	5
CUR-1741	1.8	1.3	5															
CUR-1742	1.9	0.8	5				5.5	1.0	12									
CUR-1743	3.3	1.1	5				5.6	1.7	5									
CUR-1744	2.7	1.4	5				6.8	1.3	6									
CUR-1762	2.8	1.6	5	0.9	0.1	4	1.1	0.5	2									
CUR-1763	2.9	1.5	6	1.2	0.1	11	1.5	0.5	10									
CUR-1764	15.0	5.1	12	2.3	0.5	20	1.3	0.5	18	0.8	0.2	5	0.7	0.2	4			
CUR-1766	0.6	0.3	5	0.7	0.1	3	1.5	0.6	6									
CUR-1767							1.3	0.8	5									
CUR-1768	1.1	0.5	3	1.5	0.3	5	1.5	0.6	5							1.9	0.7	5
CUR-1769	0.8	0.7	10	1.0	0.1	3	2.6	0.8	7									
CUR-1770	22.9	4.1	25	6.7	2.0	12	2.7	1.0	20									
CUR-1798																		
CUR-1799																1.0	0.3	5
CUR-1836				1.1	0.3	8	1.3	0.6	5				1.1	0.3	5			
CUR-1837	3.2	0.6	9	2.4	0.3	11	4.2	1.0	24	1.0	0.1	9	1.2	0.5	10			
CUR-1838	2.0	0.6	6	1.7	0.2	5	34.1	4.0	14				1.3	0.3	5			

ID#	SCN1A fibroblasts			SK-N-AS			Vero76			3T3			HepG2			CHP-212		
	Avg	Std	N	Avg	Std	N	Avg	Std	N	Avg	Std	N	Avg	Std	N	Avg	Std	N
CUR-1839				1.3	0.2	9	1.3	0.5	5				1.0	0.2	4			
CUR-1891							1.0	0.1	4									
CUR-1892							1.2	0.1	5									
CUR-1895							0.9	0.2	4				0.9	0.1	7			
CUR-1896							2.0	0.9	8				0.9	0.2	10			
CUR-1900										1.1	0.2	8						
CUR-1901	0.9	1.2	4							1.5	0.4	24						
CUR-1916	17.3	3.0	27	10.0	1.5	9	2.2	0.7	21				1.4	0.2	8			
CUR-1917							0.6	0.3	3				1.0	0.1	9			
CUR-1918										1.1	0.4	8						
CUR-1919										1.0	0.3	10						
CUR-1920										1.0	0.2	10						
CUR-1921										1.0	0.1	10						
CUR-1922							1.0	0.2	4	1.5	0.4	4						
CUR-1923							0.5	0.1	3	1.3	0.3	4						
CUR-1924							3.7	1.6	8	1.3	0.1	4						
CUR-1925	0.7	0.7	5				1.4	0.5	5	1.2	0.2	3						
CUR-1926							0.8	0.3	5	1.1	0.1	5						
CUR-1927							0.7	0.3	5	1.1	0.1	2						
CUR-1928	3.0	2.6	4				0.9	0.2	2	1.4	0.2	3						
CUR-1929	1.3	0.2	3	1.5	0.4	5												
CUR-1930	2.5	0.9	5															
CUR-1931	2.3	1.4	5															
CUR-1932	1.0	0.6	3															
CUR-1933	4.7	0.8	9				8.8	2.4	3									
CUR-1940	1.2	0.5	4															
CUR-1941	1.1	0.2	4															
CUR-1942	4.5	2.0	5															
CUR-1943	3.8	1.3	5															
CUR-1944	3.0	2.3	9															
CUR-1945	64.9	8.2	5															
CUR-1946	11.1	1.4	5															

[00149] The modulation of a desired target nucleic acid can be carried out in several ways known in the art. For example, antisense oligonucleotides, siRNA etc. Enzymatic nucleic acid molecules (e.g., ribozymes) are nucleic acid molecules capable of catalyzing one or more of a variety of reactions, including the ability to repeatedly cleave other separate nucleic acid molecules in a nucleotide base sequence-specific manner. Such enzymatic nucleic acid molecules can be used, for example, to target virtually any RNA transcript.

[00150] Because of their sequence-specificity, trans-cleaving enzymatic nucleic acid molecules show promise as therapeutic agents for human disease. Enzymatic nucleic acid molecules can be designed to cleave specific RNA

targets within the background of cellular RNA. Such a cleavage event renders the mRNA non-functional and abrogates protein expression from that RNA. In this manner, synthesis of a protein associated with a disease state can be selectively inhibited.

5 [00151] In general, enzymatic nucleic acids with RNA cleaving activity act by first binding to a target RNA. Such binding occurs through the target binding portion of an enzymatic nucleic acid which is held in close proximity to an enzymatic portion of the molecule that acts to cleave the target RNA. Thus, the enzymatic nucleic acid first recognizes and then binds a target RNA through complementary base pairing, and once bound to the correct site, acts enzymatically to cut the target RNA. Strategic cleavage of such a target RNA will destroy its ability to direct synthesis of an encoded protein. After an enzymatic nucleic acid has bound and cleaved its RNA target, it is released from that  
10 RNA to search for another target and can repeatedly bind and cleave new targets.

[00152] Several approaches such as in vitro selection (evolution) strategies (Orgel, (1979) Proc. R. Soc. London, B 205, 435) have been used to evolve new nucleic acid catalysts capable of catalyzing a variety of reactions, such as cleavage and ligation of phosphodiester linkages and amide linkages.

15 [00153] The development of ribozymes that are optimal for catalytic activity would contribute significantly to any strategy that employs RNA-cleaving ribozymes for the purpose of regulating gene expression. The hammerhead ribozyme, for example, functions with a catalytic rate ( $k_{cat}$ ) of about  $1 \text{ min}^{-1}$  in the presence of saturating (10 mM) concentrations of  $\text{Mg}^{2+}$  cofactor. An artificial "RNA ligase" ribozyme has been shown to catalyze the corresponding self-modification reaction with a rate of about  $100 \text{ min}^{-1}$ . In addition, it is known that certain modified hammerhead ribozymes that have substrate binding arms made of DNA catalyze RNA cleavage with multiple turn-over rates that  
20 approach  $100 \text{ min}^{-1}$ . Finally, replacement of a specific residue within the catalytic core of the hammerhead with certain nucleotide analogues gives modified ribozymes that show as much as a 10-fold improvement in catalytic rate. These findings demonstrate that ribozymes can promote chemical transformations with catalytic rates that are significantly greater than those displayed in vitro by most natural self-cleaving ribozymes. It is then possible that the structures of certain self-cleaving ribozymes may be optimized to give maximal catalytic activity, or that entirely new RNA motifs  
25 can be made that display significantly faster rates for RNA phosphodiester cleavage.

[00154] Intermolecular cleavage of an RNA substrate by an RNA catalyst that fits the "hammerhead" model was first shown in 1987 (Uhlenbeck, O. C. (1987) Nature, 328: 596-600). The RNA catalyst was recovered and reacted with multiple RNA molecules, demonstrating that it was truly catalytic.

30 [00155] Catalytic RNAs designed based on the "hammerhead" motif have been used to cleave specific target sequences by making appropriate base changes in the catalytic RNA to maintain necessary base pairing with the target sequences. This has allowed use of the catalytic RNA to cleave specific target sequences and indicates that catalytic RNAs designed according to the "hammerhead" model may possibly cleave specific substrate RNAs in vivo.

[00156] RNA interference (RNAi) has become a powerful tool for modulating gene expression in mammals and mammalian cells. This approach requires the delivery of small interfering RNA (siRNA) either as RNA itself or as DNA, using an expression plasmid or virus and the coding sequence for small hairpin RNAs that are processed to siRNAs. This system enables efficient transport of the pre-siRNAs to the cytoplasm where they are active and permit  
5 the use of regulated and tissue specific promoters for gene expression.

[00157] In an embodiment, an oligonucleotide or antisense compound comprises an oligomer or polymer of ribonucleic acid (RNA) and/or deoxyribonucleic acid (DNA), or a mimetic, chimera, analog or homolog thereof. This term includes oligonucleotides composed of naturally occurring nucleotides, sugars and covalent internucleoside (backbone) linkages as well as oligonucleotides having non-naturally occurring portions which function similarly. Such  
10 modified or substituted oligonucleotides are often desired over native forms because of desirable properties such as, for example, enhanced cellular uptake, enhanced affinity for a target nucleic acid and increased stability in the presence of nucleases.

[00158] According to the present invention, the oligonucleotides or "antisense compounds" include antisense oligonucleotides (e.g. RNA, DNA, mimetic, chimera, analog or homolog thereof), ribozymes, external guide sequence (EGS) oligonucleotides, siRNA compounds, single- or double-stranded RNA interference (RNAi) compounds such as  
15 siRNA compounds, saRNA, aRNA, and other oligomeric compounds which hybridize to at least a portion of the target nucleic acid and modulate its function. As such, they may be DNA, RNA, DNA-like, RNA-like, or mixtures thereof, or may be mimetics of one or more of these. These compounds may be single-stranded, double-stranded, circular or hairpin oligomeric compounds and may contain structural elements such as internal or terminal bulges, mismatches or  
20 loops. Antisense compounds are routinely prepared linearly but can be joined or otherwise prepared to be circular and/or branched. Antisense compounds can include constructs such as, for example, two strands hybridized to form a wholly or partially double-stranded compound or a single strand with sufficient self-complementarity to allow for hybridization and formation of a fully or partially double-stranded compound. The two strands can be linked internally leaving free 3' or 5' termini or can be linked to form a continuous hairpin structure or loop. The hairpin structure may  
25 contain an overhang on either the 5' or 3' terminus producing an extension of single stranded character. The double stranded compounds optionally can include overhangs on the ends. Further modifications can include conjugate groups attached to one of the termini, selected nucleotide positions, sugar positions or to one of the internucleoside linkages. Alternatively, the two strands can be linked via a non-nucleic acid moiety or linker group. When formed from only one strand, dsRNA can take the form of a self-complementary hairpin-type molecule that doubles back on itself to form a  
30 duplex. Thus, the dsRNAs can be fully or partially double stranded. Specific modulation of gene expression can be achieved by stable expression of dsRNA hairpins in transgenic cell lines. When formed from two strands, or a single strand that takes the form of a self-complementary hairpin-type molecule doubled back on itself to form a duplex, the

two strands (or duplex-forming regions of a single strand) are complementary RNA strands that base pair in Watson-Crick fashion.

[00159] Once introduced to a system, the compounds of the invention may elicit the action of one or more enzymes or structural proteins to effect cleavage or other modification of the target nucleic acid or may work via occupancy-based mechanisms. In general, nucleic acids (including oligonucleotides) may be described as "DNA-like" (i.e., generally having one or more 2'-deoxy sugars and, generally, T rather than U bases) or "RNA-like" (i.e., generally having one or more 2'-hydroxyl or 2'-modified sugars and, generally U rather than T bases). Nucleic acid helices can adopt more than one type of structure, most commonly the A- and B-forms. It is believed that, in general, oligonucleotides which have B-form-like structure are "DNA-like" and those which have A-formlike structure are "RNA-like." In some (chimeric) embodiments, an antisense compound may contain both A- and B-form regions.

[00160] The antisense compounds in accordance with this invention can comprise an antisense portion from about 5 to about 80 nucleotides (i.e. from about 5 to about 80 linked nucleosides) in length. This refers to the length of the antisense strand or portion of the antisense compound. In other words, a single-stranded antisense compound of the invention comprises from 5 to about 80 nucleotides, and a double-stranded antisense compound of the invention (such as a dsRNA, for example) comprises a sense and an antisense strand or portion of 5 to about 80 nucleotides in length. One of ordinary skill in the art will appreciate that this comprehends antisense portions of 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, or 80 nucleotides in length, or any range therewithin.

[00161] In one embodiment, the antisense compounds of the invention have antisense portions of 10 to 50 nucleotides in length. One having ordinary skill in the art will appreciate that this embodies oligonucleotides having antisense portions of 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, or 50 nucleotides in length, or any range therewithin. In some embodiments, the oligonucleotides are 15 nucleotides in length.

[00162] In one embodiment, the antisense or oligonucleotide compounds of the invention have antisense portions of 12 or 13 to 30 nucleotides in length. One having ordinary skill in the art will appreciate that this embodies antisense compounds having antisense portions of 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 or 30 nucleotides in length, or any range therewithin.

[00163] In an embodiment, the oligomeric compounds of the present invention also include variants in which a different base is present at one or more of the nucleotide positions in the compound. For example, if the first nucleotide is an adenosine, variants may be produced which contain thymidine, guanosine or cytidine at this position. This may be done at any of the positions of the antisense or dsRNA compounds. These compounds are then tested using the methods described herein to determine their ability to inhibit expression of a target nucleic acid.



[00164] In some embodiments, homology, sequence identity or complementarity, between the antisense compound and target is from about 40% to about 60%. In some embodiments, homology, sequence identity or complementarity, is from about 60% to about 70%. In some embodiments, homology, sequence identity or complementarity, is from about 70% to about 80%. In some embodiments, homology, sequence identity or complementarity, is from about 80% to about 90%. In some embodiments, homology, sequence identity or complementarity, is about 90%, about 92%, about 94%, about 95%, about 96%, about 97%, about 98%, about 99% or about 100%.

[00165] In an embodiment, the antisense oligonucleotides, such as for example, nucleic acid molecules set forth in SEQ ID NOS: 29 to 94 comprise one or more substitutions or modifications. In one embodiment, the nucleotides are substituted with locked nucleic acids (LNA).

[00166] In an embodiment, the oligonucleotides target one or more regions of the nucleic acid molecules sense and/or antisense of coding and/or non-coding sequences associated with SCNA and the sequences set forth as SEQ ID NOS: 1 to 28. The oligonucleotides are also targeted to overlapping regions of SEQ ID NOS: 1 to 28.

[00167] Certain preferred oligonucleotides of this invention are chimeric oligonucleotides. "Chimeric oligonucleotides" or "chimeras," in the context of this invention, are oligonucleotides which contain two or more chemically distinct regions, each made up of at least one nucleotide. These oligonucleotides typically contain at least one region of modified nucleotides that confers one or more beneficial properties (such as, for example, increased nuclease resistance, increased uptake into cells, increased binding affinity for the target) and a region that is a substrate for enzymes capable of cleaving RNA:DNA or RNA:RNA hybrids. By way of example, RNase H is a cellular endonuclease which cleaves the RNA strand of an RNA:DNA duplex. Activation of RNase H, therefore, results in cleavage of the RNA target, thereby greatly enhancing the efficiency of antisense modulation of gene expression. Consequently, comparable results can often be obtained with shorter oligonucleotides when chimeric oligonucleotides are used, compared to phosphorothioate deoxyoligonucleotides hybridizing to the same target region. Cleavage of the RNA target can be routinely detected by gel electrophoresis and, if necessary, associated nucleic acid hybridization techniques known in the art. In one an embodiment, a chimeric oligonucleotide comprises at least one region modified to increase target binding affinity, and, usually, a region that acts as a substrate for RNase H. Affinity of an oligonucleotide for its target (in this case, a nucleic acid encoding ras) is routinely determined by measuring the  $T_m$  of an oligonucleotide/target pair, which is the temperature at which the oligonucleotide and target dissociate; dissociation is detected spectrophotometrically. The higher the  $T_m$ , the greater is the affinity of the oligonucleotide for the target.

[00168] Chimeric antisense compounds of the invention may be formed as composite structures of two or more oligonucleotides, modified oligonucleotides, oligonucleosides and/or oligonucleotides mimetics as described above. Such; compounds have also been referred to in the art as hybrids or gapmers. Representative United States patents that teach the preparation of such hybrid structures comprise, but are not limited to, US patent nos. 5,013,830; 5,149,797; 5,

220,007; 5,256,775; 5,366,878; 5,403,711; 5,491,133; 5,565,350; 5,623,065; 5,652,355; 5,652,356; and 5,700,922.

[00169] In an embodiment, the region of the oligonucleotide which is modified comprises at least one nucleotide modified at the 2' position of the sugar, most preferably a 2'-O-alkyl, 2'-O-alkyl-O-alkyl or 2'-fluoro-modified nucleotide. In other an embodiment, RNA modifications include 2'-fluoro, 2'-amino and 2' O-methyl modifications on the ribose of pyrimidines, abasic residues or an inverted base at the 3' end of the RNA. Such modifications are routinely incorporated into oligonucleotides and these oligonucleotides have been shown to have a higher  $T_m$  (i.e., higher target binding affinity) than 2'-deoxyoligonucleotides against a given target. The effect of such increased affinity is to greatly enhance RNAi oligonucleotide inhibition of gene expression. RNAse H is a cellular endonuclease that cleaves the RNA strand of RNA:DNA duplexes; activation of this enzyme therefore results in cleavage of the RNA target, and thus can greatly enhance the efficiency of RNAi inhibition. Cleavage of the RNA target can be routinely demonstrated by gel electrophoresis. In an embodiment, the chimeric oligonucleotide is also modified to enhance nuclease resistance. Cells contain a variety of exo- and endo-nucleases which can degrade nucleic acids. A number of nucleotide and nucleoside modifications have been shown to make the oligonucleotide into which they are incorporated more resistant to nuclease digestion than the native oligodeoxynucleotide. Nuclease resistance is routinely measured by incubating oligonucleotides with cellular extracts or isolated nuclease solutions and measuring the extent of intact oligonucleotide remaining over time, usually by gel electrophoresis. Oligonucleotides which have been modified to enhance their nuclease resistance survive intact for a longer time than unmodified oligonucleotides. A variety of oligonucleotide modifications have been demonstrated to enhance or confer nuclease resistance. Oligonucleotides which contain at least one phosphorothioate modification are presently more preferred. In some cases, oligonucleotide modifications which enhance target binding affinity are also, independently, able to enhance nuclease resistance.

[00170] Specific examples of some preferred oligonucleotides envisioned for this invention include those comprising modified backbones, for example, phosphorothioates, phosphotriesters, methyl phosphonates, short chain alkyl or cycloalkyl intersugar linkages or short chain heteroatomic or heterocyclic intersugar linkages. Most preferred are oligonucleotides with phosphorothioate backbones and those with heteroatom backbones, particularly  $\text{CH}_2\text{--NH--O--CH}_2$ ,  $\text{CH}_2\text{--N(CH}_3\text{)--O--CH}_2$  [known as a methylene(methylimino) or MMI backbone],  $\text{CH}_2\text{--O--N(CH}_3\text{)--CH}_2$ ,  $\text{CH}_2\text{--N(CH}_3\text{)--N(CH}_3\text{)--CH}_2$  and  $\text{O--N(CH}_3\text{)--CH}_2\text{--CH}_2$  backbones, wherein the native phosphodiester backbone is represented as  $\text{O--P--O--CH}_2$ . The amide backbones disclosed by De Mesmacker et al. (1995) *Acc. Chem. Res.* 28:366-374 are also preferred. Also preferred are oligonucleotides having morpholino backbone structures (Summerton and Weller, U.S. Pat. No. 5,034,506). In other an embodiment, such as the peptide nucleic acid (PNA) backbone, the phosphodiester backbone of the oligonucleotide is replaced with a polyamide backbone, the nucleotides being bound directly or indirectly to the aza nitrogen atoms of the polyamide backbone. Oligonucleotides may also comprise one or more substituted sugar moieties. Preferred oligonucleotides comprise one of the following at the 2'

position: OH, SH, SCH<sub>3</sub>, F, OCN, OCH<sub>3</sub> OCH<sub>3</sub>, OCH<sub>3</sub> O(CH<sub>2</sub>)<sub>n</sub> CH<sub>3</sub>, O(CH<sub>2</sub>)<sub>n</sub> NH<sub>2</sub> or O(CH<sub>2</sub>)<sub>n</sub> CH<sub>3</sub> where n is from 1 to about 10; C1 to C10 lower alkyl, alkoxyalkoxy, substituted lower alkyl, alkaryl or aralkyl; Cl; Br; CN; CF<sub>3</sub>; OCF<sub>3</sub>; O-, S-, or N-alkyl; O-, S-, or N-alkenyl; SOCH<sub>3</sub>; SO<sub>2</sub> CH<sub>3</sub>; ONO<sub>2</sub>; NO<sub>2</sub>; N<sub>3</sub>; NH<sub>2</sub>; heterocycloalkyl; heterocycloalkaryl; aminoalkylamino; polyalkylamino; substituted silyl; an RNA cleaving group; a reporter group; an intercalator; a group for improving the pharmacokinetic properties of an oligonucleotide; or a group for improving the pharmacodynamic properties of an oligonucleotide and other substituents having similar properties. A preferred modification includes 2'-methoxyethoxy [2'-O-CH<sub>2</sub> CH<sub>2</sub> OCH<sub>3</sub>, also known as 2'-O-(2-methoxyethyl)]. Other preferred modifications include 2'-methoxy (2'-O--CH<sub>3</sub>), 2'-propoxy (2'-OCH<sub>2</sub> CH<sub>2</sub>CH<sub>3</sub>) and 2'-fluoro (2'-F). Similar modifications may also be made at other positions on the oligonucleotide, particularly the 3' position of the sugar on the 3' terminal nucleotide and the 5' position of 5' terminal nucleotide. Oligonucleotides may also have sugar mimetics such as cyclobutyls in place of the pentofuranosyl group.

[00171] Oligonucleotides may also include, additionally or alternatively, nucleobase (often referred to in the art simply as "base") modifications or substitutions. As used herein, "unmodified" or "natural" nucleotides include adenine (A), guanine (G), thymine (T), cytosine (C) and uracil (U). Modified nucleotides include nucleotides found only infrequently or transiently in natural nucleic acids, e.g., hypoxanthine, 6-methyladenine, 5-Me pyrimidines, particularly 5-methylcytosine (also referred to as 5-methyl-2' deoxycytosine and often referred to in the art as 5-Me-C), 5-hydroxymethylcytosine (HMC), glycosyl HMC and gentobiosyl HMC, as well as synthetic nucleotides, e.g., 2-aminoadenine, 2-(methylamino)adenine, 2-(imidazolylalkyl)adenine, 2-(aminoalkylamino)adenine or other heterosubstituted alkyladenines, 2-thiouracil, 2-thiothymine, 5-bromouracil, 5-hydroxymethyluracil, 8-azaguanine, 7-deazaguanine, N<sub>6</sub> (6-aminoethyl)adenine and 2,6-diaminopurine. A "universal" base known in the art, e.g., inosine, may be included. 5-Me-C substitutions have been shown to increase nucleic acid duplex stability by 0.6-1.2°C. and are presently preferred base substitutions.

[00172] Another modification of the oligonucleotides of the invention involves chemically linking to the oligonucleotide one or more moieties or conjugates which enhance the activity or cellular uptake of the oligonucleotide. Such moieties include but are not limited to lipid moieties such as a cholesterol moiety, a cholesteryl moiety, an aliphatic chain, e.g., dodecandiol or undecyl residues, a polyamine or a polyethylene glycol chain, or Adamantane acetic acid. Oligonucleotides comprising lipophilic moieties, and methods for preparing such oligonucleotides are known in the art, for example, U.S. Pat. Nos. 5,138,045, 5,218,105 and 5,459,255.

[00173] It is not necessary for all positions in a given oligonucleotide to be uniformly modified, and in fact more than one of the aforementioned modifications may be incorporated in a single oligonucleotide or even at within a single nucleoside within an oligonucleotide. The present invention also includes oligonucleotides which are chimeric oligonucleotides as hereinbefore defined.

[00174] In another embodiment, the nucleic acid molecule of the present invention is conjugated with another moiety including but not limited to abasic nucleotides, polyether, polyamine, polyamides, peptides, carbohydrates, lipid, or polyhydrocarbon compounds. Those skilled in the art will recognize that these molecules can be linked to one or more of any nucleotides comprising the nucleic acid molecule at several positions on the sugar, base or phosphate group.

5 [00175] The oligonucleotides used in accordance with this invention may be conveniently and routinely made through the well-known technique of solid phase synthesis. Equipment for such synthesis is sold by several vendors including Applied Biosystems. Any other means for such synthesis may also be employed; the actual synthesis of the oligonucleotides is well within the talents of one of ordinary skill in the art. It is also well known to use similar techniques to prepare other oligonucleotides such as the phosphorothioates and alkylated derivatives. It is also well  
10 known to use similar techniques and commercially available modified amidites and controlled-pore glass (CPG) products such as biotin, fluorescein, acridine or psoralen-modified amidites and/or CPG (available from Glen Research, Sterling VA) to synthesize fluorescently labeled, biotinylated or other modified oligonucleotides such as cholesterol-modified oligonucleotides.

[00176] In accordance with the invention, use of modifications such as the use of LNA monomers to enhance the  
15 potency, specificity and duration of action and broaden the routes of administration of oligonucleotides comprised of current chemistries such as MOE, ANA, FANA, PS etc. This can be achieved by substituting some of the monomers in the current oligonucleotides by LNA monomers. The LNA modified oligonucleotide may have a size similar to the parent compound or may be larger or preferably smaller. It is preferred that such LNA-modified oligonucleotides contain less than about 70%, more preferably less than about 60%, most preferably less than about 50% LNA  
20 monomers and that their sizes are between about 5 and 25 nucleotides, more preferably between about 12 and 20 nucleotides.

[00177] Preferred modified oligonucleotide backbones comprise, but not limited to, phosphorothioates, chiral  
phosphorothioates, phosphorodithioates, phosphotriesters, aminoalkylphosphotriesters, methyl and other alkyl  
phosphonates comprising 3'alkylene phosphonates and chiral phosphonates, phosphinates, phosphoramidates  
25 comprising 3'-amino phosphoramidate and aminoalkylphosphoramidates, thionophosphoramidates,  
thionoalkylphosphonates, thionoalkylphosphotriesters, and boranophosphates having normal 3'-5' linkages, 2'-5' linked  
analogs of these, and those having inverted polarity wherein the adjacent pairs of nucleoside units are linked 3'-5' to 5'-  
3' or 2'-5' to 5'-2'. Various salts, mixed salts and free acid forms are also included.

