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(54) Title: AMINO-CONTAINING COMPOUNDS WHICH INHIBIT BETA-SECRETASE ACTIVITY AND METHODS OF USE THEREOF

(57) Abstract: The present invention provides novel beta-secretase inhibitors and methods for their use, including methods of treating of Alzheimer's disease.

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AMINO-CONTAINING COMPOUNDS WHICH INHIBIT BETA-SECRETASE ACTIVITY AND METHODS OF USE THEREOF

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/611,029, filed September 17, 2004, which is incorporated herein by reference in its entirety for all purposes.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] The invention was supported, in whole or in part, by a National Institutes of Health grants AG-18933 and AI-38189. The Government has certain rights in the invention.

10 BACKGROUND OF THE INVENTION

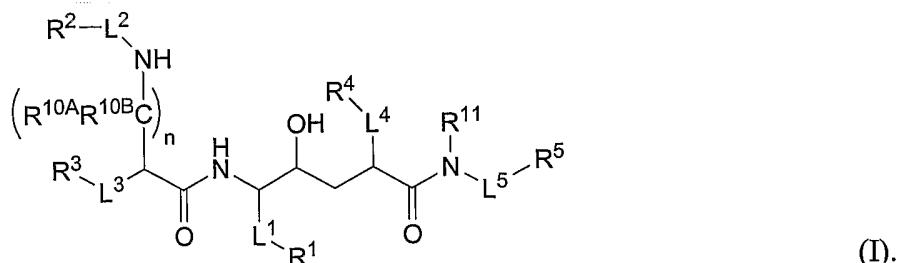
[0003] Alzheimer's disease is a progressive mental deterioration in a human resulting, *inter alia*, in loss of memory, confusion and disorientation. Alzheimer's disease accounts for the majority of senile dementias and is a leading cause of death in adults (Anderson, R. N., *Natl. Vital Stat. Rep.* 49:1-87 (2001), the teachings of which are incorporated herein in their entirety). Histologically, the brain of persons afflicted with Alzheimer's disease is characterized by a distortion of the intracellular neurofibrils and the presence of senile plaques composed of granular or filamentous argentophilic masses with an amyloid protein core, largely due to the accumulation of β -amyloid protein (A β) in the brain. A β accumulation plays a role in the pathogenesis and progression of the disease (Selkoe, D.J., *Nature* 399: 23-31 (1999)) and is a proteolytic fragment of amyloid precursor protein (APP). APP is cleaved initially by β -secretase followed by γ -secretase to generate A β (Lin, X., *et al.*, *Proc. Natl. Acad. Sci. USA* 97:1456-1460 (2000); De Strooper, B., *et al.*, *Nature* 391:387-390 (1998)).

[0004] There is a need to develop effective compounds and methods for the treatment of Alzheimer's disease. The present invention fulfills these and other needs.

25 BRIEF SUMMARY OF THE INVENTION

[0005] The present invention provides novel beta-secretase inhibitors and methods for their use, including methods of treating of Alzheimer's disease.

[0006] In one aspect, the present invention provides a compound having the formula:



[0007] In Formula (I), n is an integer from 0 to 5.

[0008] R¹, R³, R⁴, R⁵ are independently -NR²⁹R³⁰, -OR³¹, -C(O)R³², -S(O)_tR³², -N₃, hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, amino acid side chain, or -L⁶-Y. The symbol t represents an integer from 0 to 2.

[0009] R²⁹ is -C(O)R³³, hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0010] R³² is -NR³⁴R³⁵, hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0011] R³⁴ is independently -NR³⁶R³⁷, hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. Where R¹, R³, R⁴, or R⁵ is -S(O)_tR³², then R³⁴ is not -NR³⁶R³⁷.

[0012] R³⁰, R³¹, R³³, R³⁵, R³⁶, and R³⁷ are independently selected from hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0013] R² and R¹¹ are independently hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or -L⁶-Y.

[0014] R^{10A} and R^{10B} are independently selected from a hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or $-L^6-Y$. R^{10A} is optionally joined with R^2 to form a substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0015] L^2 is a bond, $-C(O)-$, $-O(CH_2)_k-$, $-C(O)NR^6-$, $-NH-$, $-C(O)O-$, $-S-$, $-S(O)-$, $-S(O)_2-$, substituted or unsubstituted alkylene, or substituted or unsubstituted heteroalkylene. R^6 is selected from hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. The symbol "k" represents an integer from 1 to 5.

[0016] L^3 is a bond, $-C(O)-$, $-O-$, $-C(O)NR^7-$, $-N(R^7)-$, $-C(O)O-$, $-S-$, $-S(O)-$, $-S(O)_2-$, $-NR^7-C(O)-NR^8-$, $-NR^7-C(O)-O-$, substituted or unsubstituted alkylene, or substituted or unsubstituted heteroalkylene. R^7 and R^8 are, independently, hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0017] L^5 is a bond, $-C(O)-$, $-C(O)NH-$, substituted or unsubstituted alkylene, or substituted or unsubstituted heteroalkylene. Y is a carrier moiety.

