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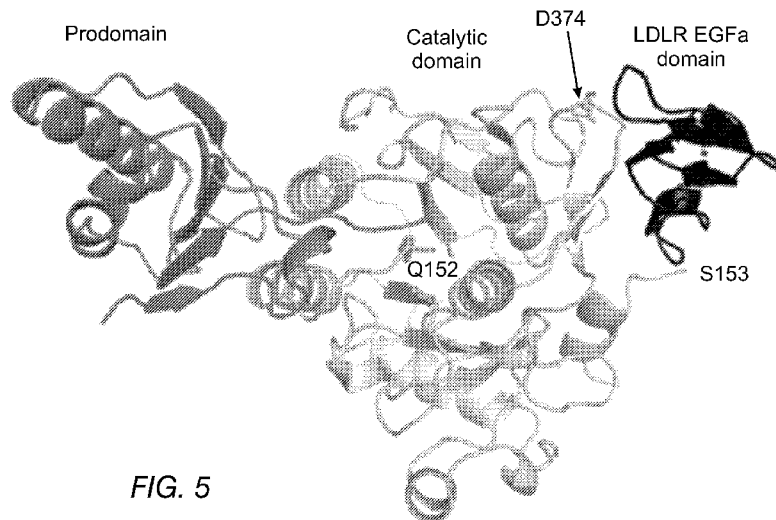


FIG. 5

(57) Abstract: Neutralizing PCSK9 variants that interact with low density lipoprotein receptor (LDLR) are described. Methods and compositions for treating disorders by administering a pharmaceutically effective amount of a neutralizing PCSK9 variant are described.



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**NEUTRALIZING PROPROTEIN CONVERTASE SUBTILISIN  
KEXIN TYPE 9 (PCSK9) VARIANTS AND USES THEREOF**

RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Provisional Application 61/125,304, filed April 23, 2008, the entirety of which is hereby incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to variants of proprotein convertase subtilisin kexin type 9 (and molecules related thereto) and methods of using the variants (and molecules related thereto) for treating various disorders.

BACKGROUND OF VARIOUS EMBODIMENTS

[0003] Proprotein convertase subtilisin kexin type 9 (PCSK9) is a serine protease involved in regulating the levels of the low density lipoprotein receptor (LDLR) protein (Horton *et al.*, 2007; Seidah and Prat, 2007). *In vitro* experiments have shown that adding PCSK9 to HepG2 cells lowers the levels of cell surface LDLR (Benjannet *et al.*, 2004; Lagace *et al.*, 2006; Maxwell *et al.*, 2005; Park *et al.*, 2004). Experiments with mice have shown that increasing PCSK9 protein levels decreases levels of LDLR protein in the liver (Benjannet *et al.*, 2004; Lagace *et al.*, 2006; Maxwell *et al.*, 2005; Park *et al.*, 2004), while PCSK9 knockout mice have increased levels of LDLR in the liver (Rashid *et al.*, 2005). Additionally, various human PCSK9 mutations that result in either increased or decreased levels of plasma LDL have been identified (Kotowski *et al.*, 2006; Zhao *et al.*, 2006). PCSK9 has been shown to directly interact with the LDLR protein, be endocytosed along with the LDLR, and co-immunofluoresce with the LDLR throughout the endosomal pathway (Lagace *et al.*, 2006). Degradation of the LDLR by PCSK9 has not been observed and the mechanism through which it lowers extracellular LDLR protein levels is uncertain.

[0004] PCSK9 is a prohormone-protein convertase in the subtilisin (S8) family of serine proteases (Seidah *et al.*, 2003). Humans have nine prohormone-protein convertases that can be divided between the S8A and S8B subfamilies (Rawlings *et al.*, 2006). Furin,

PC1/PC3, PC2, PACE4, PC4, PC5/PC6 and PC7/PC8/LPC/SPC7 are classified in subfamily S8B. Crystal and NMR structures of different domains from mouse furin and PC1 reveal subtilisin-like pro- and catalytic domains, and a P domain directly C-terminal to the catalytic domain (Henrich *et al.*, 2003; Tangrea *et al.*, 2002). Based on the amino acid sequence similarity within this subfamily, all seven members are predicted to have similar structures (Henrich *et al.*, 2005). SKI-1/S1P and PCSK9 are classified in subfamily S8A. Sequence comparisons with these proteins also suggest the presence of subtilisin-like pro- and catalytic domains (Sakai *et al.*, 1998; Seidah *et al.*, 2003; Seidah *et al.*, 1999). In these proteins the amino acid sequence C-terminal to the catalytic domain is more variable and does not suggest the presence of a P domain.

**[0005]** Prohormone-protein convertases are expressed as zymogens and they mature through a multi step process. The function of the pro-domain in this process is two-fold. The pro-domain first acts as a chaperone and is required for proper folding of the catalytic domain (Ikemura *et al.*, 1987). Once the catalytic domain is folded, autocatalysis occurs between the pro-domain and catalytic domain. Following this initial cleavage reaction, the pro-domain remains bound to the catalytic domain where it then acts as an inhibitor of catalytic activity (Fu *et al.*, 2000). When conditions are correct, maturation proceeds with a second autocatalytic event at a site within the pro-domain (Anderson *et al.*, 1997). After this second cleavage event occurs the pro-domain and catalytic domain dissociate, giving rise to an active protease.

**[0006]** Autocatalysis of the PCSK9 zymogen occurs between Gln152 and Ser153 (VFAQ|SIP) (Naureckiene *et al.*, 2003), and has been shown to be required for its secretion from cells (Seidah *et al.*, 2003). A second autocatalytic event at a site within PCSK9's pro-domain has not been observed. Purified PCSK9 is made up of two species that can be separated by non-reducing SDS-PAGE; the pro-domain at 17 Kd, and the catalytic plus C-terminal domains at 65 Kd. PCSK9 has not been isolated without its inhibitory pro-domain, and measurements of PCSK9's catalytic activity have been variable (Naureckiene *et al.*, 2003; Seidah *et al.*, 2003).

#### SUMMARY OF VARIOUS EMBODIMENTS

**[0007]** In some embodiments, the invention comprises a PCSK9 variant and/or a use thereof.

**[0008]** In some embodiments, the PCSK9 variant can be a neutralizing PCSK9 variant that can include a Pro/Cat domain, or fragment thereof, that binds to low density lipoprotein receptor (LDLR) and an inactive V domain to LDLR activity. The inactive V domain does not result in the degradation of LDLR.

**[0009]** In some embodiments, the invention comprises a nucleic acid molecule that encodes for a PCSK9 variant (or neutralizing variant).

**[0010]** In some embodiments, the invention comprises a host cell that comprises a herein disclosed nucleic acid molecule that encodes for a PCSK9 variant.

**[0011]** In some embodiments, the invention comprises a vector that comprises a herein disclosed nucleic acid molecule that encodes for a PCSK9 variant.

**[0012]** In some embodiments, the invention comprises a pharmaceutical composition comprising at least one neutralizing PCSK9 variant (or a nucleic acid sequence encoding for a neutralizing PCSK9 variant) and a pharmaceutically acceptable carrier and/or excipient.

**[0013]** In some embodiments, the invention comprises a method of treating or preventing a condition associated with elevated serum cholesterol in a patient. In some embodiments, the method can comprise administering to a patient in need thereof an effective amount of at least one of the herein disclosed compounds (including, for example, a neutralizing PCSK9 variant and/or a nucleic acid sequence encoding a neutralizing PCSK9 variant).

**[0014]** In some embodiments, the invention comprises a method of inhibiting the binding of endogenous PCSK9 to LDLR in a patient. In some embodiments, the method comprises administering an effective amount of at least one of the herein disclosed compounds (including, for example, a neutralizing PCSK9 variant and/or a nucleic acid sequence encoding a neutralizing PCSK9 variant) to a subject in need thereof.

**[0015]** In some embodiments, the invention comprises a method of treating or preventing a condition associated with elevated serum cholesterol in a subject. In some embodiments, the method can comprise administering to a subject in need thereof an effective amount at least one of the herein disclosed compounds (including, for example, a neutralizing PCSK9 variant and/or a nucleic acid sequence encoding a neutralizing PCSK9 variant) simultaneously or sequentially with an agent that elevates the availability of low density lipoprotein receptor (LDLR) protein.

**[0016]** In some embodiments, the invention comprises a method of lowering serum cholesterol in a subject. In some embodiments, the method can comprise administering to a subject an effective amount of at least one of the herein disclosed compounds (including, for example, a neutralizing PCSK9 variant and/or a nucleic acid sequence encoding a neutralizing PCSK9 variant).

**[0017]** In some embodiments, the invention comprises a method of lowering serum cholesterol in a subject. In some embodiments, the method can comprise administering to a subject an effective amount of at least one of the herein disclosed compounds (including, for example, a neutralizing PCSK9 variant and/or a nucleic acid sequence encoding a neutralizing PCSK9 variant) simultaneously or sequentially with an agent that elevates the availability of low density lipoprotein receptor (LDLR) protein.

**[0018]** In some embodiments, the invention comprises the use of at least one of the herein disclosed compounds (including, for example, a neutralizing PCSK9 variant and/or a nucleic acid sequence encoding a neutralizing PCSK9 variant) in the manufacture of a medicament for the treatment of hypercholesterolemia.

**[0019]** In some embodiments, the invention comprises at least one of the herein disclosed compounds (including, for example, a neutralizing PCSK9 variant and/or a nucleic acid sequence encoding a neutralizing PCSK9 variant) for use as a medicament.

**[0020]** In some embodiments, the invention comprises at least one of the herein disclosed compounds (including, for example, a neutralizing PCSK9 variant and/or a nucleic acid sequence encoding a neutralizing PCSK9 variant) for use in treating hypercholesterolemia.

**[0021]** In some embodiments, the invention comprises a pharmaceutical composition comprising a Pro/Cat domain, or fragment thereof, that binds to low density lipoprotein receptor (LDLR), and an inactive V domain to LDLR activity. The inactive V domain does not result in the degradation of LDLR. The pharmaceutical composition further comprises a pharmaceutically acceptable carrier or diluent.

**[0022]** In some embodiments, the invention comprises a pharmaceutical composition comprising a Pro/Cat domain, or fragment thereof, that binds to low density lipoprotein receptor (LDLR) and an inactive V domain to LDLR activity. The inactive V domain does not result in the degradation of LDLR. The pro/cat domain is present in an amount sufficient for the treatment of a cholesterol related disorder.

## BRIEF DESCRIPTION OF THE FIGURES

**[0023]** FIG. 1A depicts an amino acid sequence of the mature form of the PCSK9 with the pro-domain underlined.

**[0024]** FIGs. 1B<sub>1</sub>-1B<sub>4</sub> depict amino acid and nucleic acid sequences of PCSK9 with the pro-domain underlined and the signal sequence in bold.

**[0025]** FIG. 1C is a comparison on the sequences of PCSK9 from various organisms. (Any "O" in FIGs. 1C-1E are actually "Q")

**[0026]** FIG. 1D is a continuation of FIG. 1C.

**[0027]** FIG. 1E is a continuation of FIG. 1D.

**[0028]** FIG. 1F is an alignment of the Cat domain of the PCSK9 protein of SEQ ID NO: 3 with another Cat domain of another PCSK9 protein.

**[0029]** FIG. 1G is an alignment of the Cat domain of the PCSK9 protein of SEQ ID NO: 3 with another Cat domain of another PCSK9 protein.

**[0030]** FIG. 1H is an alignment of the Cat domain of the PCSK9 protein of SEQ ID NO: 3 with another Cat domain of another PCSK9 protein.

**[0031]** FIG. 1I is an alignment and consensus sequence for the amino acid sequence of LDLR.

**[0032]** FIG. 1J is a continuation of the alignment and consensus sequence for the amino acid sequence of LDLR presented in FIG. 1I.

**[0033]** FIG. 1K is an alignment and consensus sequence for the amino acid sequence of LDLR.

**[0034]** FIG. 1L is a continuation of the alignment and consensus sequence for the amino acid sequence of LDLR presented in FIG. 1K.

**[0035]** FIGs. 1M<sub>1</sub> and 1M<sub>2</sub> depict an embodiment of a PCSK9 protein.

**[0036]** FIGs. 1N<sub>1</sub> and 1N<sub>2</sub> depict an embodiment of a PCSK9 protein.

**[0037]** FIGs. 1O<sub>1</sub> and 1O<sub>2</sub> depict an embodiment of a PCSK9 protein.

**[0038]** FIGs. 1P<sub>1</sub> and 1P<sub>2</sub> depict an embodiment of a PCSK9 protein.

**[0039]** FIGs. 1Q<sub>1</sub> and 1Q<sub>2</sub> depict an embodiment of a PCSK9 protein.

**[0040]** FIGs. 1R<sub>1</sub> and 1R<sub>2</sub> depict an embodiment of a consensus sequence for a PCSK9 protein.

[0041] FIGs. 1S<sub>1</sub> and 1S<sub>2</sub> depict an embodiment of a human PCSK9 protein.

[0042] FIG. 2 is a graph depicting the results of a binding assay between LDLR and biotin-labeled full length PCSK9, competed with either a) unlabeled full length PCSK9, b) unlabeled residues 31-447 of PCSK9, or c) the unlabeled V domain of PCSK9 (residues 450-692).

[0043] FIG. 3A is a graph depicting the results of the activity of residues 31-447 of PCSK9 on LDL uptake.

[0044] FIG. 3B is a graph depicting the results of the activity of residues 31-447 of PCSK9 on LDL uptake.

[0045] FIG. 4 is a depiction of a Western blot comparing the effect of full length PCSK9 vs. residues 31-447 of PCSK9 (a Pro/Cat fragment) on LDLR protein levels and PCSK9 uptake. As can be seen in the left-hand side of the gel, full length PCSK9 (FL PC9) results in a decrease in LDLR, while residues 31-447 of PCSK9 (a Pro/Cat fragment that functions as a neutralizing PCSK9 variant) does not result in a decrease in LDLR.

[0046] FIG. 5 is a depiction of the structure of PCSK9 and the EGFA section of LDLR.

[0047] FIG. 6 is a depiction of a structural model of PCSK9 and LDLR.

[0048] FIG. 7 is a depiction of the structural model of PCSK9 and LDLR from an alternative perspective.

[0049] FIG. 8 is a graph depicting the results of the activity of the D374Y variant of residues 31-447 of PCSK9 (an example of another variant of the Pro/Cat domain) on LDL uptake.

[0050] FIG. 9 is a graph depicting the results of a competition assay which included the D374Y variant of residues 31-447 of PCSK9.

#### DETAILED DESCRIPTION OF CERTAIN EXEMPLARY EMBODIMENTS

[0051] Proprotein convertase subtilisin kexin type 9 (PCSK9) is a serine protease involved in regulating the levels of the low density lipoprotein receptor (LDLR) protein. It is believed that native PCSK9 binds to LDLR *in vivo* and is involved in the degradation of LDLR. This can be problematic because the reduction in available LDLR results in less binding between

LDLR and LDL, which in turn results in more LDL in the serum of the subject, resulting in an increase in serum cholesterol.

**[0052]** The full length PCSK9 protein includes a signal sequence (generally amino acids 1-30), a N-terminal prodomain (“Pro” domain, generally amino acids 31-152), a subtilisin-like catalytic domain (“Cat” domain, generally amino acids 153-446), a loop region (generally amino acids 447-453) and a C-terminal domain (“V” domain, generally amino acids 454-692).

**[0053]** Some embodiments of the invention relate to the discovery that the ability of PCSK9 (or variants thereof) to bind to LDLR can be separated from the ability of PCSK9 to effectively degrade or reduce the amount of available LDLR. It has been discovered that while parts of the Pro and/or Cat domains are involved in binding to PCSK9, the V domain is important for the effective degradation of LDLR. Furthermore, variants of PCSK9 that include an active part of the Pro and/or Cat domain can be used to block native PCSK9 from binding to LDLR. Thus, in some embodiments, the invention relates to a neutralizing PCSK9 variant that can block native PCSK9 from binding to LDLR, while the neutralizing PCSK9 variant itself will not effectively degrade LDLR. In some embodiments, the invention comprises a variant of PCSK9 that still includes an active Pro/Cat domain and that lacks a functional V domain (and thus lacks the ability to effectively lower LDLR in a subject). This variant can be used to prevent or reduce native PCSK9 from binding to LDLR. In turn, this can effectively elevate the level of LDLR in a subject and result in lower levels of LDL in the serum.

**[0054]** Some embodiments of the invention relate to the discovery that using a neutralizing PCSK9 variant (*e.g.*, a variant that includes an active Pro/Cat domain and an inactive V domain) can result in the neutralizing PCSK9 variant competitively blocking and preventing native PCSK9 from binding to and degrading LDLR, while still allowing LDLR to perform its beneficial role of sequestering LDL. As such, neutralizing variants of PCSK9 can be used to lower serum LDL in a subject. Thus, in some embodiments, the invention comprises a neutralizing PCSK9 variant (or its use) that can bind to LDLR and prevent native PCSK9 from binding to LDLR, while still allowing LDLR to bind to and act on LDL.

**[0055]** Some embodiments of the invention relate to the discovery that using a neutralizing PCSK9 variant (*e.g.*, a variant that includes an active Pro/Cat domain and an inactive V domain) can result in the neutralizing PCSK9 variant competitively blocking and preventing native PCSK9 from binding to and degrading LDLR, while still allowing LDLR to

recycle (*e.g.*, be endocytosed and then return back to the plasma membrane). Thus, in some embodiments, the invention comprises a neutralizing PCSK9 variant (or its use) that can bind to LDLR and prevent native PCSK9 from binding to LDLR, while still allowing LDLR to recycle.

**[0056]** In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of some or all of the Pro and/or Cat domains of PCSK9. In some embodiments, the neutralizing PCSK9 variant does not include some or all of the V domain. In some embodiments the neutralizing PCSK9 variant does not have a fully functional LDLR degrading V domain. In some embodiments the neutralizing PCSK9 variant has an inactive V domain. As will be appreciated by one of skill in the art, some of these embodiments can be beneficial in situations in which one wishes to lower the serum cholesterol in a subject, such as in hypercholesterolemia. Neutralizing PCSK9 variants can be used in various methods and compositions for treating subjects with elevated serum cholesterol levels, at risk of elevated serum cholesterol levels, or in those that could benefit from a reduction in their serum cholesterol levels. Thus, various methods and techniques for lowering, maintaining, or preventing an increase in serum cholesterol are also described herein.

**[0057]** Exemplary human PCSK9 amino acid sequences are presented as SEQ ID NOs: 1 and 3. An exemplary human PCSK9 coding sequence is presented as SEQ ID NO: 2, in FIG. 1A (depicting the “pro” domain of the protein as underlined) and FIG. 1B (depicting the signal sequence in bold and the pro domain underlined). Additional variants of PCSK9 (or the Cat domain of PCSK9) are shown in FIGs. 1C-1H. The structure of the PCSK9 protein has recently been solved by two groups (Cunningham et al., *Nature Structural & Molecular Biology*, 2007, and Piper et al., *Structure*, 15:1-8, 2007), the entireties of both of which are herein incorporated by reference.

**[0058]** For convenience, the following sections generally outline the various meanings of the terms used herein. Following this discussion, general aspects regarding neutralizing PCSK9 variants are discussed, followed by specific examples.

#### Definitions and Embodiments

**[0059]** It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention as claimed. In this application, the use of the singular includes the plural unless

specifically stated otherwise. In this disclosure, the use of “or” means “and/or” unless stated otherwise. Furthermore, the use of the term “including”, as well as other forms, such as “includes” and “included”, is not limiting. Also, terms such as “element” or “component” encompass both elements and components comprising one unit and elements and components that comprise more than one subunit unless specifically stated otherwise. Also, the use of the term “portion” can include part of a moiety or the entire moiety.

**[0060]** The section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described. All documents, or portions of documents, cited in this application, including but not limited to patents, patent applications, articles, books, and treatises, are hereby expressly incorporated by reference in their entirety for any purpose. As utilized in accordance with the present disclosure, the following terms, unless otherwise indicated, shall be understood to have the following meanings:

**[0061]** The term “proprotein convertase subtilisin kexin type 9” or “PCSK9” refers to a polypeptide as set forth in SEQ ID NO: 1 and/or 3 or fragments thereof, as well as related polypeptides, which include, but are not limited to, allelic variants, splice variants, derivative variants, substitution variants, and/or insertion variants including the addition of an N-terminal methionine, fusion polypeptides, and interspecies homologs. Examples of related proteins are put forth in FIGs. 1C-1H. In some embodiments, a PCSK9 polypeptide includes terminal residues, such as, but not limited to, leader sequence residues, targeting residues, amino terminal methionine residues, lysine residues, tag residues and/or fusion protein residues. “PCSK9” has also been referred to as FH3, NARC1, HCHOLA3, proprotein convertase subtilisin/kexin type 9, and neural apoptosis regulated convertase 1. The PCSK9 gene encodes a proprotein convertase protein that belongs to the proteinase K subfamily of the secretory subtilase family. The term “PCSK9” denotes both the proprotein and the product generated following autocatalysis of the proprotein. When only the autocatalyzed product is being referred to, the protein can be referred to as the “cleaved” or “processed” PCSK9. When only the inert form is being referred to, the protein can be referred to as the “inert”, “pro-form”, or “unprocessed” form of PCSK9. The term PCSK9 as used herein also includes naturally occurring alleles, such as the mutations D374Y, D374H, S127R, F216L, R46L, R237W, L253F, A443T, H553R, and others (Kotowski IK et al, A spectrum of PCSK9 alleles contributes to plasma levels of low-density lipoprotein cholesterol, *Am J. Hum. Genet.* 2006; 78:410-422). The term PCSK9 also encompasses PCSK9 molecules

incorporating post-translational modifications of the PCSK9 amino acid sequence, such as PCSK9 sequences that have been glycosylated, PEGylated, PCSK9 sequences from which its signal sequence has been cleaved, PCSK9 sequence from which its pro domain has been cleaved from the catalytic domain but not separated from the catalytic domain (e.g., FIGs. 1A and 1B).

**[0062]** The term “PCSK9 activity” includes any biological effect of PCSK9. In some embodiments, PCSK9 activity includes the ability of PCSK9 to interact or bind to a substrate or receptor. In some embodiments, PCSK9 activity is represented by the ability of PCSK9 to bind to a LDL receptor (LDLR). In some embodiments, PCSK9 binds to and catalyzes a reaction involving LDLR. In some embodiments, PCSK9 activity includes the ability of PCSK9 to alter (e.g., reduce) the availability of LDLR. In some embodiments, PCSK9 activity includes the ability of PCSK9 to increase the amount of LDL in a subject. In some embodiments, PCSK9 activity includes the ability of PCSK9 to decrease the amount of LDLR that is available to bind to LDL. In some embodiments, “PCSK9 activity” includes any biological activity resulting from PCSK9 signaling. Exemplary activities include, but are not limited to, PCSK9 binding to LDLR, PCSK9 enzyme activity that cleaves LDLR or other proteins, PCSK9 binding to proteins other than LDLR that facilitate PCSK9 action, PCSK9 altering APOB secretion (Sun X-M et al, “Evidence for effect of mutant PCSK9 on apolipoprotein B secretion as the cause of unusually severe dominant hypercholesterolemia, *Human Molecular Genetics* 14: 1161-1169, 2005 and Ouguerram K et al, “Apolipoprotein B100 metabolism in autosomal-dominant hypercholesterolemia related to mutations in PCSK9, *Arterioscler thromb Vasc Biol.* 24: 1448-1453, 2004), PCSK9’s role in liver regeneration and neuronal cell differentiation (Seidah NG et al, “The secretory proprotein convertase neural apoptosis-regulated convertase 1 (NARC-1): Liver regeneration and neuronal differentiation” *PNAS* 100: 928-933, 2003), and PCSK9s role in hepatic glucose metabolism (Costet et al., “Hepatic PCSK9 expression is regulated by nutritional status via insulin and sterol regulatory element-binding protein 1c” *J. Biol. Chem.* 281(10):6211-18, 2006). PCSK9 activity can be distinct from the terms “active Pro/Cat domain” or “inactive V domain” as defined herein.

**[0063]** The term “hypercholesterolemia,” as used herein, refers to a condition in which cholesterol levels are elevated above a desired level. In some embodiments, this denotes that serum cholesterol levels are elevated. In some embodiments, the desired level takes into

account various “risk factors” that are known to one of skill in the art (and are described or referenced herein).

**[0064]** The term “polynucleotide” or “nucleic acid” includes both single-stranded and double-stranded nucleotide polymers. The nucleotides comprising the polynucleotide can be ribonucleotides or deoxyribonucleotides or a modified form of either type of nucleotide. Said modifications include base modifications such as bromouridine and inosine derivatives, ribose modifications such as 2',3'-dideoxyribose, and internucleotide linkage modifications such as phosphorothioate, phosphorodithioate, phosphoroselenoate, phosphorodiselenoate, phosphoroanilothioate, phosphoraniladate and phosphoroamidate.

**[0065]** The term “oligonucleotide” means a polynucleotide comprising 200 or fewer nucleotides. In some embodiments, oligonucleotides are 10 to 60 bases in length. In other embodiments, oligonucleotides are 12, 13, 14, 15, 16, 17, 18, 19, or 20 to 40 nucleotides in length. Oligonucleotides can be single stranded or double stranded, *e.g.*, for use in the construction of a mutant gene. Oligonucleotides can be sense or antisense oligonucleotides. An oligonucleotide can include a label, including a radiolabel, a fluorescent label, a hapten or an antigenic label, for detection assays. Oligonucleotides can be used, for example, as PCR primers, cloning primers or hybridization probes.

**[0066]** An “isolated nucleic acid molecule” means a DNA or RNA of genomic, mRNA, cDNA, or synthetic origin or some combination thereof which is not associated with all or a portion of a polynucleotide in which the isolated polynucleotide is found in nature, or is linked to a polynucleotide to which it is not linked in nature. For purposes of this disclosure, it should be understood that “a nucleic acid molecule comprising” a particular nucleotide sequence does not encompass intact chromosomes. Isolated nucleic acid molecules “comprising” specified nucleic acid sequences can include, in addition to the specified sequences, coding sequences for up to ten or even up to twenty other proteins or portions thereof, or can include operably linked regulatory sequences that control expression of the coding region of the recited nucleic acid sequences, and/or can include vector sequences.

**[0067]** Unless specified otherwise, the left-hand end of any single-stranded polynucleotide sequence discussed herein is the 5' end; the left-hand direction of double-stranded polynucleotide sequences is referred to as the 5' direction. The direction of 5' to 3' addition of nascent RNA transcripts is referred to as the transcription direction; sequence regions

on the DNA strand having the same sequence as the RNA transcript that are 5' to the 5' end of the RNA transcript are referred to as "upstream sequences;" sequence regions on the DNA strand having the same sequence as the RNA transcript that are 3' to the 3' end of the RNA transcript are referred to as "downstream sequences."

**[0068]** The term "control sequence" refers to a polynucleotide sequence that can affect the expression and processing of coding sequences to which it is ligated. The nature of such control sequences can depend upon the host organism. In particular embodiments, control sequences for prokaryotes can include a promoter, a ribosomal binding site, and a transcription termination sequence. For example, control sequences for eukaryotes can include promoters comprising one or a plurality of recognition sites for transcription factors, transcription enhancer sequences, and transcription termination sequence. "Control sequences" can include leader sequences and/or fusion partner sequences.

**[0069]** The term "vector" means any molecule or entity (*e.g.*, nucleic acid, plasmid, bacteriophage or virus) used to transfer protein coding information into a host cell.

**[0070]** The term "expression vector" or "expression construct" refers to a vector that is suitable for transformation of a host cell and contains nucleic acid sequences that direct and/or control (in conjunction with the host cell) expression of one or more heterologous coding regions operatively linked thereto. An expression construct can include, but is not limited to, sequences that affect or control transcription, translation, and, if introns are present, affect RNA splicing of a coding region operably linked thereto.

**[0071]** As used herein, "operably linked" means that the components to which the term is applied are in a relationship that allows them to carry out their inherent functions under suitable conditions. For example, a control sequence in a vector that is "operably linked" to a protein coding sequence is ligated thereto so that expression of the protein coding sequence is achieved under conditions compatible with the transcriptional activity of the control sequences.

**[0072]** The term "host cell" means a cell that has been transformed, or is capable of being transformed, with a nucleic acid sequence and thereby expresses a gene of interest. The term includes the progeny of the parent cell, whether or not the progeny is identical in morphology or in genetic make-up to the original parent cell, so long as the gene of interest is present.

**[0073]** The term “transfection” means the uptake of foreign or exogenous DNA by a cell, and a cell has been “transfected” when the exogenous DNA has been introduced inside the cell membrane. A number of transfection techniques are well known in the art and are disclosed herein. *See, e.g.,* Graham *et al.*, 1973, *Virology* 52:456; Sambrook *et al.*, 2001, *Molecular Cloning: A Laboratory Manual, supra*; Davis *et al.*, 1986, *Basic Methods in Molecular Biology*, Elsevier; Chu *et al.*, 1981, *Gene* 13:197. Such techniques can be used to introduce one or more exogenous DNA moieties into suitable host cells.

**[0074]** The term “transformation” refers to a change in a cell's genetic characteristics, and a cell has been transformed when it has been modified to contain new DNA or RNA. For example, a cell is transformed where it is genetically modified from its native state by introducing new genetic material *via* transfection, transduction, or other techniques. Following transfection or transduction, the transforming DNA can recombine with that of the cell by physically integrating into a chromosome of the cell, or can be maintained transiently as an episomal element without being replicated, or can replicate independently as a plasmid. A cell is considered to have been “stably transformed” when the transforming DNA is replicated with the division of the cell.

**[0075]** The terms “polypeptide” or “protein” means a macromolecule having the amino acid sequence of a native protein, that is, a protein produced by a naturally-occurring and non-recombinant cell; or it is produced by a genetically-engineered or recombinant cell, and comprise molecules having the amino acid sequence of the native protein, or molecules having deletions from, additions to, and/or substitutions of one or more amino acids of the native sequence. The term also includes amino acid polymers in which one or more amino acids are chemical analogs of a corresponding naturally-occurring amino acid and polymers. The terms “polypeptide” and “protein” specifically encompass neutralizing PCSK9 variants, or sequences that have deletions from, additions to, and/or substitutions of one or more amino acid of the PCSK9 protein or variant. The term “polypeptide fragment” refers to a polypeptide that has an amino-terminal deletion, a carboxyl-terminal deletion, and/or an internal deletion as compared with the full-length native protein. Such fragments can also contain modified amino acids as compared with the native protein. In some embodiments, fragments are about five to 500 amino acids long. For example, fragments can be at least 5, 6, 7, 8, 9, 10, 10-14, 14-20, 20-50, 50-70,

70-100, 100-110, 110-150, 150-200, 200-250, 250-300, 300-350, 350-400, or 400-450 amino acids long.

**[0076]** The term “isolated protein” means that a subject protein (1) is free of at least some other proteins with which it would normally be found, (2) is essentially free of other proteins from the same source, *e.g.*, from the same species, (3) is expressed by a cell from a different species, (4) has been separated from at least about 50 percent of polynucleotides, lipids, carbohydrates, or other materials with which it is associated in nature, (5) is operably associated (by covalent or noncovalent interaction) with a polypeptide with which it is not associated in nature, or (6) does not occur in nature. Typically, an “isolated protein” constitutes at least about 5%, at least about 10%, at least about 25%, or at least about 50% of a given sample. Genomic DNA, cDNA, mRNA or other RNA, of synthetic origin, or any combination thereof can encode such an isolated protein. Preferably, the isolated protein is substantially free from proteins or polypeptides or other contaminants that are found in its natural environment that would interfere with its therapeutic, diagnostic, prophylactic, research or other use.

**[0077]** The term “amino acid” includes its normal meaning in the art and includes both naturally and non-naturally occurring amino acids.

**[0078]** A “variant” of a polypeptide (*e.g.*, a neutralizing PCSK9 variant) comprises an amino acid sequence wherein one or more amino acid residues are inserted into, deleted from and/or substituted into the amino acid sequence relative to another polypeptide sequence. Variants include fusion proteins.

**[0079]** The term “identity” refers to a relationship between the sequences of two or more polypeptide molecules or two or more nucleic acid molecules, as determined by aligning and comparing the sequences. “Percent identity” means the percent of identical residues between the amino acids or nucleotides in the compared molecules and is calculated based on the size of the smallest of the molecules being compared. For these calculations, gaps in alignments (if any) are preferably addressed by a particular mathematical model or computer program (*i.e.*, an “algorithm”). Methods that can be used to calculate the identity of the aligned nucleic acids or polypeptides include those described in *Computational Molecular Biology*, (Lesk, A. M., ed.), 1988, New York: Oxford University Press; *Biocomputing Informatics and Genome Projects*, (Smith, D. W., ed.), 1993, New York: Academic Press; *Computer Analysis of Sequence Data, Part I*, (Griffin, A. M., and Griffin, H. G., eds.), 1994, New Jersey: Humana Press; von Heinje,

G., 1987, *Sequence Analysis in Molecular Biology*, New York: Academic Press; *Sequence Analysis Primer*, (Gribskov, M. and Devereux, J., eds.), 1991, New York: M. Stockton Press; and Carillo *et al.*, 1988, *SIAM J. Applied Math.* 48:1073.

**[0080]** In calculating percent identity, the sequences being compared are typically aligned in a way that gives the largest match between the sequences. One example of a computer program that can be used to determine percent identity is the GCG program package, which includes GAP (Devereux *et al.*, 1984, *Nucl. Acid Res.* 12:387; Genetics Computer Group, University of Wisconsin, Madison, WI). The computer algorithm GAP is used to align the two polypeptides or polynucleotides for which the percent sequence identity is to be determined. The sequences are aligned for optimal matching of their respective amino acid or nucleotide (the “matched span”, as determined by the algorithm). A gap opening penalty (which is calculated as 3x the average diagonal, wherein the “average diagonal” is the average of the diagonal of the comparison matrix being used; the “diagonal” is the score or number assigned to each perfect amino acid match by the particular comparison matrix) and a gap extension penalty (which is usually 1/10 times the gap opening penalty), as well as a comparison matrix such as PAM 250 or BLOSUM 62 are used in conjunction with the algorithm. In some embodiments, a standard comparison matrix (*see*, Dayhoff *et al.*, 1978, *Atlas of Protein Sequence and Structure* 5:345-352 for the PAM 250 comparison matrix; Henikoff *et al.*, 1992, *Proc. Natl. Acad. Sci. U.S.A.* 89:10915-10919 for the BLOSUM 62 comparison matrix) is also used by the algorithm.

**[0081]** Examples of parameters that can be employed in determining percent identity for polypeptides or nucleotide sequences using the GAP program are the following:

- Algorithm: Needleman *et al.*, 1970, *J. Mol. Biol.* 48:443-453
- Comparison matrix: BLOSUM 62 from Henikoff *et al.*, 1992, *supra*
- Gap Penalty: 12 (but with no penalty for end gaps)
- Gap Length Penalty: 4
- Threshold of Similarity: 0

**[0082]** Certain alignment schemes for aligning two amino acid sequences may result in matching of only a short region of the two sequences, and this small aligned region may have very high sequence identity even though there is no significant relationship between the two full-length sequences. Accordingly, the selected alignment method (GAP program) can be adjusted

if so desired to result in an alignment that spans at least 50 or other number of contiguous amino acids of the target polypeptide.

**[0083]** As used herein, the twenty conventional (*e.g.*, naturally occurring) amino acids and their abbreviations follow conventional usage. See *Immunology--A Synthesis* (2nd Edition, E. S. Golub and D. R. Gren, Eds., Sinauer Associates, Sunderland, Mass. (1991)), which is incorporated herein by reference for any purpose. Stereoisomers (*e.g.*, D-amino acids) of the twenty conventional amino acids, unnatural amino acids such as  $\alpha$ -,  $\alpha$ -disubstituted amino acids, N-alkyl amino acids, lactic acid, and other unconventional amino acids can also be suitable components for polypeptides. Examples of unconventional amino acids include: 4-hydroxyproline,  $\gamma$ -carboxyglutamate,  $\epsilon$ -N,N,N-trimethyllysine,  $\epsilon$ -N-acetyllysine, O-phosphoserine, N-acetyls erine, N-formylmethionine, 3-methylhistidine, 5-hydroxylysine,  $\sigma$ -N-methylarginine, and other similar amino acids and imino acids (*e.g.*, 4-hydroxyproline). In the polypeptide notation used herein, the left-hand direction is the amino terminal direction and the right-hand direction is the carboxy-terminal direction, in accordance with standard usage and convention.

**[0084]** Similarly, unless specified otherwise, the left-hand end of single-stranded polynucleotide sequences is the 5' end; the left-hand direction of double-stranded polynucleotide sequences is referred to as the 5' direction. The direction of 5' to 3' addition of nascent RNA transcripts is referred to as the transcription direction; sequence regions on the DNA strand having the same sequence as the RNA and which are 5' to the 5' end of the RNA transcript are referred to as "upstream sequences"; sequence regions on the DNA strand having the same sequence as the RNA and which are 3' to the 3' end of the RNA transcript are referred to as "downstream sequences."

**[0085]** Conservative amino acid substitutions can encompass non-naturally occurring amino acid residues, which are typically incorporated by chemical peptide synthesis rather than by synthesis in biological systems. These include peptidomimetics and other reversed or inverted forms of amino acid moieties.