[00178] Representative United States patents that teach the preparation of the above phosphorus containing linkages  
30 comprise, but are not limited to, US patent nos. 3,687,808; 4,469,863; 4,476,301; 5,023,243; 5, 177,196; 5,188,897;  
5,264,423; 5,276,019; 5,278,302; 5,286,717; 5,321,131; 5,399,676; 5,405,939; 5,453,496; 5,455, 233; 5,466,677;  
5,476,925; 5,519,126; 5,536,821; 5,541,306; 5,550,111; 5,563, 253; 5,571,799; 5,587,361; and 5,625,050.

[00179] Preferred modified oligonucleotide backbones that do not include a phosphorus atom therein have backbones that are formed by short chain alkyl or cycloalkyl internucleoside linkages, mixed heteroatom and alkyl or cycloalkyl internucleoside linkages, or one or more short chain heteroatomic or heterocyclic internucleoside linkages. These comprise those having morpholino linkages (formed in part from the sugar portion of a nucleoside); siloxane backbones; sulfide, sulfoxide and 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 others having mixed N, O, S and CH<sub>2</sub> component parts.

[00180] Representative United States patents that teach the preparation of the above oligonucleosides comprise, but are not limited to, US patent nos. 5,034,506; 5,166,315; 5,185,444; 5,214,134; 5,216,141; 5,235,033; 5,264,562; 5,264,564; 5,405,938; 5,434,257; 5,466,677; 5,470,967; 5,489,677; 5,541,307; 5,561,225; 5,596,086; 5,602,240; 5,610,289; 5,602,240; 5,608,046; 5,610,289; 5,618,704; 5,623,070; 5,663,312; 5,633,360; 5,677,437; and 5,677,439.

[00181] In other preferred oligonucleotide mimetics, both the sugar and the internucleoside linkage, i.e., the backbone, of the nucleotide units are replaced with novel groups. The base units are maintained for hybridization with an appropriate nucleic acid target compound. One such oligomeric compound, an oligonucleotide mimetic that has been shown to have excellent hybridization properties, is referred to as a peptide nucleic acid (PNA). In PNA compounds, the sugar-backbone of an oligonucleotide is replaced with an amide containing backbone, in particular an aminoethylglycine backbone. The nucleobases are retained and are bound directly or indirectly to aza nitrogen atoms of the amide portion of the backbone. Representative United States patents that teach the preparation of PNA compounds comprise, but are not limited to, US patent nos. 5,539,082; 5,714,331; and 5,719,262. Further teaching of PNA compounds can be found in Nielsen, et al. (1991) Science 254, 1497-1500.

[00182] In an embodiment of the invention the oligonucleotides with phosphorothioate backbones and oligonucleosides with heteroatom backbones, and in particular- CH<sub>2</sub>-NH-O-CH<sub>2</sub>-, -CH<sub>2</sub>-N(CH<sub>3</sub>)-O-CH<sub>2</sub>-known as a methylene (methylimino) or MMI backbone, -CH<sub>2</sub>-O-N(CH<sub>3</sub>)-CH<sub>2</sub>-, -CH<sub>2</sub>N(CH<sub>3</sub>)-N(CH<sub>3</sub>)CH<sub>2</sub>-and-O-N(CH<sub>3</sub>)-CH<sub>2</sub>-CH<sub>2</sub>- wherein the native phosphodiester backbone is represented as-O-P-O-CH<sub>2</sub>- of the above referenced US patent no. 5,489,677, and the amide backbones of the above referenced US patent no. 5,602,240. Also preferred are oligonucleotides having morpholino backbone structures of the above-referenced US patent no. 5,034,506.

[00183] Modified oligonucleotides may also contain one or more substituted sugar moieties. Preferred oligonucleotides comprise one of the following at the 2' position: OH; F; O-, S-, or N-alkyl; O-, S-, or N-alkenyl; O-, S- or N-alkynyl; or O-alkyl-O-alkyl, wherein the alkyl, alkenyl and alkynyl may be substituted or unsubstituted C to CO alkyl or C<sub>2</sub> to CO alkenyl and alkynyl. Particularly preferred are O(CH<sub>2</sub>)<sub>n</sub>OmCH<sub>3</sub>, O(CH<sub>2</sub>)<sub>n</sub>OCH<sub>3</sub>, O(CH<sub>2</sub>)<sub>n</sub>NH<sub>2</sub>,

O(CH<sub>2</sub>)<sub>n</sub>CH<sub>3</sub>, O(CH<sub>2</sub>)<sub>n</sub>ONH<sub>2</sub>, and O(CH<sub>2</sub>)<sub>n</sub>ON(CH<sub>2</sub>)<sub>m</sub>CH<sub>3</sub>)<sub>2</sub> where n and m can be from 1 to about 10. Other preferred oligonucleotides comprise one of the following at the 2' position: C to CO, (lower alkyl, substituted lower alkyl, alkaryl, aralkyl, O-alkaryl or O-aralkyl, SH, SCH<sub>3</sub>, OCN, Cl, Br, CN, CF<sub>3</sub>, OCF<sub>3</sub>, SOCH<sub>3</sub>, SO<sub>2</sub>CH<sub>3</sub>, ONO<sub>2</sub>, NO<sub>2</sub>, N<sub>3</sub>, NH<sub>2</sub>, heterocycloalkyl, heterocycloalkaryl, aminoalkylamino, polyalkylamino, substituted silyl, an RNA cleaving group, a reporter group, an intercalator, a group for improving the pharmacokinetic properties of an oligonucleotide, or a group for improving the pharmacodynamic properties of an oligonucleotide, and other substituents having similar properties. A preferred modification comprises 2'-methoxyethoxy (2'-O-CH<sub>2</sub>CH<sub>2</sub>OCH<sub>3</sub>, also known as 2'-O-(2- methoxyethyl) or 2'-MOE) i.e., an alkoxyalkoxy group. A further preferred modification comprises 2'-dimethylaminoethoxy, i.e., a O(CH<sub>2</sub>)<sub>2</sub>ON(CH<sub>3</sub>)<sub>2</sub> group, also known as 2'-DMAOE, as described in examples herein below, and 2'- dimethylaminoethoxyethoxy (also known in the art as 2'-O-dimethylaminoethoxyethyl or 2'- DMAEOE), i.e., 2'-O-CH<sub>2</sub>-O-CH<sub>2</sub>-N(CH<sub>2</sub>)<sub>2</sub>.

[00184] Other preferred modifications comprise 2'-methoxy (2'-O CH<sub>3</sub>), 2'-aminopropoxy (2'-O CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub>) and 2'-fluoro (2'-F). Similar modifications may also be made at other positions on the oligonucleotide, particularly the 3' position of the sugar on the 3' terminal nucleotide or in 2'-5' linked oligonucleotides and the 5' position of 5' terminal nucleotide. Oligonucleotides may also have sugar mimetics such as cyclobutyl moieties in place of the pentofuranosyl sugar. Representative United States patents that teach the preparation of such modified sugar structures comprise, but are not limited to, US patent nos. 4,981,957; 5,118,800; 5,319,080; 5,359,044; 5,393,878; 5,446,137; 5,466,786; 5,514,785; 5,519,134; 5,567,811; 5,576,427; 5,591,722; 5,597,909; 5,610,300; 5,627,053; 5,639,873; 5,646,265; 5,658,873; 5,670,633; and 5,700,920.

[00185] Oligonucleotides may also comprise nucleobase (often referred to in the art simply as "base") modifications or substitutions. As used herein, "unmodified" or "natural" nucleotides comprise the purine bases adenine (A) and guanine (G), and the pyrimidine bases thymine (T), cytosine (C) and uracil (U). Modified nucleotides comprise other synthetic and natural nucleotides such as 5-methylcytosine (5-me-C), 5-hydroxymethyl cytosine, xanthine, hypoxanthine, 2- aminoadenine, 6-methyl and other alkyl derivatives of adenine and guanine, 2-propyl and other alkyl derivatives of adenine and guanine, 2-thiouracil, 2-thiothymine and 2-thiocytosine, 5-halouracil and cytosine, 5-propynyl uracil and cytosine, 6-azo uracil, cytosine and thymine, 5-uracil (pseudo-uracil), 4-thiouracil, 8-halo, 8-amino, 8-thiol, 8-thioalkyl, 8-hydroxyl and other 8-substituted adenines and guanines, 5-halo particularly 5-bromo, 5-trifluoromethyl and other 5-substituted uracils and cytosines, 7-methylguanine and 7-methyladenine, 8-azaguanine and 8-azaadenine, 7-deazaguanine and 7-deazaadenine and 3-deazaguanine and 3-deazaadenine.

[00186] Further, nucleotides comprise those disclosed in United States Patent No. 3,687,808, those disclosed in 'The Concise Encyclopedia of Polymer Science And Engineering', pages 858-859, Kroschwitz, J.I., ed. John Wiley & Sons, 1990, those disclosed by Englisch et al., 'Angewandte Chemie, International Edition', 1991, 30, page 613, and those disclosed by Sanghvi, Y.S., Chapter 15, 'Antisense Research and Applications', pages 289-302, Crooke, S.T. and

Lebleu, B. et al., CRC Press, 1993. Certain of these nucleotides are particularly useful for increasing the binding affinity of the oligomeric compounds of the invention. These comprise 5-substituted pyrimidines, 6-azapyrimidines and N-2, N-6 and O-6 substituted purines, comprising 2-aminopropyladenine, 5-propynyluracil and 5-propynylecytosine. 5-methylcytosine substitutions have been shown to increase nucleic acid duplex stability by 0.6-1.2°C (Sanghvi, Y.S.,  
5 Crooke, S.T. and Lebleu, B., eds, 'Antisense Research and Applications', CRC Press, Boca Raton, 1993, pp. 276-278) and are presently preferred base substitutions, even more particularly when combined with 2'-O-methoxyethyl sugar modifications.

[00187] Representative United States patents that teach the preparation of the above noted modified nucleotides as well as other modified nucleotides comprise, but are not limited to, US patent nos. 3,687,808, as well as 4,845,205;  
10 5,130,302; 5,134,066; 5,175,273; 5,367,066; 5,432,272; 5,457,187; 5,459,255; 5,484,908; 5,502,177; 5,525,711; 5,552,540; 5,587,469; 5,596,091; 5,614,617; 5,750,692, and 5,681,941.

[00188] Another modification of the oligonucleotides of the invention involves chemically linking to the oligonucleotide one or more moieties or conjugates, which enhance the activity, cellular distribution, or cellular uptake  
15 of the oligonucleotide.

[00189] Such moieties comprise but are not limited to, lipid moieties such as a cholesterol moiety, cholic acid, a thioether, e.g., hexyl-S-tritylthiol, a thiocholesterol, an aliphatic chain, e.g., dodecandiol or undecyl residues, a phospholipid, e.g., di-hexadecyl-rac-glycerol or triethylammonium 1,2-di-O-hexadecyl-rac-glycero-3-H-phosphonate, a polyamine or a polyethylene glycol chain, or Adamantane acetic acid, a palmitoyl moiety, or an octadecylamine or  
20 hexylamino-carbonyl-t oxycholesterol moiety.

[00190] Representative United States patents that teach the preparation of such oligonucleotides conjugates comprise, but are not limited to, US patent nos. 4,828,979; 4,948,882; 5,218,105; 5,525,465; 5,541,313; 5,545,730; 5,552,538; 5,578,717; 5,580,731; 5,580,731; 5,591,584; 5,109,124; 5,118,802; 5,138,045; 5,414,077; 5,486,603; 5,512,439; 5,578,718; 5,608,046; 4,587,044; 4,605,735; 4,667,025; 4,762,779; 4,789,737; 4,824,941; 4,835,263; 4,876,335;  
25 4,904,582; 4,958,013; 5,082,830; 5,112,963; 5,214,136; 5,082,830; 5,112,963; 5,214,136; 5,245,022; 5,254,469; 5,258,506; 5,262,536; 5,272,250; 5,292,873; 5,317,098; 5,371,241; 5,391,723; 5,416,203; 5,451,463; 5,510,475; 5,512,667; 5,514,785; 5,565,552; 5,567,810; 5,574,142; 5,585,481; 5,587,371; 5,595,726; 5,597,696; 5,599,923; 5,599,928 and 5,688,941.

[00191] *Drug discovery*: The compounds of the present invention can also be applied in the areas of drug discovery  
30 and target validation. The present invention comprehends the use of the compounds and preferred target segments identified herein in drug discovery efforts to elucidate relationships that exist between Sodium channel, voltage-gated, alpha subunit (SCNA) polynucleotides and a disease state, phenotype, or condition. These methods include detecting or modulating SCNA polynucleotides comprising contacting a sample, tissue, cell, or organism with the compounds of

the present invention, measuring the nucleic acid or protein level of SCNA polynucleotides and/or a related phenotypic or chemical endpoint at some time after treatment, and optionally comparing the measured value to a non-treated sample or sample treated with a further compound of the invention. These methods can also be performed in parallel or in combination with other experiments to determine the function of unknown genes for the process of target validation or to determine the validity of a particular gene product as a target for treatment or prevention of a particular disease, condition, or phenotype.

*Assessing Upregulation or Inhibition of Gene Expression:*

[00192] Transfer of an exogenous nucleic acid into a host cell or organism can be assessed by directly detecting the presence of the nucleic acid in the cell or organism. Such detection can be achieved by several methods well known in the art. For example, the presence of the exogenous nucleic acid can be detected by Southern blot or by a polymerase chain reaction (PCR) technique using primers that specifically amplify nucleotide sequences associated with the nucleic acid. Expression of the exogenous nucleic acids can also be measured using conventional methods including gene expression analysis. For instance, mRNA produced from an exogenous nucleic acid can be detected and quantified using a Northern blot and reverse transcription PCR (RT-PCR).

[00193] Expression of RNA from the exogenous nucleic acid can also be detected by measuring an enzymatic activity or a reporter protein activity. For example, antisense modulatory activity can be measured indirectly as a decrease or increase in target nucleic acid expression as an indication that the exogenous nucleic acid is producing the effector RNA. Based on sequence conservation, primers can be designed and used to amplify coding regions of the target genes. Initially, the most highly expressed coding region from each gene can be used to build a model control gene, although any coding or non coding region can be used. Each control gene is assembled by inserting each coding region between a reporter coding region and its poly(A) signal. These plasmids would produce an mRNA with a reporter gene in the upstream portion of the gene and a potential RNAi target in the 3' non-coding region. The effectiveness of individual antisense oligonucleotides would be assayed by modulation of the reporter gene. Reporter genes useful in the methods of the present invention include acetohydroxyacid synthase (AHAS), alkaline phosphatase (AP), beta galactosidase (LacZ), beta glucuronidase (GUS), chloramphenicol acetyltransferase (CAT), green fluorescent protein (GFP), red fluorescent protein (RFP), yellow fluorescent protein (YFP), cyan fluorescent protein (CFP), horseradish peroxidase (HRP), luciferase (Luc), nopaline synthase (NOS), octopine synthase (OCS), and derivatives thereof. Multiple selectable markers are available that confer resistance to ampicillin, bleomycin, chloramphenicol, gentamycin, hygromycin, kanamycin, lincomycin, methotrexate, phosphinothricin, puromycin, and tetracycline. Methods to determine modulation of a reporter gene are well known in the art, and include, but are not limited to, fluorometric methods (e.g. fluorescence spectroscopy, Fluorescence Activated Cell Sorting (FACS), fluorescence microscopy), antibiotic resistance determination.



[00194] Target nucleic acid segments can also be detected in the cell based assays. Experiments are conducted to detect the Scn1a natural antisense BG724147 in HepG2, in Primary human fibroblasts carrying a Dravet syndrome-associated mutation and also in human Testis. For HepG2 as well as Primary human fibroblasts carrying a Dravet syndrome-associated mutation the cells are grown and RNA is extracted For the human Testis, polyA isolated RNA is purchased and utilized. This experiment is called a RACE (Rapid Amplification of cDNA Ends) and specific primers for the BG724147 RNA transcript are used.

[00195] A PCR product very similar in polyA isolated RNA from HepG2 and polyA isolated RNA from Primary human fibroblasts carrying a Dravet syndrome-associated mutation was detected but this product was not detected in poly A isolated RNA from human Testis. Furthermore, that PCR product was not detected (or in very very low amounts) in the total RNA from HepG2 cells and total RNA from Primary human fibroblasts carrying a Dravet syndrome-associated mutation. The results suggest that the natural antisense for Scn1a called BG724147 is present in HepG2 cells and Primary human fibroblasts carrying a Dravet syndrome-associated mutation but not in human Testis.

[00196] SCNA protein and mRNA expression can be assayed using methods known to those of skill in the art and described elsewhere herein. For example, immunoassays such as the ELISA can be used to measure protein levels. SCNA ELISA assay kits are available commercially, e.g., from R&D Systems (Minneapolis, MN).

[00197] In embodiments, SCNA expression (e.g., mRNA or protein) in a sample (e.g., cells or tissues in vivo or in vitro) treated using an antisense oligonucleotide of the invention is evaluated by comparison with SCNA expression in a control sample. For example, expression of the protein or nucleic acid can be compared using methods known to those of skill in the art with that in a mock-treated or untreated sample. Alternatively, comparison with a sample treated with a control antisense oligonucleotide (e.g., one having an altered or different sequence) can be made depending on the information desired. In another embodiment, a difference in the expression of the SCNA protein or nucleic acid in a treated vs. an untreated sample can be compared with the difference in expression of a different nucleic acid (including any standard deemed appropriate by the researcher, e.g., a housekeeping gene) in a treated sample vs. an untreated sample.

[00198] Observed differences can be expressed as desired, e.g., in the form of a ratio or fraction, for use in a comparison with control. In embodiments, the level of SCNA mRNA or protein, in a sample treated with an antisense oligonucleotide of the present invention, is increased or decreased by about 1.25-fold to about 10-fold or more relative to an untreated sample or a sample treated with a control nucleic acid. In embodiments, the level of SCNA mRNA or protein is increased or decreased by at least about 1.25-fold, at least about 1.3-fold, at least about 1.4-fold, at least about 1.5-fold, at least about 1.6-fold, at least about 1.7-fold, at least about 1.8-fold, at least about 2-fold, at least about 2.5-fold, at least about 3-fold, at least about 3.5-fold, at least about 4-fold, at least about 4.5-fold, at least about 5-fold, at least about 5.5-fold, at least about 6-fold, at least about 6.5-fold, at least about 7-fold, at least about 7.5-fold, at least about 8-fold, at least about 8.5-fold, at least about 9-fold, at least about 9.5-fold, or at least about 10-fold or more.

*Kits, Research Reagents, Diagnostics, and Therapeutics*

[00199] The compounds of the present invention can be utilized for diagnostics, therapeutics, and prophylaxis, and as research reagents and components of kits. Furthermore, antisense oligonucleotides, which are able to inhibit gene expression with exquisite specificity, are often used by those of ordinary skill to elucidate the function of particular genes or to distinguish between functions of various members of a biological pathway.

[00200] For use in kits and diagnostics and in various biological systems, the compounds of the present invention, either alone or in combination with other compounds or therapeutics, are useful as tools in differential and/or combinatorial analyses to elucidate expression patterns of a portion or the entire complement of genes expressed within cells and tissues.

[00201] As used herein the term "biological system" or "system" is defined as any organism, cell, cell culture or tissue that expresses, or is made competent to express products of the Sodium channel, voltage-gated, alpha subunit (SCNA) genes. These include, but are not limited to, humans, transgenic animals, cells, cell cultures, tissues, xenografts, transplants and combinations thereof.

[00202] As one non limiting example, expression patterns within cells or tissues treated with one or more antisense compounds are compared to control cells or tissues not treated with antisense compounds and the patterns produced are analyzed for differential levels of gene expression as they pertain, for example, to disease association, signaling pathway, cellular localization, expression level, size, structure or function of the genes examined. These analyses can be performed on stimulated or unstimulated cells and in the presence or absence of other compounds that affect expression patterns.

[00203] Examples of methods of gene expression analysis known in the art include DNA arrays or microarrays, SAGE (serial analysis of gene expression), READS (restriction enzyme amplification of digested cDNAs), TOGA (total gene expression analysis), protein arrays and proteomics, expressed sequence tag (EST) sequencing, subtractive RNA fingerprinting (SuRF), subtractive cloning, differential display (DD), comparative genomic hybridization, FISH (fluorescent in situ hybridization) techniques and mass spectrometry methods.

[00204] The compounds of the invention are useful for research and diagnostics, because these compounds hybridize to nucleic acids encoding Sodium channel, voltage-gated, alpha subunit (SCNA). For example, oligonucleotides that hybridize with such efficiency and under such conditions as disclosed herein as to be effective SCNA modulators are effective primers or probes under conditions favoring gene amplification or detection, respectively. These primers and probes are useful in methods requiring the specific detection of nucleic acid molecules encoding SCNA and in the amplification of said nucleic acid molecules for detection or for use in further studies of SCNA. Hybridization of the antisense oligonucleotides, particularly the primers and probes, of the invention with a nucleic acid encoding SCNA can be detected by means known in the art. Such means may include conjugation of an enzyme to the oligonucleotide,

radiolabeling of the oligonucleotide, or any other suitable detection means. Kits using such detection means for detecting the level of SCNA in a sample may also be prepared.

[00205] The specificity and sensitivity of antisense are also harnessed by those of skill in the art for therapeutic uses. Antisense compounds have been employed as therapeutic moieties in the treatment of disease states in animals, including humans. Antisense oligonucleotide drugs have been safely and effectively administered to humans and numerous clinical trials are presently underway. It is thus established that antisense compounds can be useful therapeutic modalities that can be configured to be useful in treatment regimes for the treatment of cells, tissues and animals, especially humans.

[00206] For therapeutics, an animal, preferably a human, suspected of having a disease or disorder which can be treated by modulating the expression of SCNA polynucleotides is treated by administering antisense compounds in accordance with this invention. For example, in one non-limiting embodiment, the methods comprise the step of administering to the animal in need of treatment, a therapeutically effective amount of SCNA modulator. The SCNA modulators of the present invention effectively modulate the activity of the SCNA or modulate the expression of the SCNA protein. In one embodiment, the activity or expression of SCNA in an animal is inhibited by about 10% as compared to a control. Preferably, the activity or expression of SCNA in an animal is inhibited by about 30%. More preferably, the activity or expression of SCNA in an animal is inhibited by 50% or more. Thus, the oligomeric compounds modulate expression of Sodium channel, voltage-gated, alpha subunit (SCNA) mRNA by at least 10%, by at least 50%, by at least 25%, by at least 30%, by at least 40%, by at least 50%, by at least 60%, by at least 70%, by at least 75%, by at least 80%, by at least 85%, by at least 90%, by at least 95%, by at least 98%, by at least 99%, or by 100% as compared to a control.

[00207] In one embodiment, the activity or expression of Sodium channel, voltage-gated, alpha subunit (SCNA) and/or in an animal is increased by about 10% as compared to a control. Preferably, the activity or expression of SCNA in an animal is increased by about 30%. More preferably, the activity or expression of SCNA in an animal is increased by 50% or more. Thus, the oligomeric compounds modulate expression of SCNA mRNA by at least 10%, by at least 50%, by at least 25%, by at least 30%, by at least 40%, by at least 50%, by at least 60%, by at least 70%, by at least 75%, by at least 80%, by at least 85%, by at least 90%, by at least 95%, by at least 98%, by at least 99%, or by 100% as compared to a control.

[00208] For example, the reduction of the expression of Sodium channel, voltage-gated, alpha subunit (SCNA) may be measured in serum, blood, adipose tissue, liver or any other body fluid, tissue or organ of the animal. Preferably, the cells contained within said fluids, tissues or organs being analyzed contain a nucleic acid molecule encoding SCNA peptides and/or the SCNA protein itself.

[00209] The compounds of the invention can be utilized in pharmaceutical compositions by adding an effective amount of a compound to a suitable pharmaceutically acceptable diluent or carrier. Use of the compounds and methods of the invention may also be useful prophylactically.

#### *Conjugates*

5 [00210] Another modification of the oligonucleotides of the invention involves chemically linking to the oligonucleotide one or more moieties or conjugates that enhance the activity, cellular distribution or cellular uptake of the oligonucleotide. These moieties or conjugates can include conjugate groups covalently bound to functional groups such as primary or secondary hydroxyl groups. Conjugate groups of the invention include intercalators, reporter molecules, polyamines, polyamides, polyethylene glycols, polyethers, groups that enhance the pharmacodynamic properties of oligomers, and groups that enhance the pharmacokinetic properties of oligomers. Typical conjugate groups include cholesterol, lipids, phospholipids, biotin, phenazine, folate, phenanthridine, anthraquinone, acridine, fluoresceins, rhodamines, coumarins, and dyes. Groups that enhance the pharmacodynamic properties, in the context of this invention, include groups that improve uptake, enhance resistance to degradation, and/or strengthen sequence-specific hybridization with the target nucleic acid. Groups that enhance the pharmacokinetic properties, in the context of this invention, include groups that improve uptake, distribution, metabolism or excretion of the compounds of the present invention. Representative conjugate groups are disclosed in International Patent Application No. PCT/US92/09196, filed Oct. 23, 1992, and U.S. Pat. No. 6,287,860. Conjugate moieties include, but are not limited to, lipid moieties such as a cholesterol moiety, cholic acid, a thioether, e.g., hexyl-5- tritylthiol, a thiocholesterol, an aliphatic chain, e.g., dodecandiol or undecyl residues, a phospholipid, e.g., di-hexadecyl-rac-glycerol or triethylammonium 1,2-di-O-hexadecyl-rac-glycero-3-Hphosphonate, a polyamine or a polyethylene glycol chain, or Adamantane acetic acid, a palmitoyl moiety, or an octadecylamine or hexylamino-carbonyl-oxycholesterol moiety. Oligonucleotides of the invention may also be conjugated to active drug substances, for example, aspirin, warfarin, phenylbutazone, ibuprofen, suprofen, fenbufen, ketoprofen, (S)-(+)-pranoprofen, carprofen, dansylsarcosine, 2,3,5-triodobenzoic acid, flufenamic acid, folic acid, a benzothiadiazide, chlorothiazide, a diazepine, indomethacin, a barbiturate, a cephalosporin, a sulfa drug, an antidiabetic, an antibacterial or an antibiotic.