[0018] L^6 is selected from a bond, $-OP(OH)_2O-$, $-C(O)OR^{26}-$, $-C(O)NHR^{27}-$, $-S(O)_2NHR^{28}-$, substituted or unsubstituted alkylene, substituted or unsubstituted heteroalkylene, or a peptidyl linker. R^{26} , R^{27} , and R^{28} are each independently selected from the following: substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0019] In another aspect of the present invention, the β -secretase inhibitor compounds of the invention can be employed in methods to decrease memapsin 2 β -secretase activity, decrease hydrolysis of a β -secretase site of a memapsin 2 β -secretase substrate, and/or decrease the accumulation of β -amyloid protein relative to the amount of memapsin 2 β -

secretase activity, hydrolysis of a β -secretase site, and accumulation of β -amyloid protein, respectively, in the absence of the β -secretase inhibitor.

[0020] In another aspect, the present invention provides pharmaceutical compositions comprising a memapsin 2 β -secretase inhibitor compound of the invention or a memapsin

5 2 β -secretase inhibitor compound in combination with a pharmaceutically acceptable carrier.

[0021] In another aspect of the present invention, the β -secretase inhibitor compounds of the invention can be employed in the treatment of diseases or conditions associated with β -secretase activity, hydrolysis of a β -secretase site of a β -amyloid precursor protein, and/or

10 β -amyloid protein accumulation. Typically, a mammal is treated for the disease or condition. In an exemplary embodiment, the disease is Alzheimer's disease.

DETAILED DESCRIPTION OF THE INVENTION

Abbreviations and Definitions

[0022] The abbreviations used herein have their conventional meaning within the

15 chemical and biological arts.

[0023] Where substituent groups are specified by their conventional chemical formulae, written from left to right, they equally encompass the chemically identical substituents that would result from writing the structure from right to left, e.g., $-\text{CH}_2\text{O}-$ is equivalent to $-\text{OCH}_2-$.

20 [0024] The term "alkyl," by itself or as part of another substituent, means, unless otherwise stated, a straight (i.e. unbranched) or branched chain, or combination thereof, which may be fully saturated, mono- or polyunsaturated and can include di- and multivalent radicals, having the number of carbon atoms designated (i.e. $\text{C}_1\text{-C}_{10}$ means one to ten carbons). Examples of saturated hydrocarbon radicals include, but are not limited to, groups such as methyl, ethyl, n-propyl, isopropyl, n-butyl, t-butyl, isobutyl, sec-butyl, cyclohexyl, (cyclohexyl)methyl, cyclopropylmethyl, homologs and isomers of, for example, n-pentyl, n-hexyl, n-heptyl, n-octyl, and the like. An unsaturated alkyl group is one having one or more double bonds or triple bonds. Examples of unsaturated alkyl groups include, but are not limited to, vinyl, 2-propenyl, crotyl, 2-isopentenyl, 2-(butadienyl), 2,4-pentadienyl, 3-(1,4-pentadienyl), ethynyl, 1- and 3-propynyl, 3-butynyl, and the higher homologs and isomers.

[0025] The term "alkylene" by itself or as part of another substituent means a divalent radical derived from an alkyl, as exemplified, but not limited, by $-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-$. Typically, an alkyl (or alkylene) group will have from 1 to 24 carbon atoms, with those groups having 10 or fewer carbon atoms being preferred in the present invention. A "lower alkyl" or "lower alkylene" is a shorter chain alkyl or alkylene group, generally having eight or fewer carbon atoms.