**[0086]** Naturally occurring residues can be divided into classes based on common side chain properties:

- 1) hydrophobic: norleucine, Met, Ala, Val, Leu, Ile;
- 2) neutral hydrophilic: Cys, Ser, Thr, Asn, Gln;

- 3) acidic: Asp, Glu;
- 4) basic: His, Lys, Arg;
- 5) residues that influence chain orientation: Gly, Pro; and
- 6) aromatic: Trp, Tyr, Phe.

For example, non-conservative substitutions can involve the exchange of a member of one of these classes for a member from another class. Such substituted residues can be introduced, for example, into regions of a PCSK9 protein that are homologous with non-human PCSK9 proteins, or into the non-homologous regions of the molecule.

**[0087]** In making changes to the PCSK9 protein or variant thereof, according to certain embodiments, the hydropathic index of amino acids can be considered. Each amino acid has been assigned a hydropathic index on the basis of its hydrophobicity and charge characteristics. They are: isoleucine (+4.5); valine (+4.2); leucine (+3.8); phenylalanine (+2.8); cysteine/cystine (+2.5); methionine (+1.9); alanine (+1.8); glycine (-0.4); threonine (-0.7); serine (-0.8); tryptophan (-0.9); tyrosine (-1.3); proline (-1.6); histidine (-3.2); glutamate (-3.5); glutamine (-3.5); aspartate (-3.5); asparagine (-3.5); lysine (-3.9); and arginine (-4.5).

**[0088]** The importance of the hydropathic amino acid index in conferring interactive biological function on a protein is understood in the art. Kyte *et al.*, J. Mol. Biol., 157:105-131 (1982). It is known that certain amino acids can be substituted for other amino acids having a similar hydropathic index or score and still retain a similar biological activity. In making changes based upon the hydropathic index, in some embodiments, the substitution of amino acids whose hydropathic indices are within  $\pm 2$  is included. In some embodiments, those which are within  $\pm 1$  are included, and in some embodiments, those within  $\pm 0.5$  are included.

**[0089]** It is also understood in the art that the substitution of like amino acids can be made effectively on the basis of hydrophilicity, particularly where the biologically functional protein or peptide thereby created is intended for use in immunological embodiments, as in the present case. In some embodiments, the greatest local average hydrophilicity of a protein, as governed by the hydrophilicity of its adjacent amino acids, correlates with its immunogenicity and antigenicity, i.e., with a biological property of the protein.

**[0090]** The following hydrophilicity values have been assigned to these amino acid residues: arginine (+3.0); lysine (+3.0); aspartate (+3.0  $\pm$  1); glutamate (+3.0  $\pm$  1); serine (+0.3); asparagine (+0.2); glutamine (+0.2); glycine (0); threonine (-0.4); proline (-0.5  $\pm$  1); alanine (-

0.5); histidine (-0.5); cysteine (-1.0); methionine (-1.3); valine (-1.5); leucine (-1.8); isoleucine (-1.8); tyrosine (-2.3); phenylalanine (-2.5) and tryptophan (-3.4). In making changes based upon similar hydrophilicity values, in some embodiments, the substitution of amino acids whose hydrophilicity values are within  $\pm 2$  is included, in some embodiments, those which are within  $\pm 1$  are included, and in some embodiments, those within  $\pm 0.5$  are included. One can also identify epitopes from primary amino acid sequences on the basis of hydrophilicity. These regions are also referred to as "epitopic core regions."

[0091] Exemplary amino acid substitutions are set forth in Table 1.

TABLE 1  
Amino Acid Substitutions

Original Residues	Exemplary Substitutions	Preferred Substitutions
Ala	Val, Leu, Ile	Val
Arg	Lys, Gln, Asn	Lys
Asn	Gln	Gln
Asp	Glu	Glu
Cys	Ser, Ala	Ser
Gln	Asn	Asn
Glu	Asp	Asp
Gly	Pro, Ala	Ala
His	Asn, Gln, Lys, Arg	Arg
Ile	Leu, Val, Met, Ala, Phe, Norleucine	Leu
Leu	Norleucine, Ile, Val, Met, Ala, Phe	Ile
Lys	Arg, 1,4 Diamino-butyric Acid, Gln, Asn	Arg
Met	Leu, Phe, Ile	Leu
Phe	Leu, Val, Ile, Ala, Tyr	Leu
Pro	Ala	Gly

Original Residues	Exemplary Substitutions	Preferred Substitutions
Ser	Thr, Ala, Cys	Thr
Thr	Ser	Ser
Trp	Tyr, Phe	Tyr
Tyr	Trp, Phe, Thr, Ser	Phe
Val	Ile, Met, Leu, Phe, Ala, Norleucine	Leu

**[0092]** The term “derivative” refers to a molecule that includes a chemical modification other than an insertion, deletion, or substitution of amino acids (or nucleic acids). In some embodiments, derivatives comprise covalent modifications, including, but not limited to, chemical bonding with polymers, lipids, or other organic or inorganic moieties. In some embodiments, a chemically modified neutralizing PCSK9 variant can have a greater circulating half-life than a neutralizing PCSK9 variant that is not chemically modified. In some embodiments, a chemically modified neutralizing PCSK9 variant can have improved targeting capacity for desired cells, tissues, and/or organs. In some embodiments, a derivative neutralizing PCSK9 variant is covalently modified to include one or more water soluble polymer attachments, including, but not limited to, polyethylene glycol, polyoxyethylene glycol, or polypropylene glycol. *See, e.g.*, U.S. Patent Nos: 4,640,835, 4,496,689, 4,301,144, 4,670,417, 4,791,192 and 4,179,337. In some embodiments, a derivative neutralizing PCSK9 variant comprises one or more polymer, including, but not limited to, monomethoxy-polyethylene glycol, dextran, cellulose, or other carbohydrate based polymers, poly-(N-vinyl pyrrolidone)-polyethylene glycol, propylene glycol homopolymers, a polypropylene oxide/ethylene oxide co-polymer, polyoxyethylated polyols (e.g., glycerol) and polyvinyl alcohol, as well as mixtures of such polymers.

**[0093]** In some embodiments, a derivative is covalently modified with polyethylene glycol (PEG) subunits. In some embodiments, one or more water-soluble polymer is bonded at one or more specific position, for example at the amino terminus, of a derivative. In some embodiments, one or more water-soluble polymer is randomly attached to one or more side chains of a derivative. In some embodiments, PEG is used to improve the therapeutic capacity

for a neutralizing PCSK9 variant. In some embodiments, PEG is used to improve the therapeutic capacity of a molecule. Certain such methods are discussed, for example, in U.S. Patent No. 6,133,426, which is hereby incorporated by reference for any purpose.

**[0094]** Peptide analogs are commonly used in the pharmaceutical industry as non-peptide drugs with properties analogous to those of the template peptide. These types of non-peptide compound are termed “peptide mimetics” or “peptidomimetics.” Fauchere, J., *Adv. Drug Res.*, 15:29 (1986); Veber & Freidinger, *TINS*, p.392 (1985); and Evans *et al.*, *J. Med. Chem.*, 30:1229 (1987), which are incorporated herein by reference for any purpose. Such compounds are often developed with the aid of computerized molecular modeling. Peptide mimetics that are structurally similar to therapeutically useful peptides can be used to produce a similar therapeutic or prophylactic effect. Generally, peptidomimetics are structurally similar to a paradigm polypeptide (i.e., a polypeptide that has a biochemical property or pharmacological activity), such as human antibody, but have one or more peptide linkages optionally replaced by a linkage selected from: --CH<sub>2</sub> NH--, --CH<sub>2</sub> S--, --CH<sub>2</sub> -CH<sub>2</sub> --, --CH=CH-(cis and trans), --COCH<sub>2</sub> --, --CH(OH)CH<sub>2</sub> --, and --CH<sub>2</sub> SO--, by methods well known in the art. Systematic substitution of one or more amino acids of a consensus sequence with a D-amino acid of the same type (e.g., D-lysine in place of L-lysine) can be used in some embodiments to generate more stable peptides. In addition, constrained peptides comprising a consensus sequence or a substantially identical consensus sequence variation can be generated by methods known in the art (Rizo and Gierasch, *Ann. Rev. Biochem.*, 61:387 (1992), incorporated herein by reference for any purpose); for example, by adding internal cysteine residues capable of forming intramolecular disulfide bridges which cyclize the peptide.

**[0095]** The term “naturally occurring” as used throughout the specification in connection with biological materials such as polypeptides, nucleic acids, host cells, and the like, refers to materials which are found in nature or a form of the materials that is found in nature.

**[0096]** A “recombinant neutralizing PCSK9 variant” is a protein made using recombinant techniques, *i.e.*, through the expression of a recombinant nucleic acid as described herein. Methods and techniques for the production of recombinant proteins are well known in the art.

**[0097]** The term “neutralizing PCSK9 variant” refers to a PCSK9 variant that associates and/or binds to LDLR competitively with a full length human PCSK9. The

neutralizing PCSK9 variant also has a reduced ability to degrade or remove LDLR from a system compared to wild-type PCSK9 (*e.g.*, SEQ ID NO: 3). In some embodiments, the neutralizing PCSK9 variant lacks a fully functional LDLR degrading V domain (*e.g.*, the PCSK9 protein has an inactive V domain). In some embodiments, the neutralizing PCSK9 variant has a reduced ability to degrade or take LDLR out of a system compared to a similar variant lacking a fully functional V domain. Stated another way, a neutralizing PCSK9 variant has the ability to directly or indirectly reduce the degradation of LDLR and thus maintain or increase LDLR levels in a system.

**[0098]** The term “pro” or “pro domain” is used to refer to at least a part of the prodomain of PCSK9. In some embodiments, the prodomain of PCSK9 is involved (either directly or indirectly (such as by allowing proper folding of the Cat domain)) in the binding of PCSK9 to LDLR. While the exact starting and ending residue of the pro domain can vary based on the specific embodiment, the pro domain will at least comprise residues 61-152 of SEQ ID NO: 3 and variants thereof. In some embodiments, the pro domain comprises amino acids 31-152 of SEQ ID NO: 3, or variants thereof. Variants of the Pro domain can be 50% or more (*e.g.*, 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, or 99-100 percent identical to the corresponding Pro domain of SEQ ID NO: 3 and/or a consensus sequence (*e.g.*, shown in FIG. 1C-1E).

**[0099]** The term “Cat” or “cat domain” is used to refer to at least a part of the catalytic domain of PCSK9. In some embodiments, the “cat domain” is involved in the binding of PCSK9 to LDLR. While the exact starting and ending residue of the Cat domain can vary based on the specific embodiment, the Cat domain will at least comprise residues 153-381 and in some embodiments will comprise at least residues 153-445 of SEQ ID NO: 3 and variants thereof. Variants of the Cat domain can be 50% or more (*e.g.*, 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, or 99-100 percent) identical to the corresponding Cat domain of SEQ ID NO: 3. In some embodiments, the cat domain can start at residue 153 of SEQ ID NO: 3 (and variants thereof) and ends at any one of residues 447, 448, 449, 450, 451, 452, or 453 of SEQ ID NO: 3 (and variants thereof). Thus, the Cat domain can include residues 153-447, 153-448, 153-449, 153-450, 153-451, 153-452, 153-453, or 153-454 of SEQ ID NO: 3 (and variants thereof) and/or a consensus sequences (*e.g.*, shown in FIGs. 1C-1H and FIGs. 1R<sub>1</sub>-1R<sub>2</sub>, SEQ ID NOs: 9, 11, 13, 15, and 30 where FIGs. 1F-1H display examples of a Cat domain).

**[0100]** The term “Pro/Cat” or “Pro/Cat domain” is used to refer to the section of PCSK9 that is involved in binding to LDLR. The “Pro/Cat domain” need not include both the Pro and Cat domain. In particular, something referred to as the “Pro/Cat domain” can comprise the Pro domain without the Cat domain, or the Cat domain without the Pro domain. While the term also encompasses a PCSK9 protein that includes both the Pro and the Cat domain, when both of these domains are required to be present the phrase “Pro domain and Cat domain” or similar phrase is generally employed. In some embodiments, the pro/cat domain can start at residues 31 or 61 of SEQ ID NO: 3 (and variants thereof) and end at any one of residues 447, 448, 449, 450, 451, 452, or 453 of SEQ ID NO: 3 (and variants thereof). Thus, in some embodiments, the Pro/Cat domain can include residues 31-447, 31-448, 31-449, 31-450, 31-451, 31-452, 31-453, 61-447, 61-448, 61-449, 61-450, 61-451, 61-452, and 61-453 of SEQ ID NO: 3 (and variants thereof), and/or SEQ ID NOs: 4, 5, 6, 7, 8, 24-29 and/or 31 and/or a consensus sequence (*e.g.*, shown in FIGs. 1C-1E and 1R<sub>1</sub>-1R<sub>2</sub> SEQ ID NOs: 9 and 30 (and F-H for the Cat domain, SEQ ID Nos: 11, 13, and 15)). Of course, the “pro/cat” domain can also simply include the pro or cat regions noted above. In some embodiments, variants of the pro/cat domain can be 50% or more (*e.g.*, 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, or 99-100 percent) identical to the corresponding pro/cat domain of SEQ ID NO: 3. In some embodiments, the pro/cat domain is at least 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 96, 97, 98, 99, or more percent identical for the conserved sections of the pro/cat domain. In some embodiments, while the sections of the pro/cat domain that are 100% conserved (shown in FIGs. 1C-1E) are conserved in the pro/cat variant, the remaining positions can be changed. In some embodiments, the changes in these remaining positions can result in a pro/cat variant that is 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, or 99-100 percent identical to the corresponding pro/cat domain of SEQ ID NO: 3. In some embodiments, the variable positions are those shown as spaces or gaps in the consensus sequence in FIGs. 1C-1E and FIG. 1R<sub>1</sub>-1R<sub>2</sub> or non specific amino acids in FIGs. 1F-1H (and/or shown as “Xaa” in SEQ ID NOs: 9, 11, 13, 15, and 30).

**[0101]** As will be appreciated by one of skill in the art, the sequence alignment shown in the attached figures (1C-1H and 1I-1L) denote the residues that, in some embodiments (including various neutralizing PCSK9 variants), can be conserved in order to obtain a functional Pro, Cat, Pro/Cat, or LDLR domain or protein and those that can be changed (and how they can be changed). In some embodiments, the sections denoted by spaces in the consensus sequences

are amino acid(s) where conservation is not required and any or no amino acid can be used at these locations (*e.g.*, variation is readily allowable at these locations). In some embodiments, the sections denoted by “+” can similarly be altered with any amino acid. In some embodiments, the sections denoted by “+” are conservative replacements, or the replacements noted for that position in the sequence listing (or in the various organisms for the sequence alignment). As noted herein, various consensus sequences are disclosed within FIGs. 1C-1L. Thus, consensus sequences in addition to the consensus sequence explicitly identified in the figures are also disclosed herein.

**[0102]** The term “V” or “V domain” is used to refer the section of the PCSK9 protein that is involved in the effective degradation of LDLR. While the exact starting and ending residues of the V domain can vary based on the specific embodiment, the V domain will at least comprise residues 455-682 of SEQ ID NO: 3 and variants thereof. In some embodiment the V domain will at least comprise residues 457-679, 454-692, 457-692, 457-682, 455-692, 455-679, 454-682, or 454-679. Variants of the V domain can be 55% or more (*e.g.*, 55-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, or 99-100 percent identical to the corresponding V domain of SEQ ID NO: 3. Simply because there is an amino acid sequence on the c-terminal end of a pro/cat domain does not make that sequence a V domain or an active V domain. An active V domain will also have the above noted function in regard to LDLR. As will be appreciated by one of skill in the art, inactive V domains encompass a broader scope of possible domains, sequences, and structures than do active V domains. Any protein, or a lack of PCSK9 protein, that does not achieve the V domain’s function noted above can be characterized as an inactive V domain.

**[0103]** The term “loop” is used to refer to the section between the V domain and the Cat domain. This section need not be called out explicitly in every embodiment. While the exact starting and ending residues of the loop can vary based on the specific embodiment, the loop can comprise residues 447-453 of SEQ ID NO: 3 and variants thereof. Variants of the loop can be 0% or more (*e.g.*, 0-10, 10-20, 20-30, 30-40, 40-50 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, 99 percent identical to the loop of SEQ ID NO: 3. In some embodiments, any structure or section connecting the V domain to the Cat domain can be considered as a loop section. In some embodiments, the loop domain is not explicitly denoted as such and is simply part of either the Cat domain or the V domain.

**[0104]** The phrase “LDLR degrading” refers to the ability of the V domain (or subpart thereof), when part of a whole PCSK9 protein, to promote the degradation of LDLR. As will be appreciated by one of skill in the art in light of the present disclosure, the LDLR degrading ability of the V domain need not be a direct role. In particular, it can be possible for LDLR to be degraded by PCSK9 variants that lack the V domain. Thus, the LDLR “degrading role” or “ability” of the V domain denotes that this section of the PCSK9 protein is involved in the effective degradation of LDLR. The removal of the V domain need not completely prevent all LDLR degradation under all possible variables and circumstances (and, as noted below in the examples, in some circumstances, does not).

**[0105]** The phrase “fully functional LDLR degrading” or “fully functional LDLR degradation” refers to the amount of LDLR degradation that occurs from a PCSK9 protein that has the wild-type V domain following amino acid 450 of SEQ ID NO: 3. Thus, a “fully functional LDLR degrading V domain” will degrade LDLR at a rate equal to and/or greater than wild type PCSK9 (for example, SEQ ID NO: 3). Proteins that are not fully functional for LDLR degradation, that have an inactive V domain, or that lack a fully functional LDLR degrading V domain will degrade LDLR less effectively than the wild type PCSK9. Thus, for example, a variant of PCSK9 that is only 90% as effective as wild-type PCSK9 can be characterized as lacking a fully functional LDLR degrading V domain or as having an inactive V domain. A PCSK9 variant that lacks a V domain can also be described as lacking a fully functional LDLR degrading V domain or as having an inactive V domain. A PCSK9 protein that lacks a fully functional LDLR degrading V domain, that has an inactive V domain, or that lacks a V domain is less than 100% as effective as the wild type PCSK9 (SEQ ID NO: 3), include, for example, PCSK9 proteins that are 99-90, 90-80, 80-70, 70-60, 60-50, 50-40, 40-30, 30-20, 20-10, 10-5, 5-1, 1-0.1, 0.1-0.01, 0.01-0.001, 0.001-0.0001, and 0.0001 to 0% as effective as the wild type PCSK9 protein. As will be appreciated by one of skill in the art, a neutralizing PCSK9 variant can contain some or all of the V domain, as long as the V domain is not fully functional for LDLR degradation. The functionality of the V domain can be adjusted by various approaches, including, for example, removal, point mutations, insertions, deletions, etc.

**[0106]** The phrase term “active” as used in “active Pro domain,” “active Pro/Cat domain,” or “active Cat domain” denotes that the protein can bind to LDLR.

**[0107]** The term “inactive” as used in “inactive V domain” denotes that the molecule in question does not have a PCSK9 V domain that functions in LDLR degradation as effectively as the V domain in wild-type PCSK9. An inactive V domain does not require that the sequence of the V domain be present. In some embodiments, a neutralizing PCSK9 variant will have an inactive V domain if it lacks a V domain protein sequence.

**[0108]** The phrase “has an inactive V domain” denotes that the section of the V domain, if any section is present, is not as effective at degrading LDLR as the V domain in the full length PCSK9 protein. This does not require that any part of the V domain actually be present. Thus, a PCSK9 protein that lacks the entire V domain can also be characterized as “having an inactive V domain.” As above, the definition does not require that the protein with the inactive V domain exhibit a complete absence of LDLR degrading ability. A PCSK9 protein that has an inactive V domain will be less than 100% as effective as the wild type PCSK9 (SEQ ID NO: 3). Examples of such lower levels of effectiveness include, for example, PCSK9 proteins having V domains that are 99-90, 90-80, 80-70, 70-60, 60-50, 50-40, 40-30, 30-20, 20-10, 10-5, 5-1, 1-0.1, 0.1-0.01, 0.01-0.001, 0.001-0.0001, and 0.0001 to 0% as effective as the wild type PCSK9 protein. Nonlimiting examples of inactive or inactivated V domains include, for example, proteins that lack V domains (*e.g.*, the entire V domain is absent from the PCSK9 protein), proteins that lack 14 or more amino acids from the end (c-terminal) of the PCSK9 protein (*e.g.*, SEQ ID NO: 3), proteins in which the V domain is improperly folded (in comparison to wild-type PCSK9; *e.g.*, the C679X mutation).

**[0109]** The phrase “lacks the entirety of amino acids ###-###” denotes that the entire and exact amino acid sequence defined therein is absent from the protein. Subparts of the amino acid sequence or range can be present. For example, if the protein “lacks the entirety of amino acids 10-100 of SEQ ID NO: X,” then amino acids 10-99 or 11-100 of SEQ ID NO: X can be present, although 10-100 are excluded from being present.

**[0110]** The phrase “attached adjacent to an amino acid ### of SEQ ID NO: X” denotes that whatever is (or is not) to be attached is (or is not) attached immediately adjacent to a specific amino acid (###). When the phrase is being used in a negative context (for example as an exclusion), then it denotes that, if amino acid ### is present, then the item in question is not attached adjacent to it. However, the use of this phrase does not imply or require that amino acid ### is actually present when used in its negative context. As an example, the phrase “lacks the

entirety of amino acids 10-100 of SEQ ID NO: X attached adjacent to an amino acid 9 of SEQ ID NO: X” denotes that all 91 amino acids of amino acids 10-100 of SEQ ID NO: X are missing from the position adjacent to amino acid 9 of SEQ ID NO: X (if amino acid 9 is present). Thus, amino acids 11-100 can be present and attached adjacent to amino acid 9, amino acids 10-99 can be present and attached adjacent to amino acid 9, or amino acids 10-100 can be present and attached to either amino acid 8 or 11 of SEQ ID NO: 3. It is noted that, for the above type of exclusion, amino acid 9 does not need to be present. Thus, amino acids 1-5 of SEQ ID NO: X would also meet the above description, (as there is no amino acid 9 and there can be no amino acid adjacent to it). In addition, unless explicitly noted, the position “adjacent to” a specific amino acid is only the position that is greater than the noted amino acid. Thus, if the relevant amino acid is 9, then the only position adjacent to 9 is 10 (and thus position 8 is not considered “adjacent” to position 9 for the purposes of this definition). In other words, adjacent to only applies to the amino acid in the carboxy direction, not in the amino direction.

**[0111]** The phrase “at the appropriate position” as used in the phrase “at the appropriate position in the variant,” denotes that, the appropriate position is present in the variant. For example, the phrase, “the neutralizing PCSK9 variant has a cysteine at position 30” denotes that the variant has an amino acid at position 30 and that it is a cysteine. When the phrase is used in reference to another SEQ ID NO:, it denotes that the variant is (or is not) similar to that other SEQ ID NO: in the manner described. When the phrase is used as an exclusion, then, as noted in the above definition, the position itself need not be present in the variant, but if it is, then it will not be the item described.

**[0112]** The term “target” refers to a molecule or a portion of a molecule capable of being bound by a neutralizing PCSK9 variant.

**[0113]** The terms “compete” or “competitive,” when used in reference to “neutralizing PCSK9 variant” refers to the competition between a) native PCSK9 and b) PCSK9 variants for LDLR. Numerous types of competitive binding assays can be used to determine if one neutralizing PCSK9 variant competes with native PCSK9, for example: solid phase direct or indirect radioimmunoassay (RIA), solid phase direct or indirect enzyme immunoassay (EIA), sandwich competition assay (*see, e.g.,* Stahli *et al.*, 1983, *Methods in Enzymology* 9:242-253); solid phase direct biotin-avidin EIA (*see, e.g.,* Kirkland *et al.*, 1986, *J. Immunol.* 137:3614-3619) solid phase direct labeled assay, solid phase direct labeled sandwich assay (*see, e.g.,* Harlow and

Lane, 1988, *Antibodies, A Laboratory Manual*, Cold Spring Harbor Press); solid phase direct label RIA using I-125 label (*see, e.g.*, Morel *et al.*, 1988, *Molec. Immunol.* 25:7-15); solid phase direct biotin-avidin EIA (*see, e.g.*, Cheung, *et al.*, 1990, *Virology* 176:546-552); and direct labeled RIA (Moldenhauer *et al.*, 1990, *Scand. J. Immunol.* 32:77-82).

**[0114]** As used herein, “substantially pure” means that the described species of molecule is the predominant species present, that is, on a molar basis it is more abundant than any other individual species in the same mixture. In some embodiments, a substantially pure molecule is a composition wherein the object species comprises at least 50% (on a molar basis) of all macromolecular species present. In other embodiments, a substantially pure composition will comprise at least 80%, 85%, 90%, 95%, or 99% of all macromolecular species present in the composition. In other embodiments, the object species is purified to essential homogeneity wherein contaminating species cannot be detected in the composition by conventional detection methods and thus the composition consists of a single detectable macromolecular species.

**[0115]** The term “agent” is used herein to denote a chemical compound, a mixture of chemical compounds, a biological macromolecule, or an extract made from biological materials.

**[0116]** As used herein, the terms “label” or “labeled” refers to incorporation of a detectable marker. Examples include incorporation of a radiolabeled amino acid or attachment to a polypeptide of biotin moieties that can be detected by marked avidin (e.g., streptavidin containing a fluorescent marker or enzymatic activity that can be detected by optical or colorimetric methods). In some embodiments, the label or marker can also be therapeutic. Various methods of labeling polypeptides and glycoproteins are known in the art and can be used. Examples of labels for polypeptides include, but are not limited to, the following: radioisotopes or radionuclides (e.g.,  $^3\text{H}$ ,  $^{14}\text{C}$ ,  $^{15}\text{N}$ ,  $^{35}\text{S}$ ,  $^{90}\text{Y}$ ,  $^{99}\text{Tc}$ ,  $^{111}\text{In}$ ,  $^{125}\text{I}$ ,  $^{131}\text{I}$ ), fluorescent labels (e.g., FITC, rhodamine, lanthanide phosphors), enzymatic labels (e.g., horseradish peroxidase,  $\beta$ -galactosidase, luciferase, alkaline phosphatase), chemiluminescent, biotinyl groups, predetermined polypeptide epitopes recognized by a secondary reporter (e.g., leucine zipper pair sequences, binding sites for secondary antibodies, metal binding domains, epitope tags). In some embodiments, labels are attached by spacer arms of various lengths to reduce potential steric hindrance.

**[0117]** The term “biological sample”, as used herein, includes, but is not limited to, any quantity of a substance from a living thing or formerly living thing. Such living things

include, but are not limited to, humans, mice, monkeys, rats, rabbits, and other animals. Such substances include, but are not limited to, blood, serum, urine, cells, organs, tissues, bone, bone marrow, lymph nodes, and skin.

**[0118]** The term “pharmaceutical agent composition” (or agent or drug) as used herein refers to a chemical compound, composition, agent or drug capable of inducing a desired therapeutic effect when properly administered to a patient. It does not necessarily require more than one type of ingredient.

**[0119]** The term “therapeutically effective amount” refers to the amount of a neutralizing PCSK9 variant determined to produce a therapeutic response in a mammal. Such therapeutically effective amounts are readily ascertained by one of ordinary skill in the art.

**[0120]** The term “modulator,” as used herein, is a substance that changes or alters the activity or function of a molecule. For example, a modulator can cause an increase or decrease in the magnitude of a certain activity or function of a molecule compared to the magnitude of the activity or function observed in the absence of the modulator. In some embodiments, a modulator is an inhibitor, which decreases the magnitude of at least one activity or function of a molecule. Certain exemplary activities and functions of a molecule include, but are not limited to, binding affinity, enzymatic activity, and signal transduction. Certain exemplary inhibitors include, but are not limited to, proteins, peptides, antibodies, peptibodies, carbohydrates or small organic molecules. Peptibodies are described in, e.g., U.S. Patent No. 6,660,843 (corresponding to PCT Application No. WO 01/83525).

**[0121]** The terms “patient” and “subject” are used interchangeably and include human and non-human animal subjects as well as those with formally diagnosed disorders, those without formally recognized disorders, those receiving medical attention, those at risk of developing the disorders, etc.

**[0122]** The term “treat” and “treatment” includes therapeutic treatments, prophylactic treatments, and applications in which one reduces the risk that a subject will develop a disorder or other risk factor. Treatment does not require the complete curing of a disorder and encompasses embodiments in which one reduces symptoms and/or underlying risk factors.

**[0123]** The term “prevent” does not require the 100% elimination of the possibility of an event. Rather, it denotes that the likelihood of the occurrence of the event has been reduced in the presence of the compound or method.

**[0124]** The term "native Fc" refers to molecule or sequence comprising the sequence of a non-antigen-binding fragment resulting from digestion of whole antibody, whether in monomeric or multimeric form. The original immunoglobulin source of the native Fc is preferably of human origin and can be any of the immunoglobulins, although IgG1 and IgG2 are preferred, Native Fc's are made up of monomeric polypeptides that can be linked into dimeric or multimeric forms by covalent (i.e., disulfide bonds) and non-covalent association. The number of intermolecular disulfide bonds between monomeric subunits of native Fc molecules ranges from 1 to 4 depending on class (e.g., IgG, IgA, and IgE) or subclass (e.g., IgG1, IgG2, IgG3, IgA1, IgGA2). One example of a native Fc is a disulfide-bonded dimer resulting from papain digestion of an IgG (see Ellison et al. (1982), *Nucleic Acids Res.* 10: 4071-9). The term "native Fc" as used herein is generic to the monomeric, dimeric, and multimeric forms.

**[0125]** The term "Fc variant" refers to a molecule or sequence that is modified from a native Fc but still comprises a binding site for the salvage receptor, FcRn. International applications WO 97/34631 (published Sep. 25, 1997) and WO 96/32478 describe exemplary Fc variants, as well as interaction with the salvage receptor, and are hereby incorporated by reference. Thus, the term "Fc variant" comprises a molecule or sequence that is humanized from a non-human native Fc. Furthermore, a native Fc comprises sites that can be removed because they provide structural features or biological activity that are not required for the fusion molecules of PCSK9. Thus, the term "Fc variant" comprises a molecule or sequence that lacks one or more native Fc sites or residues that affect or are involved in (1) disulfide bond formation, (2) incompatibility with a selected host cell (3) N-terminal heterogeneity upon expression in a selected host cell, (4) glycosylation, (5) interaction with complement, (6) binding to an Fc receptor other than a salvage receptor, or (7) antibody-dependent cellular cytotoxicity (ADCC). Fc variants are described in further detail hereinafter.

**[0126]** The term "Fc domain" encompasses native Fc and Fc variant molecules and sequences as defined above. As with Fc variants and native Fc's, the term "Fc domain" includes molecules in monomeric or multimeric form, whether digested from whole antibody or produced by other means. In some embodiments, an Fc domain can be associated to a neutralizing PCSK9 variant (e.g., via a covalent bond between the Fc domain and the neutralizing PCSK9 variant).

**[0127]** The term "multimer" as applied to Fc domains or molecules comprising Fc domains refers to molecules having two or more polypeptide chains associated covalently,

noncovalently, or by both covalent and non-covalent interactions. IgG molecules typically form dimers; IgM, pentamers; IgD, dimers; and IgA, monomers, dimers, trimers, or tetramers. Multimers can be formed by exploiting the sequence and resulting activity of the native Ig source of the Fc or by derivatizing (as defined below) such a native Fc.

**[0128]** The term "dimer" as applied to Fc domains or molecules comprising Fc domains refers to molecules having two polypeptide chains associated covalently or non-covalently.

**[0129]** Standard techniques can be used for recombinant DNA, oligonucleotide synthesis, and tissue culture and transformation (e.g., electroporation, lipofection). Enzymatic reactions and purification techniques can be performed according to manufacturer's specifications or as commonly accomplished in the art or as described herein. The foregoing techniques and procedures can be generally performed according to conventional methods well known in the art and as described in various general and more specific references that are cited and discussed throughout the present specification. *See, e.g., Sambrook et al., Molecular Cloning: A Laboratory Manual* (2d ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. (1989)), which is incorporated herein by reference for any purpose. Unless specific definitions are provided, the nomenclatures utilized in connection with, and the laboratory procedures and techniques of, analytical chemistry, synthetic organic chemistry, and medicinal and pharmaceutical chemistry described herein are those well known and commonly used in the art. Standard techniques can be used for chemical syntheses, chemical analyses, pharmaceutical preparation, formulation, and delivery, and treatment of patients.

#### Neutralizing PCSK9 Variants

**[0130]** In some embodiments, the neutralizing PCSK9 variant provided herein is capable of inhibiting native PCSK9 from binding to LDLR. In some embodiments, this blocking results in a decrease in the degradation of LDLR *in vivo*; thereby resulting in a lowering of serum LDL in a subject.

**[0131]** As noted above, the ability of PCSK9 to bind to LDLR and the ability of wild-type PCSK9 to effectively degrade LDLR appear to be due to two different sections of the PCSK9 protein. As noted in the examples below, the ability of PCSK9 to effectively degrade LDLR appears to be linked to the V domain of PCSK9. Thus, in some embodiments, variants of

PCSK9 that lack fully functional LDLR degrading V domains (or have an inactive V domain) can be introduced into a system or subject without adversely increasing the amount of LDLR degradation. Moreover, as described herein, the binding of PCSK9 to LDLR is mediated by sections of the Pro and/or Cat domains of PCSK9. Thus, neutralizing PCSK9 variants that contain sufficient sections of the Pro and/or Cat domain(s) can still bind to LDLR and compete with native PCSK9 for binding to LDLR. In some embodiments, when the variant also lacks a fully functional LDLR degrading V domain (or have an inactive V domain), then the PCSK9 variant will not only block native PCSK9, but will do so while lowering LDLR degradation, thereby increasing LDLR availability and in turn decreasing the amount of LDL in the serum. Thus, in some embodiments, a neutralizing PCSK9 variant is a PCSK9 protein that has an active Pro/Cat domain and an inactive V domain.

**[0132]** In some embodiments, the neutralizing PCSK9 variant includes, consists, or consists essentially of the Pro and/or Cat domain(s) of PCSK9. In some embodiments, the variant includes a signal sequence (for example, amino acids 1-30 of SEQ ID NO: 3). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of amino acids 31-447 of SEQ ID NO: 3 (or a variant of amino acids 31-447). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of amino acids 153-374 of SEQ ID NO: 3 (or a variant of amino acids 153-374). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of amino acids 31-374 of SEQ ID NO: 3 (or a variant of amino acids 31-374). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of amino acids 153-454 of SEQ ID NO: 3 (or a variant of amino acids 153-454). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of amino acids 31-449 of SEQ ID NO: 3 (or a variant of amino acids 31-449). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of amino acids 153-381 of SEQ ID NO: 3 (or a variant of amino acids 153-381). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of amino acids 31-381 of SEQ ID NO: 3 (or a variant of amino acids 31-381). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of amino acids 153-382 of SEQ ID NO: 3 (or a variant of amino acids 153-382). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of

amino acids 31-382 of SEQ ID NO: 3 (or a variant of amino acids 31-382). In some embodiments, the neutralizing PCSK9 variant comprises, consists, or consists essentially of an amino acid starting at either position 31, 61, or 153 of SEQ ID NO: 3 and ending at position 374, 381, 382, 447, 448, 449, 450, 451, 452, 453, 454, or 455 of SEQ ID NO: 3 (or a variant thereof). In some embodiments, variants can be at least 50 percent identical, for example 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99 or greater identity, to the relevant section (*e.g.*, any of the above noted sections) of SEQ ID NO: 3. In some embodiments, variants can have at least 70% homology, for example 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99 or greater homology, to the relevant section of SEQ ID NO: 3.

**[0133]** In some embodiments, the V domain can be entirely removed. In some embodiments, a section of the V domain can be removed or altered. The section can be sufficient to prevent the neutralizing PCSK9 variant from significantly degrading LDLR

**[0134]** In some embodiments, the variant lacks some or all of the V domain. In some embodiments, the V domain will be inactive and will not allow for wild-type levels of degradation of LDLR. In some embodiments, the neutralizing PCSK9 variant lacks the V domain completely. In some embodiments, the variant lacks residues 447-692, 448-692, 449-692, 450-692, 451-692, 452-692, 453-692, or 454-692 of SEQ ID NO: 3. In some embodiments, any of the above missing sections, can be present in the variant, but will not be placed immediately adjacent to the amino acid positioned in front of it in SEQ ID NO: 3. Thus, for example, 453-692, 454-692, 450-692, or 447-692 of SEQ ID NO: 3 can be present in the variant, but will not be positioned following amino acid 452, 453, 449, or 446 respectively of SEQ ID NO: 3. In some embodiments, at least the last 14 amino acids from the C-terminus of SEQ ID NO: 3 are missing (or different from the amino acids in SEQ ID NO: 3), thereby creating an inactive V domain. For example, 14-16, 16-20, 20-25, 25-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100, 100-120, 120-140, 140-160, 160-200, 200-220, 220-225 amino acids can be deleted from the C terminal portion of the V domain to produce an inactive V domain.