25 [00211] Representative United States patents that teach the preparation of such oligonucleotides conjugates include, but are not limited to, U.S. Pat. Nos. 4,828,979; 4,948,882; 5,218,105; 5,525,465; 5,541,313; 5,545,730; 5,552,538; 5,578,717; 5,580,731; 5,580,731; 5,591,584; 5,109,124; 5,118,802; 5,138,045; 5,414,077; 5,486,603; 5,512,439; 5,578,718; 5,608,046; 4,587,044; 4,605,735; 4,667,025; 4,762,779; 4,789,737; 4,824,941; 4,835,263; 4,876,335; 30 4,904,582; 4,958,013; 5,082,830; 5,112,963; 5,214,136; 5,082,830; 5,112,963; 5,214,136; 5,245,022; 5,254,469; 5,258,506; 5,262,536; 5,272,250; 5,292,873; 5,317,098; 5,371,241; 5,391,723; 5,416,203; 5,451,463; 5,510,475; 5,512,667; 5,514,785; 5,565,552; 5,567,810; 5,574,142; 5,585,481; 5,587,371; 5,595,726; 5,597,696; 5,599,923; 5,599,928 and 5,688,941.

*Formulations*

[00212] The compounds of the invention may also be admixed, encapsulated, conjugated or otherwise associated with other molecules, molecule structures or mixtures of compounds, as foreexample, liposomes, receptor-targeted molecules, oral, rectal, topical or other formulations, for assisting in uptake, distribution and/or absorption.

5 Representative United States patents that teach the preparation of such uptake, distribution and/or absorption-assisting formulations include, but are not limited to, U.S. Pat. Nos. 5,108,921; 5,354,844; 5,416,016; 5,459,127; 5,521,291; 5,543,165; 5,547,932; 5,583,020; 5,591,721; 4,426,330; 4,534,899; 5,013,556; 5,108,921; 5,213,804; 5,227,170; 5,264,221; 5,356,633; 5,395,619; 5,416,016; 5,417,978; 5,462,854; 5,469,854; 5,512,295; 5,527,528; 5,534,259; 5,543,152; 5,556,948; 5,580,575; and 5,595,756.

10 [00213] Although, the antisense oligonucleotides do not need to be administered in the context of a vector in order to modulate a target expression and/or function, embodiments of the invention relates to expression vector constructs for the expression of antisense oligonucleotides, comprising promoters, hybrid promoter gene sequences and possess a strong constitutive promoter activity, or a promoter activity which can be induced in the desired case.

[00214] In an embodiment, invention practice involves administering at least one of the foregoing antisense  
15 oligonucleotides with a suitable nucleic acid delivery system. In one embodiment, that system includes a non-viral vector operably linked to the polynucleotide. Examples of such nonviral vectors include the oligonucleotide alone (e.g. any one or more of SEQ ID NOS: 29 to 94) or in combination with a suitable protein, polysaccharide or lipid formulation.

[00215] Additionally suitable nucleic acid delivery systems include viral vector, typically sequence from at least one  
20 of an adenovirus, adenovirus-associated virus (AAV), helper-dependent adenovirus, retrovirus, or hemagglutinin virus of Japan-liposome (HVJ) complex. Preferably, the viral vector comprises a strong eukaryotic promoter operably linked to the polynucleotide e.g., a cytomegalovirus (CMV) promoter.

[00216] Additionally preferred vectors include viral vectors, fusion proteins and chemical conjugates. Retroviral  
25 vectors include Moloney murine leukemia viruses and HIV-based viruses. One preferred HIV-based viral vector comprises at least two vectors wherein the gag and pol genes are from an HIV genome and the env gene is from another virus. DNA viral vectors are preferred. These vectors include pox vectors such as orthopox or avipox vectors, herpesvirus vectors such as a herpes simplex I virus (HSV) vector, Adenovirus Vectors and Adeno-associated Virus Vectors.

[00217] The antisense compounds of the invention encompass any pharmaceutically acceptable salts, esters, or salts of  
30 such esters, or any other compound which, upon administration to an animal, including a human, is capable of providing (directly or indirectly) the biologically active metabolite or residue thereof.

[00218] The term "pharmaceutically acceptable salts" refers to physiologically and pharmaceutically acceptable salts of the compounds of the invention: i.e., salts that retain the desired biological activity of the parent compound and do

not impart undesired toxicological effects thereto. For oligonucleotides, preferred examples of pharmaceutically acceptable salts and their uses are further described in U.S. Pat. No. 6,287,860.

5 [00219] The present invention also includes pharmaceutical compositions and formulations that include the antisense compounds of the invention. The pharmaceutical compositions of the present invention may be administered in a number of ways depending upon whether local or systemic treatment is desired and upon the area to be treated. Administration may be topical (including ophthalmic and to mucous membranes including vaginal and rectal delivery), pulmonary, e.g., by inhalation or insufflation of powders or aerosols, including by nebulizer; intratracheal, intranasal, epidermal and transdermal), oral or parenteral. Parenteral administration includes intravenous, intraarterial, 10 subcutaneous, intraperitoneal or intramuscular injection or infusion; or intracranial, e.g., intrathecal or intraventricular, administration.

[00220] For treating tissues in the central nervous system, administration can be made by, e.g., injection or infusion into the cerebrospinal fluid. Administration of antisense RNA into cerebrospinal fluid is described, e.g., in U.S. Pat. App. Pub. No. 2007/0117772, "Methods for slowing familial ALS disease progression."

15 [00221] When it is intended that the antisense oligonucleotide of the present invention be administered to cells in the central nervous system, administration can be with one or more agents capable of promoting penetration of the subject antisense oligonucleotide across the blood-brain barrier. Injection can be made, e.g., in the entorhinal cortex or hippocampus. Delivery of neurotrophic factors by administration of an adenovirus vector to motor neurons in muscle 20 tissue is described in, e.g., U.S. Pat. No. 6,632,427, "Adenoviral-vector-mediated gene transfer into medullary motor neurons," incorporated herein by reference. Delivery of vectors directly to the brain, e.g., the striatum, the thalamus, the hippocampus, or the substantia nigra, is known in the art and described, e.g., in U.S. Pat. No. 6,756,523, "Adenovirus vectors for the transfer of foreign genes into cells of the central nervous system particularly in brain." Administration can be rapid as by injection or made over a period of time as by slow infusion or administration of slow release 25 formulations.

[00222] The subject antisense oligonucleotides can also be linked or conjugated with agents that provide desirable pharmaceutical or pharmacodynamic properties. For example, the antisense oligonucleotide can be coupled to any substance, known in the art to promote penetration or transport across the blood-brain barrier, such as an antibody to the transferrin receptor, and administered by intravenous injection. The antisense compound can be linked with a viral 30 vector, for example, that makes the antisense compound more effective and/or increases the transport of the antisense compound across the blood-brain barrier. Osmotic blood brain barrier disruption can also be accomplished by, e.g., infusion of sugars including, but not limited to, meso erythritol, xylitol, D(+) galactose, D(+) lactose, D(+) xylose, dulcitol, myo-inositol, L(-) fructose, D(-) mannitol, D(+) glucose, D(+) arabinose, D(-) arabinose, cellobiose, D(+)

maltose, D(+) raffinose, L(+) rhamnose, D(+) melibiose, D(-) ribose, adonitol, D(+) arabinol, L(-) arabinol, D(+) fucose, L(-) fucose, D(-) lyxose, L(+) lyxose, and L(-) lyxose, or amino acids including, but not limited to, glutamine, lysine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glycine, histidine, leucine, methionine, phenylalanine, proline, serine, threonine, tyrosine, valine, and taurine. Methods and materials for enhancing blood brain barrier penetration are described, e.g., in U. S. Patent No. 4,866,042, "Method for the delivery of genetic material across the blood brain barrier," 6,294,520, "Material for passage through the blood-brain barrier," and 6,936,589, "Parenteral delivery systems."

[00223] The subject antisense compounds may be admixed, encapsulated, conjugated or otherwise associated with other molecules, molecule structures or mixtures of compounds, for example, liposomes, receptor-targeted molecules, oral, rectal, topical or other formulations, for assisting in uptake, distribution and/or absorption. For example, cationic lipids may be included in the formulation to facilitate oligonucleotide uptake. One such composition shown to facilitate uptake is LIPOFECTIN (available from GIBCO-BRL, Bethesda, MD).

[00224] Oligonucleotides with at least one 2'-O-methoxyethyl modification are believed to be particularly useful for oral administration. Pharmaceutical compositions and formulations for topical administration may include transdermal patches, ointments, lotions, creams, gels, drops, suppositories, sprays, liquids and powders. Conventional pharmaceutical carriers, aqueous, powder or oily bases, thickeners and the like may be necessary or desirable. Coated condoms, gloves and the like may also be useful.

[00225] The pharmaceutical formulations of the present invention, which may conveniently be presented in unit dosage form, may be prepared according to conventional techniques well known in the pharmaceutical industry. Such techniques include the step of bringing into association the active ingredients with the pharmaceutical carrier(s) or excipient(s). In general, the formulations are prepared by uniformly and intimately bringing into association the active ingredients with liquid carriers or finely divided solid carriers or both, and then, if necessary, shaping the product.

[00226] The compositions of the present invention may be formulated into any of many possible dosage forms such as, but not limited to, tablets, capsules, gel capsules, liquid syrups, soft gels, suppositories, and enemas. The compositions of the present invention may also be formulated as suspensions in aqueous, non-aqueous or mixed media. Aqueous suspensions may further contain substances that increase the viscosity of the suspension including, for example, sodium carboxymethylcellulose, sorbitol and/or dextran. The suspension may also contain stabilizers.

[00227] Pharmaceutical compositions of the present invention include, but are not limited to, solutions, emulsions, foams and liposome-containing formulations. The pharmaceutical compositions and formulations of the present invention may comprise one or more penetration enhancers, carriers, excipients or other active or inactive ingredients.

[00228] Emulsions are typically heterogeneous systems of one liquid dispersed in another in the form of droplets usually exceeding 0.1  $\mu\text{m}$  in diameter. Emulsions may contain additional components in addition to the dispersed phases, and the active drug that may be present as a solution in either the aqueous phase, oily phase or itself as a

separate phase. Microemulsions are included as an embodiment of the present invention. Emulsions and their uses are well known in the art and are further described in U.S. Pat. No. 6,287,860.

5 [00229] Formulations of the present invention include liposomal formulations. As used in the present invention, the term "liposome" means a vesicle composed of amphiphilic lipids arranged in a spherical bilayer or bilayers. Liposomes are unilamellar or multilamellar vesicles which have a membrane formed from a lipophilic material and an aqueous interior that contains the composition to be delivered. Cationic liposomes are positively charged liposomes that are believed to interact with negatively charged DNA molecules to form a stable complex. Liposomes that are pH-sensitive or negatively-charged are believed to entrap DNA rather than complex with it. Both cationic and noncationic liposomes have been used to deliver DNA to cells.

10 [00230] Liposomes also include "sterically stabilized" liposomes, a term which, as used herein, refers to liposomes comprising one or more specialized lipids. When incorporated into liposomes, these specialized lipids result in liposomes with enhanced circulation lifetimes relative to liposomes lacking such specialized lipids. Examples of sterically stabilized liposomes are those in which part of the vesicle-forming lipid portion of the liposome comprises one or more glycolipids or is derivatized with one or more hydrophilic polymers, such as a polyethylene glycol (PEG) moiety. Liposomes and their uses are further described in U.S. Pat. No. 6,287,860.

15 [00231] The pharmaceutical formulations and compositions of the present invention may also include surfactants. The use of surfactants in drug products, formulations and in emulsions is well known in the art. Surfactants and their uses are further described in U.S. Pat. No. 6,287,860.

[00232] In one embodiment, the present invention employs various penetration enhancers to effect the efficient delivery of nucleic acids, particularly oligonucleotides. In addition to aiding the diffusion of non-lipophilic drugs across cell membranes, penetration enhancers also enhance the permeability of lipophilic drugs. Penetration enhancers may be classified as belonging to one of five broad categories, i.e., surfactants, fatty acids, bile salts, chelating agents, and non-chelating nonsurfactants. Penetration enhancers and their uses are further described in U.S. Pat. No. 6,287,860.

25 [00233] One of skill in the art will recognize that formulations are routinely designed according to their intended use, i.e. route of administration.

[00234] Preferred formulations for topical administration include those in which the oligonucleotides of the invention are in admixture with a topical delivery agent such as lipids, liposomes, fatty acids, fatty acid esters, steroids, chelating agents and surfactants. Preferred lipids and liposomes include neutral (e.g. dioleoyl-phosphatidyl DOPE ethanolamine, dimyristoylphosphatidyl choline DMPC, distearoylphosphatidyl choline) negative (e.g. dimyristoylphosphatidyl glycerol DMPG) and cationic (e.g. dioleoyltetramethylaminopropyl DOTAP and dioleoyl-phosphatidyl ethanolamine DOTMA).



[00235] For topical or other administration, oligonucleotides of the invention may be encapsulated within liposomes or may form complexes thereto, in particular to cationic liposomes. Alternatively, oligonucleotides may be complexed to lipids, in particular to cationic lipids. Preferred fatty acids and esters, pharmaceutically acceptable salts thereof, and their uses are further described in U.S. Pat. No. 6,287,860.

5 [00236] Compositions and formulations for oral administration include powders or granules, microparticulates, nanoparticulates, suspensions or solutions in water or non-aqueous media, capsules, gel capsules, sachets, tablets or minitabets. Thickeners, flavoring agents, diluents, emulsifiers, dispersing aids or binders may be desirable. Preferred oral formulations are those in which oligonucleotides of the invention are administered in conjunction with one or more penetration enhancers surfactants and chelators. Preferred surfactants include fatty acids and/or esters or salts thereof,  
10 bile acids and/or salts thereof. Preferred bile acids/salts and fatty acids and their uses are further described in U.S. Pat. No. 6,287,860. Also preferred are combinations of penetration enhancers, for example, fatty acids/salts in combination with bile acids/salts. A particularly preferred combination is the sodium salt of lauric acid, capric acid and UDCA. Further penetration enhancers include polyoxyethylene-9-lauryl ether, polyoxyethylene-20-cetyl ether. Oligonucleotides of the invention may be delivered orally, in granular form including sprayed dried particles, or  
15 complexed to form micro or nanoparticles. Oligonucleotide complexing agents and their uses are further described in U.S. Pat. No. 6,287,860.

[00237] Compositions and formulations for parenteral, intrathecal or intraventricular administration may include sterile aqueous solutions that may also contain buffers, diluents and other suitable additives such as, but not limited to, penetration enhancers, carrier compounds and other pharmaceutically acceptable carriers or excipients.

20 [00238] Certain embodiments of the invention provide pharmaceutical compositions containing one or more oligomeric compounds and one or more other chemotherapeutic agents that function by a non-antisense mechanism. Examples of such chemotherapeutic agents include but are not limited to cancer chemotherapeutic drugs such as daunorubicin, daunomycin, dactinomycin, doxorubicin, epirubicin, idarubicin, esorubicin, bleomycin, mafosfamide, ifosfamide, cytosine arabinoside, bischloroethyl- nitrosurea, busulfan, mitomycin C, actinomycin D, mithramycin,  
25 prednisone, hydroxyprogesterone, testosterone, tamoxifen, dacarbazine, procarbazine, hexamethylmelamine, pentamethylmelamine, mitoxantrone, amsacrine, chlorambucil, methylcyclohexylnitrosurea, nitrogen mustards, melphalan, cyclophosphamide, 6-mercaptopurine, 6-thioguanine, cytarabine, 5- azacytidine, hydroxyurea, deoxycoformycin, 4-hydroxyperoxycyclo-phosphoramidate, 5-fluorouracil (5-FU), 5-fluorodeoxyuridine (5-FUdR), methotrexate (MTX), colchicine, taxol, vincristine, vinblastine, etoposide (VP-16), trimetrexate, irinotecan, topotecan,  
30 gemcitabine, teniposide, cisplatin and diethylstilbestrol (DES). When used with the compounds of the invention, such chemotherapeutic agents may be used individually (e.g., 5-FU and oligonucleotide), sequentially (e.g., 5-FU and oligonucleotide for a period of time followed by MTX and oligonucleotide), or in combination with one or more other such chemotherapeutic agents (e.g., 5-FU, MTX and oligonucleotide, or 5-FU, radiotherapy and oligonucleotide). Anti-

inflammatory drugs, including but not limited to nonsteroidal anti-inflammatory drugs and corticosteroids, and antiviral drugs, including but not limited to ribivirin, vidarabine, acyclovir and ganciclovir, may also be combined in compositions of the invention. Combinations of antisense compounds and other non-antisense drugs are also within the scope of this invention. Two or more combined compounds may be used together or sequentially.

5 [00239] In another related embodiment, compositions of the invention may contain one or more antisense compounds, particularly oligonucleotides, targeted to a first nucleic acid and one or more additional antisense compounds targeted to a second nucleic acid target. For example, the first target may be a particular antisense sequence of Sodium channel, voltage-gated, alpha subunit (SCNA), and the second target may be a region from another nucleotide sequence. Alternatively, compositions of the invention may contain two or more antisense compounds targeted to different  
10 regions of the same Sodium channel, voltage-gated, alpha subunit (SCNA) nucleic acid target. Numerous examples of antisense compounds are illustrated herein and others may be selected from among suitable compounds known in the art. Two or more combined compounds may be used together or sequentially.

*Dosing:*

[00240] The formulation of therapeutic compositions and their subsequent administration (dosing) is believed to be  
15 within the skill of those in the art. Dosing is dependent on severity and responsiveness of the disease state to be treated, with the course of treatment lasting from several days to several months, or until a cure is effected or a diminution of the disease state is achieved. Optimal dosing schedules can be calculated from measurements of drug accumulation in the body of the patient. Persons of ordinary skill can easily determine optimum dosages, dosing methodologies and repetition rates. Optimum dosages may vary depending on the relative potency of individual oligonucleotides, and can  
20 generally be estimated based on EC50s found to be effective *in vitro* and *in vivo* animal models. In general, dosage is from 0.01 µg to 100 mg per kg of body weight, and may be given once or more daily, weekly, monthly or yearly, or even once every 2 to 20 years. Persons of ordinary skill in the art can easily estimate repetition rates for dosing based on measured residence times and concentrations of the drug in bodily fluids or tissues. Following successful treatment, it may be desirable to have the patient undergo maintenance therapy to prevent the recurrence of the disease state,  
25 wherein the oligonucleotide is administered in maintenance doses, ranging from 0.01 µg to 100 mg per kg of body weight, once or more daily, to once every 20 years.

[00241] In embodiments, a patient is treated with a dosage of drug that is at least about 1, at least about 2, at least about 3, at least about 4, at least about 5, at least about 6, at least about 7, at least about 8, at least about 9, at least about 10, at least about 15, at least about 20, at least about 25, at least about 30, at least about 35, at least about 40, at least  
30 about 45, at least about 50, at least about 60, at least about 70, at least about 80, at least about 90, or at least about 100 mg/kg body weight. Certain injected dosages of antisense oligonucleotides are described, e.g., in U.S. Pat. No. 7,563,884, "Antisense modulation of PTP1B expression."

[00242] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. Numerous changes to the disclosed embodiments can be made in accordance with the disclosure herein without departing from the spirit or scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above described embodiments.

5 [00243] By their citation of various references in this document, Applicants do not admit any particular reference is "prior art" to their invention. Embodiments of inventive compositions and methods are illustrated in the following examples.

10

### EXAMPLES

[00244] The following non-limiting Examples serve to illustrate selected embodiments of the invention. It will be appreciated that variations in proportions and alternatives in elements of the components shown will be apparent to those skilled in the art and are within the scope of embodiments of the present invention.

15

*Example 1: Design of antisense oligonucleotides specific for a nucleic acid molecule antisense to a Sodium channel, voltage-gated, alpha subunit (SCNA) and/or a sense strand of SCNA polynucleotide*

[00245] As indicated above the term "oligonucleotide specific for" or "oligonucleotide targets" refers to an oligonucleotide having a sequence (i) capable of forming a stable complex with a portion of the targeted gene, or (ii) capable of forming a stable duplex with a portion of an mRNA transcript of the targeted gene.

20

[00246] Selection of appropriate oligonucleotides is facilitated by using computer programs (e.g. IDT AntiSense Design, IDT OligoAnalyzer) that automatically identify in each given sequence subsequences of 19-25 nucleotides that will form hybrids with a target polynucleotide sequence with a desired melting temperature (usually 50-60°C) and will not form self-dimers or other complex secondary structures.

25

[00247] Selection of appropriate oligonucleotides is further facilitated by using computer programs that automatically align nucleic acid sequences and indicate regions of identity or homology. Such programs are used to compare nucleic acid sequences obtained, for example, by searching databases such as GenBank or by sequencing PCR products. Comparison of nucleic acid sequences from a range of genes and intergenic regions of a given genome allows the selection of nucleic acid sequences that display an appropriate degree of specificity to the gene of interest. These procedures allow the selection of oligonucleotides that exhibit a high degree of complementarity to target nucleic acid sequences and a lower degree of complementarity to other nucleic acid sequences in a given genome. One skilled in the art will realize that there is considerable latitude in selecting appropriate regions of genes for use in the present invention.

30

[00248] An antisense compound is "specifically hybridizable" when binding of the compound to the target nucleic acid interferes with the normal function of the target nucleic acid to cause a modulation of function and/or activity, and

there is a sufficient degree of complementarity to avoid non-specific binding of the antisense compound to non-target nucleic acid sequences under conditions in which specific binding is desired, i.e., under physiological conditions in the case of *in vivo* assays or therapeutic treatment, and under conditions in which assays are performed in the case of *in vitro* assays.

5 [00249] The hybridization properties of the oligonucleotides described herein can be determined by one or more *in vitro* assays as known in the art. For example, the properties of the oligonucleotides described herein can be obtained by determination of binding strength between the target natural antisense and a potential drug molecules using melting curve assay.

10 [00250] The binding strength between the target natural antisense and a potential drug molecule (Molecule) can be estimated using any of the established methods of measuring the strength of intermolecular interactions, for example, a melting curve assay.

[00251] Melting curve assay determines the temperature at which a rapid transition from double-stranded to single-stranded conformation occurs for the natural antisense/Molecule complex. This temperature is widely accepted as a reliable measure of the interaction strength between the two molecules.

15 [00252] A melting curve assay can be performed using a cDNA copy of the actual natural antisense RNA molecule or a synthetic DNA or RNA nucleotide corresponding to the binding site of the Molecule. Multiple kits containing all necessary reagents to perform this assay are available (e.g. Applied Biosystems Inc. MeltDoctor kit). These kits include a suitable buffer solution containing one of the double strand DNA (dsDNA) binding dyes (such as ABI HRM dyes, SYBR Green, SYTO, etc.). The properties of the dsDNA dyes are such that they emit almost no fluorescence in free  
20 form, but are highly fluorescent when bound to dsDNA.

[00253] To perform the assay the cDNA or a corresponding oligonucleotide are mixed with Molecule in concentrations defined by the particular manufacturer's protocols. The mixture is heated to 95 °C to dissociate all pre-formed dsDNA complexes, then slowly cooled to room temperature or other lower temperature defined by the kit manufacturer to allow the DNA molecules to anneal. The newly formed complexes are then slowly heated to 95 °C  
25 with simultaneous continuous collection of data on the amount of fluorescence that is produced by the reaction. The fluorescence intensity is inversely proportional to the amounts of dsDNA present in the reaction. The data can be collected using a real time PCR instrument compatible with the kit (e.g. ABI's StepOne Plus Real Time PCR System or lightTyper instrument, Roche Diagnostics, Lewes, UK).

[00254] Melting peaks are constructed by plotting the negative derivative of fluorescence with respect to temperature  
30  $(-d(\text{Fluorescence})/dT)$  on the y-axis against temperature (x-axis) using appropriate software (for example lightTyper (Roche) or SDS Dissociation Curve, ABI). The data is analyzed to identify the temperature of the rapid transition from dsDNA complex to single strand molecules. This temperature is called  $T_m$  and is directly proportional to the strength of interaction between the two molecules. Typically,  $T_m$  will exceed 40 °C.