[0026] The term "heteroalkyl," by itself or in combination with another term, means, unless otherwise stated, a stable straight or branched chain, or cyclic hydrocarbon radical, or combinations thereof, consisting of at least one carbon atoms and at least one heteroatom selected from the group consisting of O, N, P, Si and S, and wherein the nitrogen and sulfur atoms may optionally be oxidized and the nitrogen heteroatom may optionally be quaternized. The heteroatom(s) O, N, P and S and Si may be placed at any interior position of the heteroalkyl group or at the position at which the alkyl group is attached to the remainder of the molecule. Examples include, but are not limited to, $-\text{CH}_2\text{CH}_2\text{OCH}_3$, $-\text{CH}_2\text{CH}_2\text{NHCH}_3$, $-\text{CH}_2\text{CH}_2\text{N}(\text{CH}_3)\text{CH}_3$, $-\text{CH}_2\text{SCH}_2\text{CH}_3$, $-\text{CH}_2\text{CH}_2\text{S(O)CH}_3$, $-\text{CH}_2\text{CH}_2\text{S(O)CH}_2\text{CH}_3$, $-\text{CH}=\text{CH-OCH}_3$, $-\text{Si}(\text{CH}_3)_3$, $-\text{CH}_2\text{CH}=\text{N-OCH}_3$, $-\text{CH}=\text{CH-N}(\text{CH}_3)\text{CH}_3$, OCH_3 , $-\text{OCH}_2\text{CH}_3$, and $-\text{CN}$. Up to two heteroatoms may be consecutive, such as, for example, $-\text{CH}_2\text{NH-OCH}_3$ and $-\text{CH}_2\text{O-Si}(\text{CH}_3)_3$. Similarly, the term "heteroalkylene" by itself or as part of another substituent means a divalent radical derived from heteroalkyl, as exemplified, but not limited by, $-\text{CH}_2\text{CH}_2\text{SCH}_2\text{CH}_2-$ and $-\text{CH}_2\text{SCH}_2\text{CH}_2\text{NHCH}_2-$. For heteroalkylene groups, heteroatoms can also occupy either or both of the chain termini (e.g., alkyleneoxy, alkylenedioxy, alkyleneamino, alkylenediamino, and the like). Still further, for alkylene and heteroalkylene linking groups, no orientation of the linking group is implied by the direction in which the formula of the linking group is written. For example, the formula $-\text{C}(\text{O})_2\text{R}'-$ represents both $-\text{C}(\text{O})_2\text{R}'-$ and $-\text{R}'\text{C}(\text{O})_2-$. As described above, heteroalkyl groups, as used herein, include those groups that are attached to the remainder of the molecule through a heteroatom, such as $-\text{C}(\text{O})\text{R}'$, $-\text{C}(\text{O})\text{NR}'$, $-\text{NR}'\text{R}''$, $-\text{OR}'$, $-\text{SR}'$, and/or $-\text{SO}_2\text{R}'$. Where "heteroalkyl" is recited, followed by recitations of specific heteroalkyl groups, such as $-\text{NR}'\text{R}''$ or the like, it will be understood that the terms heteroalkyl and $-\text{NR}'\text{R}''$ are not redundant or mutually exclusive. Rather, the specific heteroalkyl groups are recited to add clarity. Thus, the term "heteroalkyl" should not be interpreted herein as excluding specific heteroalkyl groups, such as $-\text{NR}'\text{R}''$ or the like.

[0027] The terms "cycloalkyl" and "heterocycloalkyl", by themselves or in combination with other terms, represent, unless otherwise stated, cyclic versions of "alkyl" and "heteroalkyl", respectively. Additionally, for heterocycloalkyl, a heteroatom can occupy the position at which the heterocycle is attached to the remainder of the molecule. Examples of 5 cycloalkyl include, but are not limited to, cyclopentyl, cyclohexyl, 1-cyclohexenyl, 3-cyclohexenyl, cycloheptyl, and the like. Examples of heterocycloalkyl include, but are not limited to, 1-(1,2,5,6-tetrahydropyridyl), 1-piperidinyl, 2-piperidinyl, 3-piperidinyl, 4-morpholinyl, 3-morpholinyl, tetrahydrofuran-2-yl, tetrahydrofuran-3-yl, tetrahydrothien-2-yl, tetrahydrothien-3-yl, 1-piperazinyl, 2-piperazinyl, and the like. A "cycloalkylene" and 10 "heterocycloalkylene" refer to a divalent radical derived from cycloalkyl and heterocycloalkyl, respectively.

[0028] The terms "halo" or "halogen," by themselves or as part of another substituent, mean, unless otherwise stated, a fluorine, chlorine, bromine, or iodine atom. Additionally, terms such as "haloalkyl," are meant to include monohaloalkyl and polyhaloalkyl. For 15 example, the term "halo(C₁-C₄)alkyl" is meant to include, but not be limited to, trifluoromethyl, 2,2,2-trifluoroethyl, 4-chlorobutyl, 3-bromopropyl, and the like.

[0029] The term "aryl" means, unless otherwise stated, a polyunsaturated, aromatic, hydrocarbon substituent which can be a single ring or multiple rings (preferably from 1 to 3 rings) which are fused together or linked covalently. The term "heteroaryl" refers to aryl 20 groups (or rings) that contain from one to four heteroatoms selected from N, O, and S, wherein the nitrogen and sulfur atoms are optionally oxidized, and the nitrogen atom(s) are optionally quaternized. A heteroaryl group can be attached to the remainder of the molecule through a carbon or heteroatom. Non-limiting examples of aryl and heteroaryl groups include phenyl, 1-naphthyl, 2-naphthyl, 4-biphenyl, 1-pyrrolyl, 2-pyrrolyl, 3-pyrrolyl, 3-pyrazolyl, 2-imidazolyl, 4-imidazolyl, pyrazinyl, 2-oxazolyl, 4-oxazolyl, 2-phenyl-4-oxazolyl, 5-oxazolyl, 3-isoxazolyl, 4-isoxazolyl, 5-isoxazolyl, 2-thiazolyl, 4-thiazolyl, 5-thiazolyl, 2-furyl, 3-furyl, 2-thienyl, 3-thienyl, 2-pyridyl, 3-pyridyl, 4-pyridyl, 2-pyrimidyl, 4-pyrimidyl, 5-benzothiazolyl, purinyl, 2-benzimidazolyl, 5-indolyl, 1-isoquinolyl, 5-isoquinolyl, 2-quinoxaliny, 5-quinoxaliny, 3-quinolyl, and 6-quinolyl. Substituents for 25 each of the above noted aryl and heteroaryl ring systems are selected from the group of acceptable substituents described below. "Arylene" and "heteroarylene" refers to a divalent radical derived from a aryl and heteroaryl, respectively.