**[0135]** In some embodiments, the neutralizing PCSK9 variant includes a point mutation. In some embodiments, the point mutation is the D374Y point mutation that has an increased binding affinity to LDLR. In some embodiments, one or more other point mutations are also included in the neutralizing PCSK9 variant. For example, mutations such as I474V, R273W, H87N, A103D, G308R, S376G, D480G, R499C, D374X, where X can be Y, A, H, R,

E, F, K, L,, Y142X, C679X, R46L, L253F, A443T, A53V, H553R, Q619P, E670G and those disclosed in Kotowski IK et al, Am. J. Hum. Genet. 2006;78:410-422, (incorporated herein by reference).

**[0136]** In some embodiments, any of the above variations (including mutations) and lengths of the V domain can be included or excluded from any of the above variations (including mutations) in the above noted pro and/or cat domains in order to produce a neutralizing PCSK9 variant. Thus, for example, the neutralizing variant can lack residues 453-692, 454-692, 450-692, or 447-692 of SEQ ID NO: 3 (or a variant thereof) positioned next to positions 452, 453, 449, or 446 respectively of SEQ ID NO: 3, while having any one of the above pro and/or cat regions (for example, 331-454, 31-447, 31-449, 153-374, 153-454, and 31-374 of SEQ ID NO: 3 (or a variant thereof)). In addition, any of the herein disclosed neutralizing PCSK9 variants can include a valine at 474 (instead of an isoleucine), a glycine at 670 (instead of a glutamate), and/or a glutamate at 620 (instead of a glycine). In some embodiments, the wild-type PCSK9 protein is that sequence defined in Genbank sequence NM\_174936. Other SNP variants can be found in Kotowski IK et al, Am. J. Hum. Genet. 2006; 78:410-422 and include R46L, A53V, L253F, R237W, A443T, I474V, Q619P, E670G, and others.

**[0137]** In some embodiments, variants of neutralizing PCSK9 proteins are selected by comparing various PCSK9 sequences to one another in order to determine those positions that are conserved and those positions that vary between PCSK9 sequences. In some embodiments, amino acids in the pro and/or cat domains that are conserved between various organisms are conserved while amino acids that are not conserved across two or more species are allowed to vary. Such variants can still have pro and/or cat domain(s) that still compete with native PCSK9 for binding. An example of a sequence alignment between PCSK9 proteins of various organisms can be found in FIGs. 1C to 1E. As will be appreciated by one of skill in the art, the space(s) in the consensus sequence can be filled with any of the other amino acids in the comparison at the corresponding location, or, in some embodiments, any amino acid. FIGs. 1F-1H depict another series of alignments of just the cat domain (the top sequence in the figures are from SEQ ID NO: 3, where amino acid 1-153 (of SEQ ID NO: 3) and amino acid 321-454 (of SEQ ID NO: 3)). As will be appreciated by one of skill in the art, the space(s) in the consensus sequences can be filled with any of the other amino acids in the comparison at the corresponding location, or, in some embodiments, any amino acid. Given the similarity between the sequences in FIG. 1C-1H and

SEQ ID NO: 3, the present invention contemplates that any of the above pro and/or cat domains can function as desired in a neutralizing PCSK9 variant (including variants that contain any one of the identified consensus sequences). As such, in some embodiments, any position that varies between the different PCSK9 sequences can be a position that can be altered in a neutralizing PCSK9 variant. In some embodiments, the position is altered to the other amino acid noted in the alignment. In some embodiments, the position is altered to a different amino acid. It is noted that the human PCSK9 sequence in FIGs. 1C-1E, while similar to SEQ ID NO: 3, includes an extra series of amino acids on the end of the sequence, including a glycine, followed by a proline, followed by 8 histidines. While the glycine or proline can be present or can be absent in various embodiments, the histidines are just part of a histidine tag, and are not a necessary part of the alignment or any of the proteins in the alignment. Thus, the consensus sequence need not have any of the histidines in it (all 8 can be removed in some embodiments as these are not structural elements of the protein). In some embodiments, the rat sequence in FIGs. 1C-1E has a glycine, followed by a proline, followed by 8 histidines on its end, just like the other sequences shown in FIG. 1E. Additional embodiments of PCSK9 sequences can be found in FIGs. 1M<sub>1</sub>-1S<sub>2</sub>, SEQ ID Nos: 25-31.

**[0138]** As noted above, the consensus sequences shown in the attached figures (1C-1H) indicate the residues that, in some embodiments, can be conserved in order to obtain a functional Pro/Cat domain and those that can be changed (and how they can be changed). In some embodiments, the sections of the consensus sequence denoted by spaces are amino acid(s) where conservation is not required and any or no amino acid can be used at these locations (*e.g.*, variation is readily allowable at these locations). In some embodiments, the sections denoted by “+” can similarly be altered with any amino acid. In some embodiments, the sections denoted by “+” are conservative replacements, or the replacements noted for that position in the sequence listing (or in the various organisms for the sequence alignment).

**[0139]** In FIGs. 1C-1E, as more than two amino acid sequences have been aligned, the consensus sequence does not display spaces at each amino acid position that can be varied without the Pro/Cat domain losing its functionality. Thus, in this alignment, for some embodiments, even amino acids designated as a specific amino acid in the explicitly noted consensus sequence can be varied and still result in a functioning Pro/Cat domain. For example, in some embodiments, an amino acid position that is assigned a specific amino acid in the

consensus sequence (in FIGs. 1C-1E), but varies between the various organisms, can be altered. Thus, in some embodiments, amino acid positions that are conserved between organisms (for example, as shown in FIGs. 1C-1E), are conserved in the neutralizing PCSK9 variant, but the other amino acid positions (those that are different between the various organisms) can be replaced with amino acids that are different from the amino acid denoted in their particular position of the consensus sequence. In some embodiments, the amino acid that replaces the amino acid in the consensus sequence is any amino acid (or none) and need not be limited to those amino acids appearing in the different sequences shown in FIGs. 1C-1E. In some embodiments, the amino acid change is to an amino acid that is the same as at least one of the amino acids shown in that position in the various amino acid sequences shown. In some embodiments, if the amino acids aligned for one position are different, but are conserved, then the amino acid position in the consensus sequence can be any amino acid having conserved properties (*e.g.*, polar). In some embodiments, while amino acids that are identical between one or more of the species are present in the neutralizing PCSK9 variant, one or more of the other amino acids at the other position(s) are varied. In some embodiments, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 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, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, or more amino acids that are not identical between the various organisms in FIGs. 1C-1E can be replaced by any other amino acid. In some embodiments, while the amino acids that are identical across all of the species noted in the figures are kept the same, the amino acids at the other positions are allowed to vary, with as much as 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 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, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, or 100% of these amino acids being altered to another amino acid. In some embodiments, the conserved amino acids noted in the figures can be altered or replaced by another amino acid(s).

**[0140]** In some embodiments, in creating a neutralizing PCSK9 variant, amino acids in the V domain that are conserved between various PCSK9 proteins of various organisms are

altered while amino acids that are not conserved across one or more species are conserved, thereby producing a protein where the V domain is not active (or is inactive). An example of this comparison, between PCSK9 from various animals, can be found in FIGs. 1C to 1E. Thus, in some embodiments, any of the conserved amino acids in the V domain of PCSK9 can be altered while the conserved amino acids in the pro and/or cat domains can be maintained in order to produce a neutralizing PCSK9 variant. In some embodiments, the amino acid is altered to the other amino acid noted in the alignment. In some embodiments, the amino acid is altered to a different amino acid.

**[0141]** In some embodiments, residues that are important in the binding of PCSK9 to LDLR are maintained in the pro and/or cat domain(s). For example, those residues identified herein as part of the binding surface between LDLR and LDL or LDLR and PCSK9, or involved in the creation of the binding surface, as well as those residues discussed in "Molecular basis for LDL recognition by PCSK9" (PNAS, 105:1820-1825, 2008), such as Arg 194 and Phe 379 are maintained, if present within the fragment sequence. In some embodiments, the neutralizing PCSK9 variant includes at least residues 194-379.

**[0142]** In some embodiments, a neutralizing PCSK9 variant can inhibit, interfere with or modulate one or more biological activities of PCSK9. In one embodiment, the neutralizing PCSK9 variant competes with native PCSK9 for binding to LDLR. In some embodiments, the neutralizing PCSK9 variant reduces binding of native PCSK9 to LDLR by at least 1%, for example, at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 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, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, or 100 percent reduction of native PCSK9 binding to LDLR.

**[0143]** In some embodiments, the neutralizing PCSK9 variant has an  $IC_{50}$  for blocking the binding of native PCSK9 to LDLR of less than 1 microMolar, 1000 nM to 100 nM, 100nM to 10 nM, 10nM to 1 nM, 1000pM to 500pM, 500 pM to 200 pM, less than 200 pM, 200 pM to 150 pM, 200 pM to 100 pM, 100 pM to 10 pM, 10 pM to 1 pM. This  $IC_{50}$  can be measured between native PCSK9 to LDLR and the neutralizing PCSK9 variant to LDLR.

**[0144]** In some embodiments, a neutralizing PCSK9 variant does not include a C679X and/or a Q554E point mutation. In some embodiments, the neutralizing PCSK9 variant

does not include a His tag. In some embodiments, the neutralizing PCSK9 variant does not include a GST tag. In some embodiments, the neutralizing PCSK9 variant includes residue 453 of SEQ ID NO: 3, at the corresponding position in the variant. In some embodiments, the PCSK9 variant does not have the entirety of residues 453-692 removed from the protein. For example, in some embodiments, the neutralizing PCSK9 variant includes residues 31-453. In some embodiments, the neutralizing PCSK9 variant lacks residues such as 447, 448, 449, 450, 451, and 452 (or some combination thereof) of SEQ ID NO: 3. In some embodiments, the neutralizing PCSK9 variant lacks any amino acid at these positions. In some embodiments, the neutralizing PCSK9 variant lacks the corresponding amino acid at the specific position identified above in regard to SEQ ID NO: 3. In some embodiments, when explicitly stated, the neutralizing PCSK9 variants can exclude the PCSK9 variants disclosed in U.S. application 12/197093, filed August 22, 2008, hereby incorporated by reference in its entirety and especially in regard to its disclosure regarding antigen binding proteins and PCSK9 proteins and variants thereof. For example, when explicitly stated, the neutralizing PCSK9 variants can exclude a PCSK9 proteins/variants such as PCSK9 ProCat 31-449 and/or PCSK9 ProCat 31-454, with or without a his tag. In some embodiments, when explicitly stated, the neutralizing PCSK9 variants can exclude the PCSK9 variants that consist of residues 1-452 (having a His tag or a GST tag, (sequence numbering as defined in Fan et al., American Chemical Society, "Self-Association of Human PCSK9 Correlates with its LDLR-Degrading Activity"); residues 1-454, and 1-681 219-692 (sequence numbering as defined in Benjannet et al., Journal of Biological Chemistry, "NARC-1/PCSK9 and Its Natural Mutants," 279:48865-48875, 2004); residues 219-692 (sequence numbering as defined in Benhannet et al., J. of Biol. Chemistry, "The Proprotein Convertase (PC) PCSK9 is Inactivated by Furin and/or PC5/6A," 281 (41):30561-30572 (2006); residues 1-452 and 423-692 (sequence numbering as defined in Fan et al., Biochemistry, "Self-Association of Human PCSK9 Correlates with its LDLR-Degrading Activity," 47:1631-1639 2008); residues 1-455, 1-454, and/or residues 31-454 (sequence numbering as defined by Nassoury et al., Traffic, "The Cellular Trafficking of Secretory Proprotein Convertase PCSK9 and its Dependence on the LDLR," 8:718-732, 2007); any C terminal deletions in WO 2007/128121; residues 1-454 (sequence numbering as defined by Zhang et al., PNAS, "Structural Requirements for PCSK9-mediated degradation of the low-density lipoprotein Receptor," 105:13045-13050, 2008); residues 1-425, 1-453, 1-694, 31-453, and 1-507 (sequence

numbering as defined by Naureckiene S. et al, Archives of Biochemistry and Biophysics, “Functional Characterization of Narcl, a Novel Proteinase Related to Proteinase K”, 420:55-67, 2003); residues 31-451 and/or residues 53-451 (including variants of either of these, such as the following: P155G, W156L, N157K, L158A, I161A, R194A, D238A, D374Y, S386A, with or without a his tag)(sequence numbering as defined in Bottomley et al., J. of Biological Chemistry, “Structural and Biochemical Characterization of the Wild Type PCSK9/EGF-AB Complex and Natural FH mutants,” 284:1313-23, 2008); an in-frame deletion of the eighth exon of 58 amino acids, e.g., deletion of residues 395-452 (keeping 1-394 and 453 to the end, as described in Schmidt et al., DNA and Cell Biology, “A Novel Splicing Variant of Proprotein Convertase Subtilisin/Kexin Type 9, 27:183-189, 2008); and/or residues 1-692 (human), 1-691 (rat), 1-316 (rat), 1-390 (rat), 1-390 (S385A, rat), 1-425 (rat), 1-453 (rat), 1-507 (rat), 31-691 (rat), 148-691 (rat), 1-691 (rat, including optional deletion of 31-147, optional deletion of 148-425, optional deletion of 219-395, histidine 225 to tryptophan, serine 385 to alanine, or histidine 225 to tryptophan and serine 385 to alanine), 1-142, and/or 1-679 (sequence numbering as defined in Bingham et al., Cytometry A., “Proapoptotic effects of NARC 1 (= PCSK9), the gene encoding a novel serine proteinase,” 69(11):1123-31, 2006). The entirety of the disclosure of each of the above noted references is incorporated herein by reference, especially in regard to their disclosures of the various PCSK9 sequences and discussion thereof. In some embodiments, any one or more of the abovevariants are encompassed within the group of useful neutralizing PCSK9 variants. In some embodiments, any or all of the above can be combined with or in a pharmaceutically acceptable carrier or be used for the preparation of a medicament.

**[0145]** In some embodiments, the neutralizing PCSK9 variant has a pro/cat domain that is different from the pro/cat domain in the cDNA sequence of NM-174936 or gi31317306. In some embodiments, the neutralizing PCSK9 variant includes point mutations at least one of the following positions: 474, 620, or 670. In some embodiments, the point mutation is Val474Iso, Gly670Glu, and/or Glu620Gly.

### Vehicles

**[0146]** The term "vehicle" refers to a molecule that prevents degradation and/or increases half-life, reduces toxicity, reduces immunogenicity, or increases biological activity of a therapeutic protein when covalently or non-covalently bound to the therapeutic protein.

Exemplary vehicles include an Fc domain (including, for example, native Fcs, Fc variants, Fc domains, multimers, and dimers) as well as a linear polymer (e.g., polyethylene glycol (PEG), polylysine, dextran, etc.); a branched-chain polymer (see, for example, U.S. Pat. No. 4,289,872 to Denkenwalter et al., issued Sep. 15, 1981; U.S. Pat. No. 5,229,490 to Tam, issued Jul. 20, 1993; WO 93/21259 by Frechet et al., published Oct. 28, 1993); a lipid; a cholesterol group (such as a steroid); a carbohydrate or oligosaccharide; or any natural or synthetic protein, polypeptide or peptide that binds to a salvage receptor. Vehicles are further described in U.S. Pat. No. 6,660,843, herein incorporated by reference in its entirety. In some embodiments, multiple vehicles are used, for example, Fc's at each terminus or an Fc at a terminus and a PEG group at the other terminus or a sidechain. In some embodiments, the neutralizing PCSK9 variant is combined, associated, mixed, or bonded to any one or more of the above vehicles.

**[0147]** An alternative vehicle would be a protein, polypeptide, peptide, antibody, antibody fragment, or small molecule (e.g., a peptidomimetic compound) capable of binding to a salvage receptor. For example, one could use as a vehicle a polypeptide as described in U.S. Pat. No. 5,739,277, issued Apr. 14, 1998 to Presta et al. Peptides could also be selected by phage display for binding to the FcRn salvage receptor. Such salvage receptor-binding compounds are also included within the meaning of "vehicle" and are within the scope of this invention. Such vehicles should be selected for increased half-life (e.g., by avoiding sequences recognized by proteases) and decreased immunogenicity (e.g., by favoring non-immunogenic sequences, as discovered in antibody humanization).

**[0148]** As noted above, polymer vehicles can also be used. Various means for attaching chemical moieties useful as vehicles are currently available, see e.g., Patent Cooperation Treaty ("PCT") International Publication No. WO 96/11953, entitled "N-Terminally Chemically Modified Protein Compositions and Methods," herein incorporated by reference in its entirety. This PCT publication discloses, among other things, the selective attachment of water soluble polymers to the N-terminus of proteins.

**[0149]** In some embodiments, the polymer vehicle is polyethylene glycol (PEG). The PEG group can be of any convenient molecular weight and can be linear or branched. The average molecular weight of the PEG will preferably range from about 2 kiloDalton ("kD") to about 100 kDa and more preferably from about 5 kDa to about 50 kDa. The PEG groups will generally be attached to the neutralizing PCSK9 variant via acylation or reductive alkylation

through a reactive group on the PEG moiety (e.g., an aldehyde, amino, thiol, or ester group) to a reactive group on the inventive compound (e.g., an aldehyde, amino, or ester group).

**[0150]** In some embodiments, a useful strategy for the PEGylation of synthetic peptides involves combining, through forming a conjugate linkage in solution, a peptide and a PEG moiety, each bearing a special functionality that is mutually reactive toward the other. The peptides can be easily prepared with conventional solid phase synthesis. The peptides are "preactivated" with an appropriate functional group at a specific site. The precursors are purified and fully characterized prior to reacting with the PEG moiety. Ligation of the peptide with PEG usually takes place in aqueous phase and can be easily monitored by reverse phase analytical HPLC. The PEGylated peptides can be easily purified by preparative HPLC and characterized by analytical HPLC, amino acid analysis and laser desorption mass spectrometry.

**[0151]** Polysaccharide polymers are another type of water soluble polymer which can be used for protein modification. Dextrans are polysaccharide polymers comprised of individual subunits of glucose predominantly linked by alpha 1-6 linkages. The dextran itself is available in many molecular weight ranges, and is readily available in molecular weights from about 1 kD to about 70 kD. Dextran is a suitable water soluble polymer for use as a vehicle by itself or in combination with another vehicle (e.g., Fc). See, for example, WO 96/11953 and WO 96/05309. The use of dextran conjugated to therapeutic or diagnostic immunoglobulins has been reported; see, for example, European Patent Publication No. 0 315 456, which is hereby incorporated by reference. Dextran of about 1 kD to about 20 kD can be used.

**[0152]** In another embodiment a vehicle is a non-Fc peptide or polypeptide known or believed to prevent degradation and/or increases half-life, reduces toxicity, reduces immunogenicity, or increases biological activity of a therapeutic protein. Example of such a protein vehicle include transthyretin or HSA protein fusions. These vehicles can be fused to a PCSK9 variant.

#### *Linkers*

**[0153]** Any "linker" group is optional. When present, its chemical structure is not critical, since it serves primarily as a spacer. The linker can be made up of amino acids linked together by peptide bonds. Thus, in some embodiments, the linker is made up of from 1 to 20 amino acids linked by peptide bonds, wherein the amino acids are selected from the 20 naturally

occurring amino acids. Some of these amino acids can be glycosylated, as is well understood by those in the art. In some embodiments, the 1 to 20 amino acids are selected from glycine, alanine, proline, asparagine, glutamine, and lysine. In some embodiments, a linker is made up of a majority of amino acids that are sterically unhindered, such as glycine and alanine. In some embodiments, linkers are polyglycines (particularly (Gly)<sub>4</sub>, (Gly)<sub>5</sub>), poly(Gly-Ala), and polyalanines. Other specific examples of linkers are: (Gly)<sub>3</sub> Lys(Gly)<sub>4</sub>; (Gly)<sub>3</sub> AsnGlySer(Gly)<sub>2</sub>; (Gly)<sub>3</sub> Cys(Gly)<sub>4</sub>; and GlyProAsnGlyGly.

**[0154]** To explain the above nomenclature, for example, (Gly)<sub>3</sub> Lys(Gly)<sub>4</sub> means Gly-Gly-Gly-Lys-Gly-Gly-Gly-Gly. Combinations of Gly and Ala are also preferred. The linkers shown here are exemplary and can be much longer and can include other residues.

**[0155]** Non-peptide linkers are also possible. For example, alkyl linkers such as --NH--(CH<sub>2</sub>)<sub>s</sub>--C(O)--, wherein s=2-20 could be used. These alkyl linkers can further be substituted by any non-sterically hindering group such as lower alkyl (e.g., C<sub>1</sub>--C<sub>6</sub>) lower acyl, halogen (e.g., Cl, Br), CN, NH<sub>2</sub>, phenyl, etc. An exemplary non-peptide linker is a PEG linker, wherein the linker has a molecular weight of 100 to 5000 kD, for example, 100 to 500 kD. The peptide linkers can be altered to form derivatives in the same manner as described above.

### Derivatives

**[0156]** In some embodiments, the neutralizing PCSK9 variant (and/or the vehicle) is derivatized. Such derivatives can improve the solubility, absorption, biological half life, and the like of the compounds. The moieties can alternatively eliminate or attenuate any undesirable side-effect of the compounds and the like. In some embodiments, the moiety can add additional properties to the molecule as a whole. Exemplary derivatives are provided herein.

**[0157]** The neutralizing PCSK9 variant or some portion thereof is cyclic. For example, the peptide portion can be modified to contain two or more Cys residues (e.g., in the linker), which could cyclize by disulfide bond formation.

**[0158]** The neutralizing PCSK9 variant is cross-linked or is rendered capable of cross-linking between molecules. For example, the peptide portion can be modified to contain one Cys residue and thereby be able to form an intermolecular disulfide bond with a like molecule. The compound can also be cross-linked through its C-terminus.

**[0159]** One or more peptidyl [--C(O)NR--] linkages (bonds) is replaced by a non-peptidyl linkage. Exemplary non-peptidyl linkages are --CH<sub>2</sub>-carbamate [--CH<sub>2</sub>--OC(O)NR--], phosphonate, --CH<sub>2</sub>-sulfonamide [--CH<sub>2</sub>--S(O)<sub>2</sub>NR--], urea [--NHC(O)NH--], --CH<sub>2</sub>-secondary amine, and alkylated peptide [--C(O)NR<sub>6</sub>-- wherein R<sub>6</sub> is lower alkyl].

**[0160]** The N-terminus is derivatized. Typically, the N-terminus can be acylated or modified to a substituted amine. Exemplary N-terminal derivative groups include --NRR<sub>1</sub> (other than --NH<sub>2</sub>), --NRC(O)R<sub>4</sub>, --NRC(O)OR<sub>1</sub>, --NRS(O)<sub>2</sub>R<sub>1</sub>, --NHC(O)NHR<sub>1</sub>, succinimide, or benzyloxycarbonyl-NH-- (CBZ--NH--), wherein R and R<sub>1</sub> are each independently hydrogen or lower alkyl and wherein the phenyl ring can be substituted with 1 to 3 substituents selected from the group consisting of C<sub>1</sub>-C<sub>4</sub> alkyl, C<sub>1</sub>-C<sub>4</sub> alkoxy, chloro, and bromo.

**[0161]** The free C-terminus is derivatized. Typically, the C-terminus is esterified or amidated. For example, one can use methods described in the art to add (NH--CH<sub>2</sub>--CH<sub>2</sub>--NH<sub>2</sub>)<sub>2</sub> to neutralizing PCSK9 variants. Likewise, one can use methods described in the art to add --NH<sub>2</sub> to neutralizing PCSK9 variants. Exemplary C-terminal derivative groups include, for example, --C(O)R<sub>2</sub> wherein R<sub>2</sub> is lower alkoxy or --NR<sub>3</sub>R<sub>4</sub> wherein R<sub>3</sub> and R<sub>4</sub> are independently hydrogen or C<sub>1</sub>-C<sub>8</sub> alkyl (preferably C<sub>1</sub>-C<sub>4</sub> alkyl).

**[0162]** A disulfide bond is replaced with another, preferably more stable, cross-linking moiety (*e.g.*, an alkylene). See, *e.g.*, Bhatnagar et al. (1996), *J. Med. Chem.* 39: 3814-9; Alberts et al. (1993) Thirteenth Am. Pep. Symp., 357-9. 8. One or more individual amino acid residues are modified. Various derivatizing agents are known to react specifically with selected sidechains or terminal residues, as described in detail below.

**[0163]** Lysinyl residues and amino terminal residues can be reacted with succinic or other carboxylic acid anhydrides, which reverse the charge of the lysinyl residues. Other suitable reagents for derivatizing alpha-amino-containing residues include imidoesters such as methyl picolinimidate; pyridoxal phosphate; pyridoxal; chloroborohydride; trinitrobenzenesulfonic acid; O-methylisourea; 2,4 pentanedione; and transaminase-catalyzed reaction with glyoxylate. Arginyl residues can be modified by reaction with any one or combination of several conventional reagents, including phenylglyoxal, 2,3-butanedione, 1,2-cyclohexanedione, and ninhydrin. Derivatization of arginyl residues requires that the reaction be performed in alkaline conditions because of the high pKa of the guanidine functional group. Furthermore, these reagents can react with the groups of lysine as well as the arginine epsilon-amino group.

Specific modification of tyrosyl residues has been studied extensively, with particular interest in introducing spectral labels into tyrosyl residues by reaction with aromatic diazonium compounds or tetranitromethane. Most commonly, N-acetylimidazole and tetranitromethane are used to form O-acetyl tyrosyl species and 3-nitro derivatives, respectively. Carboxyl sidechain groups (aspartyl or glutamyl) can be selectively modified by reaction with carbodiimides ( $R'-N=C=N-R'$ ) such as 1-cyclohexyl-3-(2-morpholinyl-(4-ethyl) carbodiimide or 1-ethyl-3-(4-azonia-4,4-dimethylpentyl) carbodiimide. Furthermore, aspartyl and glutamyl residues can be converted to asparaginyl and glutaminyl residues by reaction with ammonium ions. Glutaminyl and asparaginyl residues can be deamidated to the corresponding glutamyl and aspartyl residues. Alternatively, these residues are deamidated under mildly acidic conditions. Cysteiny residues can be replaced by amino acid residues or other moieties either to eliminate disulfide bonding or, conversely, to stabilize cross-linking. See, e.g., Bhatnagar et al. (1996), J. Med. Chem. 39: 3814-9.

**[0164]** Derivatization with bifunctional agents can be useful for cross-linking the peptides or their functional derivatives to a water-insoluble support matrix or to other macromolecular vehicles. Commonly used cross-linking agents include, e.g., 1,1-bis(diazoacetyl)-2-phenylethane, glutaraldehyde, N-hydroxysuccinimide esters, for example, esters with 4-azidosalicylic acid, homobifunctional imidoesters, including disuccinimidyl esters such as 3,3'-dithio-bis(succinimidylpropionate), and bifunctional maleimides such as bis-N-maleimido-1,8-octane. Derivatizing agents such as methyl-3-[(p-azidophenyl)dithio]propioimidate yield photoactivatable intermediates that are capable of forming crosslinks in the presence of light. Alternatively, reactive water-insoluble matrices such as cyanogen bromide-activated carbohydrates and the reactive substrates described in U.S. Pat. Nos. 3,969,287; 3,691,016; 4,195,128; 4,247,642; 4,229,537; and 4,330,440 are employed for protein immobilization.

**[0165]** Carbohydrate (oligosaccharide) groups can be attached to sites that are known to be glycosylation sites in proteins. Generally, O-linked oligosaccharides are attached to serine (Ser) or threonine (Thr) residues while N-linked oligosaccharides are attached to asparagine (Asn) residues when they are part of the sequence Asn-X-Ser/Thr, where X can be any amino acid except proline. X is preferably one of the 19 naturally occurring amino acids other than proline. The structures of N-linked and O-linked oligosaccharides and the sugar residues found

in each type are different. One type of sugar that is commonly found on both is N-acetylneuraminic acid (referred to as sialic acid). Sialic acid is usually the terminal residue of both N-linked and O-linked oligosaccharides and, by virtue of its negative charge, can confer acidic properties to the glycosylated compound. Such site(s) can be incorporated in the linker of the neutralizing PCSK9 variant and can be glycosylated by a cell during recombinant production of the polypeptide compounds (e.g., in mammalian cells such as CHO, BHK, COS). However, such sites can further be glycosylated by synthetic or semi-synthetic procedures known in the art.

**[0166]** Other possible modifications include hydroxylation of proline and lysine, phosphorylation of hydroxyl groups of seryl or threonyl residues, oxidation of the sulfur atom in Cys, methylation of the alpha-amino groups of lysine, arginine, and histidine side chains. Creighton, *Proteins: Structure and Molecule Properties* (W. H. Freeman & Co., San Francisco), pp. 79-86 (1983).

**[0167]** In some embodiments, cysteine(s), arginine(s), and/or lysine(s) can be introduced into the neutralizing PCSK9 variant as a site(s) of pegylation.

**[0168]** Neutralizing PCSK9 variants can be changed at the DNA level, as well. The DNA sequence of any portion of the compound can be changed to codons more compatible with the chosen host cell. Codons can be substituted to eliminate restriction sites or to include silent restriction sites, which can aid in processing of the DNA in the selected host cell. The vehicle, linker and peptide DNA sequences can be modified to include any of the foregoing sequence changes.

**[0169]** In some embodiments, neutralizing PCSK9 variants include glycosylation wherein the number and/or type of glycosylation site has been altered compared to the amino acid sequences of a parent polypeptide. In some embodiments, protein variants comprise a greater or a lesser number of N-linked glycosylation sites than the native protein. An N-linked glycosylation site is characterized by the sequence: Asn-X-Ser or Asn-X-Thr, wherein the amino acid residue designated as X can be any amino acid residue except proline. The substitution of amino acid residues to create this sequence provides a potential new site for the addition of an N-linked carbohydrate chain. Alternatively, substitutions which eliminate this sequence will remove an existing N-linked carbohydrate chain. Also provided is a rearrangement of N-linked carbohydrate chains wherein one or more N-linked glycosylation sites (typically those that are naturally occurring) are eliminated and one or more new N-linked sites are created. Additional

preferred variants include cysteine variants wherein one or more cysteine residues are deleted from or substituted for another amino acid (e.g., serine) as compared to the parent amino acid sequence. Cysteine variants generally have fewer cysteine residues than the native protein, and typically have an even number to minimize interactions resulting from unpaired cysteines.

**[0170]** In some embodiments, the neutralizing PCSK9 variant is associated with at least a part of an antibody. In some embodiments, the neutralizing PCSK9 variant is part of an antibody fusion protein. As will be appreciated by one of skill in the art, a fusion protein can include various antibody sequences. In some embodiments, the neutralizing PCSK9 variant is fused to a full length antibody. In some embodiments, the neutralizing PCSK9 variant is fused to an antibody that binds to LDLR, thereby further increasing the likelihood that the neutralizing PCSK9 variant will be directed to its target. Non-neutralizing antibody fusions also form an aspect of the present invention. In this embodiment the non-neutralizing antibody fused to a PCSK9 variant can perform the function of increasing the half life of the PCSK9 variant.

**[0171]** In some embodiments, as noted above, the neutralizing PCSK9 variant is fused to a fragment of an antibody, such as a Fc domain. In some embodiments, the fusion protein will comprise, consist, or consist essentially of a Fc domain. In some embodiments, the fusion protein will comprise, consist, or consist essentially of a native Fc region. In some embodiments, the antibody or binding fragment thereof that is attached or fused to the neutralizing PCSK9 variant will bind to LDLR.

**[0172]** In some embodiments, any of the herein disclosed neutralizing PCSK9 variants, including antibody fusions, can be made from nucleic acid sequences encoding such protein sequences. Thus, nucleic acid sequences, vectors, and cells comprising these compounds are also contemplated herein.

**[0173]** In some embodiments, the neutralizing PCSK9 variant binds to a LDLR variant. In some embodiments, the variants of LDLR are at least 50% identical to human LDLR. It is noted that variants of LDLR are known to those of skill in the art (e.g., Brown MS et al, "Calcium cages, acid baths and recycling receptors" Nature 388: 629-630, 1997). In some embodiments, the neutralizing PCSK9 variant can raise the level of effective LDLR in heterozygote familial hypercholesterolemia (where a loss-of function variant of LDLR is present). Three exemplary LDLR sequences are shown in FIGS. 11-1L (mouse, cynomolgus monkey, and human amino acid sequences). In some embodiments, the neutralizing PCSK9

variant will bind to a protein comprising at least one of the sequences in FIG. 11-1L. In some embodiments the native PCSK9 variant will bind to a LDLR variant that comprises, consists, or consists essentially of the consensus sequence in FIGS. 11-1L. In some embodiments, the LDLR variant will comprise each of the conserved amino acids identified in the consensus sequence in FIGS. 11-1L. As will be appreciated by one of skill in the art, the space(s) in the consensus sequence can be filled with any of the other amino acids in the comparison at the corresponding location, or, in some embodiments, any amino acid.

**[0174]** In some embodiments, the neutralizing PCSK9 variant binds to and blocks LDLR from binding to other variants of PCSK9. These variants of PCSK9 are at least 50%, 50-60, 60-70, 70-80, 80-90, 90-95, 95-99, or greater percent identity to the form of PCSK9 depicted in FIG. 1A. In some embodiments, the neutralizing PCSK9 variant is a human variant, such as variants at position 474. In some embodiments, the amino acid at position 474 is valine (as in other humans) or threonine (as in cyno and mouse).

**[0175]** In some embodiments, variants of PCSK9 are contemplated, wherein one freely mutates the amino acids on the exterior of PCSK9, while conservatively altering those inside of PCSK9. In some embodiments, variants of PCSK9 are contemplated where one does not or only conservatively alters those residues on the binding surface between PCSK9 and LDLR, while freely or conservatively altering the residues on the rest of the PCSK9 surface or the inside of the protein. Various neutralizing PCSK9 variants are discussed herein and in the above sections.

**[0176]** In some embodiments, the neutralizing PCSK9 variant comprises a protein that has a sequence that start at residues 31 or 61 of SEQ ID NO: 3 (and variants thereof) and ends at any one of residues 447, 448, 449, 450, 451, 452, or 453 of SEQ ID NO: 3 (and variants thereof). Thus, in some embodiments, the neutralizing PCSK9 variant can include residues 31-447, 31-448, 31-449, 31-450, 31-451, 31-452, 31-453, 61-447, 61-448, 61-449, 61-450, 61-451, 61-452, and 61-453 of SEQ ID NO: 3 (and variants thereof) and/or a consensus sequence (*e.g.*, shown in FIGs. 1C-1E, FIG. 1R<sub>1</sub>-1R<sub>2</sub> (SEQ ID NO: 30) and FIG. F-H (for the Cat domain). In some embodiments, variants can be 50% or more (*e.g.*, 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, or 99-100 percent) identical to the pro/cat domain of SEQ ID NO: 3 over the specific sequence length. In some embodiments, the neutralizing PCSK9 variant is at least 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 96, 97, 98, 99%, or more identical for the conserved sections of the pro/cat

domain. In some embodiments, while the sections of the pro/cat domain in the neutralizing PCSK9 variant that are 100% conserved (e.g., as shown in FIGs. 1C-1E) are present, the remaining positions can be changed. In some embodiments, the changes in these remaining positions can result in a pro/cat section in the neutralizing PCSK9 variant that is 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, or 99-100 percent identical to the corresponding pro/cat domain of SEQ ID NO: 3.

**[0177]** Additionally, one skilled in the art can review structure-function studies identifying residues in similar polypeptides that are important for activity or structure. In view of such a comparison, one can predict the importance of amino acid residues in a protein that correspond to amino acid residues which are important for activity or structure in similar proteins. One skilled in the art can opt for chemically similar amino acid substitutions for such predicted important amino acid residues.

**[0178]** One skilled in the art can also analyze the three-dimensional structure and amino acid sequence in relation to that structure. In view of such information, one skilled in the art can predict the alignment of amino acid residues of a protein fragment with respect to its three dimensional structure. In some embodiments, one skilled in the art can choose not to make radical changes to amino acid residues predicted to be on the surface of the protein, since such residues can be involved in important interactions with other molecules. Moreover, one skilled in the art can generate and test variants containing a single amino acid substitution at each desired amino acid residue. The variants can then be screened using activity assays known to those skilled in the art, or as described in the Examples disclosed herein. Such variants can be used to gather information about suitable variants. For example, if one discovered that a change to a particular amino acid residue resulted in destroyed, undesirably reduced, or unsuitable activity, variants with such a change can be avoided. In other words, based on information gathered from such routine experiments, one skilled in the art can readily determine the amino acids where further substitutions should be avoided either alone or in combination with other mutations.

**[0179]** A number of scientific publications have been devoted to the prediction of secondary structure. See Moulton J., *Curr. Op. in Biotech.*, 7(4):422-427 (1996), Chou *et al.*, *Biochemistry*, 13(2):222-245 (1974); Chou *et al.*, *Biochemistry*, 113(2):211-222 (1974); Chou *et al.*, *Adv. Enzymol. Relat. Areas Mol. Biol.*, 47:45-148 (1978); Chou *et al.*, *Ann. Rev. Biochem.*,

47:251-276 and Chou *et al.*, *Biophys. J.*, 26:367-384 (1979). Moreover, computer programs are currently available to assist with predicting secondary structure. One method of predicting secondary structure is based upon homology modeling. For example, two polypeptides or proteins which have a sequence identity of greater than 30%, or similarity greater than 40% often have similar structural topologies. The recent growth of the protein structural database (PDB) has provided enhanced predictability of secondary structure, including the potential number of folds within a polypeptide's or protein's structure. *See* Holm *et al.*, *Nucl. Acid. Res.*, 27(1):244-247 (1999).