*Example 2: Modulation of SCNA polynucleotides**Treatment of HepG2 cells with antisense oligonucleotides*

[00255] HepG2 cells from ATCC (cat# HB-8065) were grown in growth media (MEM/EBSS (Hyclone cat #SH30024, or Mediatech cat # MT-10-010-CV) +10% FBS (Mediatech cat# MT35- 011-CV)+ penicillin/streptomycin (Mediatech cat# MT30-002-CD)) at 37°C and 5% CO<sub>2</sub>. One day before the experiment the cells were replated at the density of  $1.5 \times 10^5$ /ml into 6 well plates and incubated at 37°C and 5% CO<sub>2</sub>. On the day of the experiment the media in the 6 well plates was changed to fresh growth media. All antisense oligonucleotides were diluted to the concentration of 20 µM. Two µl of this solution was incubated with 400 µl of Opti-MEM media (Gibco cat#31985-070) and 4 µl of Lipofectamine 2000 (Invitrogen cat# 11668019) at room temperature for 20 min and applied to each well of the 6 well plates with HepG2 cells. A Similar mixture including 2 µl of water instead of the oligonucleotide solution was used for the mock-transfected controls. After 3-18 h of incubation at 37°C and 5% CO<sub>2</sub> the media was changed to fresh growth media. 48 h after addition of antisense oligonucleotides the media was removed and RNA was extracted from the cells using SV Total RNA Isolation System from Promega (cat # Z3105) or RNeasy Total RNA Isolation kit from Qiagen (cat# 74181) following the manufacturers' instructions. 600 ng of RNA was added to the reverse transcription reaction performed using Verso cDNA kit from Thermo Scientific (cat#AB1453B) or High Capacity cDNA Reverse Transcription Kit (cat# 4368813) as described in the manufacturer's protocol. The cDNA from this reverse transcription reaction was used to monitor gene expression by real time PCR using ABI Taqman Gene Expression Mix (cat#4369510) and primers/probes designed by ABI (Applied Biosystems Taqman Gene Expression Assay: Hs00374696\_m1, Hs00897350\_m1 or Hs00897341\_m1 for human SCNA) by Applied Biosystems Inc., Foster City CA). The following PCR cycle was used: 50°C for 2 min, 95°C for 10 min, 40 cycles of (95°C for 15 seconds, 60°C for 1 min) using StepOne Plus Real Time PCR Machine (Applied Biosystems).

[00256] Fold change in gene expression after treatment with antisense oligonucleotides was calculated based on the difference in 18S-normalized dCt values between treated and mock-transfected samples.

*Results:* Real Time PCR results show that levels of SCNA mRNA in HepG2 cells are significantly increased 48h after treatment with antisense oligonucleotides to SCNA antisense BG724147 (Fig 1,4). Other oligonucleotides designed to SCNA antisense BG724147 and Hs.662210 did not elevate SCNA levels. (Fig 2, 3)

*Example 3: Upregulation of SCNA mRNA in different cell lines by treatment with antisense oligonucleotides targeting SCNA-specific natural antisense transcript*

[00257] In Example 3 antisense oligonucleotides of different chemistries targeting SCNA-specific natural antisense transcript were screened in a panel of various cell lines at a final concentration of 20 nM. The cell lines used originate from different organs and different animal species. The data below confirms that upregulation of SCNA mRNA/protein through modulation of the function of the SCNA-specific natural antisense transcript is not limited to a single oligonucleotide, tissue or species and thus represents a general phenomenon.

*Materials and Methods*

[00258] *Primary human fibroblasts carrying a Dravet syndrome-associated mutation.* Primary human skin fibroblasts carrying a Dravet syndrome-associated mutation E1099X introduced into culture by Dr. N.Kenyon (University of Miami) were grown in Growth Media consisting of a-MEM (Gibco, cat: 12561-056)+10% FBS (Mediatech, cat: 35-015 CV) + 1% Antimycotic-Antibiotic (Gibco, cat: 15240-062) at 37°C and 5% CO<sub>2</sub>. The cells were treated with antisense oligonucleotides using one of the following methods. For the Next Day Method, one day before the experiment the cells were replated at the density of approximately 2x10<sup>5</sup>/well into 6 well plates in Growth Media and incubated at 37°C and 5% CO<sub>2</sub> overnight. Next day, the media in the 6 well plates was changed to fresh Growth Media (1.5 ml/well) and the cells were dosed with antisense oligonucleotides. All antisense oligonucleotides were manufactured by IDT Inc. (Coralville, IA) or Exiqon (Vedback, Denmark). The sequences for all oligonucleotides are listed in Table 1. Stock solutions of oligonucleotides were diluted to the concentration of 20 µM in DNase/RNase-free sterile water. To dose one well, 2 µl of this solution was incubated with 400 µl of Opti-MEM media (Gibco cat#31985-070) and 4 µl of Lipofectamine 2000 (Invitrogen cat# 11668019) at room temperature for 20 min and applied dropwise to one well of a 6 well plate with cells. Similar mixture including 2 µl of water instead of the oligonucleotide solution was used for the mock-transfected controls. Additionally an inactive oligonucleotide CUR-1462 at the same concentration was used as control. After about 18 h of incubation at 37°C and 5% CO<sub>2</sub> the media was changed to fresh Growth Media. Forty eight hours after addition of antisense oligonucleotides the media was removed and RNA was extracted from the cells using SV Total RNA Isolation System from Promega (cat # Z3105) following the manufacturers' instructions. Six hundred nanograms of purified total RNA was added to the reverse transcription reaction performed using SuperScript VILO cDNA Synthesis Kit from Invitrogen (cat#11754-250) as described in the manufacturer's protocol. The cDNA from this reverse transcription reaction was used to monitor gene expression by real time PCR using ABI Taqman Gene Expression Mix (cat#4369510) and primers/probes designed by ABI (assays Hs00374696\_m1, Hs00897350\_m1 or Hs00897341\_m1 for human SCN1A). Results obtained using all three assays were very similar. The following PCR cycle was used: 50°C for 2 min, 95°C for 10 min, 40 cycles of (95°C for 15 seconds, 60°C for 1 min) using StepOne Plus Real Time PCR system (Applied Biosystems). The assay for 18S was manufactured by ABI (cat# 4319413E). Fold change in gene expression after treatment with antisense oligonucleotides was calculated based on the difference in 18S-normalized dCt values between treated and mock-transfected samples. For the alternative Same Day Method all procedures were performed similarly, but cells were dosed with antisense oligonucleotides on the first day, immediately after they were distributed into 6-well plates.

[00259] *SK-N-AS cell line.* SK-N-AS human neuroblastoma cells from ATCC (cat# CRL-2137) were grown in Growth Media (DMEM (Mediatech cat# 10-013-CV) +10% FBS (Mediatech cat# MT35-011-CV)+ penicillin/streptomycin (Mediatech cat# MT30-002-CI)+ Non-Essential Amino Acids (NEAA)(HyClone SH30238.01)) at 37°C and 5% CO<sub>2</sub>. The cells were treated with antisense oligonucleotides using one of the following

methods. For the Next Day Method, one day before the experiment the cells were replated at the density of approximately  $3 \times 10^5$ /well into 6 well plates in Growth Media and incubated at  $37^\circ\text{C}$  and  $5\% \text{CO}_2$  overnight. Next day, the media in the 6 well plates was changed to fresh Growth Media (1.5 ml/well) and the cells were dosed with antisense oligonucleotides. All antisense oligonucleotides were manufactured by IDT Inc. (Coralville, IA) or Exiqon (Vedback, Denmark). The sequences for all oligonucleotides are listed in Table 1. Stock solutions of oligonucleotides were diluted to the concentration of  $20 \mu\text{M}$  in DNase/RNase-free sterile water. To dose one well,  $2 \mu\text{l}$  of this solution was incubated with  $400 \mu\text{l}$  of Opti-MEM media (Gibco cat#31985-070) and  $4 \mu\text{l}$  of Lipofectamine 2000 (Invitrogen cat# 11668019) at room temperature for 20 min and applied dropwise to one well of a 6 well plate with cells. Similar mixture including  $2 \mu\text{l}$  of water instead of the oligonucleotide solution was used for the mock-transfected controls. Additionally an inactive oligonucleotide CUR-1462 at the same concentration was used as control. After about 18 h of incubation at  $37^\circ\text{C}$  and  $5\% \text{CO}_2$  the media was changed to fresh Growth Media. Forty eight hours after addition of antisense oligonucleotides the media was removed and RNA was extracted from the cells using SV Total RNA Isolation System from Promega (cat # Z3105) following the manufacturers' instructions. Six hundred nanograms of purified total RNA was added to the reverse transcription reaction performed using SuperScript VILO cDNA Synthesis Kit from Invitrogen (cat#11754-250) as described in the manufacturer's protocol. The cDNA from this reverse transcription reaction was used to monitor gene expression by real time PCR using ABI Taqman Gene Expression Mix (cat#4369510) and primers/probes designed by ABI (assays Hs00374696\_m1, Hs00897350\_m1 or Hs00897341\_m1 for human SCN1A). Results obtained using all three assays were very similar. The following PCR cycle was used:  $50^\circ\text{C}$  for 2 min,  $95^\circ\text{C}$  for 10 min, 40 cycles of ( $95^\circ\text{C}$  for 15 seconds,  $60^\circ\text{C}$  for 1 min) using StepOne Plus Real Time PCR system (Applied Biosystems). The assay for 18S was manufactured by ABI (cat# 4319413E). Fold change in gene expression after treatment with antisense oligonucleotides was calculated based on the difference in 18S-normalized  $\text{dCt}$  values between treated and mock-transfected samples. For the alternative Same Day Method all procedures were performed similarly, but cells were dosed with antisense oligonucleotides on the first day, immediately after they were distributed into 6-well plates.

[00260] *CHP-212 cell line.* CHP-212 human neuroblastoma cells from ATCC (cat# CRL-2273) were grown in growth media (1: mixture of MEM and F12 (ATCC cat # 30-2003 and Mediatech cat# 10-080-CV respectively) +10% FBS (Mediatech cat# MT35-011-CV) + penicillin/streptomycin (Mediatech cat# MT30-002-CD) at  $37^\circ\text{C}$  and  $5\% \text{CO}_2$ . The cells were treated with antisense oligonucleotides using one of the following methods. For the Next Day Method, one day before the experiment the cells were replated at the density of approximately  $2 \times 10^5$ /well into 6 well plates in Growth Media and incubated at  $37^\circ\text{C}$  and  $5\% \text{CO}_2$  overnight. Next day, the media in the 6 well plates was changed to fresh Growth Media (1.5 ml/well) and the cells were dosed with antisense oligonucleotides. All antisense oligonucleotides were manufactured by IDT Inc. (Coralville, IA) or Exiqon (Vedback, Denmark). The sequences for all oligonucleotides are listed in Table 1. Stock solutions of oligonucleotides were diluted to the concentration of  $20 \mu\text{M}$  in

DNase/RNase-free sterile water. To dose one well, 2  $\mu$ l of this solution was incubated with 400  $\mu$ l of Opti-MEM media (Gibco cat#31985-070) and 4  $\mu$ l of Lipofectamine 2000 (Invitrogen cat# 11668019) at room temperature for 20 min and applied dropwise to one well of a 6 well plate with cells. Similar mixture including 2  $\mu$ l of water instead of the oligonucleotide solution was used for the mock-transfected controls. Additionally an inactive oligonucleotide CUR-1462 at the same concentration was used as control. After about 18 h of incubation at 37°C and 5% CO<sub>2</sub> the media was changed to fresh Growth Media. Forty eight hours after addition of antisense oligonucleotides the media was removed and RNA was extracted from the cells using SV Total RNA Isolation System from Promega (cat # Z3105) following the manufacturers' instructions. Six hundred nanograms of purified total RNA was added to the reverse transcription reaction performed using SuperScript VILO cDNA Synthesis Kit from Invitrogen (cat#11754-250) as described in the manufacturer's protocol. The cDNA from this reverse transcription reaction was used to monitor gene expression by real time PCR using ABI Taqman Gene Expression Mix (cat#4369510) and primers/probes designed by ABI (assays Hs00374696\_m1, Hs00897350\_m1 or Hs00897341\_m1 for human SCN1A). Results obtained using all three assays were very similar. The following PCR cycle was used: 50°C for 2 min, 95°C for 10 min, 40 cycles of (95°C for 15 seconds, 60°C for 1 min) using StepOne Plus Real Time PCR system (Applied Biosystems). The assay for 18S was manufactured by ABI (cat# 4319413E). Fold change in gene expression after treatment with antisense oligonucleotides was calculated based on the difference in 18S-normalized dCt values between treated and mock-transfected samples. For the alternative Same Day Method all procedures were performed similarly, but cells were dosed with antisense oligonucleotides on the first day, immediately after they were distributed into 6-well plates.

[00261] *Vero76 cell line.* Vero76 African green monkey embryonic kidney cells from ATCC (cat# CRL-1587) were grown in growth media (Dulbecco's Modified Eagle's Medium (Cellgrow 10-013-CV)+5% FBS (Mediatech cat# MT35- 011-CV)+ penicillin/streptomycin (Mediatech cat# MT30-002-CT)) at 37°C and 5% CO<sub>2</sub>. The cells were treated with antisense oligonucleotides using one of the following methods. For the Next Day Method, one day before the experiment the cells were replated at the density of approximately 105/well into 6 well plates in Growth Media and incubated at 37°C and 5% CO<sub>2</sub> overnight. Next day, the media in the 6 well plates was changed to fresh Growth Media (1.5 ml/well) and the cells were dosed with antisense oligonucleotides. All antisense oligonucleotides were manufactured by IDT Inc. (Coralville, IA) or Exiqon (Vedbaek, Denmark). The sequences for all oligonucleotides are listed in Table 1. Stock solutions of oligonucleotides were diluted to the concentration of 20  $\mu$ M in DNase/RNase-free sterile water. To dose one well, 2  $\mu$ l of this solution was incubated with 400  $\mu$ l of Opti-MEM media (Gibco cat#31985-070) and 4  $\mu$ l of Lipofectamine 2000 (Invitrogen cat# 11668019) at room temperature for 20 min and applied dropwise to one well of a 6 well plate with cells. Similar mixture including 2  $\mu$ l of water instead of the oligonucleotide solution was used for the mock-transfected controls. Additionally an inactive oligonucleotide CUR-1462 at the same concentration was used as control. After about 18 h of incubation at 37°C and 5% CO<sub>2</sub> the media was changed to fresh Growth Media. Forty eight hours after addition of antisense oligonucleotides the media was removed and RNA was



extracted from the cells using SV Total RNA Isolation System from Promega (cat # Z3105) following the manufacturers' instructions. Six hundred nanograms of purified total RNA was added to the reverse transcription reaction performed using SuperScript VILO cDNA Synthesis Kit from Invitrogen (cat#11754-250) as described in the manufacturer's protocol. The cDNA from this reverse transcription reaction was used to monitor gene expression by real time PCR using ABI Taqman Gene Expression Mix (cat#4369510) and primers/probes designed by ABI (assays Hs00374696\_m1, Hs00897350\_m1 or Hs00897341\_m1 for human SCN1A). The following PCR cycle was used: 50°C for 2 min, 95°C for 10 min, 40 cycles of (95°C for 15 seconds, 60°C for 1 min) using StepOne Plus Real Time PCR system (Applied Biosystems). The assay for 18S was manufactured by ABI (cat# 4319413E). Fold change in gene expression after treatment with antisense oligonucleotides was calculated based on the difference in 18S-normalized dCt values between treated and mock-transfected samples. For the alternative Same Day Method all procedures were performed similarly, but cells were dosed with antisense oligonucleotides on the first day, immediately after they were distributed into 6-well plates.

[00262] *3T3 cell line.* 3T3 mouse embryonic fibroblast cells from ATCC (cat# CRL-1658) were grown in Growth Media (Dulbecco's Modified Eagle's Medium (Cellgrow 10-013-CV) + 10% Fetal Calf Serum (Cellgrow 35-22-CV)+ penicillin/streptomycin (Mediatech cat# MT30-002-CI)) at 37°C and 5% CO<sub>2</sub>. The cells were treated with antisense oligonucleotides using one of the following methods. For the Next Day Method, one day before the experiment the cells were replated at the density of approximately 105/well into 6 well plates in Growth Media and incubated at 37°C and 5% CO<sub>2</sub> overnight. Next day, the media in the 6 well plates was changed to fresh Growth Media (1.5 ml/well) and the cells were dosed with antisense oligonucleotides. All antisense oligonucleotides were manufactured by IDT Inc. (Coralville, IA) or Exiqon (Vedback, Denmark). The sequences for all oligonucleotides are listed in Table 1. Stock solutions of oligonucleotides were diluted to the concentration of 20 µM in DNase/RNase-free sterile water. To dose one well, 2 µl of this solution was incubated with 400 µl of Opti-MEM media (Gibco cat#31985-070) and 4 µl of Lipofectamine 2000 (Invitrogen cat# 11668019) at room temperature for 20 min and applied dropwise to one well of a 6 well plate with cells. Similar mixture including 2 µl of water instead of the oligonucleotide solution was used for the mock-transfected controls. Additionally an inactive oligonucleotide CUR-1462 at the same concentration was used as control. After about 18 h of incubation at 37°C and 5% CO<sub>2</sub> the media was changed to fresh Growth Media. Forty eight hours after addition of antisense oligonucleotides the media was removed and RNA was extracted from the cells using SV Total RNA Isolation System from Promega (cat # Z3105) following the manufacturers' instructions. Six hundred nanograms of purified total RNA was added to the reverse transcription reaction performed using SuperScript VILO cDNA Synthesis Kit from Invitrogen (cat#11754-250) as described in the manufacturer's protocol. The cDNA from this reverse transcription reaction was used to monitor gene expression by real time PCR using ABI Taqman Gene Expression Mix (cat#4369510) and primers/probes designed by ABI (assays Hs00374696\_m1, Hs00897350\_m1 or Hs00897341\_m1 for human SCN1A). Results obtained using all three assays were very similar. The following PCR

cycle was used: 50°C for 2 min, 95°C for 10 min, 40 cycles of (95°C for 15 seconds, 60°C for 1 min) using StepOne Plus Real Time PCR system (Applied Biosystems). The assay for 18S was manufactured by ABI (cat# 4319413E). Fold change in gene expression after treatment with antisense oligonucleotides was calculated based on the difference in 18S-normalized dCt values between treated and mock-transfected samples. For the alternative Same Day Method all procedures were performed similarly, but cells were dosed with antisense oligonucleotides on the first day, immediately after they were distributed into 6-well plates.

[00263] *HepG2 cell line.* HepG2 human hepatocellular carcinoma cells from ATCC (cat# HB-8065) were grown in growth media (MEM/EBSS (Hyclone cat #SH30024, or Mediatech cat # MT-10-010-CV) +10% FBS (Mediatech cat# MT35- 011-CV)+ penicillin/streptomycin (Mediatech cat# MT30-002-CI)) at 37°C and 5% CO<sub>2</sub>. The cells were treated with antisense oligonucleotides using one of the following methods. For the Next Day Method, one day before the experiment the cells were replated at the density of approximately 3x10<sup>5</sup>/well into 6 well plates in Growth Media and incubated at 37°C and 5% CO<sub>2</sub> overnight. Next day, the media in the 6 well plates was changed to fresh Growth Media (1.5 ml/well) and the cells were dosed with antisense oligonucleotides. All antisense oligonucleotides were manufactured by IDT Inc. (Coralville, IA) or Exiqon (Vedbaek, Denmark). The sequences for all oligonucleotides are listed in Table 1. Stock solutions of oligonucleotides were diluted to the concentration of 20 µM in DNase/RNase-free sterile water. To dose one well, 2 µl of this solution was incubated with 400 µl of Opti-MEM media (Gibco cat#31985-070) and 4 µl of Lipofectamine 2000 (Invitrogen cat# 11668019) at room temperature for 20 min and applied dropwise to one well of a 6 well plate with cells. Similar mixture including 2 µl of water instead of the oligonucleotide solution was used for the mock-transfected controls. Additionally an inactive oligonucleotide CUR-1462 at the same concentration was used as control. After about 18 h of incubation at 37°C and 5% CO<sub>2</sub> the media was changed to fresh Growth Media. Forty eight hours after addition of antisense oligonucleotides the media was removed and RNA was extracted from the cells using SV Total RNA Isolation System from Promega (cat # Z3105) following the manufacturers' instructions. Six hundred nanograms of purified total RNA was added to the reverse transcription reaction performed using SuperScript VILO cDNA Synthesis Kit from Invitrogen (cat#11754-250) as described in the manufacturer's protocol. The cDNA from this reverse transcription reaction was used to monitor gene expression by real time PCR using ABI Taqman Gene Expression Mix (cat#4369510) and primers/probes designed by ABI (assays Hs00374696\_m1, Hs00897350\_m1 or Hs00897341\_m1 for human SCN1A). Results obtained using all three assays were very similar. The following PCR cycle was used: 50°C for 2 min, 95°C for 10 min, 40 cycles of (95°C for 15 seconds, 60°C for 1 min) using StepOne Plus Real Time PCR system (Applied Biosystems). The assay for 18S was manufactured by ABI (cat# 4319413E). Fold change in gene expression after treatment with antisense oligonucleotides was calculated based on the difference in 18S-normalized dCt values between treated and mock-transfected samples. For the alternative Same Day Method all procedures were performed similarly, but cells were dosed with antisense oligonucleotides on the first day, immediately after they were distributed into 6-well plates.

[00264] *Results.* SCN1A mRNA levels in different cell lines after treatment with 20 nM of antisense oligonucleotides compared to mock-transfected control are shown in Table 2. As seen from the data some of the oligonucleotides when applied at 20 nM were highly active at upregulating the levels of SCN1A mRNA and showed upregulation consistently in several species (human, African green monkey and mouse), in cell lines derived from different organs/cell types (liver, kidney, brain, embryonic fibroblasts) and primary skin fibroblasts carrying the SCN1A mutation. Upregulation of SCN1A protein in cells carrying the Dravet mutation supports the suitability of the method for the treatment of diseases associated with mutations in SCN1A gene. Some of the oligonucleotides designed against the natural antisense sequence did not affect or only marginally affected the SCN1A mRNA levels in all, or some, of the cell lines tested. These differences are in agreement with literature data which indicates that binding of oligonucleotides may depend on the secondary and tertiary structures of the oligonucleotide's target sequence. Notably the SCN1A levels in cells treated with an oligonucleotide with no homology to the SCN1A natural antisense sequence but of similar chemistry (CUR-1462) are not significantly different from mock transfected control which confirms that the effects of the targeted oligonucleotides do not depend on the non-specific toxicity of these molecules.

*Example 4: Dose-dependency of SCNA mRNA upregulation in different cell lines by treatment with antisense oligonucleotides targeting SCNA-specific natural antisense transcript*

[00265] In Example 4 antisense oligonucleotides of different chemistries targeting SCNA-specific natural antisense transcript were screened in a panel of various cell lines at final concentrations ranging from 5 to 80 nM. The cell lines used originated from different organs and different animal species. The data below confirms that the degree of upregulation of SCNA mRNA through modulation of the function of the SCNA-specific natural antisense transcript can be varied by applying varying amounts of active oligonucleotides.

[00266] *Materials and Methods.* SK-N-AS, Vero 76 and primary human fibroblasts carrying a Dravet mutation were treated with antisense oligonucleotides as described in Example 2 with the exception of oligonucleotide and Lipofectamine 2000 concentrations used to treat each well. The oligonucleotide and Lipofectamine 2000 concentrations were adjusted so as to ensure the final oligonucleotide concentrations of 5, 10, 20, 40 and 80 nM and the ratio of Lipofectamine 2000 to 20  $\mu$ M oligonucleotide stock solution of 2:1 (v:v).

[00267] *Results.* The results of dose response experiments have confirmed that the antisense oligonucleotides targeted against SCN1A-specific natural antisense RNA can induce dose-dependent upregulation of SCN1A mRNA (Fig 1-3). In some cases this upregulation was very potent (up to 60-fold) at higher doses (Fig 1-3). The degree of upregulation induced by the same nucleotide in different cell lines appeared to be different, for example upregulation achieved in primary fibroblasts at 40 nM was at the level of 10-40 fold, while upregulation in Vero 76 cells by the same oligonucleotides at the same concentration was 2-6 fold (Fig.1 vs Fig.3). These differences could be due to different transfection efficiency of different cell lines and/or various feedback pathways expressed by them. The effect of most oligonucleotides reached plateau at about 40 nM, with the exception of CUR-1764 and CUR-1770 in SCN1A

fibroblasts and all oligonucleotides tested in Vero 76 cells where the plateau was not reached at the highest concentration tested (Fig. 1-3).

*Example 5: Sequence specificity of the SCN1A mRNA upregulation by antisense oligonucleotides targeting SCN1A-specific natural antisense transcript*

5 [00268] In Example 5 antisense oligonucleotides targeting SCN1A-specific natural antisense transcript were tested in experiments designed to confirm the independence of the SCN1A upregulation caused by the oligonucleotides from the non-specific toxicity associated with the oligonucleotide chemistry used. The data below confirms that the degree of upregulation of SCN1A mRNA through modulation of the function of the SCN1A-specific natural antisense transcript only depends on the amounts of active oligonucleotides, and not on the total amount of molecules of similar chemistry.

10 [00269] *Materials and Methods:* Vero 76 and primary human fibroblasts carrying a Dravet mutation were treated with antisense oligonucleotides as described in Example 2 with the exception of oligonucleotide concentrations used to treat each well. The active oligonucleotide was co-administered with an inactive oligonucleotide of similar chemistry but with no known target in the human genome (CUR-1462) and no effect on the expression of multiple genes tested (data not shown). The total amount of oligonucleotides as well as the amount of Lipofectamine 2000 were kept constant  
15 while the proportion of the active oligonucleotide in the mix was varied. The oligonucleotide concentrations were adjusted so as to ensure the final active oligonucleotide concentrations of 5, 10, 20 and 40 nM and the total oligonucleotide concentration (active+inactive) of 40 nM.

[00270] As seen from the data (Fig. 7), the dose-dependent effect of oligonucleotides targeted against SCN1A natural antisense did not result from the non-specific toxicity potentially associated with such molecules. The SCN1A mRNA  
20 levels depended on the dose of the active oligonucleotide used to treat them (Fig. 7).