[0030] For brevity, the term "aryl" when used in combination with other terms (e.g., aryloxy, arylthioxy, arylalkyl) includes both aryl and heteroaryl rings as defined above. Thus, the term "arylalkyl" is meant to include those radicals in which an aryl group is attached to an alkyl group (e.g., benzyl, phenethyl, pyridylmethyl and the like) including 5 those alkyl groups in which a carbon atom (e.g., a methylene group) has been replaced by, for example, an oxygen atom (e.g., phenoxyethyl, 2-pyridyloxymethyl, 3-(1-naphthoxy)propyl, and the like).

[0031] The term "oxo" as used herein means an oxygen that is double bonded to a carbon atom.

10 [0032] The term "alkylsulfonyl" as used herein means a moiety having the formula -S(O₂)-R', where R' is an alkyl group as defined above. R' may have a specified number of carbons (e.g. "C₁-C₄ alkylsulfonyl").

[0033] Each of the above terms (e.g., "alkyl," "heteroalkyl," "aryl" and "heteroaryl") are meant to include both substituted and unsubstituted forms of the indicated radical.

15 Preferred substituents for each type of radical are provided below.

[0034] Substituents for the alkyl and heteroalkyl radicals (including those groups often referred to as alkylene, alkenyl, heteroalkylene, heteroalkenyl, alkynyl, cycloalkyl, heterocycloalkyl, cycloalkenyl, and heterocycloalkenyl) can be one or more of a variety of groups selected from, but not limited to: -OR', =O, =NR', =N-OR', -NR'R", -SR', -halogen, -20 SiRR"R"', -OC(O)R', -C(O)R', -CO₂R', -CONR'R", -OC(O)NR'R", -NR'C(O)R', -NR'-C(O)NR"R", -NR"C(O)R", -NR-C(NR'R"R")=NR"', -NR-C(NR'R")=NR", -S(O)R', -S(O)₂R', -S(O)₂NR'R", -NRSO₂R', -CN and -NO₂ in a number ranging from zero to (2m'+1), where m' is the total number of carbon atoms in such radical. R', R", R''' and R"" each preferably independently refer to hydrogen, substituted or unsubstituted heteroalkyl, 25 substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl (e.g., aryl substituted with 1-3 halogens), substituted or unsubstituted alkyl, alkoxy or thioalkoxy groups, or arylalkyl groups. When a compound of the invention includes more than one R group, for example, each of the R groups is independently selected as are each R', R", R''' and R"" groups when more than one of these 30 groups is present. When R' and R" are attached to the same nitrogen atom, they can be combined with the nitrogen atom to form a 4-, 5-, 6-, or 7-membered ring. For example, -NR'R" is meant to include, but not be limited to, 1-pyrrolidinyl and 4-morpholinyl. From

the above discussion of substituents, one of skill in the art will understand that the term "alkyl" is meant to include groups including carbon atoms bound to groups other than hydrogen groups, such as haloalkyl (e.g., -CF₃ and -CH₂CF₃) and acyl (e.g., -C(O)CH₃, -C(O)CF₃, -C(O)CH₂OCH₃, and the like).

5 [0035] Similar to the substituents described for the alkyl radical, substituents for the aryl and heteroaryl groups are varied and are selected from, for example: halogen, -OR', -NR'R'', -SR', -halogen, -SiR'R''R'', -OC(O)R', -C(O)R', -CO₂R', -CONR'R'', -OC(O)NR'R'', -NR"C(O)R', -NR'-C(O)NR''R'', -NR"C(O)₂R', -NR-C(NR'R''R"')=NR''', -NR-C(NR'R"')=NR'', -S(O)R', -S(O)₂R', -S(O)₂NR'R'', -NRSO₂R', -CN and -NO₂, -R', -N₃, 10 -CH(Ph)₂, fluoro(C₁-C₄)alkoxy, and fluoro(C₁-C₄)alkyl, in a number ranging from zero to the total number of open valences on the aromatic ring system; and where R', R'', R''' and R'''' are preferably independently selected from hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl and substituted or 15 unsubstituted heteroaryl. When a compound of the invention includes more than one R group, for example, each of the R groups is independently selected as are each R', R'', R''' and R'''' groups when more than one of these groups is present.