**[0180]** Additional methods of predicting secondary structure include "threading" (Jones, D., *Curr. Opin. Struct. Biol.*, 7(3):377-87 (1997); Sippl *et al.*, *Structure*, 4(1):15-19 (1996)), "profile analysis" (Bowie *et al.*, *Science*, 253:164-170 (1991); Gribskov *et al.*, *Meth. Enzym.*, 183:146-159 (1990); Gribskov *et al.*, *Proc. Nat. Acad. Sci. USA*, 84(13):4355-4358 (1987)), and "evolutionary linkage" (*See* Holm, *supra* (1999), and Brenner, *supra* (1997)).

**[0181]** According to certain embodiments, amino acid substitutions are those which: (1) reduce susceptibility to proteolysis, (2) reduce susceptibility to oxidation, (3) alter binding affinity for forming protein complexes, (4) alter binding affinities, and/or (4) confer or modify other physicochemical or functional properties on such polypeptides. According to certain embodiments, single or multiple amino acid substitutions (in some embodiments, conservative amino acid substitutions) can be made in the naturally-occurring sequence (in some embodiments, in the portion of the polypeptide outside the domain(s) forming intermolecular contacts). In some embodiments, a conservative amino acid substitution typically may not substantially change the structural characteristics of the parent sequence (e.g., a replacement amino acid should not tend to break a helix that occurs in the parent sequence, or disrupt other types of secondary structure that characterizes the parent sequence). Examples of art-recognized polypeptide secondary and tertiary structures are described in *Proteins, Structures and Molecular Principles* (Creighton, Ed., W. H. Freeman and Company, New York (1984)); *Introduction to Protein Structure* (C. Branden & J. Tooze, eds., Garland Publishing, New York, N.Y. (1991)); and Thornton *et al.*, *Nature*, 354:105 (1991), which are each incorporated herein by reference.

**[0182]** In some embodiments, the neutralizing PCSK9 variant (or nucleic acid sequence encoding it) is a variant if the nucleic acid sequence that encodes the particular neutralizing PCSK9 variant can selectively hybridize to any of the nucleic acid sequences that

encode the protein in SEQ ID NO: 3 under moderately stringent or stringent conditions. In one embodiment, suitable moderately stringent conditions include prewashing in a solution of 5XSSC; 0.5% SDS, 1.0 mM EDTA (pH 8.0); hybridizing at 50° C, -65° C, 5xSSC, overnight or, in the event of cross-species homology, at 45° C with 0.5xSSC; followed by washing twice at 65° C for 20 minutes with each of 2x, 0.5x and 0.2xSSC containing 0.1% SDS. Such hybridizing DNA sequences are also within the scope of this invention, as are nucleotide sequences that, due to code degeneracy, encode a variant that is encoded by a hybridizing DNA sequence and the amino acid sequences that are encoded by these nucleic acid sequences. In some embodiments, suitable high stringency conditions are used and include hybridization at about 65° C in 0.1xSSC. In some embodiments, suitable high stringency conditions include washing in 0.1xSSPE and 0.2% SDS at 65° C for 15 minutes. In some embodiments, suitable high stringency conditions include 31% v/v to 50% v/v formamide and 0.01M to 0.15M salt at 42° C and washing conditions of 0.1xSSC, 0.5% w/v SDS at 60° C. Such hybridizing DNA sequences are also within the scope of this invention, as are nucleotide sequences that, due to code degeneracy, encode a variant that is encoded by a hybridizing DNA sequence and the amino acid sequences that are encoded by these nucleic acid sequences.

**[0183]** The phrase "selectively hybridize" referred to in this context means to detectably and selectively bind. Such, polynucleotides, oligonucleotides, and fragments thereof selectively hybridize to nucleic acid strands under hybridization and wash conditions that minimize appreciable amounts of detectable binding to nonspecific nucleic acids. High stringency conditions can be used to achieve selective hybridization conditions as known in the art and discussed herein. Generally, the nucleic acid sequence homology between the polynucleotides, oligonucleotides, and fragments and a nucleic acid sequence of interest will be at least 80%, and more typically with preferably increasing homologies of at least 85%, 90%, 95%, 99%, and 100%. Two amino acid sequences are homologous if there is a partial or complete identity between their sequences. For example, 85% homology means that 85% of the amino acids are identical when the two sequences are aligned for maximum matching. Gaps (in either of the two sequences being matched) are allowed in maximizing matching; gap lengths of 5 or less are preferred with 2 or less being more preferred. Alternatively and preferably, two protein sequences (or polypeptide sequences derived from them of at least 30 amino acids in length) are homologous, as this term is used herein, if they have an alignment score of at more

than 5 (in standard deviation units) using the program ALIGN with the mutation data matrix and a gap penalty of 6 or greater. See Dayhoff, M. O., in Atlas of Protein Sequence and Structure, pp. 101-110 (Volume 5, National Biomedical Research Foundation (1972)) and Supplement 2 to this volume, pp. 1-10. The two sequences or parts thereof are more preferably homologous if their amino acids are greater than or equal to 50% identical when optimally aligned using the ALIGN program. The term "corresponds to" is used herein to mean that a polynucleotide sequence is homologous (i.e., is identical, not strictly evolutionarily related) to all or a portion of a reference polynucleotide sequence, or that a polypeptide sequence is identical to a reference polypeptide sequence. In contradistinction, the term "complementary to" is used herein to mean that the complementary sequence is homologous to all or a portion of a reference polynucleotide sequence. For illustration, the nucleotide sequence "TATAC" corresponds to a reference sequence "TATAC" and is complementary to a reference sequence "GTATA".

**[0184]** For example, a "conservative amino acid substitution" can involve a substitution of a native amino acid residue with a nonnative residue such that there is little or no effect on the polarity or charge of the amino acid residue at that position. Furthermore, any native residue in the polypeptide can also be substituted with alanine and/or arginine, as has been previously described for "alanine scanning mutagenesis" and "arginine scanning mutagenesis."

**[0185]** Desired amino acid substitutions (whether conservative or non-conservative) can be determined by those skilled in the art at the time such substitutions are desired. In some embodiments, amino acid substitutions can be used to identify important residues of PCSK9, or to increase or decrease the affinity of the neutralizing PCSK9 variant as described herein.

#### Antibodies to Neutralizing PCSK9 Variants

**[0186]** In some embodiments, antibodies to any of the sequences or neutralizing PCSK9 variants described herein can be made and used. These antibodies are selective for the neutralizing PCSK9 variant over native PCSK9. In some embodiments, the antibody binds to a neutralizing PCSK9 variant that consists essentially of the Pro/Cat domain of PCSK9. In some embodiments, the antibody is selective for this neutralizing PCSK9 variant over wild-type PCSK9.

**[0187]** As will be appreciated by one of skill in the art, the antibodies can be created by raising antibodies to the neutralizing PCSK9 variant and then identifying those antibodies that

will not bind (or will not bind as effectively as antibodies to native PCSK9) to native PCSK9. In some embodiments, the antibodies will bind to the neutralizing PCSK9 variant with a  $K_D$  that is at least 1, 1-10, 10-50, or 50-100% better than the  $K_D$  of the antibody to human PCSK9. In some embodiments, the antibodies will bind to the neutralizing PCSK9 variant with a  $K_D$  that is at least 2-5, 5-10, 10-50, 50-100, 100-1000, 1000-10,000, 10,000-100,000, or 100,000- $10^6$  better than the  $K_D$  of the antibody for the native PCSK9. As will be appreciated by one of skill in the art, as the neutralizing PCSK9 variant will have an inactive V domain that can be structurally different (and even absent) from the wild type PCSK9 protein, such selective antibodies will be readily attainable given the present disclosure. In some embodiments, an adjuvant is used with the neutralizing PCSK9 variant to create the above antibodies.

**[0188]** As will be appreciated by one of skill in the art, the antibodies can be used to selectively observe the amount of the neutralizing PCSK9 variant without inadvertently detecting native PCSK9 as well.

#### Cell Lines and Expression of Neutralizing PCSK9 Variants

**[0189]** In some embodiments, neutralizing PCSK9 variants can be expressed in cell lines. In some embodiments, sequences encoding particular neutralizing PCSK9 variants can be used for transformation of a suitable mammalian host cell. According to certain embodiments, transformation can be by any known method for introducing polynucleotides into a host cell, including, for example packaging the polynucleotide in a virus (or into a viral vector) and transducing a host cell with the virus (or vector) or by transfection procedures known in the art, as exemplified by U.S. Pat. Nos. 4,399,216, 4,912,040, 4,740,461, and 4,959,455 (which patents are hereby incorporated herein by reference for any purpose). In some embodiments, the transformation procedure used can depend upon the host to be transformed. Methods for introduction of heterologous polynucleotides into mammalian cells are well known in the art and include, but are not limited to, dextran-mediated transfection, calcium phosphate precipitation, polybrene mediated transfection, protoplast fusion, electroporation, encapsulation of the polynucleotide(s) in liposomes, and direct microinjection of the DNA into nuclei.

**[0190]** Mammalian cell lines available as hosts for expression are well known in the art and include, but are not limited to, many immortalized cell lines available from the American Type Culture Collection (ATCC), including but not limited to Chinese hamster ovary (CHO)

cells, HeLa cells, baby hamster kidney (BHK) cells, monkey kidney cells (COS), human hepatocellular carcinoma cells (e.g., Hep G2), and a number of other cell lines. In some embodiments, cell lines can be selected through determining which cell lines have high expression levels. Appropriate expression vectors for mammalian host cells are well known.

**[0191]** In some embodiments, any of a variety of expression vector/host systems can be utilized to express polynucleotide molecules encoding polypeptides comprising one or more protein segments. Such systems include, but are not limited to, microorganisms, such as bacteria transformed with recombinant bacteriophage, plasmid, or cosmid DNA expression vectors; yeast transformed with yeast expression vectors; insect cell systems infected with virus expression vectors (e.g., baculovirus); plant cell systems transfected with virus expression vectors (e.g., cauliflower mosaic virus, CaMV, tobacco mosaic virus, TMV) or transformed with bacterial expression vectors (e.g., Ti or pBR322 plasmid); or animal cell systems.

**[0192]** In some embodiments, a polypeptide comprising one or more neutralizing PCSK9 variant is recombinantly expressed in yeast. Certain such embodiments use commercially available expression systems, e.g., the *Pichia* Expression System (Invitrogen, San Diego, CA), following the manufacturer's instructions. In some embodiments, such a system relies on the pre-pro-alpha sequence to direct secretion. In some embodiments, transcription of the insert is driven by the alcohol oxidase (AOX1) promoter upon induction by methanol.

**[0193]** In some embodiments, a secreted polypeptide comprising one or more neutralizing PCSK9 variant is purified from yeast growth medium. In some embodiments, the methods used to purify a polypeptide from yeast growth medium is the same as those used to purify the polypeptide from bacterial and mammalian cell supernatants.

**[0194]** In some embodiments, a nucleic acid encoding a polypeptide comprising one or more neutralizing PCSK9 variant is cloned into a baculovirus expression vector, such as pVL1393 (PharMingen, San Diego, CA). In some embodiments, such a vector can be used according to the manufacturer's directions (PharMingen) to infect *Spodoptera frugiperda* cells in sF9 protein-free media and to produce recombinant polypeptide. In some embodiments, a polypeptide is purified and concentrated from such media using a heparin-Sepharose column (Pharmacia).

**[0195]** In some embodiments, a polypeptide comprising one or more neutralizing PCSK9 variant is expressed in an insect system. Certain insect systems for polypeptide

expression are well known to those of skill in the art. In one such system, *Autographa californica* nuclear polyhedrosis virus (AcNPV) is used as a vector to express foreign genes in *Spodoptera frugiperda* cells or in *Trichoplusia* larvae. In some embodiments, a nucleic acid molecule encoding a polypeptide can be inserted into a nonessential gene of the virus, for example, within the polyhedrin gene, and placed under control of the promoter for that gene. In some embodiments, successful insertion of a nucleic acid molecule will render the nonessential gene inactive. In some embodiments, that inactivation results in a detectable characteristic. For example, inactivation of the polyhedrin gene results in the production of virus lacking coat protein.

**[0196]** In some embodiments, recombinant viruses can be used to infect *S. frugiperda* cells or *Trichoplusia* larvae. See, e.g., Smith *et al.*, *J. Virol.*, 46: 584 (1983); Engelhard *et al.*, *Proc. Nat. Acad. Sci. (USA)*, 91: 3224-7 (1994).

**[0197]** In some embodiments, polypeptides comprising one or more neutralizing PCSK9 variant made in bacterial cells are produced as insoluble inclusion bodies in the bacteria. In some embodiments, host cells comprising such inclusion bodies are collected by centrifugation; washed in 0.15 M NaCl, 10 mM Tris, pH 8, 1 mM EDTA; and treated with 0.1 mg/ml lysozyme (Sigma, St. Louis, MO) for 15 minutes at room temperature. In some embodiments, the lysate is cleared by sonication, and cell debris is pelleted by centrifugation for 10 minutes at 12,000 X g. In some embodiments, the polypeptide-containing pellet is resuspended in 50 mM Tris, pH 8, and 10 mM EDTA; layered over 50% glycerol; and centrifuged for 30 minutes at 6000 X g. In some embodiments, that pellet can be resuspended in standard phosphate buffered saline solution (PBS) free of Mg<sup>++</sup> and Ca<sup>++</sup>. In some embodiments, the polypeptide is further purified by fractionating the resuspended pellet in a denaturing SDS polyacrylamide gel (See, e.g., Sambrook *et al.*, *supra*). In some embodiments, such a gel can be soaked in 0.4 M KCl to visualize the protein, which can be excised and electroeluted in gel-running buffer lacking SDS. According to certain embodiments, a Glutathione-S-Transferase (GST) fusion protein is produced in bacteria as a soluble protein. In some embodiments, such GST fusion protein is purified using a GST Purification Module (Pharmacia).

**[0198]** In some embodiments, it is desirable to “refold” certain polypeptides, e.g., polypeptides comprising one or more neutralizing PCSK9 variant. In some embodiments, such polypeptides are produced using certain recombinant systems discussed herein. In some

embodiments, polypeptides are “refolded” and/or oxidized to form desired tertiary structure and/or to generate disulfide linkages. In some embodiments, such structure and/or linkages are related to certain biological activity of a polypeptide. In some embodiments, refolding is accomplished using any of a number of procedures known in the art. Exemplary methods include, but are not limited to, exposing the solubilized polypeptide agent to a pH typically above 7 in the presence of a chaotropic agent. An exemplary chaotropic agent is guanidine. In some embodiments, the refolding/oxidation solution also contains a reducing agent and the oxidized form of that reducing agent. In some embodiments, the reducing agent and its oxidized form are present in a ratio that will generate a particular redox potential that allows disulfide shuffling to occur. In some embodiments, such shuffling allows the formation of cysteine bridges. Exemplary redox couples include, but are not limited to, cysteine/cystamine, glutathione/dithiobisGSH, cupric chloride, dithiothreitol DTT/dithiane DTT, and 2-mercaptoethanol (bME)/dithio-bME. In some embodiments, a co-solvent is used to increase the efficiency of refolding. Exemplary cosolvents include, but are not limited to, glycerol, polyethylene glycol of various molecular weights, and arginine.

**[0199]** In some embodiments, a polypeptide comprising one or more neutralizing PCSK9 variants is substantially purified. Certain protein purification techniques are known to those of skill in the art. In some embodiments, protein purification involves crude fractionation of polypeptide fractionations from non-polypeptide fractions. In some embodiments, polypeptides are purified using chromatographic and/or electrophoretic techniques. Exemplary purification methods include, but are not limited to, precipitation with ammonium sulphate; precipitation with PEG; immunoprecipitation; heat denaturation followed by centrifugation; chromatography, including, but not limited to, affinity chromatography (e.g., Protein-A-Sepharose), ion exchange chromatography, exclusion chromatography, and reverse phase chromatography; gel filtration; hydroxyapatite chromatography; isoelectric focusing; polyacrylamide gel electrophoresis; and combinations of such and other techniques. In some embodiments, a polypeptide is purified by fast protein liquid chromatography or by high pressure liquid chromatography (HPLC). In some embodiments, purification steps can be changed or certain steps can be omitted, and still result in a suitable method for the preparation of a substantially purified polypeptide.

**[0200]** In some embodiments, one quantitates the degree of purification of a polypeptide preparation. Certain methods for quantifying the degree of purification are known to those of skill in the art. Certain exemplary methods include, but are not limited to, determining the specific binding activity of the preparation and assessing the amount of a polypeptide within a preparation by SDS/PAGE analysis. Certain exemplary methods for assessing the amount of purification of a polypeptide preparation comprise calculating the binding activity of a preparation and comparing it to the binding activity of an initial extract. In some embodiments, the results of such a calculation are expressed as “fold purification.” The units used to represent the amount of binding activity depend upon the particular assay performed.

**[0201]** In some embodiments, a polypeptide comprising one or more neutralizing PCSK9 variants is partially purified. In some embodiments, partial purification can be accomplished by using fewer purification steps or by utilizing different forms of the same general purification scheme. For example, in some embodiments, cation-exchange column chromatography performed utilizing an HPLC apparatus will generally result in a greater “fold purification” than the same technique utilizing a low-pressure chromatography system. In some embodiments, methods resulting in a lower degree of purification can have advantages in total recovery of polypeptide, or in maintaining binding activity of a polypeptide.

**[0202]** In certain instances, the electrophoretic migration of a polypeptide can vary, sometimes significantly, with different conditions of SDS/PAGE. *See, e.g., Capaldi et al., Biochem. Biophys. Res. Comm., 76: 425 (1977).* It will be appreciated that under different electrophoresis conditions, the apparent molecular weights of purified or partially purified polypeptide can be different.

#### Examples of Therapeutic Uses and Pharmaceutical Compositions

**[0203]** In certain instances, PCSK9 activity correlates with a number of human disease states. For example, in certain instances, too much or too little PCSK9 activity correlates with certain conditions, such as hypercholesterolemia. Therefore, in certain instances, modulating PCSK9 activity can be therapeutically useful.

**[0204]** In some embodiments, a neutralizing PCSK9 variant is used to modulate at least one native PCSK9 activity (*e.g.*, binding of native PCSK9 to LDLR). Such methods can

treat and/or prevent and/or reduce the risk of disorders that relate to elevated serum cholesterol levels or in which elevated cholesterol levels are relevant.

**[0205]** As will be appreciated by one of skill in the art, in light of the present disclosure, disorders that relate to, involve, or can be influenced by varied cholesterol, LDL, or LDLR levels can be addressed by various embodiments of the neutralizing PCSK9 variants. The neutralizing PCSK9 variants can be used in a variety of therapeutic applications. For example, in some embodiments the neutralizing PCSK9 variants are useful for treating conditions associated with PCSK9, such as cholesterol related disorders (or “serum cholesterol related disorders”) such as hypercholesterolemia, as further described herein. Some of the neutralizing PCSK9 variants described herein are useful in treating consequences, symptoms, and/or the pathology associated with PCSK9 activity.

**[0206]** In some embodiments, a “cholesterol related disorder” (which includes “serum cholesterol related disorders”) includes any one or more of the following: hypercholesterolemia, heart disease, metabolic syndrome, diabetes, coronary heart disease, stroke, cardiovascular diseases, Alzheimers disease and generally dyslipidemias, which can be manifested, for example, by an elevated total serum cholesterol, elevated LDL, elevated triglycerides, elevated VLDL, and/or low HDL. Some non-limiting examples of primary and secondary dyslipidemias that can be treated using a neutralizing PCSK9 variant, either alone, or in combination with one or more other agents include the metabolic syndrome, diabetes mellitus, familial combined hyperlipidemia, familial hypertriglyceridemia, familial hypercholesterolemias, including heterozygous hypercholesterolemia, homozygous hypercholesterolemia, familial defective apolipoprotein B-100; polygenic hypercholesterolemia; remnant removal disease, hepatic lipase deficiency; dyslipidemia secondary to any of the following: dietary indiscretion, hypothyroidism, drugs including estrogen and progestin therapy, beta-blockers, and thiazide diuretics; nephrotic syndrome, chronic renal failure, Cushing's syndrome, primary biliary cirrhosis, glycogen storage diseases, hepatoma, cholestasis, acromegaly, insulinoma, isolated growth hormone deficiency, and alcohol-induced hypertriglyceridemia. Neutralizing PCSK9 variants can also be useful in preventing or treating atherosclerotic diseases, such as, for example, coronary heart disease, coronary artery disease, peripheral arterial disease, stroke (ischemic and hemorrhagic), angina pectoris, or cerebrovascular disease and acute coronary syndrome, myocardial infarction. In some embodiments, the neutralizing PCSK9 variant is

useful in reducing the risk of: nonfatal heart attacks, fatal and non-fatal strokes, certain types of heart surgery, hospitalization for heart failure, chest pain in patients with heart disease, and/or cardiovascular events because of established heart disease such as prior heart attack, prior heart surgery, and/or chest pain with evidence of clogged arteries. In some embodiments, a neutralizing PCSK9 variant of PCSK9 and methods can be used to reduce the risk of recurrent cardiovascular events.

**[0207]** As will be appreciated by one of skill in the art, diseases or disorders that are generally addressable (either treatable or preventable) through the use of statins can also benefit from the application of the instant neutralizing PCSK9 variants. In addition, in some embodiments, disorders or diseases that can benefit from the prevention of cholesterol synthesis or increased LDLR expression can also be treated by various embodiments of the neutralizing PCSK9 variants. In addition, as will be appreciated by one of skill in the art, the use of the neutralizing PCSK9 variants can be especially useful in the treatment of Diabetes. Not only is Diabetes a risk factor for coronary heart disease, but insulin increases the expression of PCSK9. That is, people with Diabetes have elevated plasma lipid levels (which can be related to high PCSK9 levels) and can benefit from lowering those levels or modulating the activity of those levels. This is generally discussed in more detail in Costet et al. ("Hepatic PCSK9 Expression is Regulated by Nutritional Status via Insulin and Sterol Regulatory Element-binding Protein 1C", *J. Biol. Chem.*, 281: 6211-6218, 2006), the entirety of which is incorporated herein by reference.

**[0208]** In some embodiments, the neutralizing PCSK9 variant is administered to those who have diabetes mellitus, abdominal aortic aneurysm, atherosclerosis and/or peripheral vascular disease in order to decrease their serum cholesterol levels to a safer range. In some embodiments, the neutralizing PCSK9 variant is administered to patients at risk of developing any of the herein described disorders. In some embodiments, the neutralizing PCSK9 variants are administered to subjects that smoke, have hypertension or a familial history of early heart attacks.

**[0209]** In some embodiments, a subject is administered a neutralizing PCSK9 variant if they are at a moderate risk or higher on the 2004 NCEP treatment goals. In some embodiments, the neutralizing PCSK9 variant is administered to a subject if the subject's LDL cholesterol level is greater than 160 mg/dl. In some embodiments, the neutralizing PCSK9 variant is administered if the subject's LDL cholesterol level is greater than 130 (and they have a

moderate or moderately high risk according to the 2004 NCEP treatment goals). In some embodiments, the neutralizing PCSK9 variant is administered if the subjects LDL cholesterol level is greater than 100 (and they have a high or very high risk according to the 2004 NCEP treatment goals). In some embodiments, the neutralizing PCSK9 variant is administered if the subjects LDL cholesterol level does not reach a goal of less than 90, or less than 80, or less than 70 mg/dl. In some embodiments, the neutralizing PCSK9 variant is administered if the subject is intolerant or resistant to other lipid modifying regimens and medications.

**[0210]** A physician will be able to select an appropriate treatment based on the indications and target lipid levels depending on the individual profile of a particular patient. One well-accepted standard for guiding treatment of hyperlipidemia is the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of the High Blood Cholesterol in Adults (Adult Treatment Panel III) Final Report, National Institutes of Health, NIH Publication No. 02-5215 (2002), the printed publication of which is hereby incorporated by reference in its entirety.

**[0211]** In some embodiments, neutralizing PCSK9 variants to PCSK9 are used to decrease the amount of PCSK9 activity (degradation of PCSK9) from an abnormally high level or even a normal level. In some embodiments, neutralizing PCSK9 variants to PCSK9 are used to treat or prevent hypercholesterolemia and/or in the preparation of medicaments therefore and/or for other cholesterol related disorders (such as those noted herein). In some embodiments, a neutralizing PCSK9 variant is used to treat or prevent conditions such as hypercholesterolemia in which PCSK9 activity is normal. In such conditions, for example, reduction of PCSK9 activity to below normal can provide a therapeutic effect.

**[0212]** In some embodiments, more than one neutralizing PCSK9 variant is used to modulate native PCSK9 activity.

**[0213]** In some embodiments, methods are provided of treating a cholesterol related disorder, such as hypercholesterolemia comprising administering a therapeutically effective amount of one or more neutralizing PCSK9 variants and another therapeutic agent.

**[0214]** In some embodiments, a neutralizing PCSK9 variant is administered alone. In some embodiments, a neutralizing PCSK9 variant is administered prior to the administration of at least one other therapeutic agent. In some embodiments, a neutralizing PCSK9 variant is administered concurrent with the administration of at least one other therapeutic agent. In some

embodiments, a neutralizing PCSK9 variant is administered subsequent to the administration of at least one other therapeutic agent. In other embodiments, a neutralizing PCSK9 variant is administered prior to the administration of at least one other therapeutic agent. Therapeutic agents (apart from the neutralizing PCSK9 variant), include, but are not limited to, at least one other cholesterol-lowering (serum and/or total body cholesterol) agent or an agent. In some embodiments, the agent increases the expression of LDLR, have been observed to increase serum HDL levels, lower serum LDL levels or lower triglyceride levels. Exemplary agents include, but are not limited to, statins (atorvastatin, cerivastatin, fluvastatin, lovastatin, mevastatin, pitavastatin, pravastatin, rosuvastatin, simvastatin), Nicotinic acid (Niacin) (NIACOR, NIASPAN (slow release niacin), SLO-NIACIN (slow release niacin)), Fibric acid (LOPID (Gemfibrozil), TRICOR (fenofibrate), Bile acid sequestrants (QUESTRAN (cholestyramine), colesevelam (WELCHOL), COLESTID (colestipol)), Cholesterol absorption inhibitors (ZETIA (ezetimibe)), Combining nicotinic acid with statin (ADVICOR (LOVASTATIN and NIASPAN), Combining a statin with an absorption inhibitor (VYTORIN (ZOCOR and ZETIA) and/or lipid modifying agents. In some embodiments, the neutralizing PCSK9 variant is combined with PPAR gamma agonists, PPAR alpha/gamma agonists, squalene synthase inhibitors, CETP inhibitors, anti-hypertensives, anti-diabetic agents (such as sulphonyl ureas, insulin, GLP-1 analogs, DDPIV inhibitors), ApoB modulators, MTP inhibitors and /or arteriosclerosis obliterans treatments. In some embodiments, the neutralizing PCSK9 variant is combined with an agent that increases the level of LDLR protein in a subject, such as statins, certain cytokines like oncostatin M, estrogen, and/or certain herbal ingredients such as berberine. In some embodiments, the neutralizing PCSK9 variant is combined with an agent that increases serum cholesterol levels in a subject (such as certain anti-psycotic agents, certain HIV protease inhibitors, dietary factors such as high fructose, sucrose, cholesterol or certain fatty acids and certain nuclear receptor agonists and antagonists for RXR, RAR, LXR, FXR). In some embodiments, the neutralizing PCSK9 variant is combined with an agent that increases the level of PCSK9 in a subject, such as statins and/or insulin. The combination of the two can allow for the undesirable side-effects of other agents to be mitigated by the neutralizing PCSK9 variant. As will be appreciated by one of skill in the art, in some embodiments, the neutralizing PCSK9 variant is combined with the other agent/compound. In some embodiments, the neutralizing PCSK9 variant and other agent are administered concurrently. In some embodiments, the

neutralizing PCSK9 variant and other agent are not administered simultaneously, with the neutralizing PCSK9 variant being administered before or after the agent is administered. In some embodiments, the subject receives both the neutralizing PCSK9 variant and the other agent (that increases the level of LDLR) during a same period of prevention, occurrence of a disorder, and/or period of treatment.

**[0215]** Pharmaceutical compositions can be administered in combination therapy, *i.e.*, combined with other agents. In some embodiments, the combination therapy comprises a neutralizing PCSK9 variant, in combination with at least one anti-cholesterol agent. Agents include, but are not limited to, in vitro synthetically prepared chemical compositions, antibodies, antigen binding regions, and combinations and conjugates thereof. In some embodiments, an agent can act as an agonist, antagonist, allosteric modulator, or toxin. In some embodiments, an agent can act to inhibit or stimulate its target (e.g., receptor or enzyme activation or inhibition), and thereby promote increased expression of LDLR or decrease serum cholesterol levels.

**[0216]** In some embodiments, a neutralizing PCSK9 variant can be administered prior to, concurrent with, and subsequent to treatment with a cholesterol-lowering (serum and/or total cholesterol) agent. In some embodiments, a neutralizing PCSK9 variant can be administered prophylactically to prevent or mitigate the onset of hypercholesterolemia, heart disease, diabetes, and/or any of the cholesterol related disorder. In some embodiments, a neutralizing PCSK9 variant can be administered for the treatment of an existing hypercholesterolemia condition. In some embodiments, the neutralizing PCSK9 variant delays the onset of the disorder and/or symptoms associated with the disorder. In some embodiments, the neutralizing PCSK9 variant is provided to a subject lacking any symptoms of any one of the cholesterol related disorders or a subset thereof.

**[0217]** In some embodiments, a neutralizing PCSK9 variant is used with particular therapeutic agents to treat various cholesterol related disorders, such as hypercholesterolemia. In some embodiments, in view of the condition and the desired level of treatment, two, three, or more agents can be administered. In some embodiments, such agents can be provided together by inclusion in the same formulation. In some embodiments, such agent(s) and a neutralizing PCSK9 variant can be provided together by inclusion in the same formulation. In some embodiments, such agents can be formulated separately and provided together by inclusion in a treatment kit. In some embodiments, such agents and a neutralizing PCSK9 variant can be

formulated separately and provided together by inclusion in a treatment kit. In some embodiments, such agents can be provided separately. In some embodiments, when administered by gene therapy, the genes encoding protein agents and/or a neutralizing PCSK9 variant can be included in the same vector. In some embodiments, the genes encoding protein agents and/or a neutralizing PCSK9 variant can be under the control of the same promoter region. In some embodiments, the genes encoding protein agents and/or a neutralizing PCSK9 variant can be in separate vectors.

**[0218]** In some embodiments, a pharmaceutical composition comprising a neutralizing PCSK9 variant is combined with a pharmaceutically acceptable diluent, carrier, solubilizer, emulsifier, preservative and/or adjuvant.

**[0219]** In some embodiments, a pharmaceutical compositions comprising a neutralizing PCSK9 variant and a therapeutically effective amount of at least one additional therapeutic agent are combined together with a pharmaceutically acceptable diluent, carrier, solubilizer, emulsifier, preservative and/or adjuvant.

**[0220]** In some embodiments, a neutralizing PCSK9 variant can be used with at least one therapeutic agent for inflammation. In some embodiments, a neutralizing PCSK9 variant can be used with at least one therapeutic agent for an immune disorder. Exemplary therapeutic agents for inflammation and immune disorders include, but are not limited to cyclooxygenase type 1 (COX-1) and cyclooxygenase type 2 (COX-2) inhibitors small molecule modulators of 38 kDa mitogen-activated protein kinase (p38-MAPK); small molecule modulators of intracellular molecules involved in inflammation pathways, wherein such intracellular molecules include, but are not limited to, jnk, IKK, NF- $\kappa$ B, ZAP70, and I $\kappa$ B. Certain exemplary therapeutic agents for inflammation are described, e.g., in C.A. Dinarello & L.L. Moldawer *Proinflammatory and Anti-Inflammatory Cytokines in Rheumatoid Arthritis: A Primer for Clinicians* Third Edition (2001) Amgen Inc. Thousand Oaks, CA.

**[0221]** In some embodiments, pharmaceutical compositions will include more than one different neutralizing PCSK9 variant(s). In some embodiments, pharmaceutical compositions will include more than one neutralizing PCSK9 variant wherein the neutralizing PCSK9 variants bind more than one epitope. In some embodiments, the various neutralizing PCSK9 variants will not compete with one another for binding to PCSK9.

**[0222]** In some embodiments, acceptable formulation materials preferably are nontoxic to recipients at the dosages and concentrations employed. In some embodiments, the formulation material(s) are for s.c. and/or I.V. administration. In some embodiments, the pharmaceutical composition can contain formulation materials for modifying, maintaining or preserving, for example, the pH, osmolarity, viscosity, clarity, color, isotonicity, odor, sterility, stability, rate of dissolution or release, adsorption or penetration of the composition. In some embodiments, suitable formulation materials include, but are not limited to, amino acids (such as glycine, glutamine, asparagine, arginine or lysine); antimicrobials; antioxidants (such as ascorbic acid, sodium sulfite or sodium hydrogen-sulfite); buffers (such as borate, bicarbonate, Tris-HCl, citrates, phosphates or other organic acids); bulking agents (such as mannitol or glycine); chelating agents (such as ethylenediamine tetraacetic acid (EDTA)); complexing agents (such as caffeine, polyvinylpyrrolidone, beta-cyclodextrin or hydroxypropyl-beta-cyclodextrin); fillers; monosaccharides; disaccharides; and other carbohydrates (such as glucose, mannose or dextrans); proteins (such as serum albumin, gelatin or immunoglobulins); coloring, flavoring and diluting agents; emulsifying agents; hydrophilic polymers (such as polyvinylpyrrolidone); low molecular weight polypeptides; salt-forming counterions (such as sodium); preservatives (such as benzalkonium chloride, benzoic acid, salicylic acid, thimerosal, phenethyl alcohol, methylparaben, propylparaben, chlorhexidine, sorbic acid or hydrogen peroxide); solvents (such as glycerin, propylene glycol or polyethylene glycol); sugar alcohols (such as mannitol or sorbitol); suspending agents; surfactants or wetting agents (such as pluronics, PEG, sorbitan esters, polysorbates such as polysorbate 20, polysorbate 80, triton, tromethamine, lecithin, cholesterol, tyloxapal); stability enhancing agents (such as sucrose or sorbitol); tonicity enhancing agents (such as alkali metal halides, preferably sodium or potassium chloride, mannitol sorbitol); delivery vehicles; diluents; excipients and/or pharmaceutical adjuvants. (*Remington's Pharmaceutical Sciences*, 18<sup>th</sup> Edition, A.R. Gennaro, ed., Mack Publishing Company (1995)).

**[0223]** As noted above, in some embodiments, a neutralizing PCSK9 variant and/or a therapeutic molecule is linked to a half-life extending vehicle known in the art. Such vehicles include, but are not limited to, polyethylene glycol, glycogen (e.g., glycosylation of the neutralizing PCSK9 variant), and dextran. Such vehicles are described, e.g., in U.S. Application

Serial No. 09/428,082, now US Patent No. 6,660,843 and published PCT Application No. WO 99/25044, which are hereby incorporated by reference for any purpose.

**[0224]** In some embodiments, the optimal pharmaceutical composition can be determined by one skilled in the art depending upon, for example, the intended route of administration, delivery format and desired dosage. See, for example, *Remington's Pharmaceutical Sciences, supra*. In some embodiments, such compositions may influence the physical state, stability, rate of *in vivo* release and rate of *in vivo* clearance of the variants of PCSK9.

**[0225]** In some embodiments, the primary vehicle or carrier in a pharmaceutical composition can be either aqueous or non-aqueous in nature. For example, in some embodiments, a suitable vehicle or carrier can be water for injection, physiological saline solution or artificial cerebrospinal fluid, possibly supplemented with other materials common in compositions for parenteral administration. In some embodiments, the saline comprises isotonic phosphate-buffered saline. In some embodiments, neutral buffered saline or saline mixed with serum albumin are further exemplary vehicles. In some embodiments, pharmaceutical compositions comprise Tris buffer of about pH 7.0-8.5, or acetate buffer of about pH 4.0-5.5, which can further include sorbitol or a suitable substitute therefore. In some embodiments, a composition comprising a neutralizing PCSK9 variant, with or without at least one additional therapeutic agents, can be prepared for storage by mixing the selected composition having the desired degree of purity with optional formulation agents (*Remington's Pharmaceutical Sciences, supra*) in the form of a lyophilized cake or an aqueous solution. Further, in some embodiments, a composition comprising a neutralizing PCSK9 variant, with or without at least one additional therapeutic agent, can be formulated as a lyophilizate using appropriate excipients such as sucrose.

**[0226]** In some embodiments, the pharmaceutical composition can be selected for parenteral delivery. In some embodiments, the compositions can be selected for inhalation or for delivery through the digestive tract, such as orally. The preparation of such pharmaceutically acceptable compositions is within the ability of one skilled in the art.