*Example 6: Target specificity of the SCN1A mRNA upregulation by antisense oligonucleotides targeting SCN1A-specific natural antisense transcript*

[00271] In Example 6 antisense oligonucleotides targeting SCN1A-specific natural antisense transcript were tested in experiments designed to confirm the specificity of their target, i.e. SCN1A. The data below confirms that the  
25 upregulation of SCN1A mRNA through modulation of the function of the SCN1A-specific natural antisense transcript was limited to the SCN1A mRNA and did not affect the related sodium channels SCN9A, SCN8A, SCN7A, SCN3A and SCN2A.

[00272] *Materials and Methods.* Vero 76 and primary human fibroblasts carrying a Dravet mutation were treated with antisense oligonucleotides as described in Example 3. Post-treatment the isolated RNA was analyzed as described in  
30 Example 2 with the exception that the Taqman gene expression assays used to run the real time PCR detected mRNA for SCN9A, SCN8A, SCN7A, SCN3A and SCN2A channels. The assays for alpha subunits of human SCN9A, SCN8A, SCN7A, SCN3A and SCN2A channels were obtained from ABI Inc. (cat# Hs00161567\_m1, Hs00274075\_m1, Hs00161546\_m1, Hs00366902\_m1, and Hs00221379\_m1 respectively).

[00273] *Results.* As shown in Fig. 8, treatment with oligonucleotides CUR-1916 and CUR-1770 did not significantly affect the expression of SCN8A and SCN9A channels in human fibroblasts carrying Dravet mutation. Expression of SCN7A, SCN3A and SCN2A channels was undetectable in these cells before or after treatment (data not shown). The data confirms the specificity of the gene expression modulation using oligonucleotides directed against the natural antisense RNA for a given gene.

*Example 7: Stability of antisense oligonucleotides targeting SCNA-specific natural antisense transcript*

[00274] In Example 7 two batches of an antisense oligonucleotide targeting SCNA-specific natural antisense transcript were tested in experiments designed to check its stability after storage in a dilute (1 mM) aqueous solution at 4°C. The data below shows that the oligonucleotides can be stable in these conditions for periods of at least 6 months without significant loss of activity.

[00275] *Materials and Methods.* Vero 76 cells were treated with two different batches of an antisense oligonucleotide as described in Example 2. The batches were synthesized in August 2010 and March 2011. The oligonucleotide synthesized in August 2010 was stored as a 1 mM aqueous solution at 4°C. The oligonucleotide synthesized in March 2011 was shipped in lyophilized form within 3 days after synthesis and tested immediately upon arrival.

[00276] *Results:* As shown in Fig. 9 there was no significant loss of biological activity after a 6 month long storage of the oligonucleotides in aqueous solution at 4°C.

*Example 8: SCNA protein upregulation in primary human fibroblasts carrying a Dravet syndrome-associated mutation treated with antisense oligonucleotides targeting SCNA-specific natural antisense transcript*

[00277] The purpose of this experiment was to rank the antisense oligonucleotides CUR-1740, CUR-1770 and CUR-1916 according to their ability to upregulate the SCNA protein expression in fibroblast cells carrying a Dravet syndrome-associated mutation.

[00278] *Materials and Methods.* Fibroblasts carrying a Dravet syndrome-associated mutation introduced into culture by Dr. N.Kenyon (University of Miami) were grown in Growth Media consisting of a-MEM (Gibco, cat: 12561-056)+10% FBS (Mediatech, cat: 35-015 CV) + 1% Antimycotic-Antibiotic (Gibco, cat: 15240-062) at 37°C and 5% CO<sub>2</sub>. The cells were treated with antisense oligonucleotides using one of the following methods. For the Next Day Method, one day before the experiment the cells were replated at the density of approximately 4x10<sup>4</sup>/well into 24 well plates in Growth Media and incubated at 37°C and 5% CO<sub>2</sub> overnight. Next day, the media in the 24 well plates was changed to fresh Growth Media (1 ml/well) and the cells were dosed with antisense oligonucleotides CUR-1740, CUR-1770 and CUR-1916. All antisense oligonucleotides were manufactured by IDT Inc. (Coralville, IA) or Exiqon (Vedbaek, Denmark). The sequences for oligonucleotides CUR-1740, CUR-1770 and CUR-1916 are listed in Table 1. Stock solutions of oligonucleotides were diluted to the concentration of 20 µM in DNase/RNase-free sterile water. To dose one well at a final concentration of 20 nM, 1 µl of the 20 µM oligonucleotide stock solution was incubated with 200 µl of Opti-MEM media (Gibco cat#31985-070) and 2 µl of Lipofectamine 2000 (Invitrogen cat# 11668019) at

room temperature for 20 min and applied dropwise to one well of a 24 well plate with cells. To achieve final concentrations of 5, 10, 40 and 80 nM the volumes of the 20  $\mu$ M oligonucleotide stock used were adjusted accordingly. The ratio of the 20  $\mu$ M oligonucleotide stock solution to Lipofectamine 2000 was 1:2 (v:v). Similar mixture including 8  $\mu$ l of water instead of the oligonucleotide solution and the corresponding volume of Lipofectamine 2000 was used for the mock-transfected controls. After about 18 h of incubation at 37°C and 5% CO<sub>2</sub> the media was changed to fresh Growth Media. Forty eight hours after addition of antisense oligonucleotides the media was removed and cells were washed 3 times with Dulbecco's phosphate-buffered saline without calcium and magnesium (PBS) (Mediatech cat# 21-031-CV). Then PBS was discarded and the cells were fixed in the 24 well plate using 300  $\mu$ l of 100% methanol for 15 min at -20°C. After removing the methanol and washing with PBS, the cells were incubated with 3% hydrogen peroxide (Fisher Chemical cat#H325-100) for 5 min at 21°C. The cells were washed three times for 5 min with PBS, then incubated with 300  $\mu$ l of bovine serum albumin (BSA) (Sigma cat# A-9647) at 0.1% in PBS for 30 min at 21°C. The cells were washed three times for 5 min with PBS then incubated with 300  $\mu$ l of avidin solution (Vector Laboratories cat# SP-2001) for 30 min at 21°C. The cells were briefly rinsed three times with PBS then incubated with biotin solution (Vector Laboratories cat# SP-2001) for 30 min at 21°C. The cells were washed three times with PBS and then incubated overnight at 4°C with 300  $\mu$ l per well of rabbit antibody against human SCN1A (Abcam cat# ab24820) diluted at 1:250 in PBS/BSA 0.1%. After equilibrating the plate for 5 min at 21°C, the cells were washed three times 5 min each with PBS then incubated with goat anti-rabbit antibody diluted 1:200 in PBS/BSA 0.1% for 30 min at 21°C. The cells were washed three times 5 min with PBS and then incubated with 300  $\mu$ l of Vectastain Elite ABC reagent A+B solution (Vector Laboratories cat# PK-6101) for 30 min; the Vectastain Elite ABC reagent A+B solution was prepared at 21°C 30 min before incubation with the cells by adding and mixing successively 2 drops of reagent A to 5 ml of PBS and then 2 drops of reagent B. The cells were washed 3 times 5 min each with PBS at 21°C and then incubated with Diaminobenzidine (DAB) peroxidase substrate solution (Vector Laboratories cat# SK-4105) until cells are stained; the DAB peroxidase substrate solution is reconstituted before being added to the cells by mixing 1 ml of ImmPACT™DAB Diluent with 30  $\mu$ l of ImmPACT™ DAB Chromogen concentrate. At this time, the cells are briefly washed three times with PBS and 300  $\mu$ l of PBS is left in each well. The staining of the cells was analyzed directly inside the wells of the 24-well plate using an inverted Nikon Eclipse TS100 microscope equipped with a Nikon DS-R1i camera coupled with Nikon Digital-Sight equipment on the screen of a Dell Latitude D630 laptop. Photos of individual wells were made using the software provided with the Nikon camera, the NIS-Elements D 3.0.

[00279] *Results.* All antisense oligonucleotides tested efficiently upregulated SCN1A protein, CUR-1770 and CUR-1916 being the two best (Fig. 10).

*Example 9: SCN1A protein upregulation in SK-N-AS cells treated with antisense oligonucleotides targeting SCN1A-specific natural antisense transcript*

[00280] The purpose of this experiment was to rank the antisense oligonucleotides CUR-1740, CUR-1764, CUR-1770 and CUR-1916 according to their ability to upregulate the SCN1A protein expression in SK-N-AS cells. SK-N-AS is a human neuroblastoma cell line.

[00281] *Materials and Methods:* SK-N-AS human neuroblastoma cells from ATCC (cat# CRL-2137) were grown in  
5 Growth Media (DMEM (Mediatech cat# 10-013-CV) +10% FBS (Mediatech cat# MT35-011-CV)+  
penicillin/streptomycin (Mediatech cat# MT30-002-CI) + Non-Essential Amino Acids (NEAA)(HyClone  
SH30238.01)) at 37°C and 5% CO<sub>2</sub>. The cells were treated with antisense oligonucleotides using one of the following  
10 methods. For the Next Day Method, one day before the experiment the cells were replated at the density of  
approximately 5x10<sup>4</sup>/well into 24 well plates in Growth Media and incubated at 37°C and 5% CO<sub>2</sub> overnight. Next  
day, the media in the 24 well plates was changed to fresh Growth Media (1 ml/well) and the cells were dosed with  
antisense oligonucleotides CUR-1740, CUR-1764, CUR-1770 and CUR-1916. All antisense oligonucleotides were  
15 manufactured by IDT Inc. (Coralville, IA) or Exiqon (Vedbaek, Denmark). The sequences for oligonucleotides CUR-  
1740, CUR-1764, CUR-1770 and CUR-1916 are listed in Table 1. Stock solutions of oligonucleotides were diluted to  
the concentration of 20 µM in DNase/RNase-free sterile water. To dose one well at a final concentration of 20 nM, 1  
µl of the 20 µM oligonucleotide stock solution was incubated with 200 µl of Opti-MEM media (Gibco cat#31985-070)  
and 2 µl of Lipofectamine 2000 (Invitrogen cat# 11668019) at room temperature for 20 min and applied dropwise to  
20 one well of a 24 well plate with cells. To achieve final concentrations of 5, 10, 40 and 80 nM the volumes of the 20 µM  
oligonucleotide stock used were adjusted accordingly. The ratio of the 20 µM oligonucleotide stock solution to  
Lipofectamine 2000 was 1:2 (v:v). Similar mixture including 8 µl of water instead of the oligonucleotide solution and  
the corresponding volume of Lipofectamine 2000 was used for the mock-transfected controls. After about 18 h of  
25 incubation at 37°C and 5% CO<sub>2</sub> the media was changed to fresh Growth Media. Forty eight hours after addition of  
antisense oligonucleotides the media was removed and cells were washed 3 times with Dulbecco's phosphate-buffered  
saline without calcium and magnesium (PBS) (Mediatech cat# 21-031-CV). Then PBS was discarded and the cells  
were fixed in the 24 well plate using 300 µl of 100% methanol for 15 min at -20°C. After removing the methanol and  
washing with PBS, the cells were incubated with 3% hydrogen peroxide (Fisher Chemical cat#H325-100) for 5 min at  
21°C. The cells were washed three times for 5 min with PBS then incubated with 300 µl of bovine serum albumin  
(BSA) (Sigma cat# A-9647) at 0.1% in PBS for 30 min at 21°C. The cells were washed three times for 5 min with PBS  
then incubated with 300 µl of avidin solution (Vector Laboratories cat# SP-2001) for 30 min at 21°C. The cells were  
30 briefly rinsed three times with PBS then incubated with biotin solution (Vector Laboratories cat# SP-2001) for 30 min  
at 21°C. The cells were washed three times with PBS and then incubated overnight at 4°C with 300 µl per well of  
rabbit antibody against human SCN1A (Abcam cat# ab24820) diluted at 1:250 in PBS/BSA 0.1%. After equilibrating  
the plate for 5 min at 21°C, the cells were washed three times for 5 min each with PBS then incubated with goat anti-  
rabbit antibody diluted 1:200 in PBS/BSA 0.1% for 30 min at 21°C. The cells were washed three times for 5 min with

PBS and then incubated with 300  $\mu$ l of Vectastain Elite ABC reagent A+B solution (Vector Laboratories cat# PK-6101) for 30 min; the Vectastain Elite ABC reagent A+B solution was prepared at 21°C 30 min before incubation with the cells by adding and mixing successively 2 drops of reagent A to 5 ml of PBS and then 2 drops of reagent B. The cells were washed 3 times for 5 min each with PBS at 21°C and then incubated with Diaminobenzidine (DAB) peroxidase substrate solution (Vector Laboratories cat# SK-4105) until cells are stained; the DAB peroxidase substrate solution is reconstituted before being added to the cells by mixing 1ml of ImmPACT™DAB Diluent with 30  $\mu$ l of ImmPACT™ DAB Chromogen concentrate. At this time, the cells are briefly washed three times with PBS and 300  $\mu$ l of PBS is left in each well. The staining of the cells was analyzed directly inside the wells of the 24-well plate using an inverted Nikon Eclipse TS100 microscope equipped with a Nikon DS-R11 camera coupled with Nikon Digital-Sight equipment on the screen of a Dell Latitude D630 laptop. Photos of individual wells were made using the software provided with the Nikon camera, the NIS-Elements D 3.0.

[00282] *Results:* All antisense oligonucleotide tested upregulated SCN1A protein, CUR-1764 and CUR-1770 being the two best (Fig. 11).

*Example 10: SCNA protein upregulation in Vero 76 cells treated with antisense oligonucleotides targeting SCNA-specific natural antisense transcript*

[00283] The purpose of this experiment was to rank the antisense oligonucleotides CUR-1740, CUR-1770, CUR-1916, CUR-1924 and CUR-1945 according to their ability to upregulate SCN1A protein expression in Vero 76 cells. The Vero76 is a *Cercopithecus aethiops* (vervet or African green monkey) kidney cell line.

[00284] *Materials and Methods:* Vero76 African green monkey embryonic kidney cells from ATCC (cat# CRL-1587) were grown in growth media (Dulbecco's Modified Eagle's Medium (Cellgrow 10-013-CV) + 5% FBS (Mediatech cat# MT35-011-CV) + penicillin/streptomycin (Mediatech cat# MT30-002-CI)) at 37°C and 5% CO<sub>2</sub>. The cells were treated with antisense oligonucleotides using one of the following methods. For the Next Day Method, one day before the experiment the cells were replated at the density of approximately  $4 \times 10^4$ /well into 24 well plates in Growth Media and incubated at 37°C and 5% CO<sub>2</sub> overnight. Next day, the media in the 24 well plates was changed to fresh Growth Media (1 ml/well) and the cells were dosed with antisense oligonucleotides CUR-1740, CUR-1770 and CUR-1916. All antisense oligonucleotides were manufactured by IDT Inc. (Coralville, IA) or Exiqon (Vedbaek, Denmark). The sequences for oligonucleotides CUR-1740, CUR-1770, CUR-1916, CUR-1924 and CUR-1945 are listed in Table 1. Stock solutions of oligonucleotides were diluted to the concentration of 20  $\mu$ M in DNase/RNase-free sterile water. To dose one well at a final concentration of 20 nM, 1  $\mu$ l of the 20  $\mu$ M oligonucleotide solution was incubated with 200  $\mu$ l of Opti-MEM media (Gibco cat#31985-070) and 2  $\mu$ l of Lipofectamine 2000 (Invitrogen cat# 11668019) at room temperature for 20 min and applied dropwise to one well of a 24 well plate with cells. To achieve final concentrations of 5, 10, 40 and 80 nM the volumes of the 20  $\mu$ M oligonucleotide stock used were adjusted accordingly. The ratio of the 20  $\mu$ M oligonucleotide stock solution to Lipofectamine 2000 was 1:2 (v:v). Similar



mixture including 8  $\mu$ l of water instead of the oligonucleotide solution and the corresponding volume of Lipofectamine 2000 was used for the mock-transfected controls. After about 18 h of incubation at 37°C and 5% CO<sub>2</sub>, the media was changed to fresh Growth Media. Forty eight hours after addition of antisense oligonucleotides the media was removed and cells were washed 3 times with Dulbecco's phosphate-buffered saline without calcium and magnesium (PBS) (Mediatech cat# 21-031-CV). The PBS was discarded and the Vero 76 cells were fixed in the 24 well plate using 300  $\mu$ l methanol 100% for 15 min at -20°C. After removing the methanol and washing the cells with PBS, the cells were incubated with 3% hydrogen peroxide (Fisher Chemical cat#H325-100) for 5 min at 21°C. The cells were washed three times for 5 min with PBS then incubated with 300  $\mu$ l of bovine serum albumin (BSA) (Sigma cat# A-9647) at 0.1% in PBS for 30 min at 21°C. The cells were washed three times for 5 min with PBS then incubated with 300  $\mu$ l of avidin solution (Vector Laboratories cat# SP-2001) for 30 min at 21°C. The cells were briefly rinsed three times with PBS then incubated with biotin solution (Vector Laboratories cat# SP-2001) for 30 min at 21°C. The cells were washed three times with PBS and then incubated overnight at 4°C with 300  $\mu$ l per well of rabbit antibody against human SCN1A (Abcam cat# ab24820) diluted at 1:250 in PBS/BSA 0.1%. After equilibrating the plate for 5 min at 21°C, the cells were washed three times 5 min each with PBS then incubated with goat anti-rabbit antibody diluted 1:200 in PBS/BSA 0.1% for 30 min at 21°C. The cells were washed three times 5 min with PBS and then incubated with 300  $\mu$ l of Vectastain Elite ABC reagent A+B solution (Vector Laboratories cat# PK-6101) for 30 min; the Vectastain Elite ABC reagent A+B solution was prepared at 21°C 30 min before incubation with the cells by adding and mixing successively 2 drops of reagent A to 5 ml of PBS and then 2 drops of reagent B. The cells were washed 3 times 5 min each with PBS at 21°C and then incubated with Diaminobenzidine (DAB) peroxidase substrate solution (Vector Laboratories cat# SK-4105) until cells are stained; the DAB peroxidase substrate solution is reconstituted before being added to the cells by mixing 1ml of ImmPACT™DAB Diluent with 30  $\mu$ l of ImmPACT™ DAB Chromogen concentrate. At this time, the cells are briefly washed three times with PBS and 300  $\mu$ l of PBS is left in each well. The staining of the cells was analyzed directly inside the wells of the 24-well plate using an inverted Nikon Eclipse TS100 microscope equipped with a Nikon DS-R1 camera coupled with Nikon Digital-Sight equipment on the screen of a Dell Latitude D630 laptop. Photos of individual wells were made using the software provided with the Nikon camera, the NIS-Elements D 3.0.

[00285] *Results.* All antisense oligonucleotides tested upregulated SCN1A protein, CUR-1764 and CUR-1770 producing the highest upregulation (Fig 12).

*Example 11: Oligonucleotides targeting SCNA-specific natural antisense transcript powerful at upregulating SCNA mRNA do not upregulate actin mRNA in Vero76 cells*

[00286] The purpose of this experiment was to check whether antisense oligonucleotides (CUR-1924, CUR-1740, CUR-1838) targeting SCNA-specific natural antisense transcript that were shown to upregulate SCNA mRNA and

protein are able to regulate the mRNA of other non-related genes such as actin in Vero76 African green monkey embryonic kidney cells.

[00287] *Materials and Methods.* Vero76 African green monkey embryonic kidney cell line from ATCC (cat# CRL-1587) was dosed in the same conditions as described in Example 2. The actin mRNA was quantified by real-time PCR as described in Example 2 except that this time primers/probes designed by ABI were specific for actin (cat# Hs99999903\_m1). The data is presented in figure 13.

[00288] *Results.* As shown in figure 13, oligonucleotide targeting SCN1A-specific natural antisense transcript (CUR-1924, CUR-1740, CUR-1838) that were shown in Examples 3 and 10 to upregulate SCN1A mRNA and protein in Vero76 cells were tested for their effect on actin mRNA expression in Vero 76 cells. The data in figure 13 confirms that the oligonucleotides targeting SCN1A-specific natural antisense transcript do not upregulate a non related gene such as actin. Thus these oligonucleotides are specific in upregulating SCN1A.

*Example 12: Oligonucleotides targeting SCNA-specific natural antisense transcript shown to upregulate SCNA mRNA and protein do not upregulate actin mRNA in primary fibroblasts carrying a Dravet-associated mutation*

[00289] The purpose of this experiment was to check whether antisense oligonucleotides (CUR-1916, CUR-1945) targeting SCN1A-specific natural antisense transcript that were shown to upregulate SCN1A mRNA and protein are able to regulate the mRNA of other non-related genes such as actin in primary human skin fibroblasts carrying a Dravet syndrome-associated mutation E1099X.

[00290] *Materials and Methods.* Primary human skin fibroblasts carrying a Dravet syndrome-associated mutation E1099X introduced into culture by Dr. N.Kenyon (University of Miami) were dosed in the same conditions as described in Example 3. The actin mRNA was quantified by real-time PCR as described in Example 3 except that this time primers/probes designed by ABI were specific for actin (cat# Hs99999903\_m1). The data is presented in figure 14.

[00291] *Results:* As shown in figure 14 oligonucleotides targeting SCN1A-specific natural antisense transcript do not upregulate a non-related gene such as actin. Thus these oligonucleotides are specific in upregulating SCN1A.

*Example 13: Oligonucleotides targeting SCNA-specific natural antisense transcript shown to upregulate SCNA mRNA and protein do not upregulate actin mRNA in SK-N-AS cells*

[00292] The purpose of this experiment was to check whether antisense oligonucleotides (CUR-1740, CUR-1764, CUR-1770, CUR-1838, CUR-1916) targeting SCN1A-specific natural antisense transcript that were shown to upregulate SCN1A mRNA and protein are able to regulate the mRNA of other non-related genes such as actin in SK-N-AS human neuroblastoma cells.

[00293] *Materials and Methods.* SK-N-AS human neuroblastoma cells from ATCC (cat# CRL-2137) were dosed in the same conditions as described in Example 2. The actin mRNA was quantified by real-time PCR as described in

Example 2 except that this time primers/probes designed by ABI were specific for actin (cat# Hs99999903\_m1). The data is presented in Figure 15.

[00294] *Results.* As shown in figure 15 oligonucleotides targeting SCN1A-specific natural antisense transcript do not upregulate a non-related gene such as actin. Thus these oligonucleotides are specific in upregulating SCN1A.

5 *Example 14: Actin protein is not upregulated in SK-N-AS cells treated with antisense oligonucleotides targeting SCNA-specific natural antisense transcript*

[00295] The purpose of this experiment was to determine whether oligonucleotides targeting SCN1A-specific natural antisense transcript (CUR-1740, CUR-1764, CUR-1770 and CUR-1916) and able to upregulate SCN1A protein are also able to regulate the expression of non-relevant proteins such as actin in SK-N-AS cells. SK-N-AS is a human  
10 neuroblastoma cell line.

[00296] *Materials and Methods:* SK-N-AS human neuroblastoma cells from ATCC (cat# CRL-2137) were grown in the same conditions as described in Example 9. The cells were fixed and stained exactly in the same conditions as described in Example 8, except that the first antibody was a rabbit anti-actin (Abcam cat#ab1801) used at a dilution of 1:500. The staining of the cells was analyzed directly inside the wells of the 24-well plate using the same process as  
15 described in Example 9.

[00297] *Results:* As shown in figure 16, none of the antisense oligonucleotides tested upregulated actin protein. Thus, these oligonucleotides are specific at upregulating SCN1A protein.

*Example 15: Actin protein is not upregulated in Vero 76 cells treated with antisense oligonucleotides targeting SCNA-specific natural antisense transcript*

20 [00298] The purpose of this experiment was to determine whether specific antisense oligonucleotides targeting SCN1A-specific natural antisense transcript (CUR-1740, CUR-1770, CUR-1916, CUR-1924 and CUR-1945) and able to upregulate SCN1A protein are also able to regulate the protein expression of non-relevant genes such as actin in Vero76 cells. The Vero76 is a *Cercopithecus aethiops* (vervet or African green monkey) kidney cell line.

[00299] *Materials and Methods.* Vero76 African green monkey embryonic kidney cell line from ATCC (cat# CRL-25 1587) was grown in the same conditions that described in Example 10. The cells were fixed and stained exactly in the same conditions as described in Example 10, except that the first antibody was a rabbit anti-actin (Abcam cat#ab1801) used at a dilution of 1:500. The staining of the cells was analyzed directly inside the wells of the 24-well plate using the same process as described in Example 10.

[00300] *Results.* As shown in figure 17, none of the antisense oligonucleotides tested upregulated actin protein. Thus,  
30 these oligonucleotides are specific at upregulating SCN1A protein.

*Example 16: Actin protein is not upregulated in primary human fibroblasts carrying a Dravet syndrome-associated mutation treated with antisense oligonucleotides targeting SCNA-specific natural antisense transcript*

[00301] The purpose of this experiment was to determine whether oligonucleotides targeting SCN1A-specific natural antisense transcript (CUR-1740, CUR-1764, CUR-1770, CUR-1838 and CUR-1916) and able to upregulate SCN1A protein are also able to regulate the protein expression of non-relevant genes such as actin in primary human fibroblasts carrying a Dravet syndrome-associated mutation.

5 [00302] *Materials and Methods.* Fibroblasts carrying a Dravet syndrome-associated mutation introduced into culture by Dr. N.Kenyon (University of Miami) were grown in the same conditions as described in Example 8. The cells were fixed and stained exactly in the same conditions as described in Example 8, except that the first antibody was a rabbit anti-actin (Abcam cat#ab1801) used at a dilution of 1:500. The staining of the cells was analyzed directly inside the wells of the 24-well plate using the same process as described in Example 8.

10 [00303] *Results:* As shown in figure 18, none of the antisense oligonucleotides tested upregulated actin protein. Thus, these oligonucleotides are specific at upregulating SCN1A protein.