[0036] Two of the substituents on adjacent atoms of the aryl or heteroaryl ring may 20 optionally form a ring of the formula -T-C(O)-(CRR')_q-U-, wherein T and U are independently -NR-, -O-, -CRR'- or a single bond, and q is an integer of from 0 to 3. Alternatively, two of the substituents on adjacent atoms of the aryl or heteroaryl ring may 25 optionally be replaced with a substituent of the formula -A-(CH₂)_r-B-, wherein A and B are independently -CRR'-, -O-, -NR-, -S-, -S(O)-, -S(O)₂-, -S(O)₂NR'- or a single bond, and r is an integer of from 1 to 4. One of the single bonds of the new ring so formed may optionally 30 be replaced with a double bond. Alternatively, two of the substituents on adjacent atoms of the aryl or heteroaryl ring may optionally be replaced with a substituent of the formula -(CRR')_s-X'-(C''R''')_d-, where s and d are independently integers of from 0 to 3, and X' is -O-, -NR'-, -S-, -S(O)-, -S(O)₂-, or -S(O)₂NR'-. The substituents R, R', R'' and R''' are preferably independently selected from hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl.

[0037] As used herein, the term "heteroatom" or "ring heteroatom" is meant to include oxygen (O), nitrogen (N), sulfur (S), phosphorus (P), and silicon (Si).

[0038] A "substituent group," as used herein, means a group selected from the following moieties:

5 [0039] (A) -OH, -NH₂, -SH, -CN, -CF₃, -NO₂, oxo, halogen, unsubstituted alkyl, unsubstituted heteroalkyl, unsubstituted cycloalkyl, unsubstituted heterocycloalkyl, unsubstituted aryl, unsubstituted heteroaryl, and

[0040] (B) alkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, aryl, and heteroaryl, substituted with at least one substituent selected from:

10 [0041] (i) oxo, -OH, -NH₂, -SH, -CN, -CF₃, -NO₂, halogen, unsubstituted alkyl, unsubstituted heteroalkyl, unsubstituted cycloalkyl, unsubstituted heterocycloalkyl, unsubstituted aryl, unsubstituted heteroaryl, and

[0042] (ii) alkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, aryl, and heteroaryl, substituted with at least one substituent selected from:

15 [0043] (a) oxo, -OH, -NH₂, -SH, -CN, -CF₃, -NO₂, halogen, unsubstituted alkyl, unsubstituted heteroalkyl, unsubstituted cycloalkyl, unsubstituted heterocycloalkyl, unsubstituted aryl, unsubstituted heteroaryl, and

[0044] (b) alkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, aryl, or heteroaryl, substituted with at least one substituent selected from oxo, -OH, -NH₂, -SH, -CN, -CF₃, -NO₂, halogen, unsubstituted alkyl, unsubstituted heteroalkyl, unsubstituted cycloalkyl, unsubstituted heterocycloalkyl, unsubstituted aryl, and unsubstituted heteroaryl.

20 [0045] A "size-limited substituent" or "size-limited substituent group," as used herein means a group selected from all of the substituents described above for a "substituent group," wherein each substituted or unsubstituted alkyl is a substituted or unsubstituted C₁-C₂₀ alkyl, each substituted or unsubstituted heteroalkyl is a substituted or unsubstituted 2 to 20 membered heteroalkyl, each substituted or unsubstituted cycloalkyl is a substituted or

unsubstituted C₄-C₈ cycloalkyl, and each substituted or unsubstituted heterocycloalkyl is a substituted or unsubstituted 4 to 8 membered heterocycloalkyl.

[0046] A "lower substituent" or "lower substituent group," as used herein means a group selected from all of the substituents described above for a "substituent group," wherein each substituted or unsubstituted alkyl is a substituted or unsubstituted C₁-C₈ alkyl, each substituted or unsubstituted heteroalkyl is a substituted or unsubstituted 2 to 8 membered heteroalkyl, each substituted or unsubstituted cycloalkyl is a substituted or unsubstituted C₃-C₇ cycloalkyl, and each substituted or unsubstituted heterocycloalkyl is a substituted or unsubstituted 3 to 7 membered heterocycloalkyl.

[0047] The term "pharmaceutically acceptable salts" is meant to include salts of the active compounds which are prepared with relatively nontoxic acids or bases, depending on the particular substituents found on the compounds described herein. When compounds of the present invention contain relatively acidic functionalities, base addition salts can be obtained by contacting the neutral form of such compounds with a sufficient amount of the desired base, either neat or in a suitable inert solvent. Examples of pharmaceutically acceptable base addition salts include sodium, potassium, calcium, ammonium, organic amino, or magnesium salt, or a similar salt. When compounds of the present invention contain relatively basic functionalities, acid addition salts can be obtained by contacting the neutral form of such compounds with a sufficient amount of the desired acid, either neat or in a suitable inert solvent. Examples of pharmaceutically acceptable acid addition salts include those derived from inorganic acids like hydrochloric, hydrobromic, nitric, carbonic, monohydrogencarbonic, phosphoric, monohydrogenphosphoric, dihydrogenphosphoric, sulfuric, monohydrogensulfuric, hydriodic, or phosphorous acids and the like, as well as the salts derived from relatively nontoxic organic acids like acetic, propionic, isobutyric, maleic, malonic, benzoic, succinic, suberic, fumaric, lactic, mandelic, phthalic, benzenesulfonic, p-tolylsulfonic, citric, tartaric, methanesulfonic, and the like. Also included are salts of amino acids such as arginate and the like, and salts of organic acids like glucuronic or galactunoric acids and the like (see, for example, Berge *et al.*, "Pharmaceutical Salts", *Journal of Pharmaceutical Science*, 1977, 66, 1-19). Certain specific compounds of the present invention contain both basic and acidic functionalities that allow the compounds to be converted into either base or acid addition salts.