**[0227]** In some embodiments, the formulation components are present in concentrations that are acceptable to the site of administration. In some embodiments, buffers

are used to maintain the composition at physiological pH or at a slightly lower pH, typically within a pH range of from about 5 to about 8.

**[0228]** In some embodiments, when parenteral administration is contemplated, a therapeutic composition can be in the form of a pyrogen-free, parenterally acceptable aqueous solution comprising a desired neutralizing PCSK9 variant, with or without additional therapeutic agents, in a pharmaceutically acceptable vehicle. In some embodiments, a vehicle for parenteral injection is sterile distilled water in which a neutralizing PCSK9 variant, with or without at least one additional therapeutic agent, is formulated as a sterile, isotonic solution, properly preserved. In some embodiments, the preparation can involve the formulation of the desired molecule with an agent, such as injectable microspheres, bio-erodible particles, polymeric compounds (such as polylactic acid or polyglycolic acid), beads or liposomes, that can provide for the controlled or sustained release of the product which can then be delivered via a depot injection. In some embodiments, hyaluronic acid can also be used, and can have the effect of promoting sustained duration in the circulation. In some embodiments, implantable drug delivery devices can be used to introduce the desired molecule.

**[0229]** In some embodiments, a pharmaceutical composition can be formulated for inhalation. In some embodiments, a neutralizing PCSK9 variant, with or without at least one additional therapeutic agent, can be formulated as a dry powder for inhalation. In some embodiments, an inhalation solution comprising a neutralizing PCSK9 variant, with or without at least one additional therapeutic agent, can be formulated with a propellant for aerosol delivery. In some embodiments, solutions can be nebulized. Pulmonary administration is further described in PCT application no. PCT/US94/001875, which describes pulmonary delivery of chemically modified proteins.

**[0230]** In some embodiments, it is contemplated that formulations can be administered orally. In some embodiments, a neutralizing PCSK9 variant, with or without at least one additional therapeutic agents, that is administered in this fashion can be formulated with or without those carriers customarily used in the compounding of solid dosage forms such as tablets and capsules. In some embodiments, a capsule can be designed to release the active portion of the formulation at the point in the gastrointestinal tract when bioavailability is maximized and pre-systemic degradation is minimized. In some embodiments, at least one additional agent can be included to facilitate absorption of a neutralizing PCSK9 variant and/or

any additional therapeutic agents. In some embodiments, diluents, flavorings, low melting point waxes, vegetable oils, lubricants, suspending agents, tablet disintegrating agents, and binders can also be employed.

**[0231]** In some embodiments, a pharmaceutical composition can involve an effective quantity of a neutralizing PCSK9 variant, with or without at least one additional therapeutic agent, in a mixture with non-toxic excipients which are suitable for the manufacture of tablets. In some embodiments, by dissolving the tablets in sterile water, or another appropriate vehicle, solutions can be prepared in unit-dose form. In some embodiments, suitable excipients include, but are not limited to, inert diluents, such as calcium carbonate, sodium carbonate or bicarbonate, lactose, or calcium phosphate; or binding agents, such as starch, gelatin, or acacia; or lubricating agents such as magnesium stearate, stearic acid, or talc.

**[0232]** Additional pharmaceutical compositions will be evident to those skilled in the art, including formulations involving neutralizing PCSK9 variants, with or without at least one additional therapeutic agent(s), in sustained- or controlled-delivery formulations. In some embodiments, techniques for formulating a variety of other sustained- or controlled-delivery means, such as liposome carriers, bio-erodible microparticles or porous beads and depot injections, are also known to those skilled in the art. See for example, PCT Application No. PCT/US93/00829 which describes the controlled release of porous polymeric microparticles for the delivery of pharmaceutical compositions. In some embodiments, sustained-release preparations can include semipermeable polymer matrices in the form of shaped articles, *e.g.* films, or microcapsules. Sustained release matrices can include polyesters, hydrogels, polylactides (U.S. 3,773,919 and EP 058,481), copolymers of L-glutamic acid and gamma ethyl-L-glutamate (Sidman *et al.*, *Biopolymers*, 22:547-556 (1983)), poly (2-hydroxyethyl-methacrylate) (Langer *et al.*, *J. Biomed. Mater. Res.*, 15:167-277 (1981) and Langer, *Chem. Tech.*, 12:98-105 (1982)), ethylene vinyl acetate (Langer *et al.*, *supra*) or poly-D(-)-3-hydroxybutyric acid (EP 133,988). In some embodiments, sustained release compositions can also include liposomes, which can be prepared by any of several methods known in the art. *See, e.g.*, Eppstein *et al.*, *Proc. Natl. Acad. Sci. USA*, 82:3688-3692 (1985); EP 036,676; EP 088,046 and EP 143,949.

**[0233]** The pharmaceutical composition to be used for *in vivo* administration typically is sterile. In some embodiments, this can be accomplished by filtration through sterile

filtration membranes. In some embodiments, where the composition is lyophilized, sterilization using this method can be conducted either prior to or following lyophilization and reconstitution. In some embodiments, the composition for parenteral administration can be stored in lyophilized form or in a solution. In some embodiments, parenteral compositions generally are placed into a container having a sterile access port, for example, an intravenous solution bag or vial having a stopper pierceable by a hypodermic injection needle. In some embodiments, the pharmaceutical composition is sterile.

**[0234]** In some embodiments, the pharmaceutical composition will comprise at least a sufficient amount of the neutralizing PCSK9 variant to reduce an amount of native PCSK9 from binding in a human, *in vivo*. In some embodiments the pharmaceutical composition will comprise at least a sufficient amount of the neutralizing PCSK9 variant to reduce a symptom of a “cholesterol related disorder” (which includes “serum cholesterol related disorders”). In some embodiments the pharmaceutical composition will comprise at least a sufficient amount of the neutralizing PCSK9 variant to modulate at least one native PCSK9 activity (*e.g.*, binding of native PCSK9 to LDLR).

**[0235]** In some embodiments, the pharmaceutical composition comprises at least an amount of a neutralizing PCSK9 variant sufficient for treating any one or more of the cholesterol related disorders disclosed herein.

**[0236]** In some embodiments, the pharmaceutical composition comprises at least an amount of a neutralizing PCSK9 variant sufficient to treat a symptom of a cholesterol related disorder of an adult male and/or female. In some embodiments the amount of the neutralizing PCSK9 variant is at least sufficient to treat (*e.g.*, reduce a symptom of) an adult male weighing between 10 and 250 kg. In some embodiments, the amount is at least sufficient to treat a 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, or 200 kg subject so as to lessen a symptom of at least any one of the cholesterol related disorders, to raise the level of LDLR in the subject, or to lower the level of LDL in the subject. In some embodiments, the amount of a neutralizing PCSK9 variant present in the pharmaceutical composition is at least sufficient to raise the level of LDLR in a subject by some detectable amount. In some embodiments, the level of LDLR in a subject is raised by at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100 percent. In some embodiments the level of LDLR in a

subject is increased by at least 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, or 100 fold over an untreated healthy subject and/or over an untreated subject that has a cholesterol related disorder. In yet other embodiments the neutralizing PCSK9 variant is sufficient to maintain the level of LDLR in a subject at a desired level. The appropriate level can be determined by the subject's health care provider and can take into account particular aspects of the subject's physical condition and health issues and concerns.

**[0237]** In some embodiments, the amount of neutralizing PCSK9 variant present in the pharmaceutical composition is at least sufficient to block a significant amount of the activity of the native PCSK9 *in vivo*. In some embodiments, the amount is sufficient to block at least 1% of the activity of native PCSK9, for example, at least 1, 1-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, 99-100 percent of the native PCSK9 is blocked by the amount of PCSK9 present in the pharmaceutical composition.

**[0238]** In some embodiments, the amount of neutralizing PCSK9 variant present in the pharmaceutical composition is at least sufficient to lower serum LDL in a subject. In some embodiments, the amount is sufficient to lower the amount of serum LDL in a subject by at least 1% of the native level of serum LDL, for example, at least 1, 1-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-95, 95-98, 98-99, 99-100 percent of the level of serum LDL for the subject, for a subject having a cholesterol related disorder, or for a healthy subject.

**[0239]** In some embodiments, the amount of neutralizing PCSK9 variant present in the pharmaceutical composition is a significant amount. In some embodiments, the amount of neutralizing PCSK9 variant present in a pharmaceutical dose to be given to a subject is at least 1 ng, for example, the amount is at least 1, 10, 20, 50, 100, 500, 1000, 10,000,  $10^5$ ,  $10^6$ ,  $10^7$ ,  $10^8$ ,  $10^9$ ,  $10^{10}$ , or  $10^{11}$  nanograms, including any amount defined between any two of the previous numbers and any amount above any of the previous numbers. In some embodiments the amount is in a single pill. In some embodiments, the amount is in multiple pills. In some embodiments, the amount of the neutralizing PCSK9 variant administered is from about 1 to 500 mg, 50 to 400 mg, or 100 to 300 mg.

**[0240]** In some embodiments, the neutralizing PCSK9 variant is included in a solid form, such as in a tablet or pill.

**[0241]** In some embodiments, the amount of the neutralizing PCSK9 variant is a dosage sufficient to achieve any of the herein described goals (or amounts) for at least 1 hour. In

some embodiments, the amount is sufficient to treat a cholesterol related disorder for at least one hour, for example, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, or 24 hours. In some embodiments, the amount of the neutralizing PCSK9 variant that is present is sufficient to achieve any of the herein described goals for at least one day. Thus, in some embodiments, the dosage is a once daily amount.

**[0242]** In some embodiments, the neutralizing PCSK9 variant is relatively pure. In some embodiments, apart from a pharmaceutical acceptable carrier or diluent and the neutralizing PCSK9 variant, nothing else is present in the composition. In some embodiments, a compound comprising the neutralizing PCSK9 variant is at least 0.01% neutralizing PCSK9 variant (by weight). In some embodiments, at least  $1 \times 10^{-8}$ ,  $1 \times 10^{-7}$ ,  $1 \times 10^{-6}$ ,  $1 \times 10^{-5}$ , 0.0001, 0.001, 0.01, 0.1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 98, 99, or 100 percent of the compound is a neutralizing PCSK9 variant. In some embodiments, the percent is a range defined between any two of the previous percents.

**[0243]** As will be appreciated by one of skill in the art, any of the above parameters describing the amount of the neutralizing PCSK9 variant present can be combined with any of the other parameters. For example, any of the parameters regarding the percent of native PCSK9 blocked *in vivo* can be combined for any of the specific weights supplied for the subjects.

**[0244]** In some embodiments, the pharmaceutical composition does not include ingredients that are harmful to a subject.

**[0245]** In some embodiments, the pharmaceutical composition does not include 50 mM sodium phosphate and/or 50 mM sodium chloride. In some embodiments, the pharmaceutical composition does not include sodium phosphate and/or sodium chloride. In some embodiments the pharmaceutical composition does not contain cell lysates. In some embodiments the pharmaceutical composition does not contain cell medium. In some embodiments, the pharmaceutical composition does not include BS3 (bis[sulfosuccinimidyl]suberate). In some embodiments, the pharmaceutical composition does not include potassium formate. In some embodiments, the pharmaceutical composition does not include PEG 3350. In some embodiments, the pharmaceutical composition does not include 0.2 M potassium formate. In some embodiments, the pharmaceutical composition does not include 20% PEG 3350. In some embodiments, the pharmaceutical composition does not include 50 mM Tris. In some embodiments, the pharmaceutical composition does not include 4 mM

EDTA. In some embodiments, the pharmaceutical composition does not include 0.01-2% Triton X-100. In some embodiments, the pharmaceutical composition does not include 0.5 sodium deoxycholate. In some embodiments, the pharmaceutical composition does not include 0.1-2% sodium dodecyl sulfate. In some embodiments, the pharmaceutical composition does not include 10-20% glycerol. In some embodiments, the pharmaceutical composition does not include 1M NDSB. In some embodiments, the pharmaceutical composition does not include 1-20 mM calcium chloride. In some embodiments, the pharmaceutical composition does not include  $\text{KH}_2\text{PO}_4/\text{NaOH}$ . In some embodiments, the pharmaceutical composition does not include citric acid and sodium phosphate. In some embodiments, the pharmaceutical composition does not include  $\text{Na}_2\text{HPO}_4$  and NaOH. In some embodiments, the pharmaceutical composition does not include the combination of two or more of the above ingredients. In some embodiments, the pharmaceutical composition does not include the combination of three or more of the above ingredients. In some embodiments, the pharmaceutical composition does not include the combination of four or more of the above ingredients. In some embodiments, the pharmaceutical composition does include one or more of the above ingredients.

**[0246]** In some embodiments, the neutralizing PCSK9 variant is not created in *E. coli*. In some embodiments, any of the herein disclosed neutralizing PCSK9 variants is a self-processed or self-cleaved protein. In some embodiments, any of the herein disclosed neutralizing PCSK9 variants is a processed or cleaved protein.

**[0247]** In some embodiments, once the pharmaceutical composition has been formulated, it can be stored in sterile vials as a solution, suspension, gel, emulsion, solid, or as a dehydrated or lyophilized powder. In some embodiments, such formulations can be stored either in a ready-to-use form or in a form (*e.g.*, lyophilized) that is reconstituted prior to administration.

**[0248]** In some embodiments, kits are provided for producing a single-dose administration unit. In some embodiments, the kit can contain both a first container having a dried protein and a second container having an aqueous formulation. In some embodiments, kits containing single and multi-chambered pre-filled syringes (*e.g.*, liquid syringes and lyosyringes) are included.

**[0249]** In some embodiments, the effective amount of a pharmaceutical composition comprising a neutralizing PCSK9 variant, with or without at least one additional therapeutic agent, to be employed therapeutically will depend, for example, upon the therapeutic context and

objectives. One skilled in the art will appreciate that the appropriate dosage levels for treatment, according to certain embodiments, will thus vary depending, in part, upon the molecule delivered, the indication for which a neutralizing PCSK9 variant, with or without at least one additional therapeutic agent, is being used, the route of administration, and the size (body weight, body surface or organ size) and/or condition (the age and general health) of the patient. In some embodiments, a clinician can titer the dosage and modify the route of administration to obtain the optimal therapeutic effect. In some embodiments, a typical dosage can range from about 0.1  $\mu\text{g}/\text{kg}$  to up to about 100  $\text{mg}/\text{kg}$  or more, depending on the factors mentioned above. In some embodiments, the dosage can range from 0.1  $\mu\text{g}/\text{kg}$  up to about 100  $\text{mg}/\text{kg}$ ; or 1  $\mu\text{g}/\text{kg}$  up to about 100  $\text{mg}/\text{kg}$ ; or 5  $\mu\text{g}/\text{kg}$  up to about 100  $\text{mg}/\text{kg}$ .

**[0250]** In some embodiments, the frequency of dosing will take into account the pharmacokinetic parameters of a neutralizing PCSK9 variant and/or any additional therapeutic agents in the formulation used. In some embodiments, a clinician will administer the composition until a dosage is reached that achieves the desired effect. In some embodiments, the composition can therefore be administered as a single dose, as two or more doses (which may or may not contain the same amount of the desired molecule) over time, or as a continuous infusion via an implantation device or catheter. Further refinement of the appropriate dosage is routinely made by those of ordinary skill in the art and is within the ambit of tasks routinely performed by them. In some embodiments, appropriate dosages can be ascertained through use of appropriate dose-response data. In some embodiments, the amount and frequency of administration can take into account the desired cholesterol level (serum and/or total) to be obtained and the subject's present cholesterol level, LDL level, and/or LDLR levels, all of which can be obtained by methods that are well known to those of skill in the art.

**[0251]** In some embodiments, the route of administration of the pharmaceutical composition is in accord with known methods, *e.g.* orally, through injection by intravenous, intraperitoneal, intracerebral (intra-parenchymal), intracerebroventricular, intramuscular, subcutaneously, intra-ocular, intraarterial, intraportal, or intralesional routes; by sustained release systems or by implantation devices. In some embodiments, the compositions can be administered by bolus injection or continuously by infusion, or by implantation device. In some embodiments, the composition is configured for administration via any of these routes.

**[0252]** In some embodiments, the composition can be administered locally via implantation of a membrane, sponge or another appropriate material onto which the desired molecule has been absorbed or encapsulated. In some embodiments, where an implantation device is used, the device can be implanted into any suitable tissue or organ, and delivery of the desired molecule can be via diffusion, timed-release bolus, or continuous administration.

**[0253]** In some embodiments, it can be desirable to use a pharmaceutical composition comprising a neutralizing PCSK9 variant, with or without at least one additional therapeutic agent, in an *ex vivo* manner. In such instances, cells, tissues and/or organs that have been removed from the patient are exposed to a pharmaceutical composition comprising a neutralizing PCSK9 variant, with or without at least one additional therapeutic agent, after which the cells, tissues and/or organs are subsequently implanted back into the patient.

**[0254]** In some embodiments, a neutralizing PCSK9 variant and/or any additional therapeutic agents can be delivered by implanting certain cells that have been genetically engineered, using methods such as those described herein, to express and secrete the polypeptides. In some embodiments, such cells can be animal or human cells, and can be autologous, heterologous, or xenogeneic. In some embodiments, the cells can be immortalized. In some embodiments, in order to decrease the chance of an immunological response, the cells can be encapsulated to avoid infiltration of surrounding tissues. In some embodiments, the encapsulation materials are typically biocompatible, semi-permeable polymeric enclosures or membranes that allow the release of the protein product(s) but prevent the destruction of the cells by the patient's immune system or by other detrimental factors from the surrounding tissues.

**[0255]** Based on the ability of a neutralizing PCSK9 variant to significantly neutralize PCSK9 activity (as demonstrated in the Examples below), these neutralizing PCSK9 variants will have therapeutic effects in treating and preventing symptoms and conditions resulting from PCSK9-mediated activity, such as hypercholesterolemia.

## EXAMPLES

**[0256]** The following examples, including the experiments conducted and results achieved, are provided for illustrative purposes only and are not to be construed as limiting the present invention.

## EXAMPLE 1

## Demonstration of a Neutralizing PCSK9 variant binding to the LDL receptor - LDLR

## Competition assay

[0257] This example is directed to the ability of a neutralizing PCSK9 variant to compete with full length PCSK9 for binding to LDLR.

[0258] Clear, 96 well plates (Nunc) were coated overnight with 2 micrograms/ml of goat anti-LDL receptor antibody (R&D Systems) diluted in buffer A (100 mM sodium cacodylate, pH 7.4). Plates were washed thoroughly with buffer A and then blocked for 2 hours with buffer B (1% milk in buffer A). After washing, plates were incubated for 1.5 hours with 2.0 ug/ml of LDL receptor (R&D Systems) diluted in buffer C (buffer B supplemented with 10 mM CaCl<sub>2</sub>). Concurrent with this incubation, 100 ng/ml of biotinylated wild-type human PCSK9 (hPCSK9), diluted in buffer C, was incubated with various concentrations of non-biotinylated competitor proteins (e.g. 31-447 of PCSK9 (SEQ ID NO: 3), full length PCSK9, and the V-domain of PCSK9, residues 450-692) also diluted in buffer C, or buffer C alone (control). The LDL receptor containing plates were washed. The biotinylated PCSK9/competitor protein mixture was transferred to the plates and incubated for 1 hour at room temperature. Binding of the biotinylated PCSK9 to the LDL receptor was detected by incubation with streptavidin-HRP (Biosource) at 500 ng/ml in buffer C followed by TMB substrate (KPL). The absorbance at 650 nm was measured.

[0259] The results are presented in FIG. 2. Both the neutralizing PCSK9 variant (amino acids 31-447 of SEQ ID NO: 3), and the full length PCSK9 (fl PCSK9), competed against biotin-labeled full length PCSK9 for binding to the immobilized LDLR. The V-domain protein did not. This data demonstrates that no more than amino acids 31-447 (of SEQ ID NO: 3) are required for binding to the LDLR.

## EXAMPLE 2

## Effect of a Neutralizing PCSK9 variant on Cell LDL uptake

[0260] The example is directed to the ability of one neutralizing PCSK9 variant to impact LDL uptake. HepG2 cells were seeded in 96-well plates (Costar) at a concentration of  $5 \times 10^5$  cells per well in DMEM medium (Mediatech, Inc) supplemented with 10% fetal bovine serum (FBS) and incubated overnight at 37°C (5% CO<sub>2</sub>). The next day, cells were washed twice

with PBS. A serial 1:2 dilution of wild-type PCSK9 or the neutralizing PCSK9 variant (31-447 of SEQ ID NO: 3) was made, ranging from 1.6 ug/ml to 50ug/ml, and was added to cells. Following the addition of 6ug/ml of BODIPY-LDL (Invitrogen) and incubation for 3 hours at 37°C (5% CO<sub>2</sub>), the cells were washed thoroughly with PBS. Lastly, the cellular associated fluorescence signal was detected by Safire (TECAN) at 480~520nm (excitation) and 520~600nm (emission).

**[0261]** The results are presented in FIGs. 3A and 3B which represent two separate experiments of identical design performed on different dates. As can be observed in the figures, full length PCSK9 (having a H8 histidine purification tag) blocked the uptake of labeled LDL in to the cultured cells as evidenced by the decrease in fluorescence from the cells with increasing PCSK9 levels added to the culture medium. In contrast, the neutralizing PCSK9 variant allows for the cells to take up LDL.

### EXAMPLE 3

#### Western Blot Analysis of the Cellular Effects of a Neutralizing PCSK9 Variant

**[0262]** This example is directed to the cellular effects of the presence of a neutralizing PCSK9 variant.

**[0263]** HepG2 cells in 6 well plates were grown to confluency at 37°C in DMEM medium with 10% fetal bovine serum (FBS). Some cells were pretreated for 30 minutes with 100 uM chloroquine to inhibit acidification of endosomes. Cells were then treated with either vehicle (PBS, less than 50 ul), full length PCSK9 (50 ug/ml, 0.65 uM), or neutralizing PCSK9 variant (31-447 of SEQ ID NO: 3) (30 micrograms/ml, 0.65 uM) in 750 ul of DMEM with 1% FBS for 4 hours at 37°C. Cells were washed three times with PBS and whole cell lysate was prepared using lysis buffer (125 mM Tris, 2 mM CaCl<sub>2</sub>, 1% triton X-100, pH 8.5). Fifty ug of cell supernatant protein was resolved by SDS PAGE and LDLR levels determined using rabbit anti-human LDLR polyclonal antibody (RDI-PRO61099, Fitzgerald Industries International Inc.). Recombinant PCSK9 associated with the cells was detected by anti-human PCSK9 monoclonal antibody that detects the ~ 14 kDa prodomain of PCSK9. HRP-conjugated secondary antibodies (Santa Cruz Biotechnology Inc.) and ECL (GE Healthcare) were used for detecting signal. (Veh=vehicle (PBS), FL=full length, PC9=PCSK9).

**[0264]** The results are shown in FIG. 4. As can be seen in the figure, the neutralizing PCSK9 variant (31-447 of SEQ ID NO: 3) associated with cells but did not cause degradation of LDLR, unlike full length PCSK9.

**[0265]** As will be appreciated by one of skill in the art, the data from the above Examples indicate that while a neutralizing PCSK9 variant (*e.g.*, 31-447 of SEQ ID NO: 3) can bind to the LDLR it does not prevent LDL binding and LDL uptake by cells and does not cause LDLR degradation. In addition, the neutralizing PCSK9 variant (31-447 of SEQ ID NO: 3) allows LDLR recycling, preserving the normal function of the LDLR.

**[0266]** Given the present results, it is apparent that neutralizing PCSK9 variants can bind to the LDLR at the cell surface preventing the interaction of full length (wild-type) PCSK9 with the LDLR. Because the neutralizing PCSK9 variant preserves normal LDLR function it acts as a therapeutic protecting the LDLR from the effects of endogenous full length PCSK9.

#### EXAMPLE 4

##### Uses of a Neutralizing PCSK9 Variant for the Treatment of Cholesterol Related Disorders

**[0267]** A human patient exhibiting a Cholesterol Related Disorder (in which a reduction in cholesterol (such as serum cholesterol) can be beneficial) is administered a therapeutically effective amount of a neutralizing PCSK9 variant. At periodic times during the treatment, the patient is monitored to determine whether a symptom of the disorder has subsided. Following treatment, it is found that patients undergoing treatment with the neutralizing PCSK9 variant have reduced serum cholesterol levels, in comparison to patients that are not treated.

#### EXAMPLE 5

##### Uses of a Neutralizing PCSK9 Variant for the Treatment of Hypercholesterolemia

**[0268]** A human patient exhibiting symptoms of hypercholesterolemia is administered a therapeutically effective amount of a neutralizing PCSK9 variant. At periodic times during the treatment, the human patient is monitored to determine whether the serum cholesterol level (either as total cholesterol or more specifically LDL cholesterol) has declined. Following treatment, it is found that the patient receiving the treatment with a neutralizing

PCSK9 variant has reduced serum cholesterol levels in comparison to arthritis patients not receiving the treatment.

#### EXAMPLE 6

##### Uses of a Neutralizing PCSK9 Variant for the Prevention of Coronary Heart Disease and/or Recurrent Cardiovascular Events

**[0269]** A human patient at risk of developing coronary heart disease is identified. The patient is administered a therapeutically effective amount of a neutralizing PCSK9 variant, either alone, concurrently or sequentially with a statin, *e.g.*, simvastatin. At periodic times during the treatment, the human patient is monitored to determine whether the patient's total serum cholesterol level changes. Throughout the preventative treatment, it is found that the patient receiving the treatment with the neutralizing PCSK9 variant has reduced serum cholesterol thereby reducing their risk to coronary heart diseases or recurrent cardiovascular events in comparison to patients not receiving the treatment.

#### EXAMPLE 7

##### Use of a Neutralizing PCSK9 Variant for the Prevention of Hypercholesterolemia

**[0270]** A human patient exhibiting a risk of developing hypercholesterolemia is identified via family history analysis and/or lifestyle, and/or current cholesterol levels. The subject is regularly administered (*e.g.*, one time weekly) a therapeutically effective amount of a neutralizing PCSK9 variant. At periodic times during the treatment, the patient is monitored to determine whether serum cholesterol levels have decreased. Following treatment, it is found that subjects undergoing preventative treatment with a neutralizing PCSK9 variant have lowered serum cholesterol levels, in comparison to subjects that are not treated.

#### EXAMPLE 8

##### Mouse Model for PCSK9

**[0271]** The present example describes how to generate a mouse model for testing various neutralizing PCSK9 variants. To generate mice which over-expressed human PCSK9, three week old WT C57Bl/6 mice were injected via tail vein administration with various concentrations of adenoassociated virus (AAV), recombinantly modified to express human

PCSK9, to determine the correct titer which would provide a measurable increase of LDL-cholesterol in the mice. Using this particular virus which expressed human PCSK9, it was determined that  $4.5 \times 10^{12}$  pfu of virus would result in an LDL-cholesterol level of approximately 40mg/dL in circulating blood (normal levels of LDL in a WT mice are approximately 10mg/dL). The human PCSK9 levels in these animals were found to be approximately 13ug/mL. A colony of mice was generated using this injection criteria.

[0272] One week after injection, mice were assessed for LDL-cholesterol levels.

#### EXAMPLE 9

[0273] The mice from Example 8 can be used to test various neutralizing PCSK9 variants to determine how effective they are and which variants work *in vivo*.

[0274] A neutralizing PCSK9 variant can be administered, via tail vein injection, in a single bolus injection, or by AAV induced over-expression. Subgroups of animals (n=6-7) can then be euthanized at 24 and 48 hours after neutralizing PCSK9 variant administration. LDL levels can then be examined and optionally compared with various controls (*e.g.*, wild-type PCSK9, a water or unrelated protein injection, and the pro/cat domain). Complete PCSK9 variants that result in mice with lower serum LDL levels will be variants that can be effective in lowering serum LDL levels.

#### EXAMPLE 10

##### The LDLR EGFa Domain Binds to the Catalytic Domain of PCSK9

[0275] The present example presents the solved crystal structure of PCSK9 Pro/Cat (31-454) bound to the LDLR EGFa domain (293-334) at 2.9 Å resolution (the conditions for which are described in the below Examples).

[0276] A representation of the structure of PCSK9 bound to EGFa is shown in FIG. 5. The crystal structure (and its depiction in FIG. 5) reveals that the EGFa domain of LDLR binds to the catalytic domain of PCSK9. In addition, the interaction of PCSK9 and EGFa appears to occur across a surface of PCSK9 that is between residues D374 and S153 in the structure depicted in FIG. 5.

[0277] Specific core PCSK9 amino acid residues of the interaction interface with the LDLR EGFa domain were defined as PCSK9 residues that are within 5 Å of the EGFa domain.

The core residues are as follows: S153, I154, P155, R194, D238, A239, I369, S372, D374, C375, T377, C378, F379, V380, and S381.

**[0278]** Boundary PCSK9 amino acid residues of the interaction interface with the LDLR EGFa domain were defined as PCSK9 residues that are 5-8 Å from the EGFa domain. The boundary residues are as follows: W156, N157, L158, E159, H193, E195, H229, R237, G240, K243, D367, I368, G370, A371, S373, S376, and Q382. Residues that are underlined are nearly or completely buried within PCSK9.

**[0279]** As will be appreciated by one of skill in the art, the results from this example demonstrate where PCSK9 and EGFa interact. Thus, neutralizing PCSK9 variants that interact with or block any of these residues can be useful to inhibit the interaction between native PCSK9 and the EGFa domain of LDLR (and/or LDLR generally). In some embodiments, neutralizing PCSK9 variants that, when bound to PCSK9, interact with or block any of the above residues or are within 15-8, 8, 8-5, or 5 angstroms of the above residues are contemplated to provide useful inhibition of PCSK9 binding to LDLR.

#### EXAMPLE 11

##### Structural Interaction of LDLR and PCSK9

**[0280]** A model of full length PCSK9 protein bound to a full length representation of the LDLR was made using the PCSK9 Pro/Cat 31-454/EGFa complex structure. The structure of full length PCSK9 (Piper, D.E. et al. The crystal structure of PCSK9: a regulator of plasma LDL-cholesterol. *Structure* 15, 545-52 (2007)) was overlaid onto the PCSK9 Pro/Cat 31-454 from the complex and the structure of the LDLR in its low pH conformation (Rudenko, G. et al. Structure of the LDL receptor extracellular domain at endosomal pH. *Science* 298, 2353-8 (2002)) was overlaid onto the EGFa domain from the complex. Depictions of the model are shown in FIGs. 6 and 7. The EGFa domain from the PCSK9 Pro/Cat 31-454 / EGFa complex is enclosed within the box. The figures show regions of the LDLR outside of the immediate EGFa binding domain that lie in close proximity to PCSK9.

#### EXAMPLE 12

##### Expression and Purification of Protein Samples

**[0281]** The present example describes some methods by which the various embodiments of the PCSK9 proteins/variants were made and purified (including the LDLR EGFa domain). PCSK9 proteins/variants (*e.g.*, PSCK9 31-692 N533A, PCSK9 449TEV and PCSK9 Pro/Cat 31-454) were expressed in baculovirus infected Hi-5 insect cells with an N-terminal honeybee melittin signal peptide followed by a His<sub>6</sub> tag. The PCSK9 proteins were purified by nickel affinity chromatography, ion exchange chromatography and size exclusion chromatography. The melittin-His<sub>6</sub> tag was removed during purification by cleavage with TEV protease. The construct PCSK9 449TEV was used to generate PCSK9 Pro/Cat (31-449 and V domain (450-692) samples. This construct had a TEV protease cleavage site inserted between PCSK9 residues 449 and 450.

**[0282]** The LDLR EGFa domain (293-334) was expressed as a GST fusion protein in *E. coli*. The EGFa domain was purified by ion exchange chromatography, glutathione sepharose affinity chromatography and size exclusion chromatography. The GST protein was removed during the purification by cleavage with PreScission protease.

### EXAMPLE 13

#### Complex Formation and Crystallization

**[0283]** The present example describes how complexes and crystals used in the above structure examination Examples were made.

**[0284]** The PCSK9 31-454 / EGFa complex was made by mixing a 1.2 molar excess of EGFa domain with PCSK9 31-454. The PCSK9 31-454 / EGFa domain complex crystallized in 0.2 M potassium formate, 20% PEG 3350.

### EXAMPLE 14

#### Data Collection and Structure Determination

**[0285]** The present example describes how the datasets were collected and the structures determined for the above structure examination Examples.

**[0286]** The PCSK9 31-454 / EGFa dataset was collected at the Berkeley Advanced Light Source beamline 5.0.2. All datasets were processed with denzo/scalepack or HKL2000 (Otwinowski, Z., Borek, D., Majewski, W. & Minor, W. Multiparametric scaling of diffraction intensities. *Acta Crystallogr A* 59, 228-34 (2003)).

**[0287]** PCSK9 / EGFa domain crystals grew in the space group  $P6_522$  with unit cell dimensions  $a=b=70.6$ ,  $c=321.8$  Å and diffract to 2.9 Å resolution. The PCSK9 / EGFa domain structure was solved by molecular replacement with the program MOLREP using the PCSK9 Pro/Cat as the starting search model. Analysis of the electron density maps showed clear electron density for the EGFa domain. The LDLR EGFa domain was fit by hand and the model was improved with multiple rounds of model building with Quanta and refinement with cnx.

**[0288]** Core interaction interface amino acids were determined as being all amino acid residues with at least one atom less than or equal to 5 Å from the PCSK9 partner protein. 5 Å was chosen as the core region cutoff distance to allow for atoms within a van der Waals radius plus a possible water-mediated hydrogen bond. Boundary interaction interface amino acids were determined as all amino acid residues with at least one atom less than or equal to 8 Å from the PCSK9 partner protein but not included in the core interaction list. Less than or equal to 8 Å was chosen as the boundary region cutoff distance to allow for the length of an extended arginine amino acid. Amino acids that met these distance criteria were calculated with the program PyMOL. (DeLano, W.L. The PyMOL Molecular Graphics System. (Palo Alto, 2002)).

**[0289]** The coordinates for the crystal structures discussed in the above Examples are presented in Table 35.2 of U.S. Prov. Pat. App. No. 61/010630, filed Jan. 9, 2008, the entirety of which is incorporated by reference. Neutralizing PCSK9 variants that interact with the relevant areas or residues of the structure of PCSK9 (including those areas or residues within 15, 15-8, 8, 8-5, 5, or fewer angstroms from where EGFa interacts with PCSK9) depicted in the figures and/or their corresponding positions on the structures from the coordinates are also contemplated.

#### EXAMPLE 15

##### Additional Neutralizing PCSK9 Variants

**[0290]** This example describes the ability of the D374Y point mutation in a neutralizing PCSK9 variant (amino acids 31-447 of SEQ ID NO: 3) to alter cell LDL uptake (FIG. 8) and compete with full length PCSK9 for binding to the LDLR (FIG. 9).

**[0291]** The protocol followed was generally similar to that outlined above regarding LDL uptake in the presence of the neutralizing PCSK9 variant (amino acids 31-447 of SEQ ID NO: 3), except that full length D374Y PCSK9, a neutralizing PCSK9 variant (amino acids 31-

447 of SEQ ID NO: 3) having the D374Y point mutation, and a full length wild-type hPCSK9 were used. The results are shown in FIG. 8.

**[0292]** In addition to the above experiment, LDLR was also captured in an ELISA plate via an LDLR antibody (2 ug/ml). Following this, biotin-WT\_PCSK9 (100 ng/ml) and various concentrations of unbiotinylated full length D374Y PCSK9, V domain (V domain), and D374Y Pro/Cat (31-447) were added to the plate. Bound biotin-PCSK9 was detected by streptavidin-HRP. The results are presented in FIG. 9 and demonstrate the ability of the D374Y Pro/Cat domain and the D374Y full length PCSK9 to compete with the full length WT PCSK9 for binding to the LDLR.

**[0293]** As can be seen in the results displayed in FIGs. 8 and 9, neutralizing PCSK9 variants will also work to increase the amount of LDL uptake with respect to uptake that occurs in the presence of other forms of PCSK9.

#### Incorporation by Reference

**[0294]** All references cited herein, including patents, patent applications, papers, text books, and the like, and the references cited therein, to the extent that they are not already, are hereby incorporated herein by reference in their entirety. To the extent that any of the definitions or terms provided in the references incorporated by reference differ from the terms and discussion provided herein, the present terms and definitions control.

#### Equivalents

**[0295]** The foregoing written specification is considered to be sufficient to enable one skilled in the art to practice the invention. The foregoing description and examples detail certain embodiments of the invention. It will be appreciated, however, that no matter how detailed the foregoing may appear in text, the invention may be practiced in many ways.