*Example 17: Quantification of SCN1A protein using ELISA in primary human fibroblasts carrying a Dravet syndrome-associated mutation treated with oligonucleotides targeting SCN1A-specific natural antisense transcript*

[00304] The purpose of this experiment was to quantify using ELISA the level of SCN1A protein upregulation due to 15 the treatment with oligonucleotides targeting SCN1A-specific natural antisense transcript (CUR-1740, CUR-1770 and CUR-1916) in primary human fibroblasts carrying a Dravet syndrome-associated mutation.

[00305] *Materials and Methods:* Fibroblasts carrying a Dravet syndrome-associated mutation introduced into culture by Dr. N.Kenyon (University of Miami) were grown in the same conditions as described in Example 8 but only 0 and 80nM concentrations of oligonucleotides were used for dosing. The cells were then counted and re-plated in 96 well 20 plates. After 24 hours, the cells were fixed exactly in the same conditions as described in Example 8 and 16 except all 300 µl volumes were reduced to 100µl. Replicate wells were stained with actin and SCN1A antibodies as described in Example 8, except that all reaction were performed in 100 µl volumes. Anti-actin antibody dilution was 1:500, anti-SCN1A dilution was 1:250 and anti-mouse dilution was 1:250. In addition, instead of diaminobenzidine (DAB) peroxidase substrate solution tetramethylbenzidine (TMB) peroxidase substrate solution was used (Thermo Scientific 25 cat#N301). After the supernatant turned blue, it was transferred to a new 96 well plate (Greiner bio one cat #65121) and 1 M sulfuric acid was added. The absorbance was read at 450nm using a Multiskan Spectrum spectrophotometer (Thermo Scientific). The background signal (read in the wells stained with an anti- mouse as primary antibody) was subtracted from all SCN1A and actin readings. Then SCN1A signal was normalized to actin signal for each condition.

[00306] *Results:* Figure 19 shows that all antisense oligonucleotides tested (CUR-1740, CUR-1770 and CUR-1916) 30 were efficient at upregulating SCN1A protein up to 40%.

*Example 18: Quantification of the SCN1A protein using ELISA in Vero76 cells treated with oligonucleotides targeting SCN1A-specific natural antisense transcript*

[00307] The purpose of this experiment was to quantify using ELISA the level of SCN1A protein upregulation due to the treatment with oligonucleotides targeting SCN1A-specific natural antisense transcript (CUR-1740, CUR-1770, CUR-1916, CUR-1924, CUR-1945) in primary human fibroblasts carrying a Dravet syndrome-associated mutation.

[00308] *Materials and Methods:* Vero76 African green monkey embryonic kidney cell were grown in the same conditions that described in Example 10 but only 0 and 80nM concentrations of oligonucleotides were used for dosing. The cells were then counted and re-plated in 96 well plates. After 24 hours, the cells were fixed exactly in the same conditions as described in Example 8 except all 300  $\mu$ l volumes were reduced to 100 $\mu$ l. Replicate wells were stained with actin and SCN1A antibodies as described in Examples 10 and 15, except that all reactions were performed at 100  $\mu$ l, the anti-actin antibody dilution was 1:500, anti-SCN1A dilution was 1:250 and anti-mouse dilution was 1:250. In addition, instead of using diaminobenzidine (DAB) peroxidase substrate solution tetramethylbenzidine (TMB) peroxidase substrate solution was used (Thermo Scientific cat#N301). After the supernatant turned blue, it was transferred to a new 96 well plate (Greiner bio one cat#651201) and 1 M sulfuric acid was added. The absorbance was read at 450nm using a Multiskan Spectrum spectrophotometer (Thermo Scientific). The background signal (read in the wells stained with an anti- mouse as primary antibody) was subtracted from all SCN1A and actin readings. Then SCN1A signal was normalized to actin signal for each condition.

[00309] *Results:* Figure 20 shows that all of the antisense oligonucleotides tested (CUR-1740, CUR-1770, CUR-1916, CUR-1924, CUR-1945) were efficient at upregulating SCN1A protein up to 300%.

*Example 19: Quantification of the SCNA protein using ELISA in SK-N-AS cells treated with oligonucleotides targeting SCNA-specific natural antisense transcript*

[00310] The purpose of this experiment was to quantify the level of SCN1A protein upregulation due to the treatment with oligonucleotides targeting SCN1A-specific natural antisense transcript (CUR-1740, CUR-1770, CUR-1924 and CUR-1945) in SK-N-AS cells.

[00311] *Materials and Methods:* SK-N-AS human neuroblastoma cells from ATCC (cat# CRL-2137) were grown the same conditions as described in Example 10 but only 0 and 20nM concentrations of oligonucleotides were used for dosing. The cells were then counted and re-plated in 96 well plates. After 24 hours, the cells were fixed exactly in the same conditions as described in Example 9 except all 300  $\mu$ l volumes were reduced to 100 $\mu$ l. Replicate wells were stained with actin and SCN1A antibodies as described in Examples 9 and 13, except that all reactions were performed at 100  $\mu$ l, the anti-actin antibody dilution was 1:500, anti-SCN1A dilution was 1:250 and anti-mouse dilution was 1:250. In addition, instead of diaminobenzidine (DAB) peroxidase substrate solution tetramethylbenzidine (TMB) peroxidase substrate solution was used spectrophotometer (Thermo Scientific cat#N301). After the supernatant turned blue, it was transferred to a new 96 well plate (Greiner bio one cat#651201) and 1 M sulfuric acid was added. The absorbance was read at 450nm using a Multiskan Spectrum (Thermo Scientific). The background signal (read in the

wells stained with an anti- mouse as primary antibody) was subtracted from all SCN1A and actin readings. Then SCN1A signal was normalized to actin signal for each condition.

[00312] *Results:* Figure 21 shows that all antisense oligonucleotides tested (CUR-1740, CUR-1770, CUR-1924 and CUR-1945) were efficient at upregulating SCN1A protein in SK-N-AS cells up to 500%.

5 *Example 20: Detection of the natural antisense BG724147 in HepG2 cells and primary human fibroblasts carrying a Dravet syndrome-associated mutation.*

[00313] The purpose of this experiment was to determine whether the natural antisense BG724147 is present in human hepatocellular carcinoma HepG2 cell line and primary human fibroblasts carrying a Dravet syndrome-associated mutation. To achieve this, two different kinds of RNA (poly A RNA and total RNA) isolated from each cell  
10 type were used. The PCR products obtained after two successive rounds of PCR using both cell types were analyzed on a gel. Amplification of bands of similar size using BG724147-specific primer confirmed the presence of BG724147 in both cell types.

#### *Materials and Methods*

[00314] *Isolation of total RNA.* HepG2 cells or primary human fibroblasts carrying a Dravet syndrome-associated  
15 mutation at 80% confluence grown in 75 cm<sup>2</sup> culture flasks were washed twice with PBS AccuGENE 1X (Lonza Rockeland Inc., Rockeland, ME). After discarding PBS, 5 ml of RLT buffer with b-mercaptoethanol (QIAGEN Inc.-USA, Valencia, CA) were added to these cells and the cell lysate was stored in 1 ml aliquots in microcentrifuge tubes at -80°C until isolation of total RNA. The total RNA isolation from these cells was done using the RNeasy midi kit (QIAGEN Inc.-USA, Valencia, CA) following the manufacturer's protocol. Briefly, the cell lysate was centrifuged at  
20 3000xg for 5 min to clear the lysate and discard any pellet. The cleared cell lysate was centrifuged through QIAshredder columns (inside 2 ml microcentrifuge tubes) at 14800xg and the resulting homogenized lysate was mixed with an equal volume of 70% ethanol. The cell lysate mixed with ethanol was applied to RNeasy midi columns (inside a 15 ml conical tube) and centrifuged for 5 min at 3000xg. The column was washed once with 4 ml of RW1 buffer and then subjected to a 15 min on-column DNase digestion with 140 µl of RNase-free DNase in RDD buffer. The DNase  
25 digestion was stopped by adding 4 ml of RW1 buffer and centrifuging the column at 3000xg. The column was washed twice with RPE buffer and total RNA binding to the filter was eluted with 150 µl of DNase and RNase free water. The total RNA was stored at -80°C until the next step.

[00315] *Isolation of poly-A RNA from total RNA of HepG2 cells.* The isolation of poly A RNA from total RNA of HepG2 cells and primary human fibroblasts carrying a Dravet syndrome-associated mutation was done using a poly-A  
30 isolation with magnetic beads kit from Ambion (Applied Biosystems/Ambion, Austin, TX) following the manufacturer protocol. Basically, 100 µg of total RNA was resuspended to a final concentration of 600 µg/ml in DNase/RNase free water and an equal volume of 2X binding solution was added. During that time, 10 µl of Oligo(dT) magnetic beads were placed in a microcentrifuge tube, captured by placing this tube on the magnetic stand and the storage buffer was

discarded. 50  $\mu$ l of Wash solution 1 was added to the beads and the tube was removed from the magnetic stand and the wash solution was discarded. At this time, the total RNA from HepG2 cells in 1X Binding buffer was mixed with the magnetic beads and heated at 70  $^{\circ}$ C for 5 min, then incubated for 60 min at room temperature with gentle agitation. The poly A RNA bound to the magnetic beads was captured by using the magnetic stand for 5 min. The supernatant was discarded. The Oligo(dT) magnetic beads were washed twice with Wash solution 1 and once with Wash solution 2 to remove the non-specifically bound RNA. The magnetic beads were captured with the magnetic stand and 200  $\mu$ l of warm RNA storage solution (preheated at 70  $^{\circ}$ C for 5 min) was added to the beads. The magnetic beads were captured by the magnetic stand, the supernatant was stored (first elution of poly A RNA). Then a second 200  $\mu$ l of warm RNA storage solution (preheated at 70 $^{\circ}$ C for 5 min) was added to the beads. The second elution of polyA RNA was added to the first elution. At this time, the eluted RNA was precipitated using 5 M ammonium acetate, glycogen and 100% ethanol at -20 $^{\circ}$ C overnight. The poly RNA was centrifuged at 14800xg for 30 min at 4 $^{\circ}$ C. The supernatant was discarded and the RNA pellet was washed three times with 1 ml of 70% ethanol, the RNA pellet was recovered each time by centrifuging for 10 min at 4 $^{\circ}$ C. Finally, the poly A RNA pellet was resuspended in RNA storage solution heated to 70 $^{\circ}$ C to dissolve RNA better. The poly A RNA was stored at -80  $^{\circ}$ C.

[00316] Addition of adenosines to the 3' end of an RNA transcript. Total RNA (40  $\mu$ g) from HepG2 cells or primary human fibroblasts carrying a Dravet syndrome-associated mutation was mixed with 2 units of RNA Poly (A) Polymerase using a final reaction volume of 100  $\mu$ l (Ambion, Applied Biosystems, St. Austin TX). The ATP used in the polyadenylation reaction was from Invitrogen. After polyadenylation, the RNA was purified using the phenol/chloroform technique followed by glycogen/sodium acetate precipitation. This RNA was resuspended in 40  $\mu$ l of DNase/RNase free water and was used in a 3' RACE reaction (FirstChoice RLM-RACE kit from Ambion, Applied Biosystems, St. Austin TX).

[00317] 3' extension of the BG724147 natural antisense transcript of SCN1A. Two different sets of 3' Rapid Amplification of cDNA Ends (RACE) reactions were performed using FirstChoice RLM-RACE kit from Ambion, Applied Biosystems (St. Austin, TX). One set used poly A RNA and the other used total RNA with one adenosine added, from HepG2 cells or primary human fibroblasts carrying a Dravet syndrome-associated mutation. Two consecutive rounds of PCR were performed. The first PCR was done using the 3' outer primer supplied in the kit and a 5' primer specific for BG724147 designed by OPKO CURNA (5' GATTCTCCTACAGCAATTGGTA 3'). The second PCR round was conducted using the 3' outer primer supplied in the kit and a different 5' primer specific for BG724147 designed by OPKO CURNA (5' GACATGTAATCACTTTCATCAA 3'). The products of the second PCR reaction were run on a 1% agarose -1xTAE gel.

[00318] *Results:* Figure 22 shows the products from the second round of PCR reactions from a 3' RACE experiments using poly A RNA and total RNA with adenosine added from HepG2 cells and poly A RNA and total RNA with adenosine added from primary human fibroblasts carrying a Dravet syndrome-associated mutation. An identical band is

observed in the poly A RNA from HepG2 cells and primary human fibroblasts carrying a Dravet syndrome-associated mutation.

[00319] *Conclusion:* PCR amplification using primers specific for the BG724147 natural antisense transcript of SCN1A produced a common PCR band in two different cells (HepG2 cells and primary human fibroblasts carrying a Dravet syndrome-associated mutation). In addition, antisense oligonucleotides targeting the SCN1A natural antisense BG724147 have been shown to upregulate SCN1A mRNA and protein in these cells as shown in Examples 2, 7 and 16. This data indicates that the BG724147 is indeed present in these two kinds of cells (HepG2 cells and primary human fibroblasts carrying a Dravet syndrome-associated mutation).

*Example 21: Extension of the SCNA natural antisense sequence BG724147*

[00320] The purpose of this experiment is to extend the known sequence of the SCN1A natural antisense BG724147 by sequencing all its sequence. The original BG724147 RNA transcript was obtained from human testis procured by Miklos Palkovits. The cDNA library was prepared in a pBluescriptR vector by Michael J. Brownstein (at NHGRI), Shiraki Toshiyuki and Piero Carninci (at RIKEN). The cDNA library was arrayed by the I.M.A.G.E. Consortium (or LLNL) and the clones were sequenced by Incyte Genomics, Inc. in May 2001. The BG724147 clone is available at Open Biosystems (Open Biosystems Products, Huntsville, AL). In 2001 the cDNA insert in the BG724147 clone was not sequenced completely. OPKO-CURNA obtained the BG724147 clone and sequenced the full insert. To achieve this, a bacterial clone containing a plasmid with the BG724147 insert was acquired from Open Biosystems and plated in a Luria Bertani (LB)-agar plate with ampicillin to isolate individual colonies. Then colonies were amplified in 5 ml of LB broth. The plasmid containing the BG724147 insert was then isolated from these bacteria and sent for sequencing to Davis Sequencing (Davis, CA).

*Material and Methods:*

[00321] *Isolation and sequencing of the plasmid containing the cDNA for the SCNA natural antisense BG724147.* Suspension of frozen bacteria containing the BG724147 plasmid was purchased from Open Biosystems (Open Biosystems Products, cat# 4829512), diluted 1:10, 1:100, 1:1000, 1:10000, 1:100000 times, then plated on Luria Bertani (LB) (BD, cat# 244520)-agar plate (Falcon, cat#351005) with 100 µg/ml of ampicillin (Calbiochem, cat#171254). After 15h, 20 individual colonies of bacteria were isolated from the plate with the 1:100000 dilution and grown separately in 5 ml of LB broth (Fisher Scientific, cat# BP1426-2) for 15h-24h. At this time, the bacteria were pelleted and the plasmid (containing the cDNA from the BG724147 RNA transcript) was isolated using the PureYield™ Plasmid Miniprep System kit from Promega (Promega, cat#A1222) following the manufacturer's protocol. The isolated DNA was diluted to 200 ng/ml and 12 µl of plasmid from each colony was sent for sequencing to Davis sequencing (Davis, CA).

[00322] *Results:* The sequences obtained from Davis sequencing provide BG724147 extended (SEQ ID NO: 12)



[00323] *Conclusion:* The successful extension of the known BG724147 sequence by 403 nucleotides served as a basis to design antisense oligonucleotides against the SCN1A natural antisense transcript BG724147.

[00324] Although the invention has been illustrated and described with respect to one or more implementations, equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In addition, while a particular feature of the invention may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application.

[00325] The Abstract of the disclosure will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An *ex vivo* method of upregulating a function of and/or an expression of a Sodium channel, voltage-gated, type1, alpha subunit (SCN1A) polynucleotide in a biological system having SEQ ID NO: 1 comprising:

contacting said biological system with at least one single stranded antisense oligonucleotide 13 to 28 nucleotides in length which targets a 13 to 28 nucleotide region of a long non-coding natural antisense polynucleotide selected from the group consisting of SEQ ID NOS: 12 to 15 and 17 to 28, wherein said at least one single stranded oligonucleotide has 100% sequence identity to a reverse complement of a polynucleotide comprising 13 to 28 consecutive nucleotides within the natural antisense polynucleotide having a nucleic acid sequence as set forth in any one of SEQ ID NOs: 12 to 15 and 17 to 28; thereby upregulating the function of and/or the expression of the SCN1A polynucleotide, and wherein the at least one oligonucleotide comprises at least one oligonucleotide sequence set forth as SEQ ID NOs: 33, 37, 40, 45, 52, 57, 62, 70, 78 and 93.

2. An *ex vivo* method of upregulating a function of and/or an expression of a human Sodium channel, voltage-gated, alpha subunit (SCN1A) polynucleotide in a biological system having SEQ ID NO: 1 comprising:

contacting said biological system with at least one single stranded antisense oligonucleotide of 13 to 30 nucleotides in length that is 100% complementary to and specifically hybridizes to a target region of a natural antisense polynucleotide of the SCN1A polynucleotide, wherein said natural antisense polynucleotide is selected from the group consisting of nucleotides 1 to 1123 of SEQ ID NO: 12, 1 to 2352 of SEQ ID NO: 13, 1 to 267 of SEQ ID NO: 14, 1 to 1080 of SEQ ID NO: 15, 1 to 618 of SEQ ID NO: 17, 1 to 871 of SEQ ID NO: 18, 1 to 304 of SEQ ID NO: 19, 1 to 293 of SEQ ID NO: 20, 1 to 892 of SEQ ID NO: 21, 1 to 260 of SEQ ID NO: 22, 1 to 982 of SEQ ID NO: 23, and 1 to 906 of SEQ ID NO: 24; thereby upregulating the function of and/or the expression of the SCN1A

polynucleotide, and wherein the at least one oligonucleotide comprises at least one oligonucleotide sequences set forth as SEQ ID NOs: 33, 37, 40, 45, 52, 57, 62, 70, 78 and 93.

3. The *ex vivo* method of claim 2, wherein the function of and/or the expression of the SCN1A is increased with respect to a control by at least 10%.

4. The *ex vivo* method of claim 2, wherein the at least one antisense oligonucleotide targets a natural antisense sequence of the SCN1A polynucleotide, wherein the natural antisense sequence comprises SEQ ID NO: 12.

5. The *ex vivo* method of claim 2, wherein the at least one antisense oligonucleotide targets a natural antisense polynucleotide antisense to coding sequences of an RNA polynucleotide transcribed from the SCN1A polynucleotide.

6. The *ex vivo* method of claim 2, wherein the at least one antisense oligonucleotide targets a natural antisense polynucleotide having overlapping and/or non-overlapping sequences with an mRNA polynucleotide of the SCN1A polynucleotide.

7. The *ex vivo* method of claim 2, wherein the at least one antisense oligonucleotide comprises at least one modification which is a modified sugar moiety, a modified internucleoside linkage, or a modified nucleotide, or any combination thereof.

8. The *ex vivo* method of claim 7, wherein the at least one modification comprises at least one modified sugar moiety which is: a 2-O-methoxyethyl modified sugar moiety, a 2'-methoxy modified sugar moiety, a 2'-O-alkyl modified sugar moiety, or a bicyclic sugar moiety, or any combination thereof.

9. The *ex vivo* method of claim 7, wherein the at least one modification comprises at least one modified internucleoside linkage which is: a phosphorothioate, an alkylphosphonate, a phosphorodithioate, an alkylphosphonothioate, a phosphoramidate, a carbamate, a carbonate, a phosphate triester, an acetamidate, or a carboxymethyl ester, or any combination thereof.
10. The *ex vivo* method of claim 7, wherein the at least one modification comprises at least one modified nucleotide which is: a peptide nucleic acid (PNA), a locked nucleic acid (LNA), or an arabino-nucleic acid or any combination thereof.
11. The *ex vivo* method of claim 2, wherein the at least one oligonucleotide comprises at least one oligonucleotide sequence set forth as SEQ ID NOs: 52, 57, 62, 70, 78 and 93.
12. The *ex vivo* method of claim 2, wherein the oligonucleotide is SEQ ID NO: 70.
13. A synthetic, modified oligonucleotide of 13 to 30 nucleotides in length and comprising at least one modification which is a modified sugar moiety, a modified internucleotide linkage, a modified nucleotide, or any combination thereof, wherein said oligonucleotide is an antisense compound which specifically hybridizes to, and is at least 92% complementary to a target region of 13 to 30 consecutive nucleotides within a natural antisense transcript of a Sodium channel, voltage-gated, type 1, alpha subunit (SCN1A) gene, wherein said natural antisense transcript has a nucleotide sequence set forth as SEQ ID NO: 12, and wherein said oligonucleotide upregulates a function of and/or an expression of the SCN1A gene *in vivo* or *in vitro* as compared to a normal control, and wherein the oligonucleotide comprises a sequence set forth as SEQ ID NO: 33, 37, 45, 52, 57, 62, 70, 78 or 93.
14. The oligonucleotide of claim 13, wherein the at least one modification comprises an internucleotide linkage which is: a phosphorothioate, an alkylphosphonate, a

phosphorodithioate, an alkylphosphonothioate, a phosphoramidate, a carbamate, a carbonate, a phosphate triester, an acetamidate, or a carboxymethyl ester, or any combination thereof.

15. The oligonucleotide of claim 13, wherein said oligonucleotide comprises at least one phosphorothioate internucleotide linkage.

16. The oligonucleotide of claim 13, wherein said oligonucleotide comprises a backbone of phosphorothioate internucleotide linkages.

17. The oligonucleotide of claim 13, wherein the oligonucleotide comprises at least one modified nucleotide which is: a peptide nucleic acid or a locked nucleic acid (LNA) or both.

18. The oligonucleotide of claim 13, wherein the oligonucleotide comprises a plurality of modifications, wherein said modifications comprise modified nucleotides that include: phosphorothioates, alkylphosphonates, phosphorodithioates, alkylphosphonothioates, phosphoramidates, carbamates, carbonates, phosphate triesters, acetamidates, or carboxymethyl esters, or any combination thereof.

19. The oligonucleotide of claim 13, wherein the oligonucleotide comprises a plurality of modifications, wherein said modifications comprise modified nucleotides that include peptide nucleic acids, locked nucleic acids (LNA) or both.

20. The oligonucleotide of claim 13, wherein the oligonucleotide comprises at least one modified sugar moiety which is: a 2'-O-methoxyethyl modified sugar moiety, a 2'-methoxy modified sugar moiety, a 2'-O-alkyl modified sugar moiety, a bicyclic sugar moiety, or any combination thereof.

21. The oligonucleotide of claim 13, wherein the oligonucleotide comprises a plurality of modifications, wherein said modifications comprise modified sugar moieties which are: 2'-

O- methoxyethyl modified sugar moieties, 2-methoxy modified sugar moieties, 2'-O-alkyl modified sugar moieties, bicyclic sugar moieties, or any combination thereof.

22. The oligonucleotide of claim 13, wherein the oligonucleotide comprises a plurality of modifications, wherein said modifications comprise a modified internucleotide linkage which is selected from a phosphorothioate or a methylphosphonate and a modified nucleotide which is selected from a peptide nucleic acid or a locked nucleic acid (LNA).

23. A pharmaceutical composition comprising one or more modified oligonucleotides as defined in any one of claims 13 to 22, and a pharmaceutically acceptable excipient.

24. Use of an oligonucleotide in the manufacture of a medicament for the prevention and/or treatment of a Sodium channel, voltage-gated, type1, alpha subunit (SCN1A) associated disease or disorder, wherein said oligonucleotide increases the expression of SCN1A and wherein said oligonucleotide is defined in any one of claims 13 to 22.

25. The use of claim 24, for the prevention and/or treatment of Severe myoclonic epilepsy of infancy (SMEI), a neurological disease or disorder, convulsion, pain, impaired electrical excitability involving sodium channel dysfunction, a disease or disorder associated with sodium channel dysfunction, misregulation of voltage-gated sodium channel alpha subunit activity, or neuromuscular system, a gastrointestinal tract disease due to dysfunction of the enteric nervous system, a cardiovascular disease or disorder, a disease or disorder of the genitourinary tract involving sympathetic and parasympathetic innervation, Generalised epilepsy with febrile seizure plus (GEFS+) or a SCNA-related seizure disorder.