[0048] Thus, the compounds of the present invention may exist as salts with pharmaceutically acceptable acids. The present invention includes such salts. Examples of such salts include hydrochlorides, hydrobromides, sulfates, methanesulfonates, nitrates, maleates, acetates, citrates, fumarates, tartrates (eg (+)-tartrates, (-)-tartrates or mixtures thereof including racemic mixtures, succinates, benzoates and salts with amino acids such as glutamic acid. These salts may be prepared by methods known to those skilled in the art.

[0049] The neutral forms of the compounds are preferably regenerated by contacting the salt with a base or acid and isolating the parent compound in the conventional manner. The parent form of the compound differs from the various salt forms in certain physical properties, such as solubility in polar solvents.

[0050] In addition to salt forms, the present invention provides compounds, which are in a prodrug form. Prodrugs of the compounds described herein are those compounds that readily undergo chemical changes under physiological conditions to provide the compounds of the present invention. Additionally, prodrugs can be converted to the compounds of the present invention by chemical or biochemical methods in an *ex vivo* environment. For example, prodrugs can be slowly converted to the compounds of the present invention when placed in a transdermal patch reservoir with a suitable enzyme or chemical reagent.

[0051] Certain compounds of the present invention can exist in unsolvated forms as well as solvated forms, including hydrated forms. In general, the solvated forms are equivalent to unsolvated forms and are encompassed within the scope of the present invention. Certain compounds of the present invention may exist in multiple crystalline or amorphous forms. In general, all physical forms are equivalent for the uses contemplated by the present invention and are intended to be within the scope of the present invention.

[0052] Certain compounds of the present invention possess asymmetric carbon atoms (optical centers) or double bonds; the racemates, diastereomers, tautomers, geometric isomers and individual isomers are encompassed within the scope of the present invention. The compounds of the present invention do not include those which are known in the art to be too unstable to synthesize and/or isolate.

[0053] The compounds of the present invention may also contain unnatural proportions of atomic isotopes at one or more of the atoms that constitute such compounds. For example, the compounds may be radiolabeled with radioactive isotopes, such as for example tritium (³H), iodine-125 (¹²⁵I) or carbon-14 (¹⁴C). All isotopic variations of the compounds of the

present invention, whether radioactive or not, are encompassed within the scope of the present invention.

[0054] A "hydrophobic" group is a group that does not reduce the solubility of a compound in octane or increases the solubility of a compound in octane. Examples of 5 hydrophobic groups include aliphatic groups, aryl groups, and aralkyl groups.

[0055] As used herein, the term "natural amino acid" refers to the twenty-three natural amino acids known in the art, which are as follows (denoted by their three letter acronym): Ala, Arg, Asn, Asp, Cys, Cys-Cys, Glu, Gln, Gly, His, Hyl, Hyp, Ile, Leu, Lys, Met, Phe, Pro, Ser, Thr, Trp, Tyr, and Val. The term "side-chain of an amino acid", as used herein, is 10 the substituent on the alpha-carbon of a natural amino acid.

[0056] The term "non-natural amino acid" refers to compounds of the formula $\text{NH}_2\text{-C}(\text{R}_{32})_2\text{-COOH}$, where R_{32} for each occurrence is, independently, any side chain moiety recognized by those skilled in the art; examples of non-natural amino acids include, but are not limited to: hydroxyproline, homoproline, 4-amino-phenylalanine, norleucine, 15 cyclohexylalanine, α -aminoisobutyric acid, N-methyl-alanine, N-methyl-glycine, N-methyl-glutamic acid, *tert*-butylglycine, α -aminobutyric acid, *tert*-butylalanine, ornithine, α -aminoisobutyric acid, 2-aminoindane-2-carboxylic acid, etc. and the derivatives thereof, especially where the amine nitrogen has been mono- or di-alkylated.

[0057] A peptide substituent is a sequence of natural or non-natural amino acids that are 20 linked together via an amide bond which is formed by reaction of the α -amine of one amino acid with the α -carboxylic acid of an adjacent amino acid. Preferably, a peptide sequence includes only natural amino acids. In one embodiment, a peptide substituent is a sequence of about 6 natural amino acids. In another embodiment, a peptide substituent is a sequence of 2 natural amino acids. In yet another embodiment, a peptide substituent is 1 natural 25 amino acid.

[0058] A "transition state isostere," or "isostere," as used herein, is a compound having 30 peptidyl component where at least one amide linkage between two consecutive natural or non-natural amino acids has been modified such that the $-\text{NH-}$ group of the amide has been replaced with a $-\text{CH}_2-$ and the carbonyl of the amide group has been replaced with a $-\text{CH}(\text{OH})-$. This isostere is also referred to herein as a "hydroxyethylene isostere" because the amide linkage between a pair of amino acids of a peptide is modified to form a

hydroxyethylene linkage between the amino acids. A hydroxyethylene group is an isostere of the transition state of hydrolysis of an amide bond. Preferably, an isostere has only one modified amide linkage.