**WHAT IS CLAIMED IS:**

1. A neutralizing PCSK9 variant comprising:  
a Pro/Cat domain, or fragment thereof, that binds to low density lipoprotein receptor (LDLR); and  
an inactive V domain to LDLR activity, wherein the inactive V domain does not result in the degradation of LDLR.
2. The neutralizing PCSK9 variant of Claim 1, wherein the Pro/Cat domain comprises amino acids 61 to 374 of SEQ ID NO: 3, and wherein the neutralizing PCSK9 variant lacks the protein sequence defined from amino acid 453 to amino acid 692 of SEQ ID NO: 3.
3. The neutralizing PCSK9 variant of Claim 1, wherein the Pro/Cat domain comprises amino acids 31 to 374 of SEQ ID NO: 3.
4. The neutralizing PCSK9 variant of Claim 1, wherein the Pro/Cat domain comprises amino acids 61 to 446 of SEQ ID NO: 3.
5. The neutralizing PCSK9 variant of Claim 1, wherein the Pro/Cat domain comprises amino acids 31 to 449 of SEQ ID NO: 3, and wherein the V domain lacks at least the last 14 amino acids of SEQ ID NO: 3.
6. The neutralizing PCSK9 variant of Claim 1, wherein the neutralizing PCSK9 variant lacks amino acids 453 to 692 of SEQ ID NO: 3.
7. The neutralizing PCSK9 variant of Claim 1, wherein the Pro/Cat domain consists essentially of amino acids 31 to 447 of SEQ ID NO: 3.
8. The neutralizing PCSK9 variant of Claim 1, wherein the Pro/Cat domain consists of amino acids 31 to 447 of SEQ ID NO: 3.
9. A nucleic acid molecule encoding the neutralizing PCSK9 variant according to any one of Claims 1-8.
10. The nucleic acid molecule according to Claim 9, wherein said nucleic acid molecule is operably linked to a control sequence.
11. A vector comprising a nucleic acid molecule according to Claim 9.
12. A host cell comprising the nucleic acid molecule according to Claim 9.
13. A host cell comprising the vector according to Claim 11.

14. A pharmaceutical composition comprising at least one neutralizing PCSK9 variant according to any one of Claims 1-8 and 28-32, and a pharmaceutically acceptable excipient.

15. The pharmaceutical composition of Claim 14, further comprising an additional active agent.

16. The pharmaceutical composition of Claim 15, wherein said additional active agent is selected from the group consisting of a radioisotope, radionuclide, a toxin, or a therapeutic and a chemotherapeutic group.

17. A method for treating or preventing a condition associated with elevated serum cholesterol in a patient, comprising administering to a patient in thereof an effective amount of at least one neutralizing PCSK9 variant according to any of Claims 1-8.

18. The method of Claim 17, wherein the condition is hypercholesterolemia.

19. A method of inhibiting binding of PCSK9 to LDLR in a patient comprising administering an effective amount of a neutralizing PCSK9 variant according to any one of Claims 1-8.

20. A method for treating or preventing a condition associated with elevated serum cholesterol in a subject, said method comprising administering to a subject in need thereof an effective amount of at least one neutralizing PCSK9 variant according to any one of Claims 1-8 simultaneously or sequentially with an agent that elevates the availability of low density lipoprotein receptor (LDLR) protein.

21. The method of Claim 20, wherein the agent that elevates the availability of LDLR protein comprises a statin.

22. The method of Claim 21, wherein the statin is selected from the group consisting of atorvastatin, cerivastatin, fluvastatin, lovastatin, mevastatin, pitavastatin, pravastatin, rosuvastatin, simvastatin, and some combination thereof.

23. A method of lowering serum cholesterol in a subject, said method comprising administering to a subject an effective amount of at least one isolated neutralizing PCSK9 variant according to any one of Claims 1-8.

24. A method of lowering serum cholesterol in a subject, said method comprising administering to a subject an effective amount of at least one neutralizing PCSK9 variant according to any of Claims 1-8 simultaneously or sequentially with an agent that elevates the availability of low density lipoprotein receptor (LDLR) protein.

25. The use of a neutralizing PCSK9 variant of Claim 1-8 in the manufacture of a medicament for the treatment of hypercholesterolemia.
26. The neutralizing PCSK9 variant of Claim 1-8, for use as a medicament.
27. The neutralizing PCSK9 variant of Claim 1-8, for use in treating hypercholesterolemia.
28. A neutralizing PCSK9 variant comprising:  
a Pro/Cat domain, or fragment thereof, that binds to low density lipoprotein receptor (LDLR), wherein said neutralizing PCSK9 variant blocks PCSK9 (SEQ ID NO: 3) from binding to LDLR, while allowing LDL to bind to LDLR.
29. The neutralizing PCSK9 variant of Claim 28, wherein the neutralizing PCSK9 variant has an inactive V domain.
30. The neutralizing PCSK9 variant of Claim 29, wherein the neutralizing PCSK9 variant has no V domain.
31. The neutralizing PCSK9 variant of Claim 1 or 28, further comprising an antibody, or fragment thereof, conjugated to the neutralizing PCSK9 variant.
32. The neutralizing PCSK9 variant of Claim 31, wherein the antibody or fragment thereof, comprises an Fc domain of an antibody.
33. The neutralizing PCSK9 variant of Claim 32, wherein the fragment of the antibody consists of an Fc domain of an antibody.
34. A pharmaceutical composition comprising at least one neutralizing PCSK9 variant according to any of the above Claims, wherein the neutralizing PCSK9 variant is present in an amount effective for the treatment of a cholesterol related disorder.
35. The pharmaceutical composition of Claim 34, wherein the effective amount comprises an amount effective for lowering the level of LDL in a human.
36. The pharmaceutical composition of Claim 34, wherein the effective amount comprises an amount that elevates the availability of low density lipoprotein receptor (LDLR) protein in a human.
37. The pharmaceutical composition of Claim 36, wherein the elevation is at least 5%.
38. The pharmaceutical composition of Claim 36, wherein the elevation is at least 20%.
39. The pharmaceutical composition of Claim 36, wherein the elevation is at least 50%.

40. The pharmaceutical composition of Claim 36, wherein the elevation is at least 100%.
41. The pharmaceutical composition of Claim 36, wherein the elevation is at least 300%.
42. The pharmaceutical composition of Claim 36, wherein the human is a 100 kg male.
43. The pharmaceutical composition of Claim 36, wherein the human is a 50 kg male.
44. A pharmaceutical composition comprising:
  - a Pro/Cat domain, or fragment thereof, that binds to low density lipoprotein receptor (LDLR), and an inactive V domain to LDLR activity, wherein the inactive V domain does not result in the degradation of LDLR; and
  - a pharmaceutically acceptable carrier or diluent.
45. The pharmaceutical composition of Claim 44, wherein the Pro/Cat domain comprises amino acids 61 to 374 of SEQ ID NO: 3, and wherein the neutralizing PCSK9 variant lacks the protein sequence defined from amino acid 453 to amino acid 692 of SEQ ID NO: 3.
46. The pharmaceutical composition of Claim 44, wherein the Pro/Cat domain comprises amino acids 31 to 374 of SEQ ID NO: 3.
47. The pharmaceutical composition of Claim 44, wherein the Pro/Cat domain comprises amino acids 61 to 446 of SEQ ID NO: 3.
48. The pharmaceutical composition of Claim 44, wherein the Pro/Cat domain comprises amino acids 31 to 449 of SEQ ID NO: 3, and wherein the V domain lacks at least the last 14 amino acids of SEQ ID NO: 3.
49. The pharmaceutical composition of Claim 44, wherein the neutralizing PCSK9 variant lacks amino acids 453 to 692 of SEQ ID NO: 3.
50. The pharmaceutical composition of Claim 44, wherein the Pro/Cat domain consists essentially of amino acids 31 to 447 of SEQ ID NO: 3.
51. The pharmaceutical composition of Claim 44, wherein the Pro/Cat domain consists of amino acids 31 to 447 of SEQ ID NO: 3.
52. A pharmaceutical composition comprising a Pro/Cat domain, or fragment thereof, that binds to low density lipoprotein receptor (LDLR), and an inactive V domain to LDLR activity, wherein the inactive V domain does not result in the degradation of LDLR, wherein the

pro/cat domain is present in an amount sufficient for the treatment of a cholesterol related disorder.

53. The pharmaceutical composition of Claim 52, wherein the Pro/Cat domain comprises the amino acid sequence of the Pro/Cat domain in SEQ ID NO: 9 or 30.

53. The pharmaceutical composition of Claim 52, wherein the Cat domain comprises the amino acid sequence of the Cat domain of at least one of the amino acids sequences of SEQ ID NOs: 9, 11, 13, 15, or 30.

54. The pharmaceutical composition of Claim 52, wherein the Pro/Cat domain consists of the amino acid sequence of the Pro/Cat domain in SEQ ID NO: 9 or 30.

55. The pharmaceutical composition of Claim 52, wherein the Pro/Cat domain consists essentially of the amino acid sequence of the Pro/Cat domain in SEQ ID NO: 9 or 30.

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QEDEDGDYEELVLALRSEEDGLAEAPEHGTTATFHRCADPWRLPGTYVVVLKEETHLSQS  
ERTARRLQAQAARRGYLTKILHVFHGLLPGFLVKMSGDLLELALKLPHVDYIEEDSSVFAQ  
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RPRGQPNQCVGHREASIHASCCHAPGLECKVKEHGI PAPQGQVTVACEEGWTLTGCSALPG  
TSHVLGAYAVDNTCVVRSRDVSTTGSTSEEAVTAVAICCRSRHLAQASQELQ

**SEQ ID NO:1****FIG. 1A**

```

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Frame1  : M G T V S S R R S W W P L P L L L SEQ ID NO:3

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-----|-----|-----|-----|-----|
Query   : gctgctgctgctgctcctgggtcccgcgggcgccgctgcccaggaggacg
Frame1  : L L L L L L L G P A G A R A Q E D E

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-----|-----|-----|-----|-----|
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Frame1  : D G D Y E E L V L A L R S E E D

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-----|-----|-----|-----|-----|
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Frame1  : G L A E A P E H G T T A T F H R C

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-----|-----|-----|-----|-----|
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Frame1  : A K D P W R L P G T Y V V V L K E

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-----|-----|-----|-----|-----|
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Frame1  : E T H L S Q S E R T A R R L Q A

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-----|-----|-----|-----|-----|
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Frame1  : Q A A R R G Y L T K I L H V F H G

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-----|-----|-----|-----|-----|
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Frame1  : L L P G F L V K M S G D L L E L A

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-----|-----|-----|-----|-----|
Query   : ccttgaagttgccccatgtcgactacatcgaggaggactcctctgtcttt
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FIG. 1B<sub>1</sub>

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Query   : tcctagacaccagcatacagagtgaccaccgggaaatcgagggcagggtc
Frame1  :   L  D  T  S  I  Q  S  D  H  R  E  I  E  G  R  V

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          -----|-----|-----|-----|-----|
Query   : atggtcaccgacttcgagaatgtgcccgaggaggacgggacccgcttcca
Frame1  : M  V  T  D  F  E  N  V  P  E  E  D  G  T  R  F  H

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          -----|-----|-----|-----|-----|
Query   : cagacaggccagcaagtgtgacagtcatggcacccacctggcaggggtgg
Frame1  :   R  Q  A  S  K  C  D  S  H  G  T  H  L  A  G  V  V

          710          720          730          740          750
          -----|-----|-----|-----|-----|
Query   : tcagcggccgggatgccggcggtggccaagggtgccagcatgcgagcctg
Frame1  :   S  G  R  D  A  G  V  A  K  G  A  S  M  R  S  L

          50          760          770          780          790          800
          -----|-----|-----|-----|-----|
Query   : cgcgtgctcaactgccaaagggaaagggcacgggttagcggcacccctcatagg
Frame1  : R  V  L  N  C  Q  G  K  G  T  V  S  G  T  L  I  G

          810          820          830          840          850
          -----|-----|-----|-----|-----|
Query   : cctggagtttattcggaaaagccagctggtccagcctgtggggccactgg
Frame1  : L  E  F  I  R  K  S  Q  L  V  Q  P  V  G  P  L  V

          50          860          870          880          890          900
          -----|-----|-----|-----|-----|
Query   : tggtgctgctgcccctggcgggtgggtacagccgcgctcctcaacgccgcc
Frame1  :   V  L  L  P  L  A  G  G  Y  S  R  V  L  N  A  A

          910          920          930          940          950
          -----|-----|-----|-----|-----|
Query   : tgccagcgcctggcgagggctggggctgctgctggtcaccgctgccggcaa
Frame1  : C  Q  R  L  A  R  A  G  V  V  L  V  T  A  A  G  N

          50          960          970          980          990          1000
          -----|-----|-----|-----|-----|
Query   : cttccgggacgatgcctgcctctactcccagcctcagctcccagaggtca
Frame1  : F  R  D  D  A  C  L  Y  S  P  A  S  A  P  E  V  I

          1010          1020          1030          1040          1050
          -----|-----|-----|-----|-----|
Query   : tcacagttggggccaccaatgccaggaccagccggtgaccctggggact
Frame1  :   T  V  G  A  T  N  A  Q  D  Q  P  V  T  L  G  T

          50          1060          1070          1080          1090          1100
          -----|-----|-----|-----|-----|
Query   : ttggggaccaactttggccgctgtgtggacctctttgccccaggggagga
Frame1  : L  G  T  N  F  G  R  C  V  D  L  F  A  P  G  E  D

```

**FIG. 1B<sub>2</sub>**

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      100      1110      1120      1130      1140      1150
      -----|-----|-----|-----|-----|
Query   : catcattggtgcctccagcgactgcagcacctgctttgtgtcacagagtg
Frame1  : I I G A S S D C S T C F V S Q S G

      150      1160      1170      1180      1190      1200
      -----|-----|-----|-----|-----|
Query   : ggacatcacaggctgctgcccacgtggctggcattgcagccatgatgctg
Frame1  : T S Q A A A H V A G I A A M M L

      200      1210      1220      1230      1240      1250
      -----|-----|-----|-----|-----|
Query   : tctgccgagccggagctcacccctggccgagttgagggcagagactgatcca
Frame1  : S A E P E L T L A E L R Q R L I H

      250      1260      1270      1280      1290      1300
      -----|-----|-----|-----|-----|
Query   : cttctctgccaaagatgtcatcaatgaggcctggttccctgaggaccagc
Frame1  : F S A K D V I N E A W F P E D Q R

      300      1310      1320      1330      1340      1350
      -----|-----|-----|-----|-----|
Query   : gggactgaccccccaacctgggtggccgcctgccccccagcacccatggg
Frame1  : V L T P N L V A A L P P S T H G

      350      1360      1370      1380      1390      1400
      -----|-----|-----|-----|-----|
Query   : gcaggttggcagctgttttgcaggactgtgtggtcagcacactcggggcc
Frame1  : A G W Q L F C R T V W S A H S G P

      400      1410      1420      1430      1440      1450
      -----|-----|-----|-----|-----|
Query   : tacacggatggccacagccatcgcccgctgcgccccagatgaggagctgc
Frame1  : T R M A T A I A R C A P D E E L L

      450      1460      1470      1480      1490      1500
      -----|-----|-----|-----|-----|
Query   : tgagctgctccagtttctccaggagtgggaagcggcggggcgagcgcag
Frame1  : S C S S F S R S G K R R G E R M

      500      1510      1520      1530      1540      1550
      -----|-----|-----|-----|-----|
Query   : gaggcccaagggggcaagctgggtctgccgggcccacaacgcttttggggg
Frame1  : E A Q G G K L V C R A H N A F G G

      550      1560      1570      1580      1590      1600
      -----|-----|-----|-----|-----|
Query   : tgagggtgtctacgccattgccagggtgctgcctgctaccccaggccaact
Frame1  : E G V Y A I A R C C L L P Q A N C