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FIGURE 1

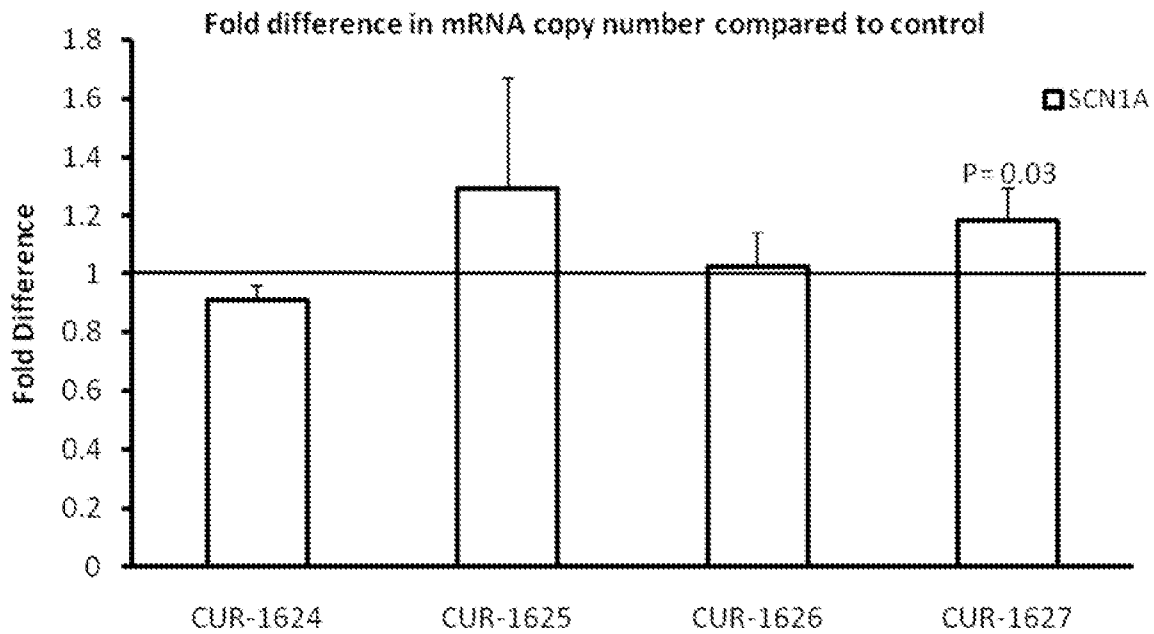


FIGURE 2

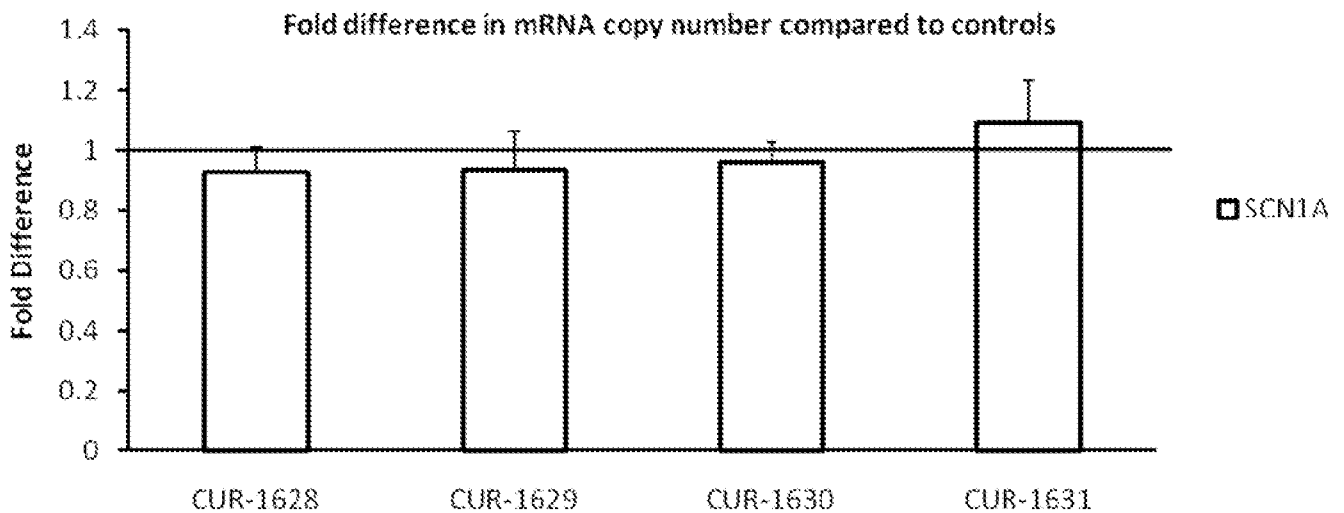


FIGURE 3

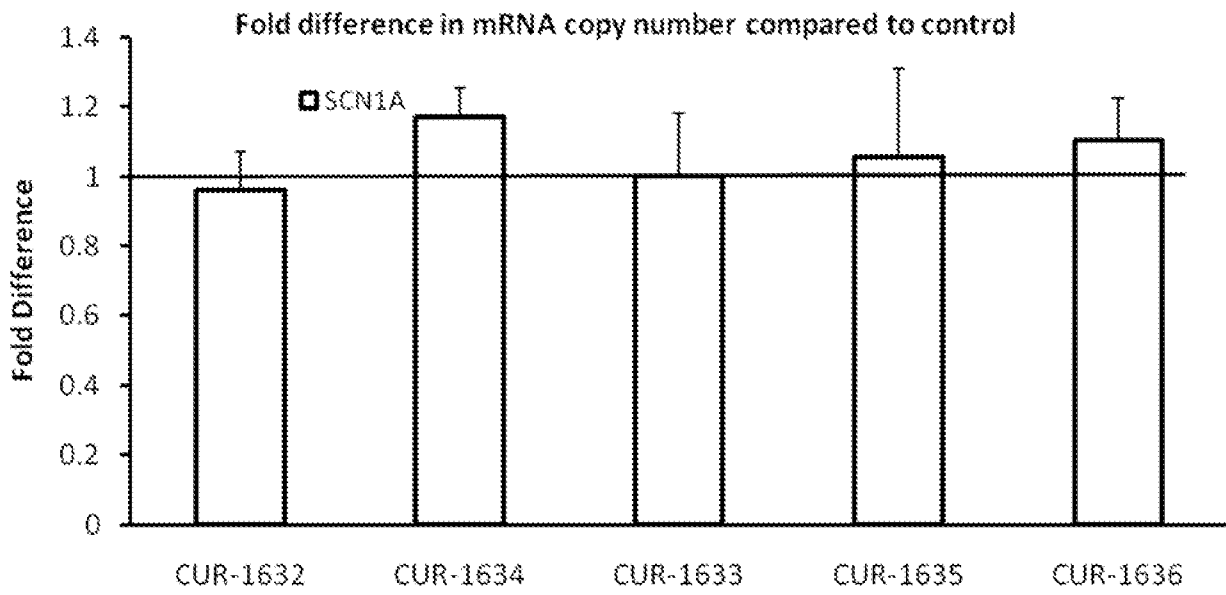


FIGURE 4

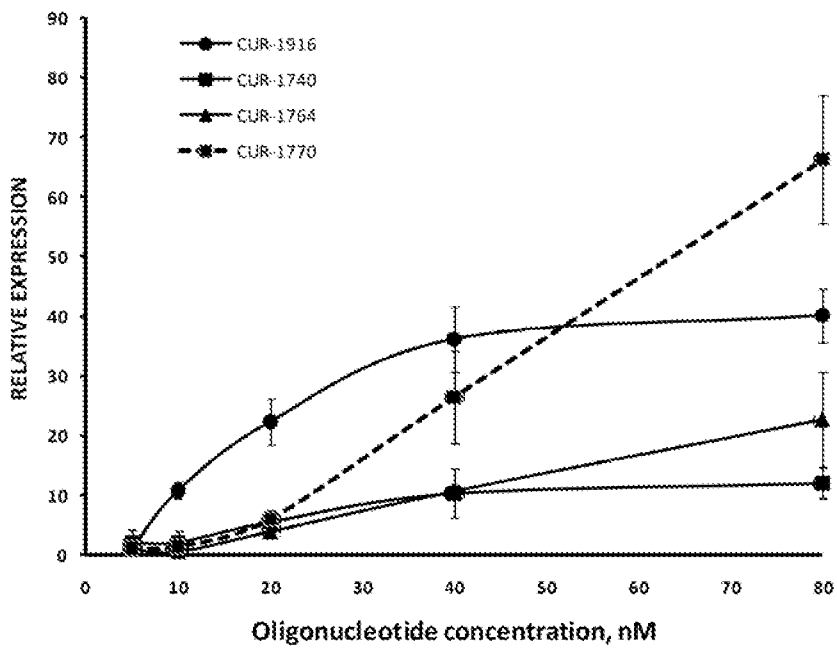




FIGURE 5

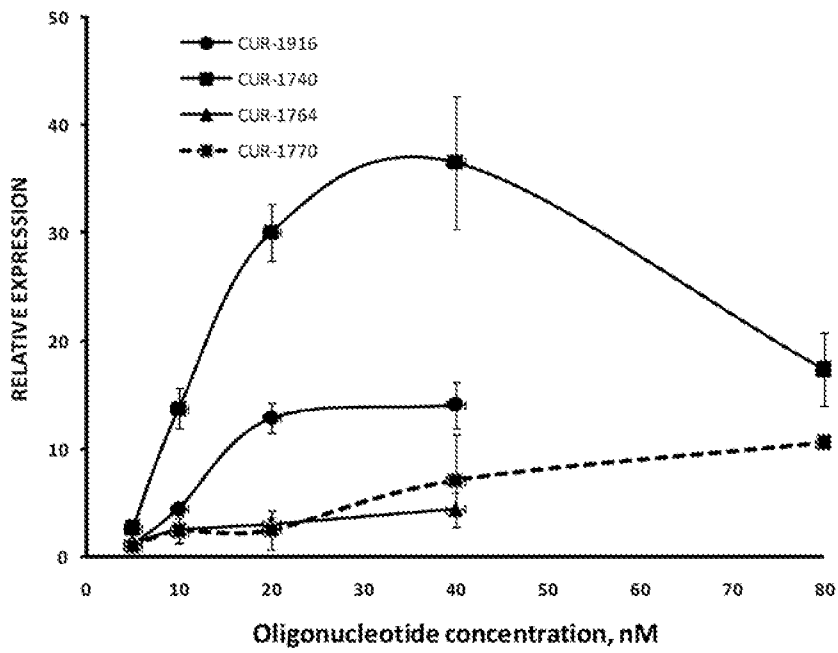


FIGURE 6

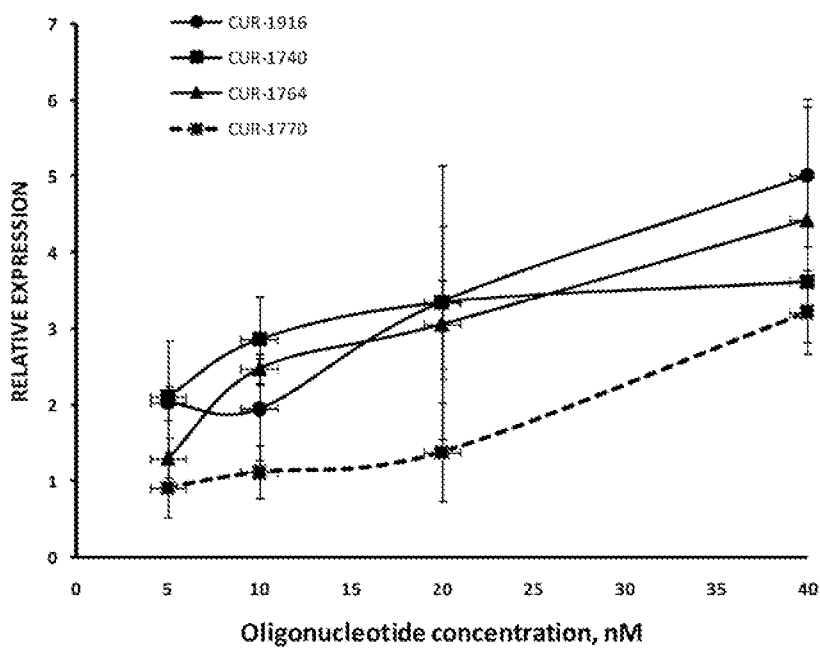
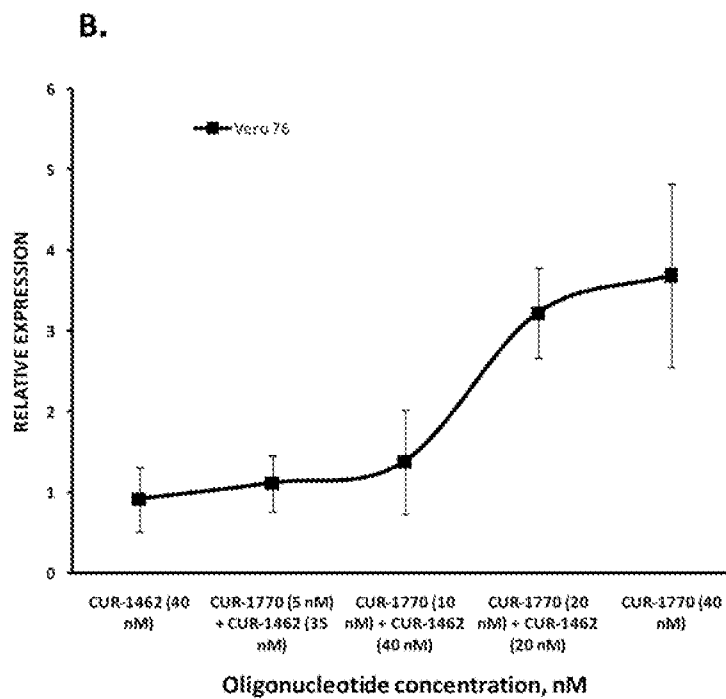
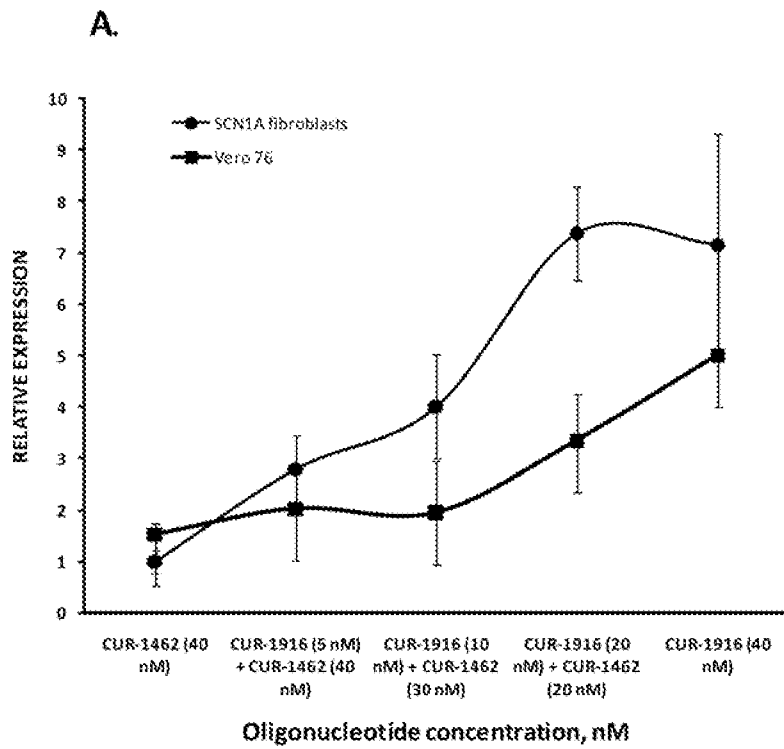
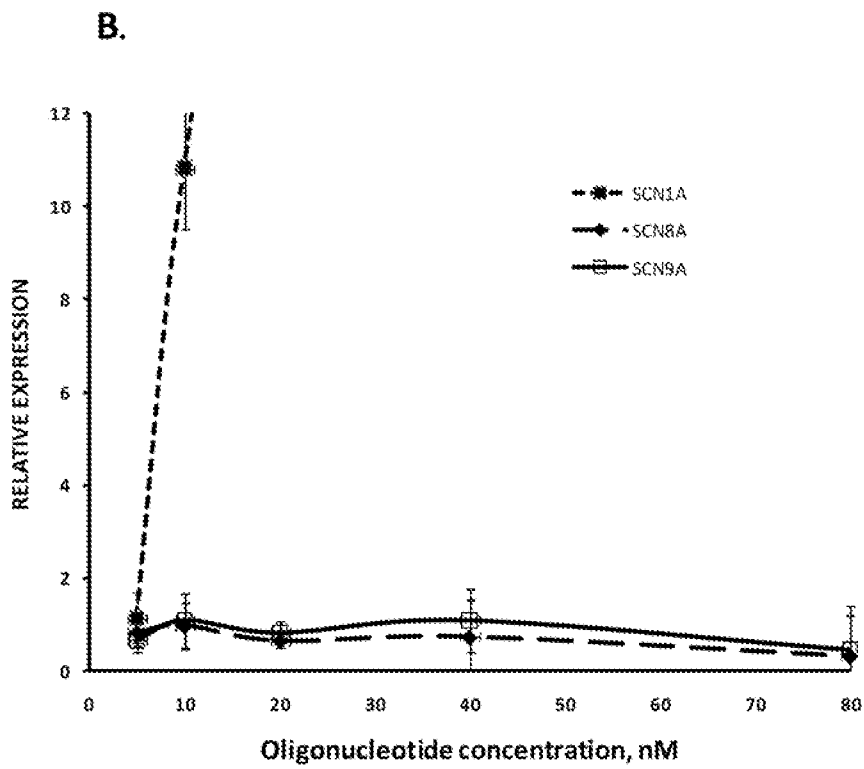
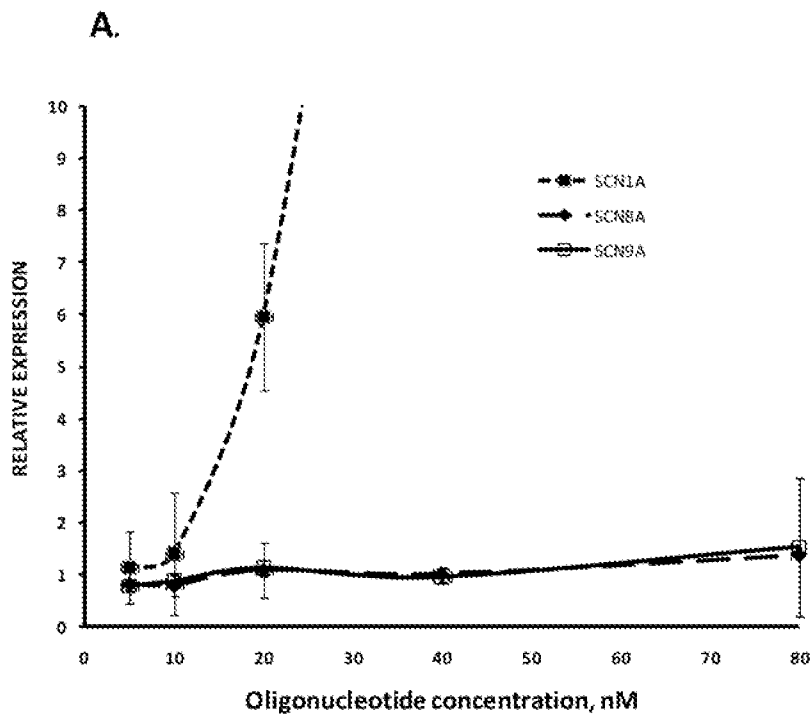


FIGURE 7



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FIGURE 8



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FIGURE 9

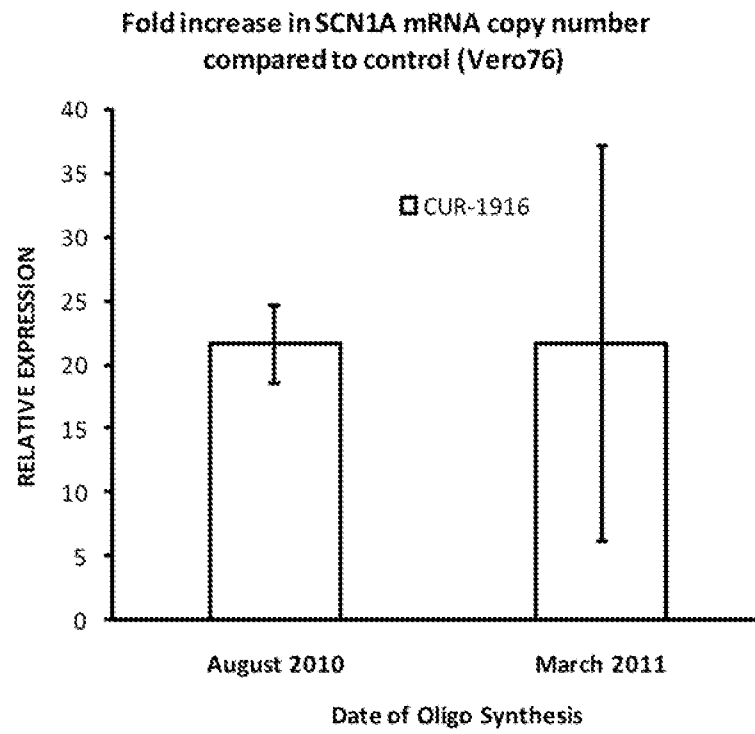


FIGURE 10

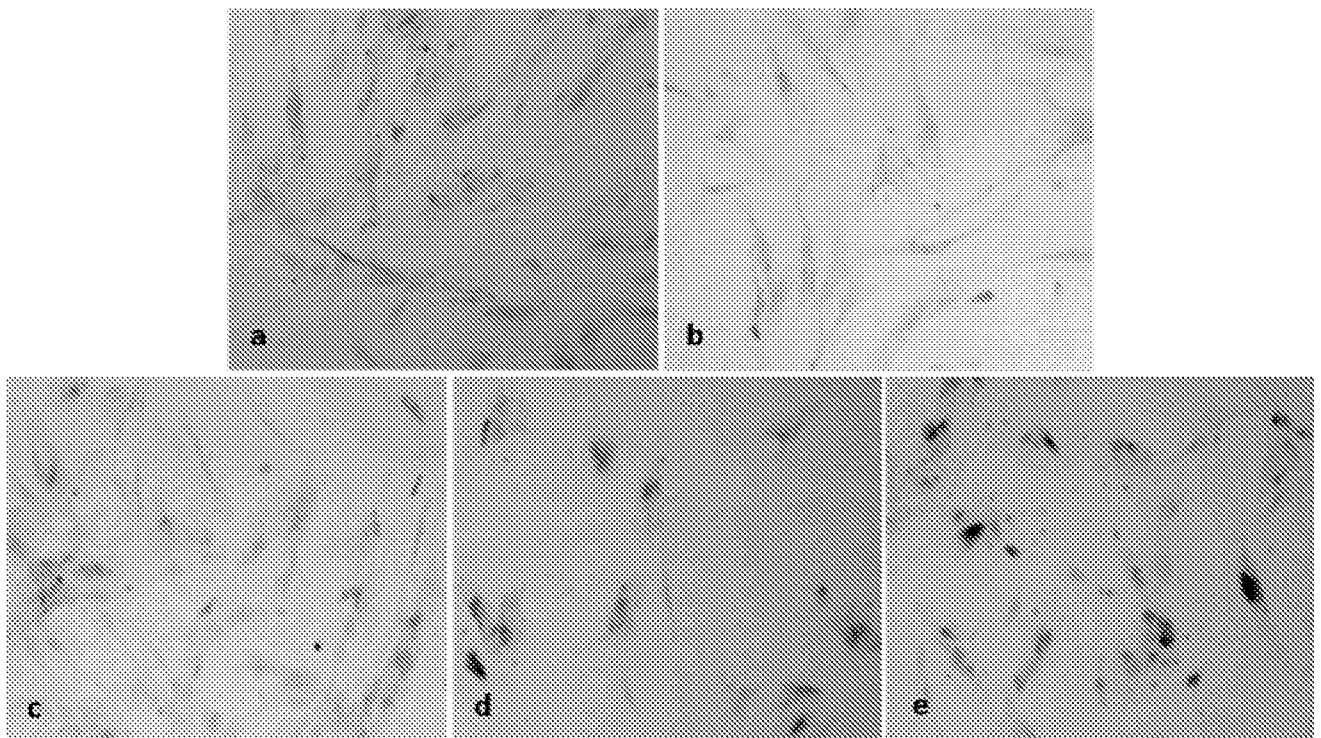


FIGURE 11

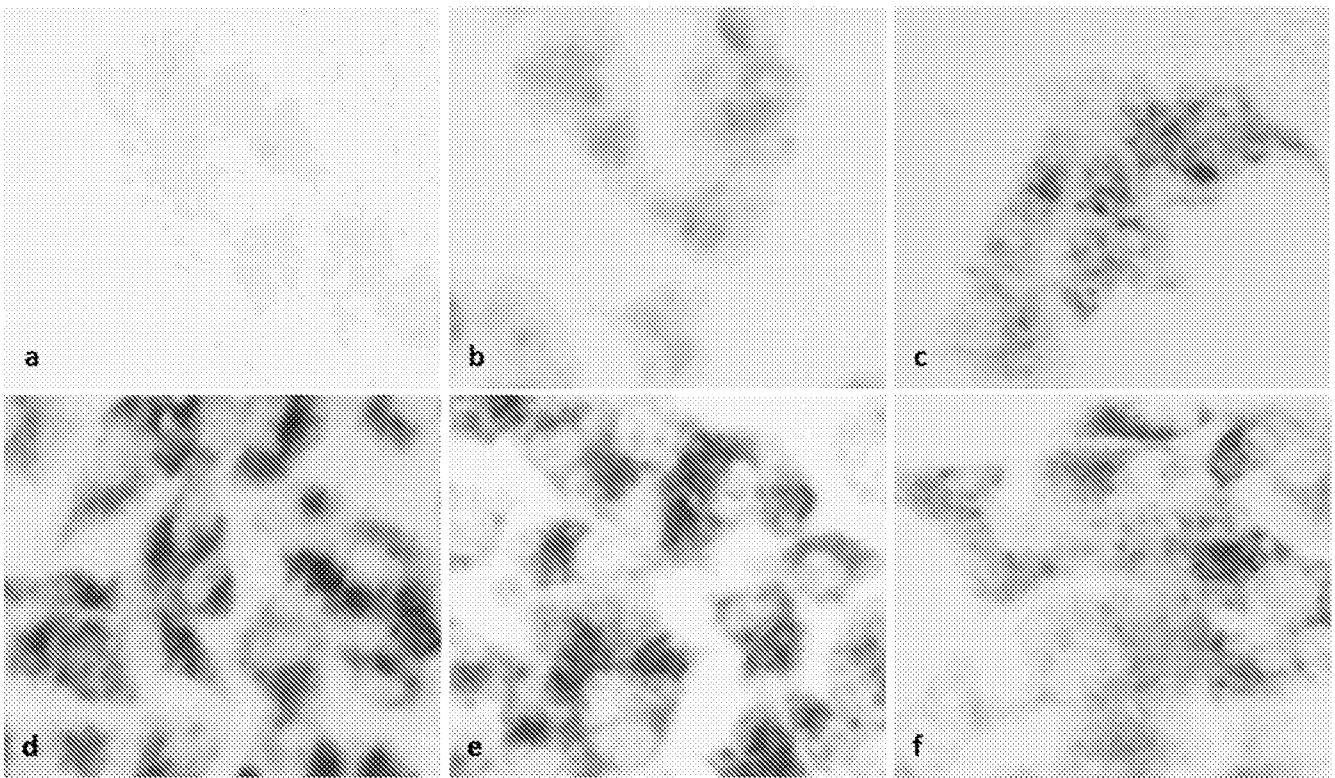
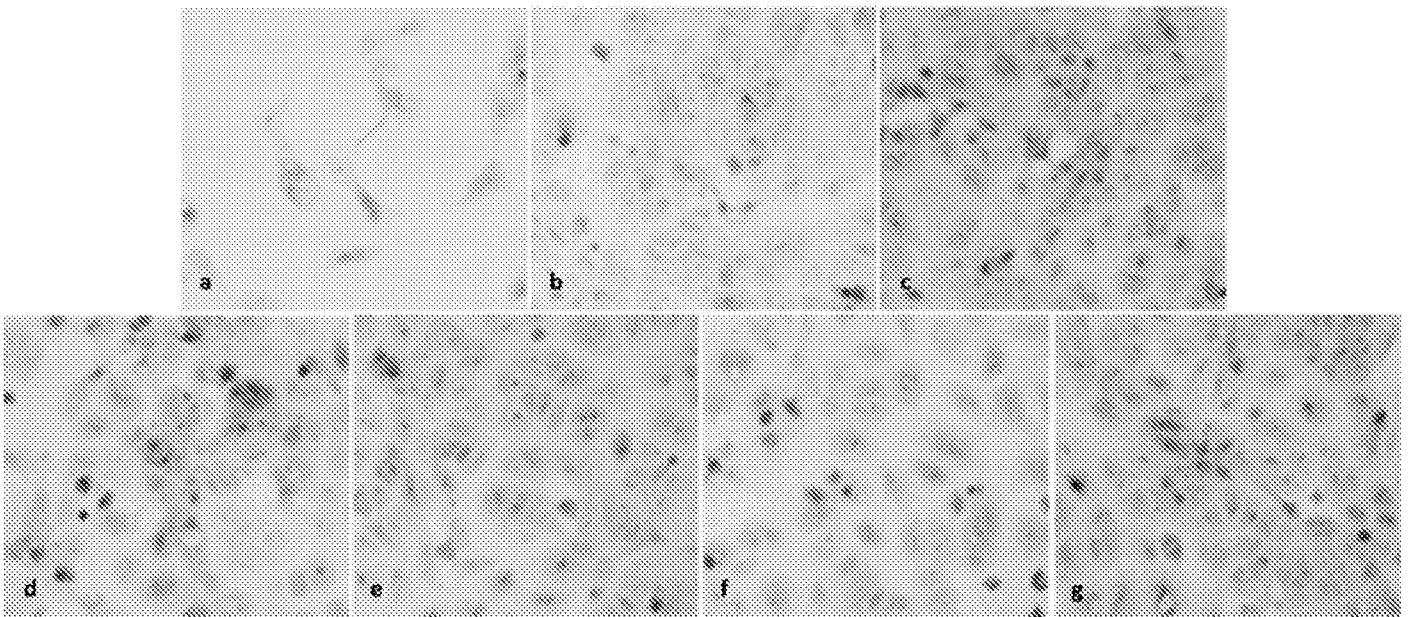