[0059] "Memapsin-2," as used herein, refers to proteins identified by National Center for Biotechnology Information ("NCBI") accession number NP_036236 (sometimes referred to as "β-site APP-cleaving enzyme 1" or "BACE-1"), including homologs, isoforms and subdomains thereof that retain proteolytic activity. Sequence identities of active memapsin 2 proteins and protein fragments (and nucleic acid coding sequences thereof) have been previously disclosed and discussed in detail in copending U.S. Application No. 10 20040121947, and International Application No. PCT/USO2/34324 (Publication No. WO 03/039454), which are herein incorporated by reference for all purposes in their entirety.

[0060] "Memapsin-1," as used herein, refers to proteins identified by National Center for Biotechnology Information ("NCBI") accession number NP_036237 (sometimes referred to as "β-site APP-cleaving enzyme 2" or "BACE-2") and/or those previously disclosed and discussed in detail in copending U.S. Application No. 20040121947, and International Application No. PCT/USO2/34324 (Publication No. WO 03/039454), incorporated by reference herein in their entirety for all purposes, including homologs, isoforms and subdomains thereof that retain proteolytic activity.

[0061] "Cathepsin D," as used herein, refers to proteins identified by National Center for Biotechnology Information ("NCBI") accession number NP_036236 (sometimes referred to as "β-site APP-cleaving enzyme 1" or "BACE-1") and or proteins identified by Enzyme Structure Database subclass EC 3.4.23.5., including homologs, isoforms and subdomains thereof that retain proteolytic activity.

[0062] A "β-secretase site" is an amino acid sequence that is cleaved by an active memapsin 2 or active fragment thereof. Specific β-secretase sites have also been previously set forth and discussed in detail in copending U.S. Application No. 20040121947, and International Application No. PCT/USO2/34324 (Publication No. WO 03/039454), which are herein incorporated by reference for all purposes in their entirety, and include the Swedish mutation sequence, and the native β-amyloid precursor protein cleavage sequence. Thus, β-secretase inhibitors may be tested for their ability to decrease the hydrolysis of the

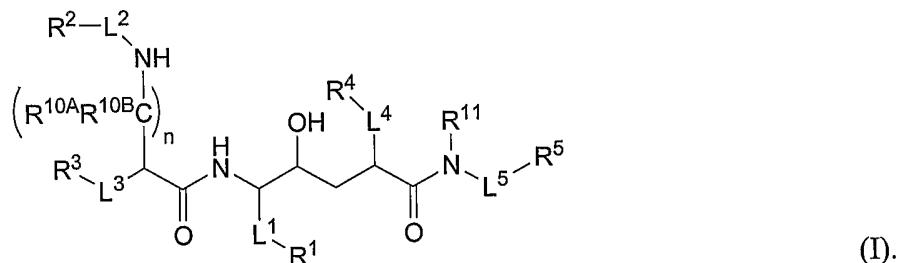
β -secretase site of a substrate, such as the β -amyloid precursor protein, analogs of β -amyloid precursor protein or fragments of β -amyloid precursor protein.

[0063] A "beta-secretase inhibitor" (i.e. β -secretase inhibitor) refers to a compound capable of reducing the proteolytic activity of memapsin-2 relative to the activity in the absence of inhibitor.

[0064] The terms "a" or "an," as used in herein means one or more. In addition, the phrase "substituted with a[n]," as used herein, means the specified group may be substituted with one or more of any or all of the named substituents. For example, where a group, such as an alkyl or heteroaryl group, is "substituted with an unsubstituted C₁-C₂₀ alkyl, or 10 unsubstituted 2 to 20 membered heteroalkyl," the group may contain one or more unsubstituted C₁-C₂₀ alkyls, and/or one or more unsubstituted 2 to 20 membered heteroalkyls.

β -Secretase Inhibitors

[0065] In one aspect, the present invention provides a β -secretase inhibitor compound 15 having the formula:



[0066] In Formula (I), n is an integer from 0 to 5 (e.g. 1 to 5).

[0067] R¹, R³, R⁴, R⁵ are independently -NR²⁹R³⁰, -OR³¹, -C(O)R³², -S(O)_tR³², -N₃, 20 hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, amino acid side chain, or -L⁶-Y. The symbol t represents an integer from 0 to 2.

[0068] R²⁹ is -C(O)R³³, hydrogen, substituted or unsubstituted alkyl, substituted or 25 unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0069] R^{32} is $-NR^{34}R^{35}$, hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

5 [0070] R^{34} is independently $-NR^{36}R^{37}$, hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. Where R^1, R^3, R^4 , or R^5 is $-S(O)_tR^{32}$, then R^{34} is not $-NR^{36}R^{37}$.

10 [0071] $R^{30}, R^{31}, R^{33}, R^{35}, R^{36}$, and R^{37} are independently selected from hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

15 [0072] R^2 and R^{11} are independently hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or $-L^6-Y$.