      600      1610      1620      1630      1640      1650
      -----|-----|-----|-----|-----|
Query   : gcagcgtccacacagctccaccagctgaggccagcatggggaccctgtgc
Frame1  : S V H T A P P A E A S M G T R V

```

**FIG. 1B<sub>3</sub>**

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650 1660 1670 1680 1690 1700  
 -----|-----|-----|-----|-----|  
 Query : cactgccaccaacagggccacgtcctcacaggctgcagctcccactggga  
 Frame1 : H C H Q Q G H V L T G C S S H W E

700 1710 1720 1730 1740 1750  
 -----|-----|-----|-----|-----|  
 Query : ggtggaggaccttggcaccacacaagccgcctgtgctgaggccacgaggtc  
 Frame1 : V E D L G T H K P P V L R P R G Q

750 1760 1770 1780 1790 1800  
 -----|-----|-----|-----|-----|  
 Query : agcccaaccagtgcgtgggcccacagggaggccagcatccacgcttctctgc  
 Frame1 : P N Q C V G H R E A S I H A S C

800 1810 1820 1830 1840 1850  
 -----|-----|-----|-----|-----|  
 Query : tgccatgccccaggtctggaatgcaaagtcaaggagcatggaatcccggc  
 Frame1 : C H A P G L E C K V K E H G I P A

850 1860 1870 1880 1890 1900  
 -----|-----|-----|-----|-----|  
 Query : ccctcaggggcaggtgaccgtggcctgcgaggaggctggaccctgactg  
 Frame1 : P Q G Q V T V A C E E G W T L T G

900 1910 1920 1930 1940 1950  
 -----|-----|-----|-----|-----|  
 Query : gctgcagcgcctccctgggacctcccacgtcctggggcctacgccgta  
 Frame1 : C S A L P G T S H V L G A Y A V

950 1960 1970 1980 1990 2000  
 -----|-----|-----|-----|-----|  
 Query : gacaacacgtgtgtagtcaggagccgggacgtcagcactacaggcagcac  
 Frame1 : D N T C V V R S R D V S T T G S T

2010 2020 2030 2040 2050  
 -----|-----|-----|-----|-----|  
 Query : cagcgaagaggccgtgacagccggttgccatctgctgccggagccggcacc  
 Frame1 : S E E A V T A V A I C C R S R H L

50 2060 2070 2080 2090 2100  
 -----|-----|-----|-----|-----|  
 Query : tggcgcaggcctcccaggagctccag  
 Frame1 : A Q A S Q E L Q

SEQ ID NO: 2  
 SEQ ID NO: 3

FIG. 1B<sub>4</sub>







Query	1	SIPWNLERITPPRYRADEYQPPDGGSLVEVYLLDTSIQSDHREIEGRVMVTFENVPEED	60
		SIPWNL+RI R++EY PP+ G VEVYLLDTS+QS HREIEG+V V DFE+VP+ED	
Sbjct	368	SIPWNLDRIVLAPSRSEEYSPNKGQVEVYLLDTSIQSGHREIEGKVTVADFEDVPDED	427
Query	61	GTRFHRQASKCDSHGTHLAGVVSGRDAGVAKGASMRSLRVLNCQKGTVSGTLIGLEFIR	120
		G +FH QASKC+SHGTH+AGV+SGRDAGVA+ A++RS+RVLNCQKGTVSGT GLEFIR	
Sbjct	428	GAQFHSQASKCESHGTHVAGVLSGRDAGVARAAA VRSVRV LNCQKGTVSGTARGLEFIR	487
Query	121	KSQLVQPVGPLVLLPLAGGYSRVLNAAACQRLARAGVVLVTAAGNFRDDACLSPASAPE	180
		++QLVQP PL+VLLP AGG+SR LNAAC+ L R+G ++ AAGN+RDDAC YSPAS PE	
Sbjct	488	RTQLVQPYSPLIIVLLPFAGHRSRTLNAACRLLVRSGAAVIAAAGNYRDDACSYSPASEPE	547
Query	181	VITVGATNAQDQPVTLLGTLGNFGRVDFLFPAGEDIIIGASSDCSTCFVSQSGTSQAAAHV	240
		VITVGATNAQDQP LG LGTNFGRVDFLFPAGEDIIIGASSDC TCF SQSGTSQAAAHV	
Sbjct	548	VITVGATNAQDQPAALGALGNFGRVDFLFPAGEDIIIGASSDCGTCFTSQSGTSQAAAHV	607
Query	241	AGIAAMMLSAEPELTLAELRQRLIHFSAKDVINEAWFPEDQRVLT PNLVAALP	293
		AGIA+M+L+AEP LT+ ELRQRLIHFS K+ INEAWFPEDQR+LTPNLVA LP	11
Sbjct	608	AGIASMLLNAEPLTVPPELRQRLIHFSVKNAINEAWFPEDQRLLT PNLVARLP	660

SEQ ID  
NO:

FIG. 1F

Query	1	SIPWNLERITPPRYRADEYQPPDGGSLVEVYLLDTSIQSDHREIEGRVMVTFENVPEED	60
		S+PWNL+RI P + A ++ PP+ G VEVYLLDTSIQS+HREIEG+V VTDF+NVPEED	
Sbjct	144	SVPWNLDRIVPAQQMASQFSPNTGDSVEVYLLDTSIQSNHREIEGKVFVTFDQNVPEED	203
Query	61	GTRFHRQASKDSDHGLAGVVSGRDAGVAKGASMRSLRVLNLCQKGTSGTLIGLEFIR	120
		GTRFHRQASKC+SHGTH+AGVV+GRDAGVAKG ++RSLRVLNLCQKGTVSG+L GLEFIR	
Sbjct	204	GTRFHRQASKCESHGTHMAGVVNGRDAGVAKGVNVRSLRVLNLCQKGTSGSLTGLEFIR	263
Query	121	KSQLVQPVGPLVLLPLAGGYSRVLNAAACQRLARAGVVLVTAAGNFRDDACLSPASAPE	180
		K+ + QP PL+V++P GGYSR+LNAA + L GV+++ AAGN++DDACLSPAS PE	
Sbjct	264	KTLIEQPNPLIIVIPFVGGYSRILNAAASRALVNTGVIIIAAAGNYKDDACLSPASEPE	323
Query	181	VITVGATNAQDQPVTLGLTGNFGRVCVDFAPGEDIIIGASSDCSTCFVSQSGTSQAAAHV	240
		VIT+GATN QDQP T+G LGTN+G C+DLFAPG+DIIIGASSDCSTCF S+SGTSQAAAHV	
Sbjct	324	VITIGATNYQDQPATMGVLTNYGNCIDLAFAPGDDIIIGASSDCSTCFTSKSGTSQAAAHV	383
Query	241	AGIAAMMLSAEPELTLAELRQRLLIHFSAKDVINEAWFPEDQRVLTPNLVAALP	293 10
		AGIAAM+L+ +P+L+++ELRQRLLI FS K VINE WFPEDQR++TPN VA LP	13
Sbjct	384	AGIAAMILNDKPDLSVELRQRLLIQFSTKKVINEVWFPEPDRQLITPNRVAGLP	436 14
			SEQ ID
			NO:

FIG. 1G

Query	3	PWNLERITPPRYRADEYQPPDGGSLVEVYLLDTSIQSDHREIEGRVMVTDFFENVPEEDGT	62
		PW+L R+ PR R P G+ VEVYL+D S+ S HRE+ GRV+VTDF +VP +	
Sbjct	84	PWSLRLPRRGR-----PGDGAAVEVYLMDGSVLSSHRELGGRLVTDHSHVPGVEAG	137
Query	63	RFHRQASKCDSHGTHLAGVVSGRDAGVAKGASMRSLRVLNCQKGTVSGTLIGLEFIRKS	122
		HR+AS+C HGTH+A VV G D GVA GA + +RVL+C+GKGTVSG L G+E+IR +	
Sbjct	138	G-HREASRCKGHGTHVAAVVMGSDTGVAPGARVNLVRVLDRCRGKGTVSGALAGVEYIRAA	196
Query	123	QLVQPVGPIVLLPLAGGYSRVLNAACQRLARAGVVLVTAAGNFRDDACLISPASAPE--	180
		P G VLLP G +SR LNAAC+ L G V+V AAGN+RDDACLISPAS PE	
Sbjct	197	LRAHPPGAAVVLLPFTGAFSRSINAACRDLVNTGAVVVAAGNYRDDACLISPASEPEVC	256
Query	181	-----VITVGATNAQDQPVTLGLTGNFGRCVDLFA	211
		VITVGA N+ DQ V+ G GTN GRCVD+FA	
Sbjct	257	TGGSARSHTHTHTHTHLLQAVLCVCVQVITVGAVNSADQLVSOQGGTNGRCVDVFA	316
Query	212	PGEDIIGASSDCSTCFVSQSGTSQAAAHVAGIAAMMLSAEPELTLAELRQRLIHFSKDV	271
		PG DI+ ASSDC TCF S SGTSQAAAH AG+AA++LS+ P LT ++ Q L+ +S	
Sbjct	317	PGGDIVSASSDCDTCFASGSGTSQAAAHAAGMAAVLLSSSPSLTPVQVLTLLRYS----	372
Query	272	INEAWFPEIDQRLVLPNLVAALPP	294
		++ + ++TP+LVAALPP	15
Sbjct	373	VSLPSVSGRRGLVTPSLVAALPP	395
			16
			SEQ ID NO:

FIG. 1H

**FIG. 1I** Sequence of Human and Mouse LDLR

	1	10	20	30	40	50	60	70	73	Section 1							
(1)		S.p.															
hLDLR P01130 (1)	MGPWGKLRW	VALLLAAAGT	AVG	DR	CERNEFQ	CDGKCI	SYK	WCDGSA	ECQDGS	DESQETC	VTCKSGDF						
mLDLR NP_034830 (1)	MSTADLMRRW	VALLLAAAGV	AVE	D	SGSRNEF	QCRDGKCI	ASK	WCDGSP	ECPCDGS	DESPKTC	MSTCQSNQF						
Consensus (1)	M	RW	IALLAAAG	AV	D	RNEFQC	DGKCI	A	KWCDGS	EC	DGSD	ES	TCLSVTC	S	F		
(74)	74	80	90	100	110	120	130	146		Section 2							
hLDLR P01130 (74)	SCGGRVNR	CIPQFWR	CDGQVDC	DNGS	DEQ	GGCP	PKTCSQ	DEFR	CHDGK	CI	SRQFV	CDSDR	DCLDG	SDEASCPV	L		
mLDLR NP_034830 (74)	SCGGRVSR	CIPDSWR	CDGQVDC	EINDS	DEQ	GGCP	PKTCSQ	DEFR	CHDGK	CI	SRQFV	CDSDR	DCLDG	SDEAHCPAT			
Consensus (74)	SCGGRV	RCIP	WRCDGQVDC	DN	SDEQ	GGCP	PKTCSQ	DD	FR	C	QFV	CD	DRD	CLDGS	DEA	CP	
(147)	147	160	170	180	190	200	219			Section 3							
hLDLR P01130 (147)	TCGPA	SFQNS	STCIPQ	LWAC	NDP	DCED	GSDE	WPQ	RCR	GLY	-VFQ	DS	S	P	C	S	
mLDLR NP_034830 (147)	TCGPA	HFRCK	SSCIP	SLWAC	DG	VDCV	DG	SH	WPQ	CA	ED	T	A	S	K	G	
Consensus (147)	TCGPA	F	C	SS	CIP	LWAC	D	DC	DGS	WPQ	C	A	G	S	SP	C	S
(220)	220	230	240	250	260	270	280	292		Section 4							
hLDLR P01130 (219)	GDCKD	KSD	EENCA	VATCR	P	DFQC	SDG	NCI	H	GS	RQ	CDRE	Y	D	C	K	
mLDLR NP_034830 (220)	EADCK	D	KEEHC	AVATCR	P	DFQC	ADG	S	C	I	H	S	RQ	CDRE	F	H	
Consensus (220)	DCKD	S	D	E	E	E	E	E	E	E	E	E	E	E	E	E	
(293)	293	300	310	320	330	340	350	365		Section 5							
hLDLR P01130 (292)	L	D	K	V	C	N	M	A	R	D	C	R	D	W	S	D	
mLDLR NP_034830 (293)	L	D	K	V	C	S	A	R	D	C	R	D	W	S	D	E	
Consensus (293)	L	D	K	V	C	A	R	D	C	R	D	W	S	D	E	E	
(366)	366	380	390	400	410	420	438			Section 6							
hLDLR P01130 (365)	S	Q	L	C	V	N	L	E	G	G	K	C	Q	C	E	E	
mLDLR NP_034830 (366)	S	Q	L	C	V	N	L	E	G	S	K	C	E	C	A	G	
Consensus (366)	S	Q	L	C	V	N	L	E	G	S	K	C	E	C	A	G	





# Sequence of Human and Cyno LDLR

## FIG. 1 L

	433	440	450	460	470	480	490	504	Section 7
hLDLR 20080009918	(433)								
cynLDLR 20080068365	(433)								
Consensus	(433)								
Section 8									
hLDLR 20080009918	(505)	510	520	530	540	550	560	576	
cynLDLR 20080068365	(505)								
Consensus	(505)								
Section 9									
hLDLR 20080009918	(577)	590	600	610	620	630	648		
cynLDLR 20080068365	(577)								
Consensus	(577)								
Section 10									
hLDLR 20080009918	(649)	660	670	680	690	700	710	720	
cynLDLR 20080068365	(649)								
Consensus	(649)								
Section 11									
hLDLR 20080009918	(721)	730	740	750	760	770	780	792	
cynLDLR 20080068365	(721)								
Consensus	(721)								
Section 12									
hLDLR 20080009918	(793)	800	810	820	830	840	850	860	SEQ ID NO:
cynLDLR 20080068365	(793)								18
Consensus	(793)								19
									22

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**Cavia porcellus PCSK9**

Met	Arg	Thr	Arg	Gly	Pro	Ala	Pro	Ala	Trp	Trp	Pro	Met	Leu	Leu	Leu
1				5					10					15	
Leu	Met	Leu	Gly	Pro	Ala	Pro	Ala	Gly	Ala	Gln	Ala	Arg	Asp	Ser	Glu
			20					25					30		
Asp	Gly	Asp	His	Glu	Gly	Leu	Ala	Phe	Ala	Phe	Pro	Pro	Glu	Glu	Asp
		35					40					45			
Gly	Pro	Ala	Glu	Ala	Ala	Pro	His	Val	Pro	Thr	Ala	Pro	Phe	His	Arg
	50					55					60				
Cys	Ser	Lys	Asp	Ala	Trp	Arg	Leu	Pro	Gly	Thr	Tyr	Leu	Val	Val	Leu
65					70					75					80
Lys	Glu	Gly	Thr	His	Arg	Gly	Gln	Thr	Lys	His	Thr	Ala	His	Arg	Leu
				85					90					95	
Gln	Ala	Lys	Ala	Ala	Arg	Arg	Gly	Tyr	Val	Thr	Thr	Val	Leu	His	Leu
			100					105					110		
Phe	His	His	Leu	Val	Pro	Gly	Phe	Leu	Val	Arg	Met	Ser	Gly	Asp	Leu
		115					120					125			
Leu	Asp	Met	Ala	Leu	Arg	Leu	Pro	Leu	Val	Gln	Tyr	Ile	Glu	Glu	Asp
	130					135					140				
Ser	Ser	Val	Phe	Ala	Gln	Ser	Val	Pro	Trp	Asn	Leu	Glu	Arg	Ile	Leu
145					150					155					160
Pro	Val	Arg	His	Gln	Ala	Lys	Glu	Tyr	Ser	Ala	Pro	Ser	His	Pro	Val
				165					170					175	
Thr	Val	Tyr	Leu	Leu	Asp	Thr	Ser	Ile	Gln	Ser	Gly	His	Arg	Glu	Ile
			180					185					190		
Gln	Gly	Arg	Ile	Thr	Val	Thr	Asp	Phe	Glu	Ser	Val	Pro	Gln	Glu	Asp
		195					200					205			
Gly	Thr	Arg	Phe	His	Arg	Gln	Ala	Ser	Lys	Cys	Asp	Ser	His	Gly	Thr
	210					215					220				
His	Leu	Ala	Gly	Val	Val	Ser	Gly	Arg	Asp	Ala	Gly	Val	Ala	Lys	Gly
225					230					235					240
Ala	Gly	Leu	Arg	Ser	Leu	Arg	Val	Leu	Asn	Cys	Gln	Gly	Arg	Gly	Thr
				245					250					255	
Val	Ser	Ser	Thr	Leu	Arg	Gly	Leu	Glu	Phe	Ile	Arg	Lys	Ser	Gln	Leu
			260					265					270		
Ala	Gln	Pro	Val	Glu	Pro	Leu	Val	Val	Leu	Leu	Pro	Leu	Ala	Gly	Gly
		275				280						285			
Tyr	Ser	Arg	Thr	Leu	Asn	Ala	Ala	Cys	His	Leu	Leu	Ala	Arg	Ala	Gly
	290					295					300				
Val	Val	Leu	Val	Ala	Ala	Ala	Gly	Asn	Phe	Arg	Asp	Asp	Ala	Cys	Leu
305					310					315					320
Tyr	Ser	Pro	Ala	Ser	Ala	Pro	Glu	Val	Ile	Thr	Val	Gly	Ala	Thr	Asn
				325					330					335	
Ala	Gln	Asp	Gln	Pro	Val	Thr	Leu	Gly	Thr	Leu	Gly	Thr	Asn	Phe	Gly
			340					345					350		
Arg	Cys	Val	Asp	Leu	Phe	Ala	Pro	Gly	Glu	Asp	Ile	Ile	Gly	Ala	Ser
		355					360					365			
Ser	Asp	Cys	Ser	Thr	Cys	Phe	Val	Ser	Arg	Ser	Gly	Thr	Ser	Gln	Ala
	370					375					380				

**FIG 1M<sub>1</sub>**

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Ala	Ala	His	Val	Ala	Gly	Ile	Val	Thr	Met	Met	Leu	Thr	Ala	Gln	Pro
385					390					395					400
Lys	Leu	Thr	Leu	Ala	Glu	Leu	Trp	Gln	Arg	Leu	Ile	His	Phe	Ala	Ala
				405					410					415	
Lys	Asp	Val	Ile	Asn	Glu	Ala	Trp	Phe	Pro	Glu	Asp	Gln	Arg	Val	Leu
			420					425					430		
Thr	Pro	Asn	Leu	Val	Ala	Thr	Leu	Pro	Pro	Ser	Thr	Arg	Gly	Ala	Gly
		435					440					445			
Gly	Arg	Leu	Leu	Cys	Arg	Thr	Val	Trp	Ser	Ala	Arg	Ser	Gly	Pro	Arg
	450					455					460				
His	Thr	Ala	Thr	Ala	Leu	Ala	His	Cys	Thr	Pro	Gly	Glu	Glu	Leu	Leu
465					470					475					480
Ser	Cys	Ser	Ser	Phe	Ser	Arg	Ser	Gly	Lys	Arg	Lys	Gly	Glu	Arg	Ile
				485					490					495	
Glu	Val	Leu	Arg	Gly	Arg	Arg	Val	Cys	Val	Ala	Tyr	Asn	Ala	Phe	Gly
			500					505					510		
Gly	Lys	Gly	Val	His	Ala	Val	Ala	Arg	Cys	Cys	Leu	Leu	Pro	Arg	Ala
		515					520					525			
Asn	Cys	Ser	Leu	His	Thr	Ala	Pro	Ala	Arg	Ala	Gly	Met	Glu	Pro	Arg
	530					535					540				
Val	His	Cys	His	Arg	Lys	Asp	Gln	Val	Leu	Thr	Gly	Cys	Ser	Ala	His
545					550					555					560
Trp	Glu	Ala	Glu	Asp	Phe	Arg	Ala	Arg	Gly	Trp	Pro	Met	Leu	Arg	Pro
				565					570					575	
Gly	Gly	Pro	Ser	Gln	Cys	Val	Gly	His	Ser	Lys	Ala	Ser	Val	His	Ala
			580					585					590		
Ser	Cys	Cys	Ser	Ala	Pro	Gly	Leu	Glu	Cys	Arg	Ile	Arg	Glu	His	Gly
		595					600						605		
Val	Pro	Trp	Pro	Ala	Glu	Gln	Val	Thr	Val	Ala	Cys	Glu	Asp	Gly	Trp
	610					615					620				
Thr	Leu	Thr	Gly	Cys	Ser	Thr	Leu	Pro	Gly	Ala	Ser	Ser	Val	Leu	Gly
625					630					635					640
Thr	Tyr	Ala	Val	Asp	Asp	Met	Cys	Val	Val	Arg	Ser	Arg	Asp	Val	Lys
				645					650					655	
Ala	Leu	Asp	Arg	Thr	Arg	Gly	Glu	Ala	Leu	Ala	Ala	Ile	Ala	Ile	Cys
			660					665					670		
Cys	Arg	Ser	Gln	Ala	Ser	Glu	Gln	Ala	Ser	Pro	Glu	Arg	Gln		
		675					680					685			

SEQ ID NO: 25

FIG 1M<sub>2</sub>

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**Mesocricetus auratus PCSK9**

Met	Gly	Thr	Ser	Cys	Ser	Ala	Arg	Pro	Arg	Trp	Leu	Leu	Ser	Pro	Leu
1				5					10					15	
Leu	Leu	Leu	Leu	Leu	Leu	Leu	Arg	Tyr	Met	Gly	Ala	Ser	Ala	Gln	Asp
			20					25					30		
Glu	Asp	Ala	Glu	Tyr	Glu	Glu	Leu	Met	Leu	Thr	Leu	Gln	Ser	Gln	Asp
		35					40					45			
Asp	Gly	Leu	Ala	Asp	Glu	Thr	Asp	Glu	Ala	Pro	Gln	Gly	Ala	Thr	Ala
	50					55					60				
Ala	Phe	His	Arg	Cys	Pro	Glu	Glu	Ala	Trp	Arg	Val	Pro	Gly	Thr	Tyr
65					70					75					80
Ile	Val	Met	Leu	Ala	Glu	Glu	Ala	Gln	Trp	Val	His	Ile	Glu	Gln	Thr
				85					90					95	
Met	His	Arg	Leu	Gln	Thr	Gln	Ala	Ala	Arg	Arg	Gly	Tyr	Val	Ile	Lys
			100					105					110		
Ile	Gln	His	Ile	Phe	Tyr	Asp	Phe	Leu	Pro	Ala	Phe	Val	Val	Lys	Met
		115					120					125			
Ser	Ser	Asp	Leu	Leu	Asp	Leu	Ala	Leu	Lys	Leu	Pro	His	Val	Lys	Tyr
	130					135					140				
Ile	Glu	Glu	Asp	Ser	Leu	Val	Phe	Ala	Gln	Ser	Ile	Pro	Trp	Asn	Leu
145					150					155					160
Asp	Arg	Ile	Ile	Pro	Ala	Gly	Arg	Gln	Ala	Gln	Glu	Tyr	Ser	Ser	Ser
				165					170					175	
Arg	Lys	Val	Pro	Ser	Gly	Ser	Gly	Gln	Val	Glu	Val	Tyr	Leu	Leu	Asp
			180					185					190		
Thr	Ser	Ile	Gln	Ser	Asp	His	Arg	Glu	Ile	Glu	Gly	Arg	Val	Thr	Val
		195					200					205			
Thr	Asp	Phe	Asn	Ser	Val	Pro	Glu	Glu	Asp	Gly	Thr	Arg	Phe	His	Arg
	210					215					220				
Gln	Ala	Ser	Lys	Cys	Asp	Ser	His	Gly	Thr	His	Leu	Ala	Gly	Val	Val
225					230					235					240
Ser	Gly	Arg	Asp	Ala	Gly	Val	Ala	Lys	Gly	Thr	Ile	Leu	His	Gly	Leu
				245					250					255	
Arg	Val	Leu	Asn	Cys	Gln	Gly	Lys	Gly	Ile	Val	Ser	Gly	Ile	Leu	Thr
			260					265					270		
Gly	Leu	Glu	Phe	Ile	Trp	Lys	Ser	Gln	Leu	Met	Gln	Pro	Ser	Gly	Pro
		275					280					285			
Gln	Val	Val	Leu	Leu	Pro	Leu	Ala	Gly	Arg	Tyr	Ser	Arg	Val	Leu	Asn
	290					295					300				
Thr	Ala	Cys	Gln	His	Leu	Ala	Arg	Thr	Gly	Val	Val	Leu	Val	Ala	Ala
305					310					315					320
Ala	Gly	Asn	Phe	Arg	Asp	Asp	Ala	Cys	Leu	Tyr	Ser	Pro	Ala	Ser	Ala
				325					330					335	
Pro	Glu	Val	Ile	Thr	Val	Gly	Ala	Thr	Asp	Val	Gln	Asp	Gln	Pro	Val
			340					345					350		
Thr	Leu	Gly	Thr	Leu	Gly	Thr	Asn	Phe	Gly	Arg	Cys	Val	Asp	Leu	Phe
		355					360					365			
Ala	Pro	Gly	Lys	Asp	Ile	Ile	Gly	Ala	Ser	Ser	Asp	Cys	Ser	Ala	Cys
	370					375					380				
Phe	Met	Ser	Gln	Ser	Gly	Thr	Ser	Gln	Ala	Ala	Ala	His	Val	Ala	Gly
385					390					395					400

**FIG 1N<sub>1</sub>**

SUBSTITUTE SHEET (RULE 26)

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Ile	Val	Ala	Met	Met	Leu	Thr	Leu	Glu	Pro	Glu	Leu	Thr	Leu	Thr	Glu
				405					410					415	
Leu	Arg	Gln	Arg	Leu	Ile	His	Phe	Ser	Thr	Lys	Asp	Ala	Ile	Asn	Met
			420					425					430		
Ala	Trp	Phe	Pro	Glu	Asp	Gln	Arg	Val	Leu	Thr	Pro	Asn	Leu	Val	Ala
		435					440					445			
Thr	Leu	Pro	Pro	Ser	Thr	His	Gly	Thr	Gly	Gly	Gln	Leu	Leu	Cys	Arg
	450					455					460				
Thr	Val	Trp	Ser	Ala	His	Ser	Gly	Pro	Thr	Arg	Ala	Ala	Thr	Ala	Thr
465					470					475					480
Ala	Arg	Cys	Ala	Pro	Gly	Glu	Glu	Leu	Leu	Ser	Cys	Ser	Ser	Phe	Ser
				485					490					495	
Arg	Ser	Gly	Arg	Arg	Arg	Gly	Asp	Arg	Ile	Glu	Ala	Ala	Gly	Thr	Gln
			500					505					510		
Gln	Val	Cys	Lys	Ala	Leu	Asn	Ala	Phe	Gly	Gly	Glu	Gly	Val	Tyr	Ala
		515					520					525			
Val	Ala	Arg	Cys	Cys	Leu	Leu	Pro	Arg	Ala	Asn	Cys	Ser	Ile	His	Thr
	530					535					540				
Thr	Pro	Ala	Ala	Arg	Thr	Ser	Leu	Glu	Thr	His	Ala	His	Cys	His	Gln
545					550					555					560
Lys	Asp	His	Val	Leu	Thr	Gly	Cys	Ser	Leu	His	Trp	Glu	Val	Glu	Gly
				565					570					575	
Ile	Gly	Val	Gln	Pro	Leu	Ala	Val	Leu	Arg	Ser	Arg	His	Gln	Pro	Gly
			580					585					590		
Gln	Cys	Thr	Gly	His	Arg	Glu	Ala	Ser	Val	His	Ala	Ser	Cys	Cys	His
		595					600					605			
Ala	Pro	Gly	Leu	Glu	Cys	Lys	Ile	Lys	Glu	His	Gly	Ile	Ser	Gly	Pro
	610					615					620				
Ala	Glu	Gln	Val	Thr	Val	Ala	Cys	Glu	Ala	Gly	Trp	Thr	Leu	Thr	Gly
625					630					635					640
Cys	Asn	Val	Leu	Pro	Gly	Ala	Phe	Ile	Thr	Leu	Gly	Ala	Tyr	Ala	Val
				645					650					655	
Asp	Asn	Thr	Cys	Val	Ala	Arg	Ser	Arg	Val	Thr	Asp	Thr	Ala	Gly	Arg
			660					665					670		
Thr	Gly	Glu	Glu	Ala	Thr	Val	Ala	Ala	Ala	Ile	Cys	Cys	Arg	Asn	Arg
		675					680					685			
Pro	Ser	Ala	Lys	Ala	Ser	Trp	Val	His	Gln						
	690					695									

SEQ ID NO: 26

FIG 1N<sub>2</sub>

SUBSTITUTE SHEET (RULE 26)

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**Mus musculus PCSK9**

Met	Gly	Thr	His	Cys	Ser	Ala	Trp	Leu	Arg	Trp	Pro	Leu	Leu	Pro	Leu
1				5				10					15		
Leu	Pro	Pro	Leu	Leu	Leu	Leu	Leu	Leu	Leu	Leu	Cys	Pro	Thr	Gly	Ala
			20					25					30		
Gly	Ala	Gln	Asp	Glu	Asp	Gly	Asp	Tyr	Glu	Glu	Leu	Met	Leu	Ala	Leu
		35					40					45			
Pro	Ser	Gln	Glu	Asp	Gly	Leu	Ala	Asp	Glu	Ala	Ala	His	Val	Ala	Thr
	50					55					60				
Ala	Thr	Phe	Arg	Arg	Cys	Ser	Lys	Glu	Ala	Trp	Arg	Leu	Pro	Gly	Thr
65					70					75					80
Tyr	Ile	Val	Val	Leu	Met	Glu	Glu	Thr	Gln	Arg	Leu	Gln	Ile	Glu	Gln
				85					90					95	
Thr	Ala	His	Arg	Leu	Gln	Thr	Arg	Ala	Ala	Arg	Arg	Gly	Tyr	Val	Ile
			100					105					110		
Lys	Val	Leu	His	Ile	Phe	Tyr	Asp	Leu	Phe	Pro	Gly	Phe	Leu	Val	Lys
		115					120					125			
Met	Ser	Ser	Asp	Leu	Leu	Gly	Leu	Ala	Leu	Lys	Leu	Pro	His	Val	Glu
	130					135					140				
Tyr	Ile	Glu	Glu	Asp	Ser	Phe	Val	Phe	Ala	Gln	Ser	Ile	Pro	Trp	Asn
145					150					155					160
Leu	Arg	Ile	Ile	Pro	Ala	Trp	His	Gln	Thr	Glu	Glu	Asp	Arg	Ser	Pro
				165					170					175	
Asp	Gly	Ser	Ser	Gln	Val	Glu	Val	Tyr	Leu	Leu	Asp	Thr	Ser	Ile	Gln
			180					185					190		
Gly	Ala	His	Arg	Glu	Ile	Glu	Gly	Arg	Val	Thr	Ile	Thr	Asp	Phe	Asn
		195					200					205			
Ser	Val	Pro	Glu	Glu	Asp	Gly	Thr	Arg	Phe	His	Arg	Gln	Ala	Ser	Lys
	210					215					220				
Cys	Asp	Ser	His	Gly	Thr	His	Leu	Ala	Gly	Val	Val	Ser	Gly	Arg	Asp
225					230					235					240
Ala	Gly	Val	Ala	Lys	Gly	Thr	Ser	Leu	His	Ser	Leu	Arg	Val	Leu	Asn
				245					250					255	
Cys	Gln	Gly	Lys	Gly	Thr	Val	Ser	Gly	Thr	Leu	Ile	Gly	Leu	Glu	Phe
			260					265					270		
Ile	Arg	Lys	Ser	Gln	Leu	Ile	Gln	Pro	Ser	Pro	Leu	Val	Val	Leu	Pro
		275					280					285			
Leu	Ala	Gly	Gly	Tyr	Ser	Arg	Ile	Leu	Asn	Ala	Ala	Cys	Arg	His	Leu
	290					295					300				
Ala	Arg	Thr	Gly	Val	Val	Leu	Val	Ala	Ala	Ala	Gly	Asn	Phe	Arg	Asp
305					310					315					320
Asp	Ala	Cys	Leu	Tyr	Ser	Pro	Ala	Ser	Ala	Pro	Glu	Val	Ile	Thr	Val
				325					330					335	
Gly	Ala	Thr	Asn	Ala	Gln	Asp	Gln	Pro	Val	Thr	Leu	Gly	Thr	Leu	Gly
			340					345					350		
Thr	Asn	Phe	Gly	Arg	Cys	Val	Asp	Leu	Phe	Ala	Pro	Gly	Lys	Asp	Ile
		355					360					365			
Ile	Gly	Ala	Ser	Ser	Asp	Cys	Ser	Thr	Cys	Phe	Met	Ser	Gln	Ser	Gly
	370					375					380				
Thr	Ser	Gln	Ala	Ala	Ala	His	Val	Ala	Gly	Ile	Val	Ala	Arg	Met	Leu
385					390					395					400

**FIG 10<sub>1</sub>**

SUBSTITUTE SHEET (RULE 26)

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Ser	Arg	Glu	Pro	Thr	Leu	Thr	Leu	Ala	Leu	Arg	Gln	Arg	Ile	His	Phe
				405					410					415	