FIGURE 12



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Figure 13

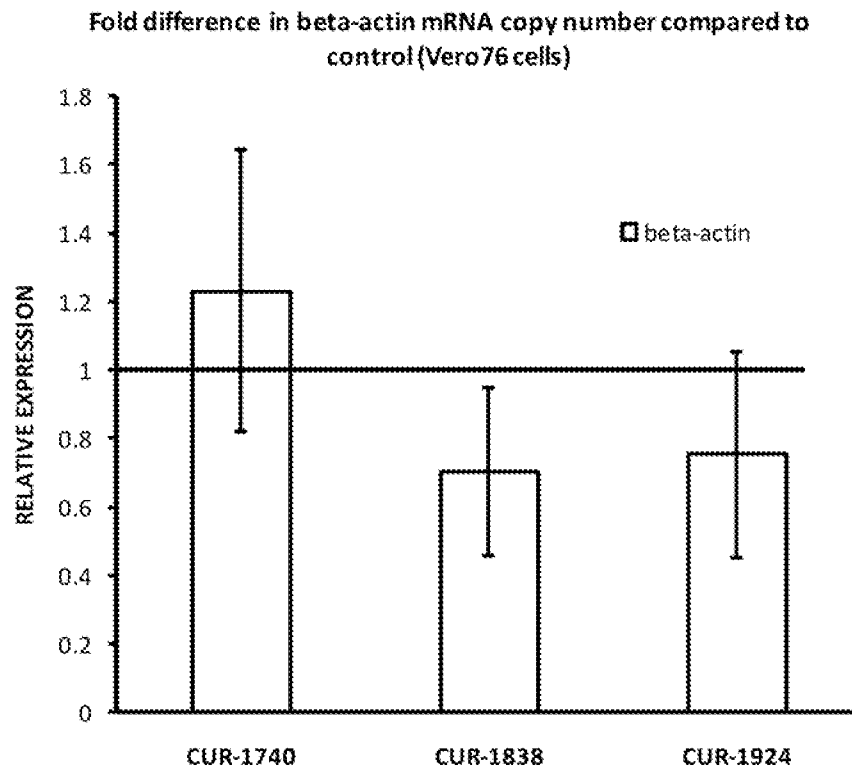
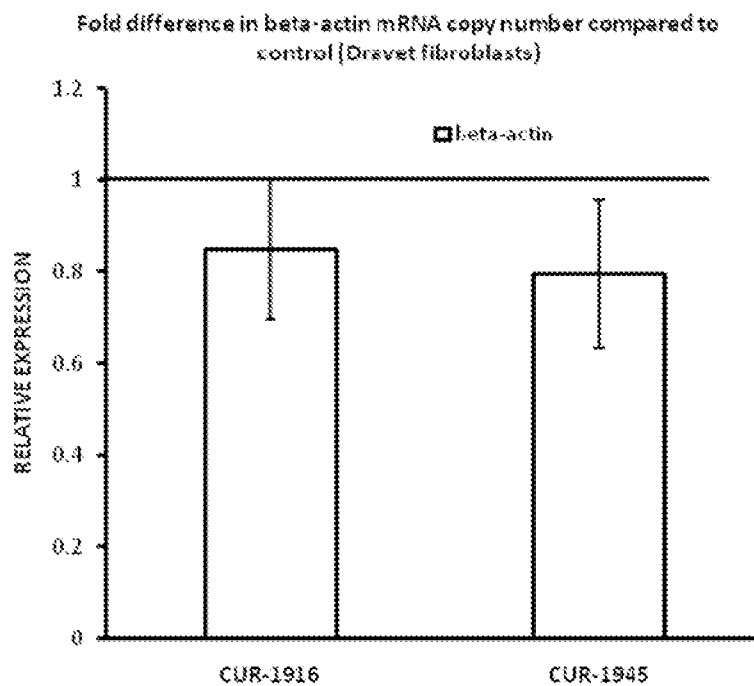


Figure 14



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Figure 15

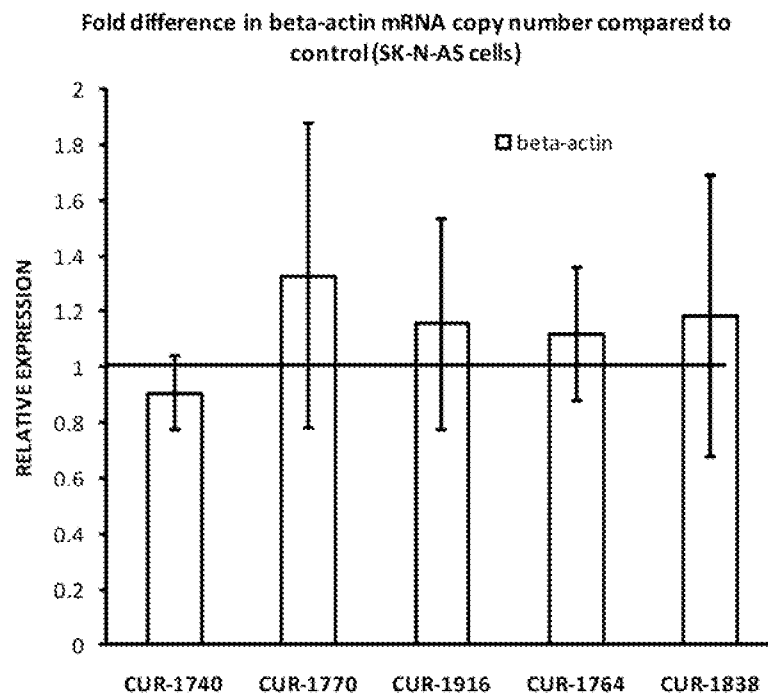


Figure 16

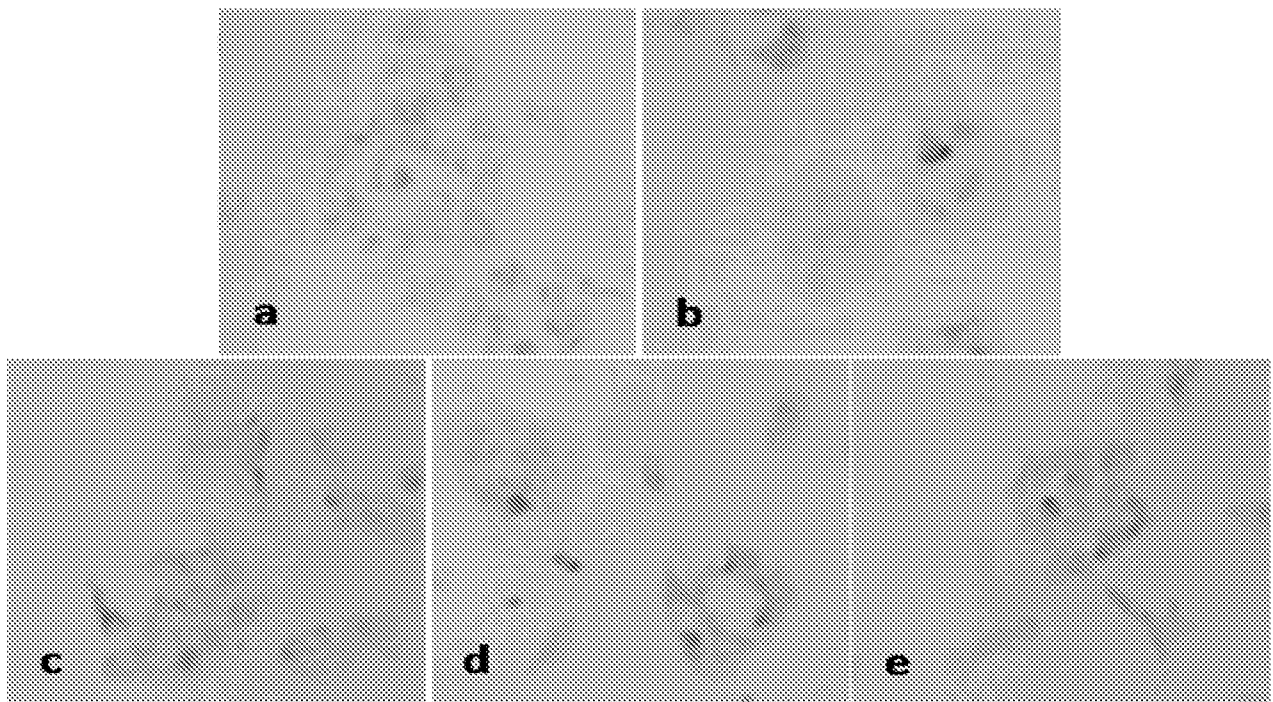


FIGURE 17

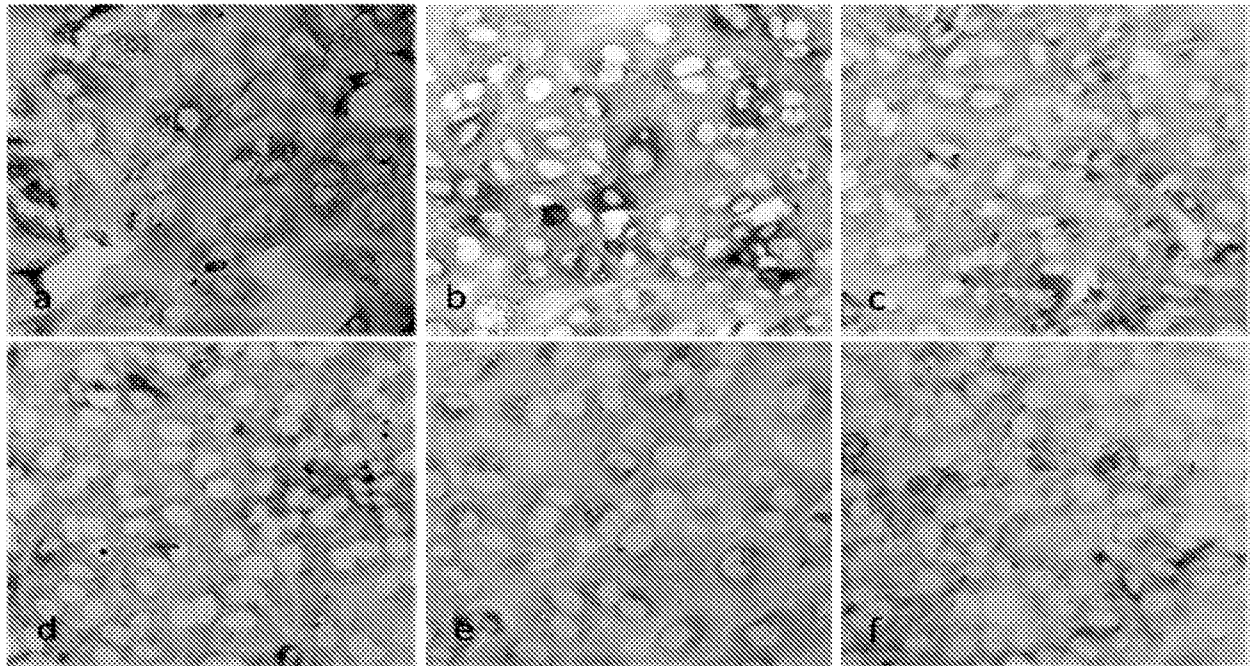
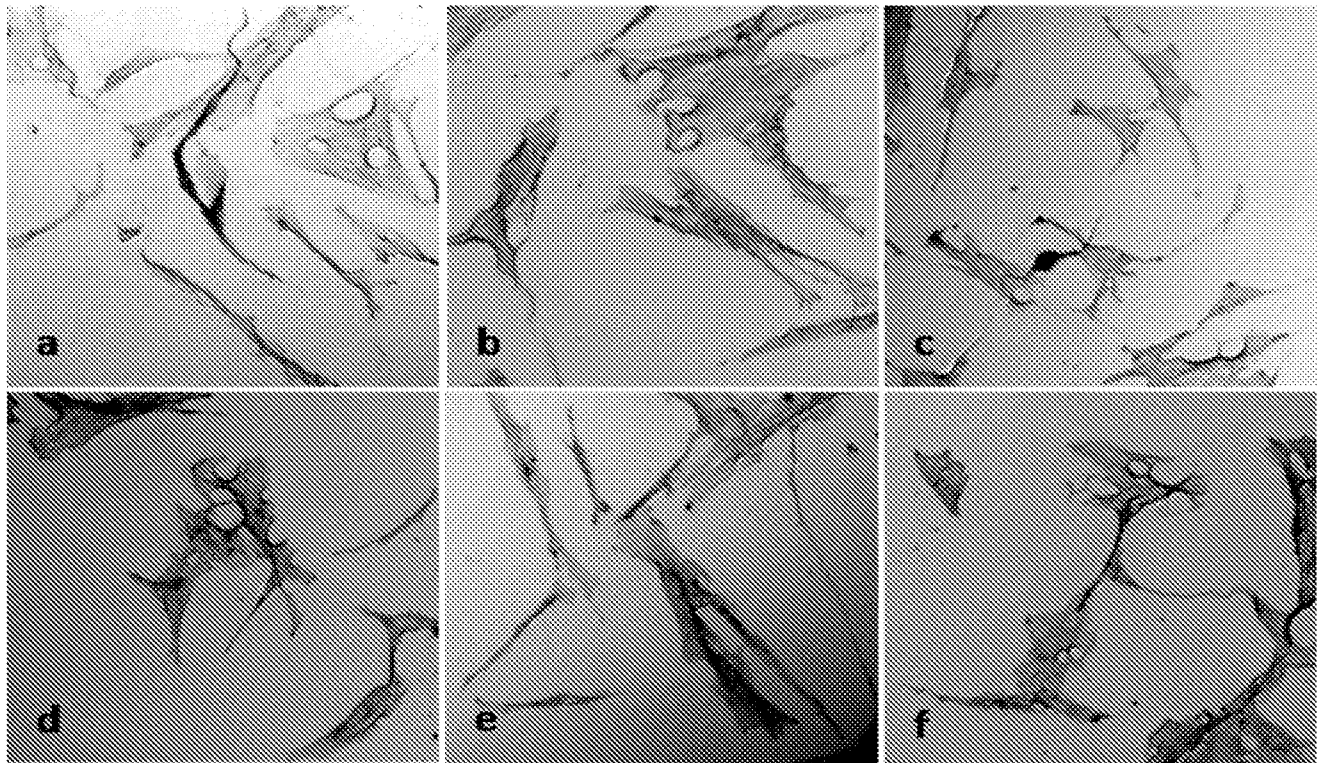


FIGURE 18





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FIGURE 19

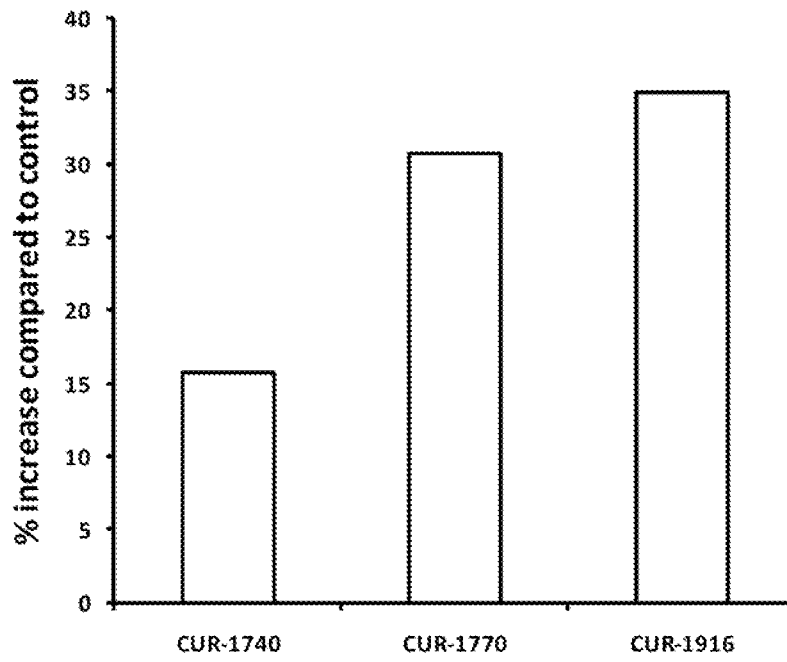
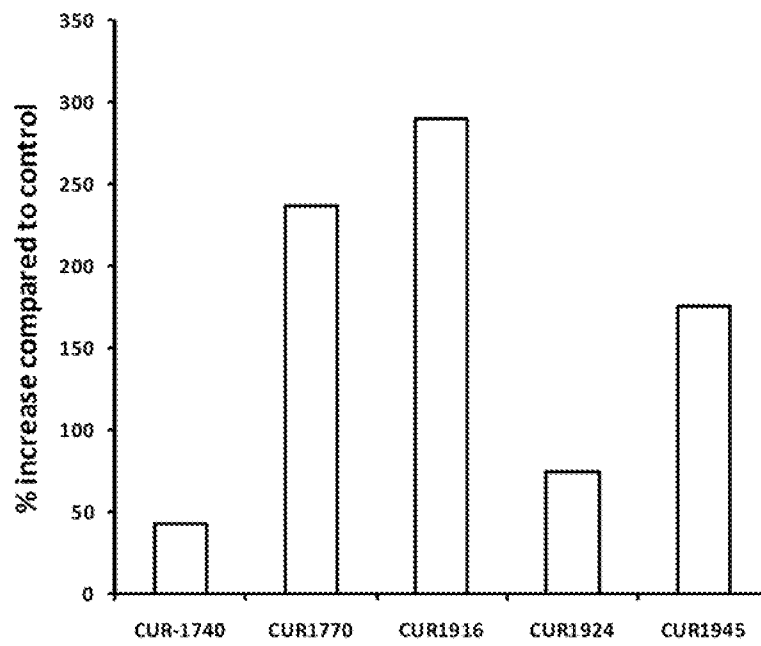


FIGURE 20



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FIGURE 21

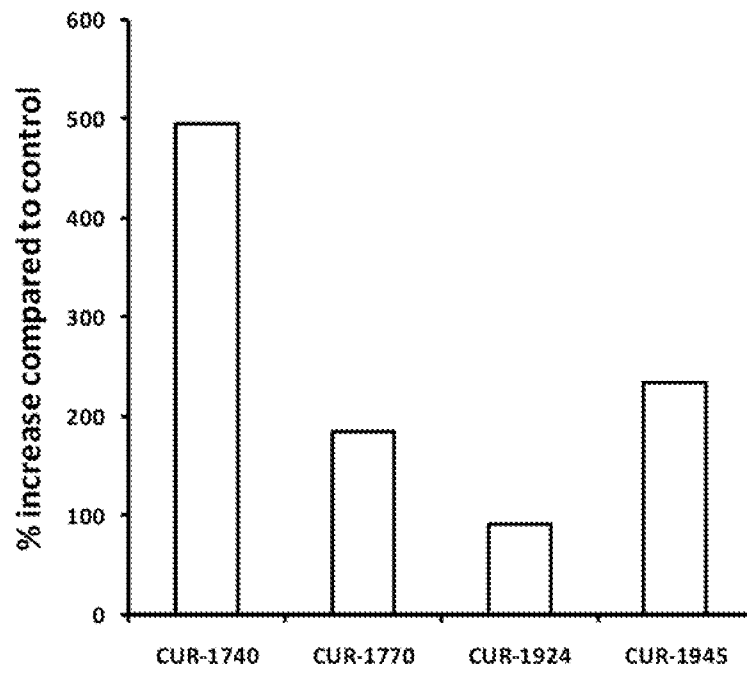
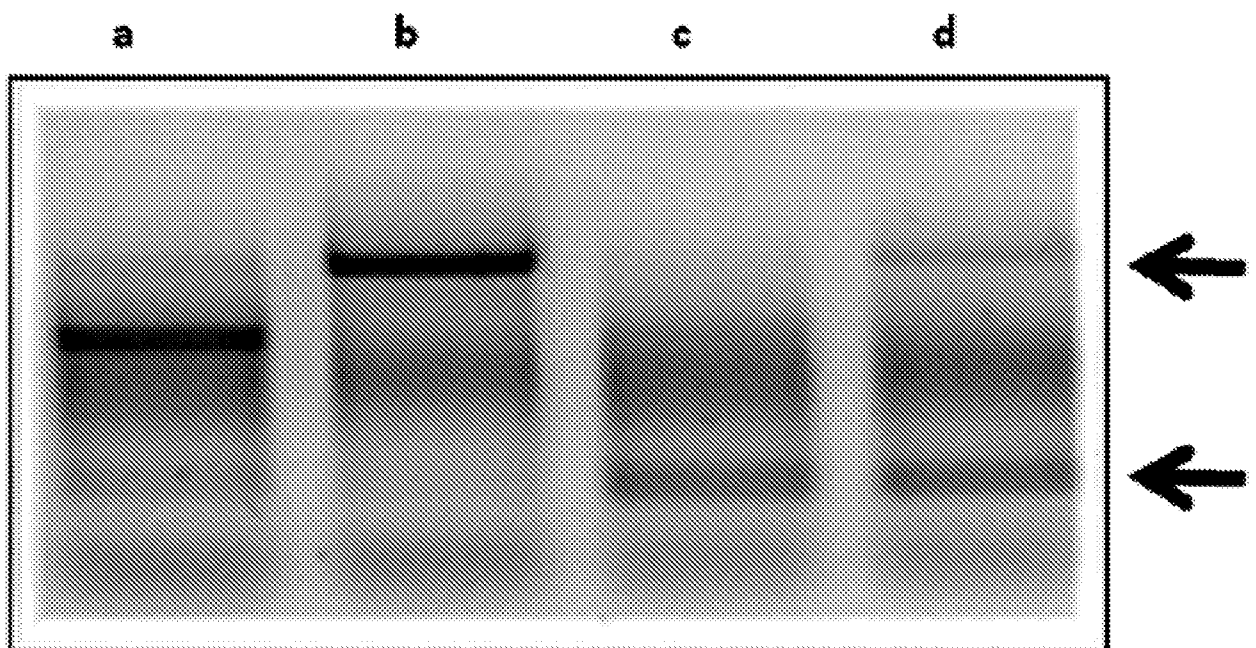


FIGURE 22



Fold difference in mRNA copy number compared to control