Ser	Thr	Lys	Asp	Val	Ile	Asn	Met	Ala	Trp	Phe	Pro	Glu	Asp	Gln	Gln
			420					425					430		
Val	Leu	Thr	Pro	Asn	Leu	Val	Ala	Thr	Leu	Pro	Pro	Ser	Thr	His	Glu
		435					440					445			
Thr	Gly	Gly	Gln	Leu	Leu	Cys	Arg	Thr	Val	Trp	Ser	Ala	His	Ser	Gly
	450					455					460				
Pro	Thr	Arg	Thr	Ala	Thr	Ala	Thr	Ala	Arg	Cys	Ala	Pro	Glu	Glu	Glu
465					470					475					480
Leu	Leu	Ser	Cys	Ser	Ser	Phe	Ser	Arg	Ser	Gly	Arg	Arg	Arg	Gly	Asp
			485						490					495	
Arg	Ile	Glu	Ala	Ile	Gly	Gly	Gln	Gln	Val	Cys	Lys	Ala	Leu	Asn	Ala
			500					505					510		
Phe	Gly	Gly	Glu	Gly	Val	Tyr	Ala	Val	Ala	Arg	Cys	Cys	Leu	Val	Pro
		515					520					525			
His	Ala	Asn	Cys	Ser	Ile	His	Asn	Pro	Ala	Ala	Ala	Gly	Leu	Glu	Thr
	530						535				540				
His	Val	His	Cys	His	Gln	Lys	Asp	His	Val	Leu	Thr	Gly	Cys	Ser	Phe
545					550					555					560
His	Trp	Glu	Val	Glu	Asp	Leu	Ser	Val	Arg	Arg	Gln	Pro	Ala	Leu	Arg
				565					570					575	
Ser	Arg	Arg	Gln	Pro	Gly	Gln	Cys	Val	Gly	His	Gln	Ala	Ala	Ser	Val
			580					585					590		
Tyr	Ala	Ser	Cys	Cys	His	Ala	Pro	Gly	Leu	Glu	Cys	Lys	Ile	Lys	Glu
		595					600					605			
His	Gly	Ile	Ser	Gly	Ser	Ser	Glu	Gln	Val	Thr	Val	Ala	Cys	Glu	Ala
	610						615					620			
Gly	Trp	Thr	Leu	Thr	Gly	Cys	Asn	Val	Leu	Pro	Gly	Ala	Ser	Leu	Thr
625					630					635					640
Leu	Gly	Ala	Tyr	Ser	Val	Asp	Asn	Leu	Cys	Val	Ala	Arg	Val	His	Asp
				645					650					655	
Thr	Ala	Arg	Ala	Asp	Arg	Thr	Gly	Glu	Thr	Val	Ala	Ala	Ala	Ile	Cys
			660					665					670		
Cys	Arg	Ser	Arg	Pro	Ser	Ala	Lys	Ala	Ser	Trp	Val	Gln			
		675					680					685			

SEQ ID NO: 27

FIG 10<sub>2</sub>

SUBSTITUTE SHEET (RULE 26)

22 / 38

**Macaca fascicularis PCSK9**

Met	Gly	Thr	Val	Ser	Ser	Arg	Arg	Ser	Trp	Trp	Pro	Leu	Pro	Leu	Pro
1				5					10					15	
Leu	Leu	Leu	Leu	Leu	Leu	Leu	Gly	Pro	Ala	Gly	Ala	Arg	Ala	Gln	Glu
			20					25					30		
Asp	Glu	Asp	Gly	Asp	Tyr	Glu	Glu	Leu	Val	Leu	Ala	Leu	Arg	Ser	Glu
		35					40					45			
Glu	Asp	Gly	Leu	Ala	Asp	Ala	Pro	Glu	His	Gly	Ala	Thr	Ala	Thr	Phe
	50					55					60				
His	Arg	Cys	Ala	Lys	Asp	Pro	Trp	Arg	Leu	Pro	Gly	Thr	Tyr	Val	Val
65					70						75				80
Val	Leu	Lys	Glu	Glu	Thr	His	Arg	Ser	Gln	Ser	Glu	Arg	Thr	Ala	Arg
				85					90					95	
Arg	Leu	Gln	Ala	Gln	Ala	Ala	Arg	Arg	Gly	Tyr	Leu	Thr	Lys	Ile	Leu
			100					105					110		
His	Val	Phe	His	His	Leu	Leu	Pro	Gly	Phe	Leu	Val	Lys	Met	Ser	Gly
		115					120					125			
Asp	Leu	Leu	Glu	Leu	Ala	Leu	Lys	Leu	Pro	His	Val	Asp	Tyr	Ile	Glu
	130					135					140				
Glu	Asp	Ser	Ser	Val	Phe	Ala	Gln	Ser	Ile	Pro	Trp	Asn	Glu	Arg	Ile
145					150					155					160
Thr	Pro	Ala	Arg	Tyr	Arg	Ala	Asp	Glu	Tyr	Gln	Pro	Pro	Lys	Gly	Gly
				165					170					175	
Ser	Leu	Val	Glu	Val	Tyr	Leu	Leu	Asp	Thr	Ser	Ile	Gln	Ser	Asp	His
			180					185					190		
Arg	Glu	Ile	Glu	Gly	Arg	Val	Met	Val	Thr	Asp	Phe	Glu	Ser	Val	Pro
		195					200					205			
Glu	Glu	Asp	Gly	Thr	Arg	Phe	His	Arg	Gln	Ala	Ser	Lys	Cys	Asp	Ser
	210					215					220				
His	Gly	Thr	His	Leu	Ala	Gly	Val	Val	Ser	Gly	Arg	Asp	Ala	Gly	Val
225					230					235					240
Ala	Lys	Gly	Ala	Gly	Leu	Arg	Ser	Leu	Arg	Val	Leu	Asn	Cys	Gln	Gly
				245					250					255	
Lys	Gly	Thr	Val	Ser	Gly	Thr	Leu	Ile	Gly	Leu	Glu	Phe	Ile	Arg	Lys
			260					265					270		
Ser	Gln	Leu	Val	Gln	Pro	Val	Pro	Leu	Val	Val	Leu	Pro	Leu	Ala	Gly
		275					280					285			
Gly	Tyr	Ser	Arg	Val	Phe	Asn	Ala	Ala	Cys	Gln	Arg	Leu	Ala	Arg	Ala
	290					295					300				
Gly	Val	Val	Leu	Val	Thr	Ala	Ala	Gly	Asn	Phe	Arg	Asp	Asp	Ala	Cys
305					310					315					320
Leu	Tyr	Ser	Pro	Ala	Ser	Ala	Pro	Glu	Val	Ile	Thr	Val	Gly	Ala	Thr
				325					330					335	
Asn	Ala	Gln	Asp	Gln	Pro	Val	Thr	Leu	Gly	Thr	Leu	Gly	Thr	Asn	Phe
			340					345					350		
Gly	Arg	Cys	Val	Asp	Leu	Phe	Ala	Pro	Gly	Glu	Asp	Ile	Ile	Gly	Ala
		355					360					365			
Ser	Ser	Asp	Cys	Ser	Thr	Cys	Phe	Val	Ser	Arg	Ser	Gly	Thr	Ser	Gln
	370					375						380			
Ala	Ala	Ala	His	Val	Ala	Gly	Ile	Ala	Ala	Met	Met	Leu	Ser	Ala	Glu
385					390					395					400

**FIG 1P<sub>1</sub>**

SUBSTITUTE SHEET (RULE 26)

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Pro	Glu	Leu	Thr	Leu	Ala	Leu	Arg	Gln	Leu	Ile	His	Phe	Ser	Ala	Lys
				405					410					415	
Asp	Val	Ile	Asn	Glu	Ala	Trp	Phe	Pro	Glu	Asp	Gln	Arg	Val	Leu	Thr
			420					425					430		
Pro	Asn	Leu	Val	Ala	Ala	Leu	Pro	Pro	Ser	Thr	His	Arg	Ala	Gly	Trp
		435					440					445			
Gln	Leu	Phe	Cys	Arg	Thr	Val	Trp	Ser	Ala	His	Ser	Gly	Pro	Thr	Arg
	450					455					460				
Met	Ala	Thr	Ala	Val	Ala	Arg	Cys	Ala	Gln	Asp	Glu	Glu	Leu	Leu	Ser
465					470					475					480
Cys	Ser	Ser	Phe	Ser	Arg	Ser	Gly	Lys	Arg	Arg	Gly	Glu	Arg	Ile	Glu
				485					490					495	
Ala	Gln	Gly	Gly	Lys	Arg	Val	Cys	Arg	Ala	His	Asn	Ala	Phe	Gly	Gly
			500					505					510		
Glu	Gly	Val	Tyr	Ala	Ile	Ala	Arg	Cys	Cys	Leu	Leu	Pro	Gln	Val	Asn
		515					520					525			
Cys	Ser	Val	His	Thr	Pro	Pro	Gly	Ala	Ser	Met	Gly	Thr	Arg	Val	His
	530					535					540				
Cys	His	Gln	Gln	Gly	His	Val	Leu	Thr	Gly	Cys	Ser	Ser	His	Trp	Glu
545					550					555					560
Val	Glu	Asp	Leu	Gly	Thr	His	Lys	Pro	Pro	Val	Leu	Arg	Pro	Arg	Gly
				565					570					575	
Gln	Pro	Asn	Gln	Cys	Val	Gly	His	Arg	Glu	Ala	Ser	Ile	His	Ala	Ser
			580					585					590		
Cys	Cys	His	Ala	Pro	Gly	Leu	Glu	Cys	Lys	Val	Arg	Glu	His	Gly	Ile
		595					600					605			
Pro	Ala	Pro	Gln	Glu	Gln	Val	Ile	Val	Ala	Cys	Glu	Asp	Gly	Trp	Thr
	610					615					620				
Leu	Thr	Gly	Cys	Ser	Ala	Leu	Pro	Gly	Thr	Ser	His	Val	Leu	Gly	Ala
625					630					635					640
Tyr	Ala	Val	Asp	Asn	Thr	Cys	Val	Val	Arg	Ser	Arg	Asp	Val	Ser	Thr
				645					650					655	
Thr	Gly	Ser	Thr	Glu	Ala	Val	Ala	Ala	Val	Ala	Ile	Cys	Cys	Arg	Ser
			660					665					670		
Arg	His	Leu	Val	Gln	Ala	Ser	Gln	Glu	Leu	Gln					
		675					680								

SEQ ID NO: 28

FIG 1P<sub>2</sub>

SUBSTITUTE SHEET (RULE 26)

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**Rattus norvegicus PCSK9**

Met	Gly	Ile	Arg	Cys	Ser	Thr	Trp	Leu	Arg	Trp	Pro	Leu	Ser	Pro	Gln
1				5					10					15	
Leu	Leu	Leu	Leu	Leu	Leu	Leu	Cys	Pro	Thr	Gly	Ser	Arg	Ala	Gln	Asp
			20					25					30		
Glu	Asp	Gly	Asp	Tyr	Glu	Glu	Leu	Met	Leu	Ala	Leu	Pro	Ser	Gln	Glu
		35					40					45			
Asp	Ser	Leu	Val	Asp	Glu	Ala	Ser	His	Val	Ala	Thr	Ala	Thr	Phe	Arg
	50					55					60				
Arg	Cys	Ser	Lys	Glu	Ala	Trp	Arg	Leu	Pro	Gly	Thr	Tyr	Val	Val	Val
65					70					75					80
Leu	Met	Glu	Glu	Thr	Gln	Arg	Leu	Gln	Val	Glu	Gln	Thr	Ala	His	Arg
				85					90					95	
Leu	Gln	Thr	Trp	Ala	Ala	Arg	Arg	Gly	Tyr	Val	Ile	Lys	Val	Leu	His
			100					105					110		
Val	Phe	Tyr	Asp	Leu	Phe	Pro	Gly	Phe	Leu	Val	Lys	Met	Ser	Ser	Asp
		115					120					125			
Leu	Leu	Gly	Leu	Ala	Leu	Lys	Leu	Pro	His	Val	Glu	Tyr	Ile	Glu	Glu
		130				135					140				
Asp	Ser	Leu	Val	Phe	Ala	Gln	Ser	Ile	Pro	Trp	Asn	Leu	Glu	Arg	Ile
145					150					155					160
Ile	Pro	Ala	Trp	Gln	Gln	Thr	Glu	Glu	Asp	Ser	Ser	Pro	Asp	Gly	Ser
				165					170					175	
Ser	Gln	Val	Glu	Val	Tyr	Leu	Leu	Asp	Thr	Ser	Ile	Gln	Ser	Gly	His
			180					185					190		
Arg	Glu	Ile	Glu	Gly	Arg	Val	Thr	Ile	Thr	Asp	Phe	Asn	Ser	Val	Pro
		195					200					205			
Glu	Glu	Asp	Gly	Thr	Arg	Phe	His	Arg	Gln	Ala	Ser	Lys	Cys	Asp	Ser
		210				215					220				
His	Gly	Thr	His	Leu	Ala	Gly	Val	Val	Ser	Gly	Arg	Asp	Ala	Gly	Val
225					230					235					240
Ala	Lys	Gly	Thr	Ser	Leu	His	Ser	Leu	Arg	Val	Leu	Asn	Cys	Gln	Gly
				245					250					255	
Lys	Gly	Thr	Val	Ser	Gly	Thr	Leu	Ile	Gly	Leu	Glu	Phe	Ile	Arg	Lys
			260					265					270		
Ser	Gln	Leu	Ile	Gln	Pro	Ser	Gly	Pro	Leu	Val	Val	Leu	Leu	Pro	Leu
		275					280					285			
Ala	Gly	Gly	Tyr	Ser	Arg	Ile	Leu	Asn	Thr	Ala	Cys	Gln	Arg	Leu	Ala
	290					295					300				
Arg	Thr	Gly	Val	Val	Leu	Val	Ala	Ala	Ala	Gly	Asn	Phe	Arg	Asp	Asp
305					310					315					320
Ala	Cys	Leu	Tyr	Ser	Pro	Ala	Ser	Ala	Pro	Glu	Val	Ile	Thr	Val	Gly
				325					330					335	
Ala	Thr	Asn	Ala	Gln	Asp	Gln	Pro	Val	Thr	Leu	Gly	Thr	Leu	Gly	Thr
			340					345					350		
Asn	Phe	Gly	Arg	Cys	Val	Asp	Leu	Phe	Ala	Pro	Gly	Lys	Asp	Ile	Ile
		355					360					365			
Gly	Ala	Ser	Ser	Asp	Cys	Ser	Thr	Cys	Tyr	Met	Ser	Gln	Ser	Gly	Thr
	370					375					380				
Ser	Gln	Ala	Ala	Ala	His	Val	Ala	Gly	Ile	Val	Ala	Met	Met	Leu	Asn
385					390					395					400

**FIG 1Q<sub>1</sub>**

SUBSTITUTE SHEET (RULE 26)

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Arg	Asp	Pro	Ala	Leu	Thr	Leu	Ala	Glu	Leu	Arg	Gln	Arg	Leu	Ile	Leu
				405					410					415	
Phe	Ser	Thr	Lys	Asp	Val	Ile	Asn	Met	Ala	Trp	Phe	Pro	Glu	Asp	Gln
			420					425					430		
Arg	Val	Leu	Thr	Pro	Asn	Arg	Val	Ala	Thr	Leu	Pro	Pro	Ser	Thr	Gln
		435					440					445			
Glu	Thr	Gly	Gly	Gln	Leu	Leu	Cys	Arg	Thr	Val	Trp	Ser	Ala	His	Ser
	450					455					460				
Gly	Pro	Thr	Arg	Thr	Ala	Thr	Ala	Thr	Ala	Arg	Cys	Ala	Pro	Glu	Glu
465					470					475					480
Glu	Leu	Leu	Ser	Cys	Ser	Ser	Phe	Ser	Arg	Ser	Gly	Arg	Arg	Arg	Gly
				485					490						495
Asp	Arg	Ile	Glu	Ala	Ile	Gly	Gly	Gln	Gln	Val	Cys	Lys	Ala	Leu	Asn
			500					505					510		
Ala	Phe	Gly	Gly	Glu	Gly	Val	Tyr	Ala	Val	Ala	Arg	Cys	Cys	Leu	Leu
		515					520					525			
Pro	Arg	Val	Asn	Cys	Ser	Ile	His	Asn	Thr	Pro	Ala	Ala	Arg	Ala	Gly
		530				535					540				
Pro	Gln	Thr	Pro	Val	His	Cys	His	Gln	Lys	Asp	His	Val	Leu	Thr	Gly
545					550					555					560
Cys	Ser	Phe	His	Trp	Glu	Val	Glu	Asn	Leu	Arg	Ala	Gln	Gln	Gln	Pro
				565					570					575	
Leu	Leu	Arg	Ser	Arg	His	Gln	Pro	Gly	Gln	Cys	Val	Gly	His	Gln	Glu
			580					585					590		
Ala	Ser	Val	His	Ala	Ser	Cys	Cys	His	Ala	Pro	Gly	Leu	Glu	Cys	Lys
		595					600					605			
Ile	Lys	Glu	His	Gly	Ile	Ala	Gly	Pro	Ala	Glu	Gln	Val	Thr	Val	Ala
	610					615					620				
Cys	Glu	Ala	Gly	Trp	Thr	Leu	Thr	Gly	Cys	Asn	Val	Leu	Pro	Gly	Ala
625					630					635					640
Ser	Leu	Pro	Leu	Gly	Ala	Tyr	Ser	Val	Asp	Asn	Val	Cys	Val	Ala	Arg
				645					650					655	
Ile	Arg	Asp	Ala	Gly	Arg	Ala	Asp	Arg	Thr	Ser	Glu	Glu	Ala	Thr	Val
			660				665						670		
Ala	Ala	Ala	Ile	Cys	Cys	Arg	Ser	Arg	Pro	Ser	Ala	Lys	Ala	Ser	Trp
		675					680					685			
Val	His	Gln													
	690														

SEQ ID NO: 29

FIG 1Q<sub>2</sub>

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**Consensus sequence of PCSK9**

Met	Gly	Thr	Xaa	Cys	Ser	Ala	Arg	Ser	Trp	Trp	Pro	Leu	Xaa	Xaa	Xaa
1				5					10				15		
Xaa	Xaa	Pro	Leu	Leu	Leu	Leu	Leu	Leu	Leu	Leu	Pro	Ala	Gly	Ala	Ala
			20					25				30			
Ala	Ala	Gln	Asp	Glu	Asp	Gly	Asp	Tyr	Glu	Glu	Leu	Met	Leu	Ala	Leu
		35				40					45				
Pro	Ser	Gln	Glu	Asp	Gly	Leu	Ala	Asp	Glu	Ala	Glu	His	Val	Xaa	Xaa
	50				55						60				
Xaa	Ala	Thr	Ala	Thr	Phe	His	Arg	Cys	Ser	Lys	Asp	Ala	Trp	Arg	Leu
65				70						75					80
Pro	Gly	Thr	Tyr	Val	Val	Val	Leu	Lys	Glu	Glu	Thr	Gln	Arg	Leu	Gln
				85					90					95	
Ser	Glu	Gln	Thr	Ala	His	Arg	Leu	Gln	Thr	Gln	Ala	Ala	Arg	Arg	Gly
			100					105					110		
Tyr	Val	Thr	Lys	Ile	Leu	His	Val	Phe	His	Asp	Leu	Leu	Pro	Gly	Phe
		115					120					125			
Leu	Val	Lys	Met	Ser	Ser	Asp	Leu	Leu	Asp	Leu	Ala	Leu	Lys	Leu	Pro
	130					135					140				
His	Val	Asp	Tyr	Ile	Glu	Glu	Asp	Ser	Ser	Val	Phe	Ala	Gln	Ser	Ile
145					150					155					160
Pro	Trp	Asn	Leu	Glu	Arg	Ile	Ile	Pro	Ala	Arg	His	Gln	Ala	Asp	Glu
				165					170					175	
Tyr	Ser	Ser	Xaa	Xaa	Xaa	Xaa	Pro	Asp	Gly	Ser	Ser	Gln	Val	Glu	Val
			180					185					190		
Tyr	Leu	Leu	Asp	Thr	Ser	Ile	Gln	Ser	Asp	His	Arg	Glu	Ile	Glu	Gly
		195					200					205			
Arg	Val	Thr	Val	Thr	Asp	Phe	Asn	Ser	Val	Pro	Glu	Glu	Asp	Gly	Thr
	210					215					220				
Arg	Phe	His	Arg	Gln	Ala	Ser	Lys	Cys	Asp	Ser	His	Gly	Thr	His	Leu
225					230					235					240
Ala	Gly	Val	Val	Ser	Gly	Arg	Asp	Ala	Gly	Val	Ala	Lys	Gly	Thr	Ser
				245					250					255	
Leu	Arg	Ser	Leu	Arg	Val	Leu	Asn	Cys	Gln	Gly	Lys	Gly	Thr	Val	Ser
			260					265					270		
Gly	Thr	Leu	Ile	Gly	Leu	Glu	Phe	Ile	Arg	Lys	Ser	Gln	Leu	Ile	Gln
		275					280					285			
Pro	Val	Gly	Pro	Leu	Val	Val	Leu	Leu	Pro	Leu	Ala	Gly	Gly	Tyr	Ser
	290					295					300				
Arg	Val	Leu	Asn	Ala	Ala	Cys	Gln	Arg	Leu	Ala	Arg	Thr	Gly	Val	Val
305					310					315					320
Leu	Val	Ala	Ala	Ala	Gly	Asn	Phe	Arg	Asp	Asp	Ala	Cys	Leu	Tyr	Ser
				325					330					335	
Pro	Ala	Ser	Ala	Pro	Glu	Val	Ile	Thr	Val	Gly	Ala	Thr	Asn	Ala	Gln
			340					345					350		
Asp	Gln	Pro	Val	Thr	Leu	Gly	Thr	Leu	Gly	Thr	Asn	Phe	Gly	Arg	Cys
		355					360					365			
Val	Asp	Leu	Phe	Ala	Pro	Gly	Lys	Asp	Ile	Ile	Gly	Ala	Ser	Ser	Asp
	370					375					380				
Cys	Ser	Thr	Cys	Phe	Met	Ser	Gln	Ser	Gly	Thr	Ser	Gln	Ala	Ala	Ala
385					390					395					400

**FIG 1R<sub>1</sub>**

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His	Val	Ala	Gly	Ile	Val	Ala	Met	Met	Leu	Ser	Ala	Glu	Pro	Glu	Leu
				405					410					415	
Thr	Leu	Ala	Glu	Leu	Arg	Gln	Arg	Leu	Ile	His	Phe	Ser	Thr	Lys	Asp
			420					425					430		
Val	Ile	Asn	Met	Ala	Trp	Phe	Pro	Glu	Asp	Gln	Arg	Val	Leu	Thr	Pro
		435					440					445			
Asn	Leu	Val	Ala	Thr	Leu	Pro	Pro	Ser	Thr	His	Gly	Thr	Gly	Gly	Gln
	450					455					460				
Leu	Leu	Cys	Arg	Thr	Val	Trp	Ser	Ala	His	Ser	Gly	Pro	Thr	Arg	Thr
465					470					475					480
Ala	Thr	Ala	Thr	Ala	Arg	Cys	Ala	Pro	Asp	Glu	Glu	Leu	Leu	Ser	Cys
				485					490					495	
Ser	Ser	Phe	Ser	Arg	Ser	Gly	Lys	Arg	Arg	Gly	Asp	Arg	Ile	Glu	Ala
			500					505					510		
Ile	Gly	Gly	Gln	Gln	Val	Cys	Lys	Ala	Leu	Asn	Ala	Phe	Gly	Gly	Glu
		515					520					525			
Gly	Val	Tyr	Ala	Val	Ala	Arg	Cys	Cys	Leu	Leu	Pro	Arg	Ala	Asn	Cys
	530					535					540				
Ser	Ile	His	Thr	Thr	Pro	Ala	Ala	Arg	Ala	Ser	Met	Glu	Thr	Arg	Val
545					550						555				560
His	Cys	His	Gln	Lys	Asp	His	Val	Leu	Thr	Gly	Cys	Ser	Ser	His	Trp
				565					570					575	
Glu	Val	Glu	Asp	Leu	Gly	Xaa	Xaa	Lys	Xaa	Pro	Val	Leu	Arg	Ser	Arg
			580					585					590		
Gly	Gln	Pro	Gly	Gln	Cys	Val	Gly	His	Arg	Glu	Ala	Ser	Val	His	Ala
		595					600					605			
Ser	Cys	Cys	His	Ala	Pro	Gly	Leu	Glu	Cys	Lys	Ile	Lys	Glu	His	Gly
	610					615					620				
Ile	Pro	Gly	Pro	Ala	Glu	Gln	Val	Thr	Val	Ala	Cys	Glu	Ala	Gly	Trp
625					630					635					640
Thr	Leu	Thr	Gly	Cys	Ser	Val	Leu	Pro	Gly	Ala	Ser	Leu	Val	Leu	Gly
				645					650					655	
Ala	Tyr	Ala	Val	Asp	Asn	Thr	Cys	Val	Val	Arg	Ser	Arg	Asp	Val	Ser
			660					665					670		
Thr	Ala	Gly	Arg	Thr	Ser	Glu	Glu	Ala	Thr	Val	Ala	Ala	Ala	Ile	Cys
		675					680					685			
Cys	Arg	Ser	Arg	Pro	Ser	Ala	Gln	Ala	Ser	Trp	Val	Xaa	Gln		
	690					695					700				

SEQ ID NO: 30

Xaa = Any Amino Acid or No Amino Acid

FIG 1R<sub>2</sub>

SUBSTITUTE SHEET (RULE 26)

**Homo sapiens PCSK9**

Met	Gly	Thr	Val	Ser	Ser	Arg	Arg	Ser	Trp	Trp	Pro	Leu	Pro	Leu	Leu
1				5					10					15	
Leu	Leu	Leu	Leu	Leu	Leu	Leu	Gly	Pro	Ala	Gly	Ala	Arg	Ala	Gln	Glu
			20					25					30		
Asp	Glu	Asp	Gly	Asp	Tyr	Glu	Glu	Leu	Val	Leu	Ala	Leu	Arg	Ser	Glu
		35					40					45			
Glu	Asp	Gly	Leu	Ala	Glu	Ala	Pro	Glu	His	Gly	Thr	Thr	Ala	Thr	Phe
	50					55					60				
His	Arg	Cys	Ala	Lys	Asp	Pro	Trp	Arg	Leu	Pro	Gly	Thr	Tyr	Val	Val
65					70						75				80
Val	Leu	Lys	Glu	Glu	Thr	His	Leu	Ser	Gln	Ser	Glu	Arg	Thr	Ala	Arg
				85					90					95	
Arg	Leu	Gln	Ala	Gln	Ala	Ala	Arg	Arg	Gly	Tyr	Leu	Thr	Lys	Ile	Leu
			100					105					110		
His	Val	Phe	His	Leu	Leu	Pro	Gly	Phe	Leu	Val	Lys	Met	Ser	Gly	Asp
		115					120					125			
Leu	Leu	Glu	Leu	Ala	Leu	Lys	Leu	Pro	His	Val	Asp	Tyr	Ile	Glu	Glu
	130					135					140				
Asp	Ser	Ser	Val	Phe	Ala	Gln	Ser	Ile	Pro	Trp	Asn	Leu	Glu	Arg	Ile
145					150					155					160
Thr	Pro	Pro	Arg	Tyr	Arg	Ala	Asp	Glu	Tyr	Gln	Pro	Pro	Asp	Gly	Gly
				165					170					175	
Ser	Leu	Val	Glu	Val	Tyr	Leu	Leu	Asp	Thr	Ser	Ile	Gln	Ser	Asp	His
			180					185					190		
Arg	Glu	Ile	Glu	Gly	Arg	Val	Met	Val	Thr	Asp	Phe	Glu	Asn	Val	Pro
		195					200					205			
Glu	Glu	Asp	Gly	Thr	Arg	Phe	His	Arg	Gln	Ala	Ser	Lys	Cys	Asp	Ser
	210					215					220				
His	Gly	Thr	His	Leu	Ala	Gly	Val	Val	Ser	Gly	Arg	Asp	Ala	Gly	Val
225					230					235					240
Ala	Lys	Gly	Ala	Ser	Met	Arg	Ser	Leu	Arg	Val	Leu	Asn	Cys	Gln	Gly
				245					250					255	
Lys	Gly	Thr	Val	Ser	Gly	Thr	Leu	Ile	Gly	Leu	Glu	Phe	Ile	Arg	Lys
			260					265					270		
Ser	Gln	Leu	Val	Gln	Pro	Val	Pro	Leu	Val	Val	Leu	Leu	Pro	Leu	Ala
		275					280					285			
Gly	Gly	Tyr	Ser	Arg	Val	Leu	Asn	Ala	Ala	Cys	Gln	Arg	Leu	Ala	Arg
	290					295					300				
Ala	Gly	Val	Val	Leu	Val	Thr	Ala	Ala	Gly	Asn	Phe	Arg	Asp	Asp	Ala
305					310					315					320
Cys	Leu	Tyr	Ser	Pro	Ala	Ser	Ala	Pro	Glu	Val	Ile	Thr	Val	Gly	Ala
				325					330					335	
Thr	Asn	Ala	Gln	Asp	Gln	Pro	Val	Thr	Leu	Gly	Thr	Leu	Gly	Thr	Asn
			340					345					350		
Phe	Gly	Arg	Cys	Val	Asp	Leu	Phe	Ala	Pro	Gly	Glu	Asp	Ile	Ile	Gly
		355					360					365			
Ala	Ser	Ser	Asp	Cys	Ser	Thr	Cys	Phe	Val	Ser	Gln	Ser	Gly	Thr	Ser
	370					375					380				
Gln	Ala	Ala	Ala	His	Val	Ala	Gly	Ile	Ala	Ala	Met	Met	Leu	Ser	Ala
385					390					395					400

**FIG 1S<sub>1</sub>**

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Glu	Pro	Glu	Leu	Thr	Leu	Ala	Glu	Leu	Arg	Gln	Leu	Ile	His	Phe	Ser
				405					410					415	
Ala	Lys	Asp	Val	Ile	Asn	Glu	Ala	Trp	Phe	Pro	Glu	Asp	Gln	Arg	Val
			420					425					430		
Leu	Thr	Pro	Asn	Leu	Val	Ala	Ala	Leu	Pro	Pro	Ser	Thr	His	Gly	Ala
		435					440					445			
Gly	Trp	Gln	Leu	Phe	Cys	Arg	Thr	Val	Trp	Ser	Ala	His	Ser	Gly	Pro
	450					455					460				
Thr	Arg	Met	Ala	Thr	Ala	Ile	Ala	Arg	Cys	Ala	Pro	Asp	Glu	Glu	Leu
465					470					475					480
Leu	Ser	Cys	Ser	Ser	Phe	Ser	Arg	Ser	Gly	Lys	Arg	Arg	Gly	Glu	Arg
				485					490					495	
Met	Glu	Ala	Gln	Gly	Gly	Lys	Leu	Val	Cys	Arg	Ala	His	Asn	Ala	Phe
			500					505					510		
Gly	Gly	Glu	Gly	Val	Tyr	Ala	Ile	Ala	Arg	Cys	Cys	Leu	Leu	Pro	Gln
		515					520					525			
Ala	Asn	Cys	Ser	Val	His	Thr	Ala	Pro	Pro	Ala	Glu	Ala	Ser	Met	Gly
	530					535					540				
Thr	Arg	Val	His	Cys	His	Gln	Gln	Gly	His	Val	Leu	Thr	Gly	Cys	Ser
545				550						555					560
Ser	His	Trp	Glu	Val	Glu	Asp	Leu	Gly	Thr	His	Lys	Pro	Pro	Val	Leu
				565					570					575	
Arg	Pro	Arg	Gly	Gln	Pro	Asn	Gln	Cys	Val	Gly	His	Arg	Glu	Ala	Ser
			580					585					590		
Ile	His	Ala	Ser	Cys	Cys	His	Ala	Pro	Gly	Leu	Glu	Cys	Lys	Val	Lys
		595					600					605			
Glu	His	Gly	Ile	Pro	Ala	Pro	Gln	Glu	Gln	Val	Thr	Val	Ala	Cys	Glu
	610					615					620				
Glu	Gly	Trp	Thr	Leu	Thr	Gly	Cys	Ser	Ala	Leu	Pro	Gly	Thr	Ser	His
625					630					635					640
Val	Leu	Gly	Ala	Tyr	Ala	Val	Asp	Asn	Thr	Cys	Val	Val	Arg	Ser	Arg
				645					650					655	
Asp	Val	Ser	Thr	Thr	Gly	Ser	Thr	Ser	Glu	Glu	Ala	Val	Thr	Ala	Val
			660					665					670		
Ala	Ile	Cys	Cys	Arg	Ser	Arg	His	Leu	Ala	Gln	Ala	Ser	Gln	Glu	Leu
		675					680						685		
Gln															

SEQ ID NO: 31

FIG 1S<sub>2</sub>

SUBSTITUTE SHEET (RULE 26)

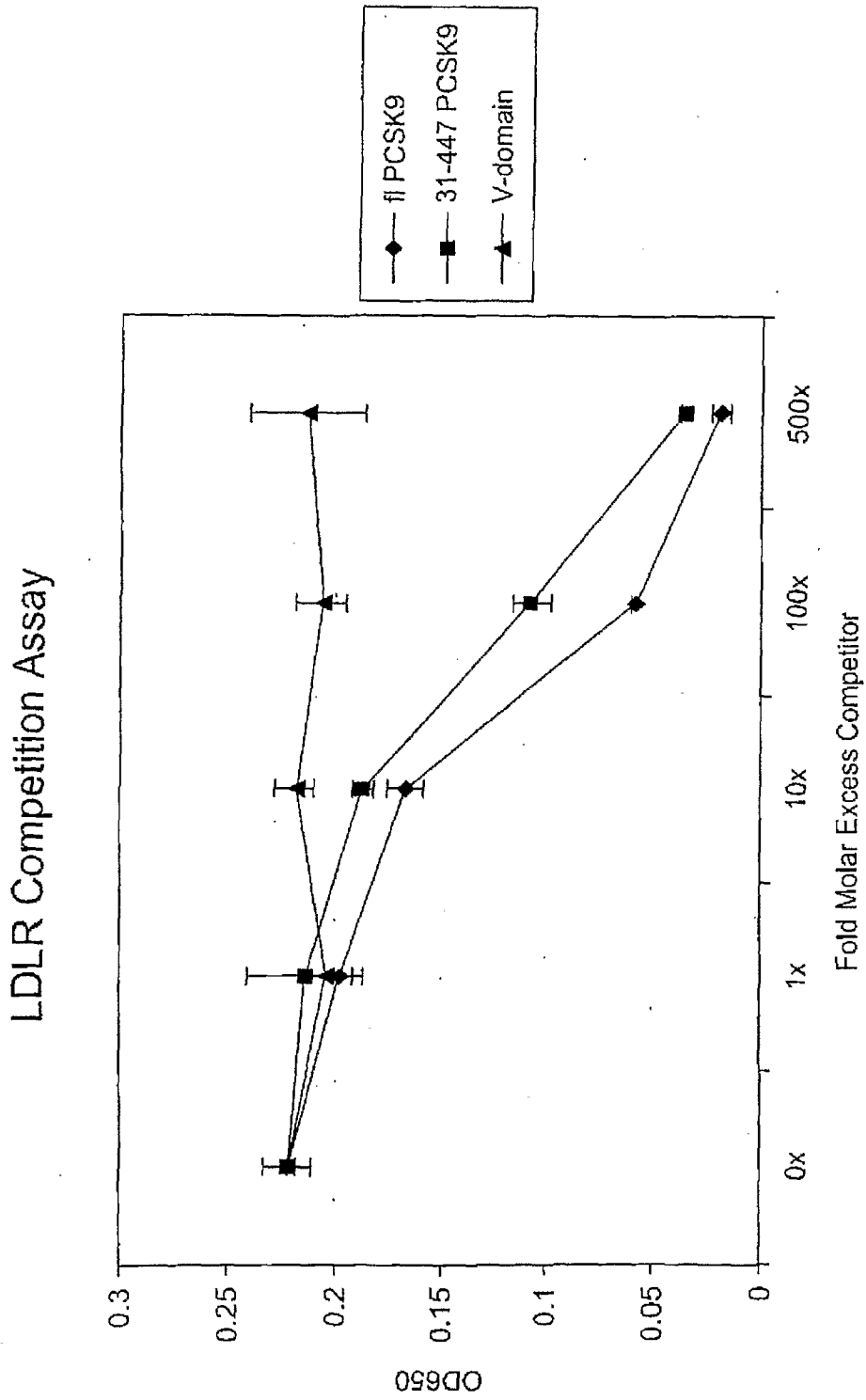


FIG. 2

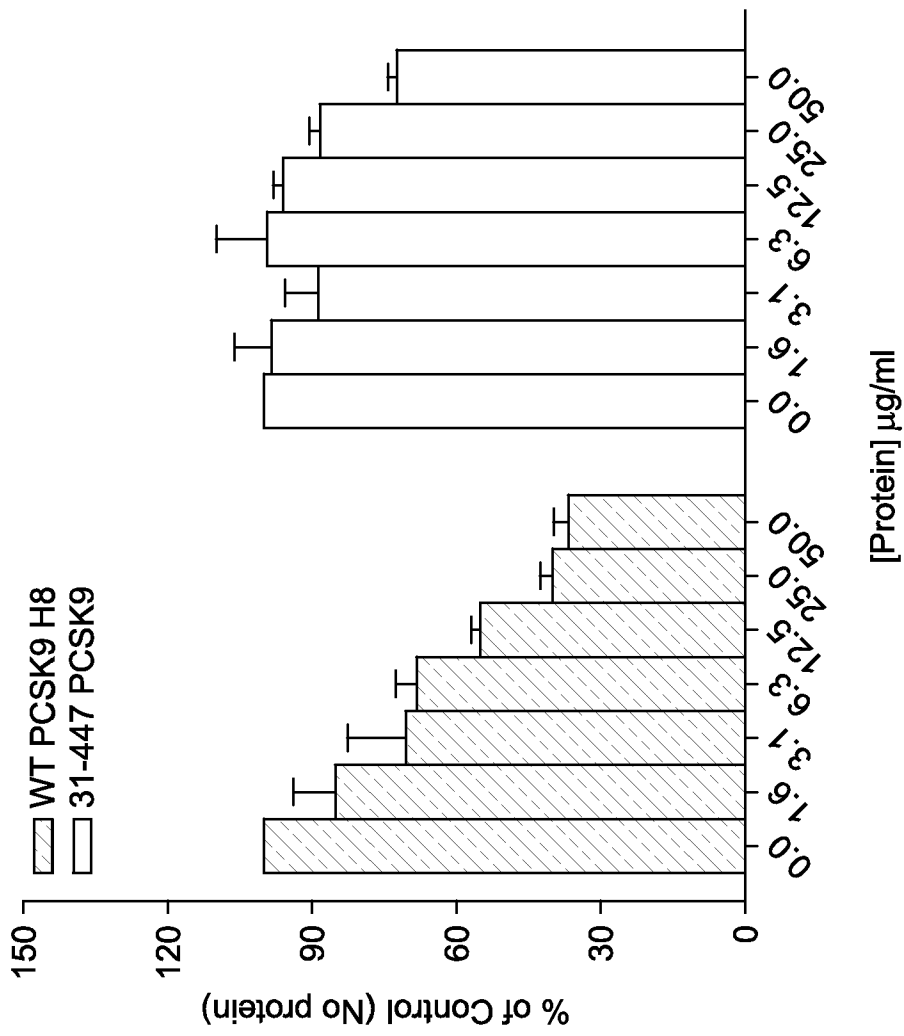


FIG. 3A

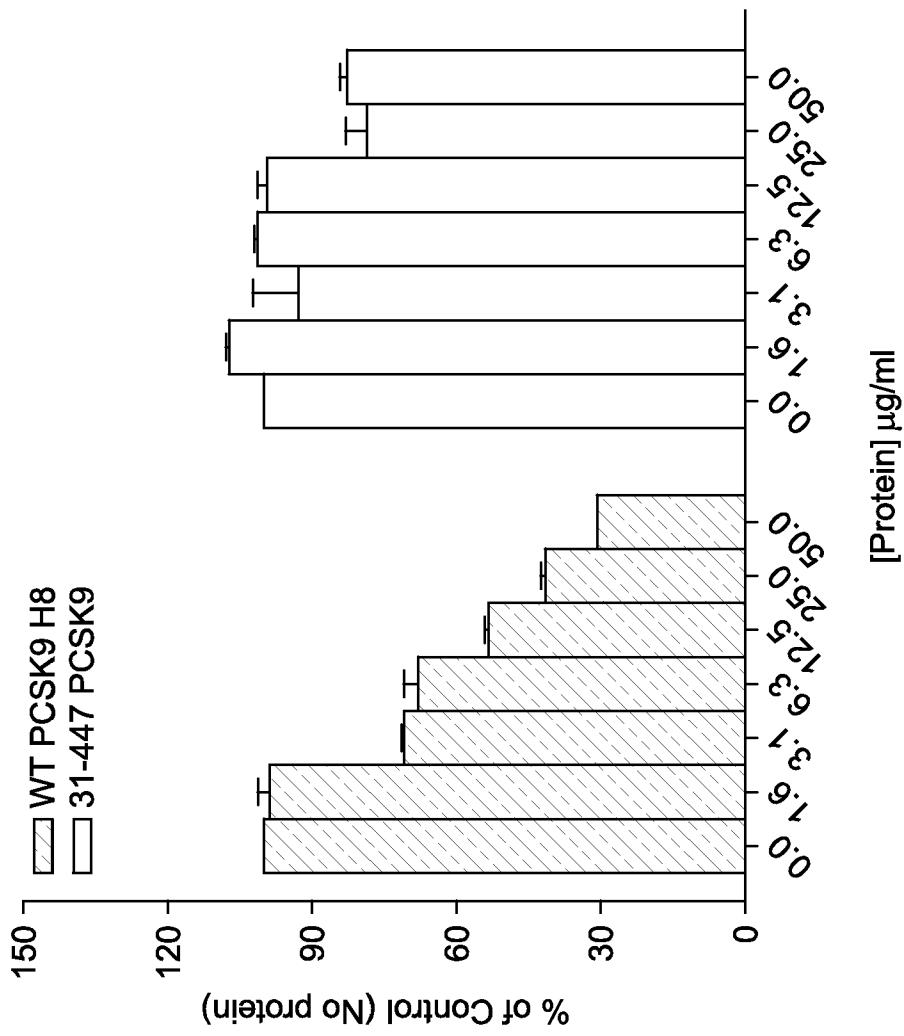


FIG. 3B

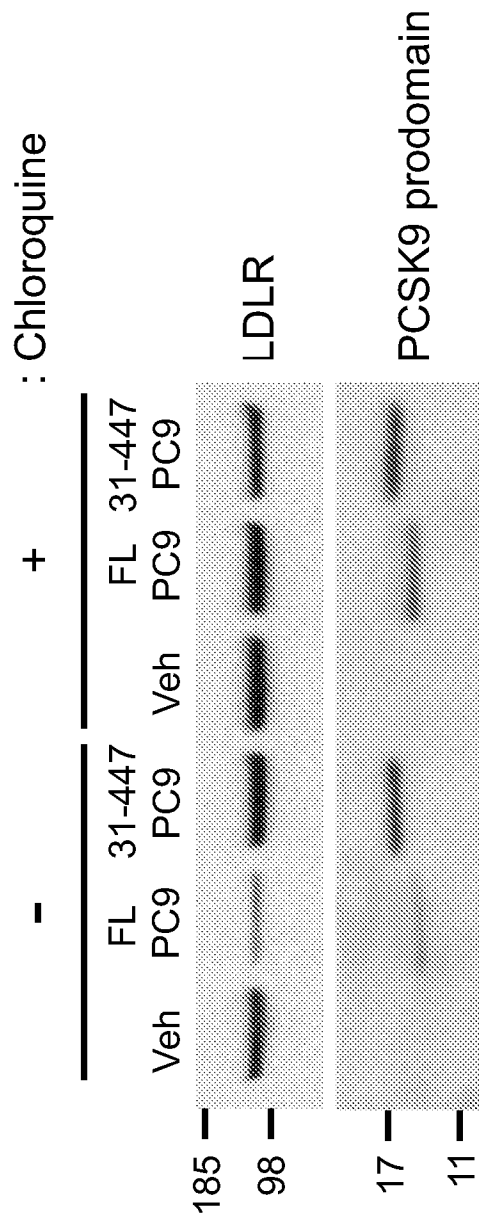


FIG. 4

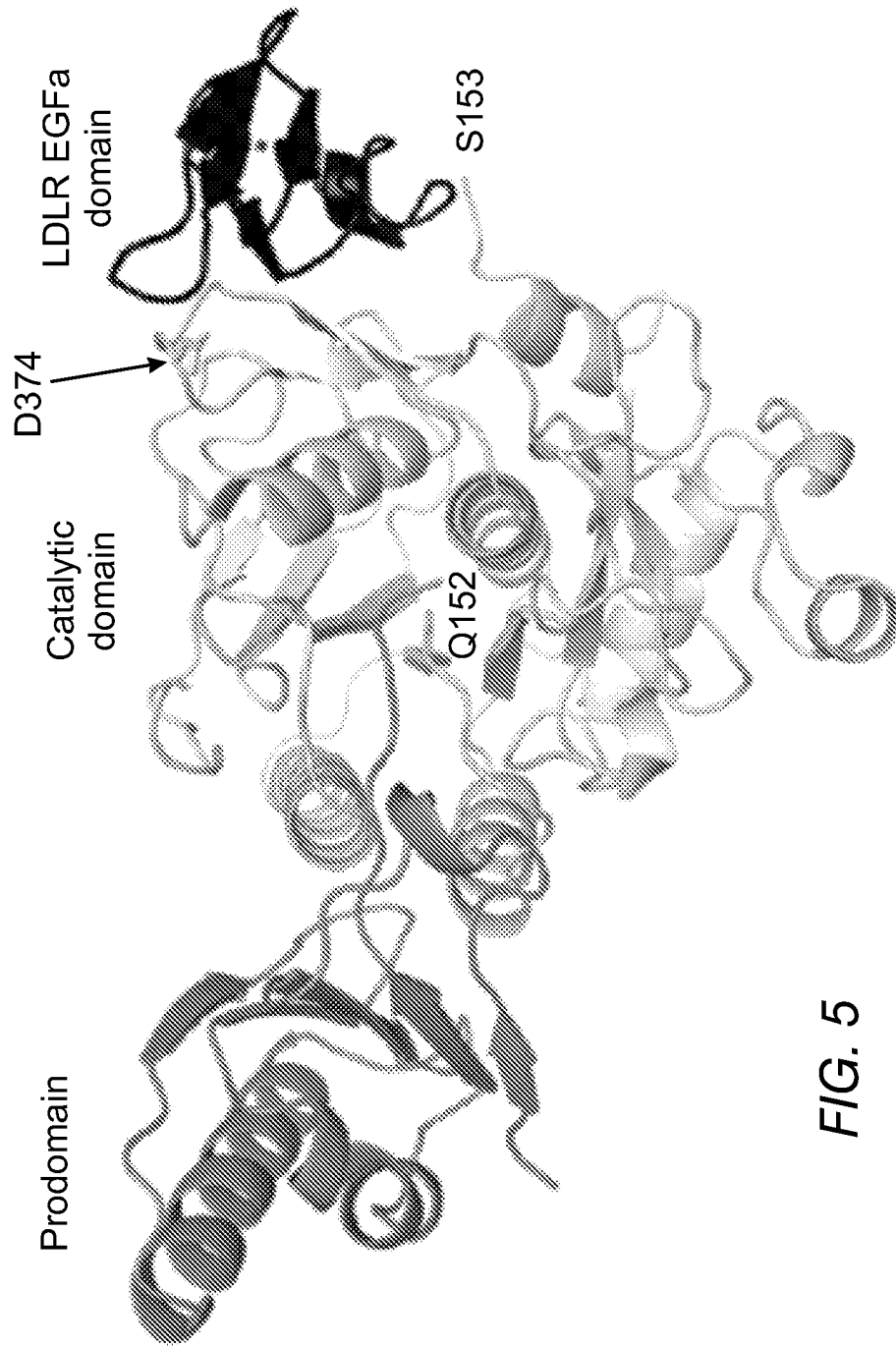


FIG. 5

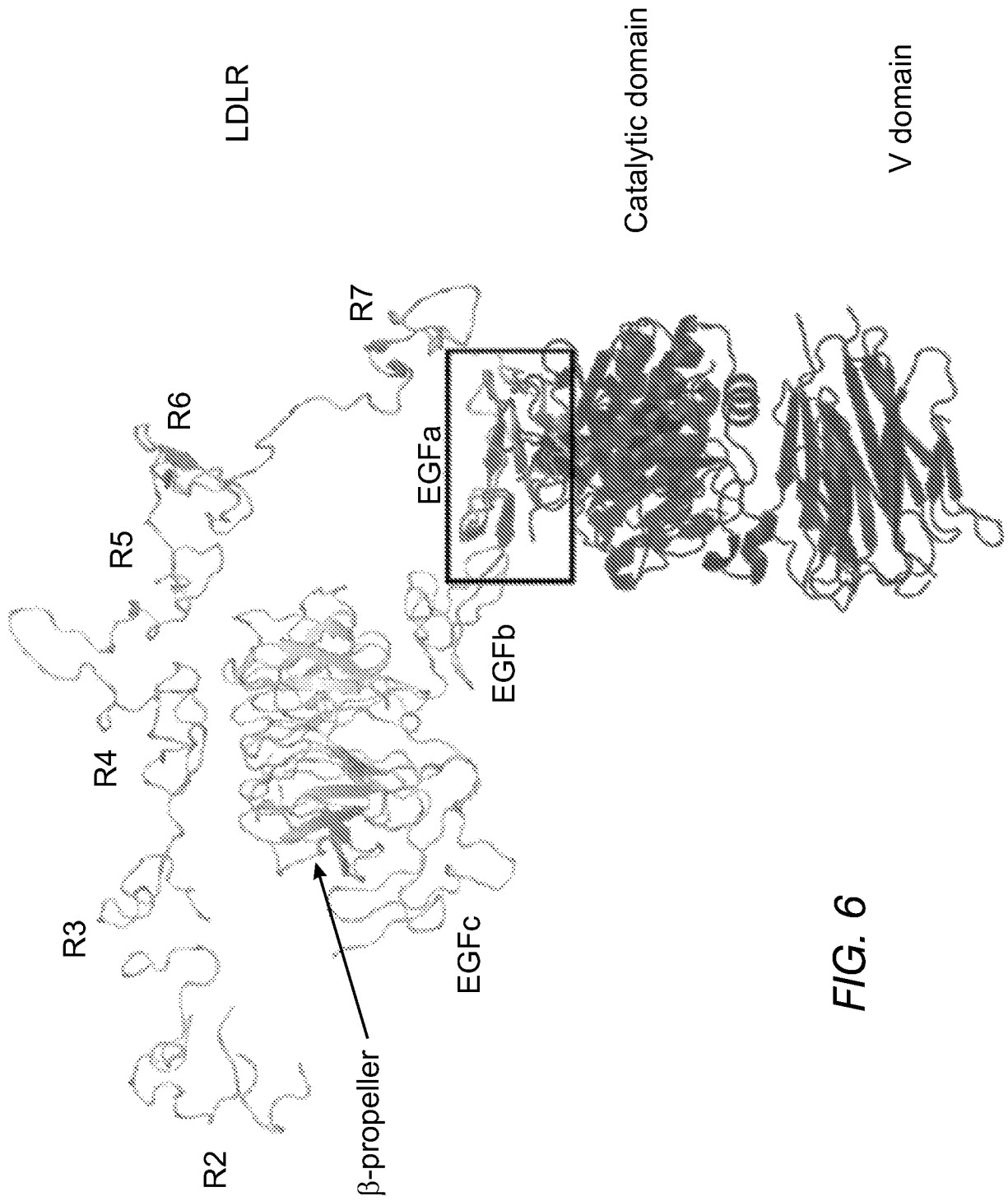
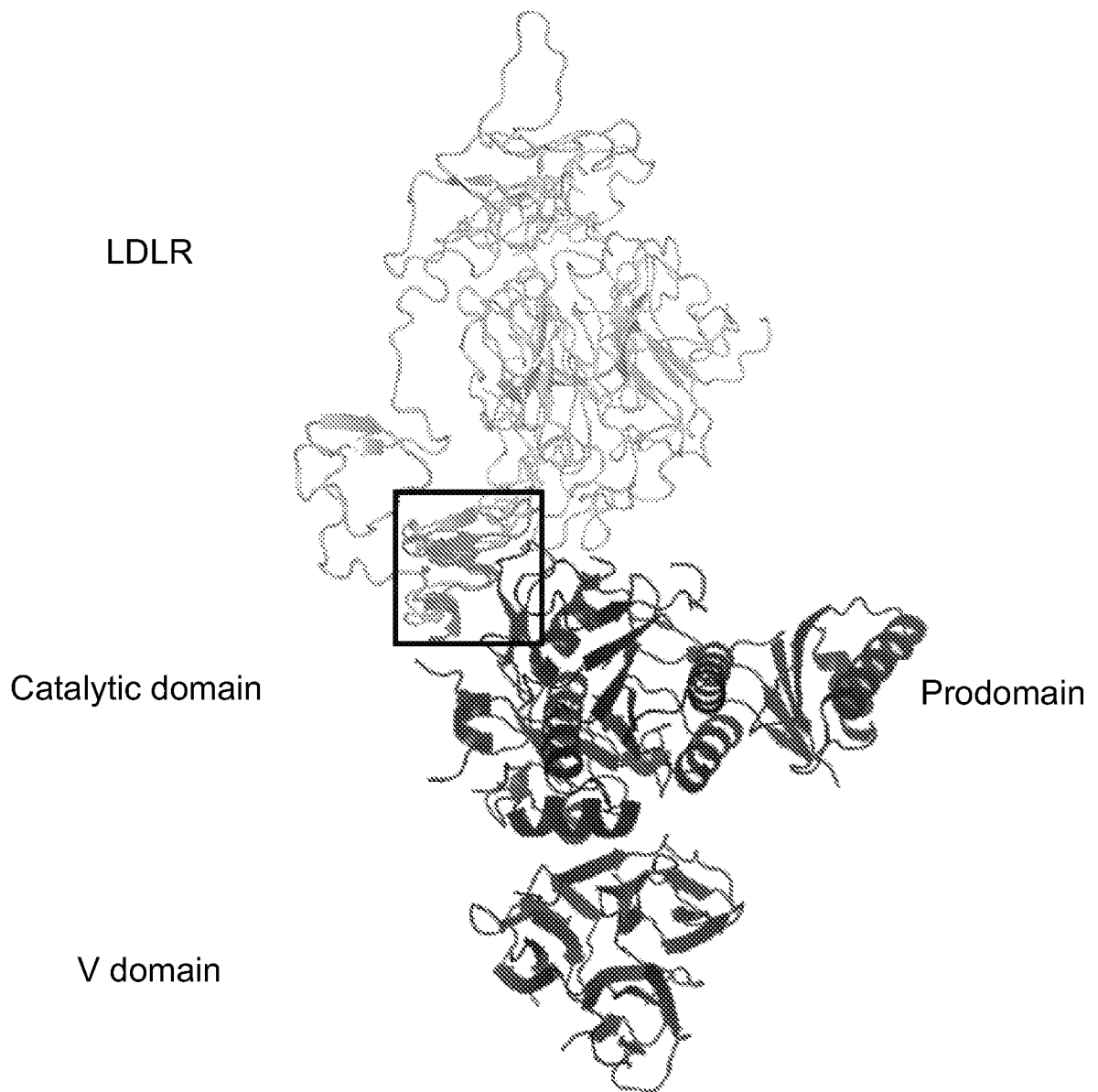


FIG. 6



**FIG. 7**

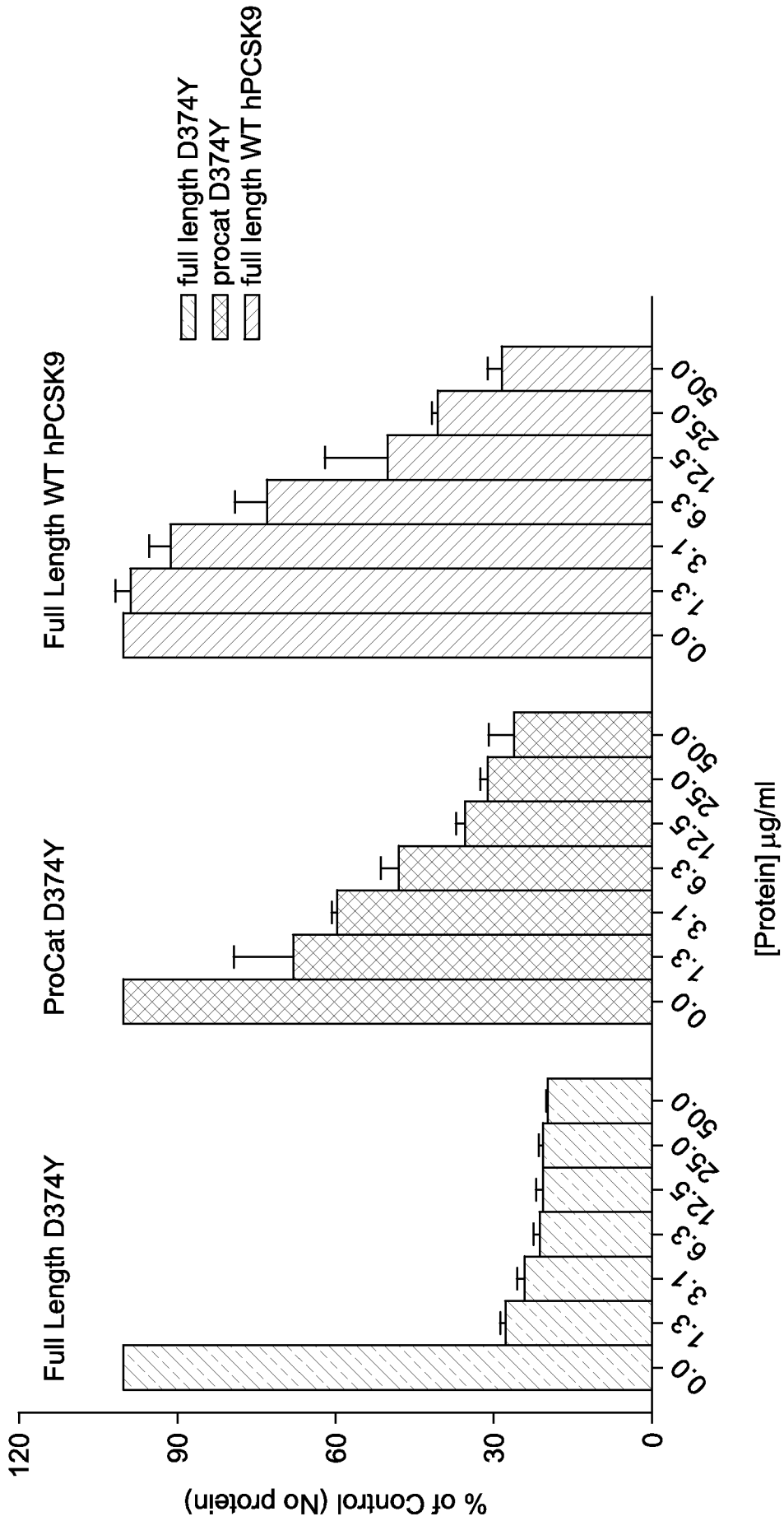


FIG. 8

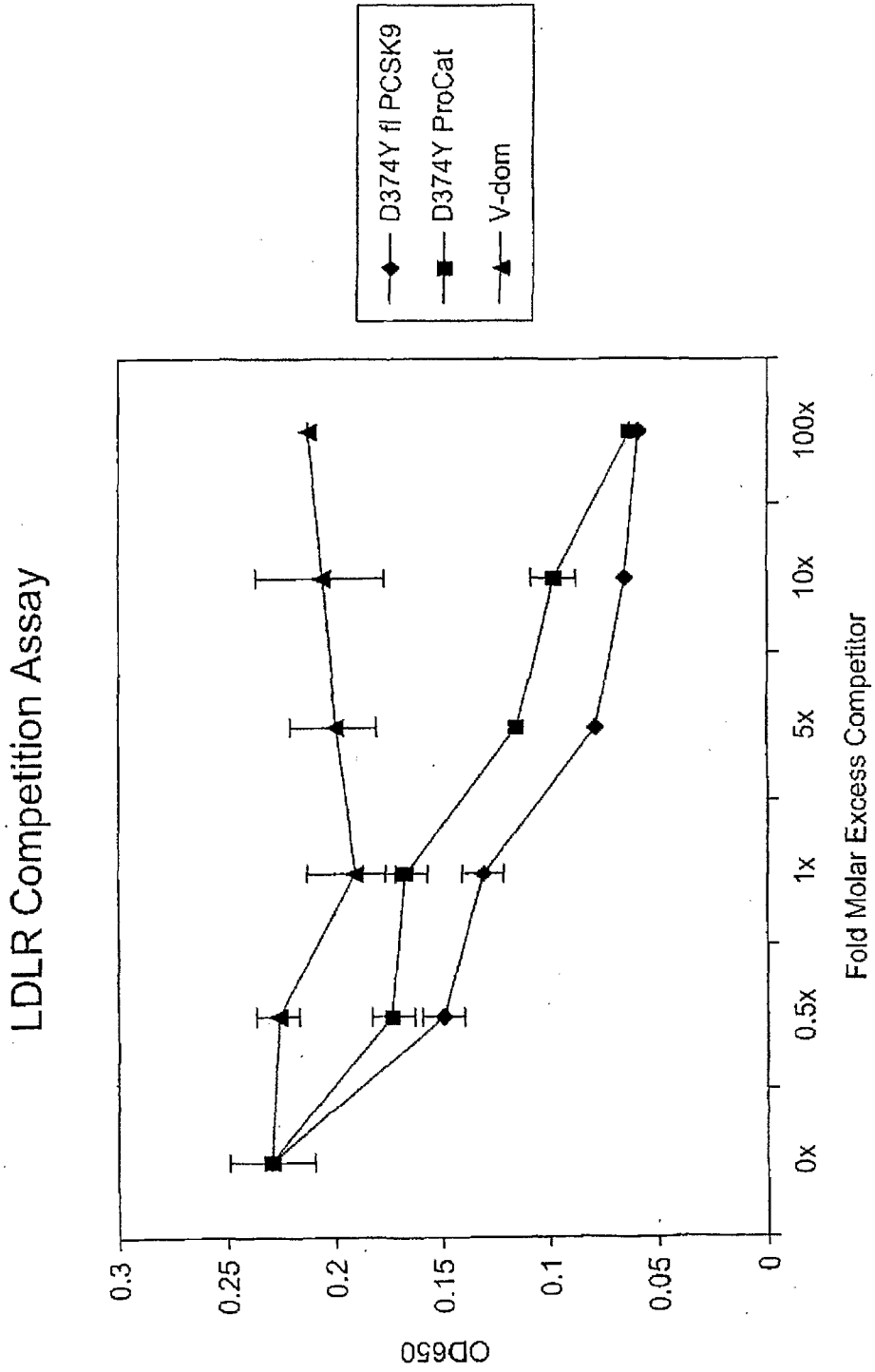


FIG. 9