20 [0073] R^{10A} and R^{10B} are independently selected from a hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or $-L^6-Y$. R^{10A} is optionally joined with R^2 to form a substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

25 [0074] L^2 is a bond, $-C(O)-$, $-O(CH_2)_k-$, $-C(O)NR^6-$, $-NH-$, $-C(O)O-$, $-S-$, $-S(O)-$, $-S(O)_2-$, substituted or unsubstituted alkylene, or substituted or unsubstituted heteroalkylene. R^6 is selected from hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. The symbol "k" represents an integer from 1 to 5. In some embodiments, k is 0.

30 [0075] L^3 is a bond, $-C(O)-$, $-O-$, $-C(O)NR^7-$, $-N(R^7)-$, $-C(O)O-$, $-S-$, $-S(O)-$, $-S(O)_2-$, $-NR^7-C(O)-NR^8-$, $-NR^7-C(O)-O-$, substituted or unsubstituted alkylene, or substituted or unsubstituted heteroalkylene. In some embodiments, if R^3 is $-NR^{29}R^{30}$, the L^3 is not $-S-$,

5 S(O)-, -S(O)₂-, -NR⁷-C(O)-NR⁸-, or -NR⁷-C(O)-O-. In some embodiments, if R³ is OR³¹, then L³ is not -O-, -C(O)O-, -S-, -S(O)-, -S(O)₂-, -NR⁷-C(O)-NR⁸-, or -NR⁷-C(O)-O-. In some embodiments, if R³ is -C(O)R³², -S(O)R³², or -N₃, then L₃ is a bond substituted or unsubstituted alkylene, or substituted or unsubstituted heteroalkylene. R⁷ and R⁸ are, independently, hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

10 [0076] L⁵ is a bond, -C(O)-, -C(O)NH-, substituted or unsubstituted alkylene, or substituted or unsubstituted heteroalkylene. In some embodiments, if R⁵ is -C(O)R³², -S(O)_tR³², or -N₃, then L⁵ is a bond, substituted or unsubstituted alkylene, or substituted or unsubstituted heteroalkylene. Y is a carrier moiety.

15 [0077] L⁶ is selected from a bond, -OP(OH)₂O-, -C(O)OR²⁶-, -C(O)NHR²⁷-, -S(O)₂NHR²⁸-, substituted or unsubstituted alkylene, substituted or unsubstituted heteroalkylene, or a peptidyl linker. R²⁶, R²⁷, and R²⁸ are each independently selected from the following: substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0078] In an exemplary embodiment, n is an integer from 0 to 2.

20 [0079] R¹ may be hydrogen, substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or unsubstituted C₃-C₇ (e.g. C₅-C₇) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or -L⁶-Y. R¹ may also be substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted 2 to 20 membered heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. Alternatively, R¹ is substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. In some embodiments, R¹ is substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or substituted or unsubstituted C₁-C₈ alkyl. In other embodiments, R¹ is selected from unsubstituted aryl; unsubstituted heteroaryl; aryl substituted with a halogen; heteroaryl substituted with a halogen; or C₁-C₂₀ alkyl substituted with a halogen, unsubstituted aryl, aryl substituted with a halogen, unsubstituted heteroaryl, or heteroaryl substituted with a

halogen. R^1 may be selected from C_1 - C_5 alkyl substituted with a substituted or unsubstituted phenyl, or substituted or unsubstituted pyridinyl. R^1 may also be selected from C_1 - C_5 alkyl substituted with unsubstituted phenyl; unsubstituted pyridinyl or phenyl substituted with a halogen, OR^{1A} , or unsubstituted (C_1 - C_5) alkyl. R^{1A} may be hydrogen or 5 unsubstituted (C_1 - C_5) alkyl.

[0080] In another exemplary embodiment, R^1 is methyl substituted with an unsubstituted phenyl, unsubstituted pyridinyl, 3,5-difluorophenyl, 4-hydroxyphenyl, 3-chloro-4-hydroxyphenyl, or 3-chloro-4-methoxyphenyl. R^1 may also be $-CH_2-CH(CH_3)-CH_3$. In some embodiments, R^1 is an amino acid side chain.

10 **[0081]** R^4 may be hydrogen, substituted or unsubstituted C_1 - C_{20} (e.g. C_1 - C_{10}) alkyl, substituted or unsubstituted 2 to 20 (e.g. 2 to 10) membered heteroalkyl, substituted or unsubstituted C_3 - C_7 (e.g. C_5 - C_7) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or $-L^6-Y$. R^4 may also be selected from substituted or unsubstituted C_1 - C_{20} 15 alkyl, substituted or unsubstituted 2 to 20 membered heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. In some embodiments, R^4 is substituted or unsubstituted C_1 - C_{20} alkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. In other embodiments, R^4 is selected from substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or substituted or unsubstituted 20 C_1 - C_8 alkyl.

25 **[0082]** Alternatively, R^4 is selected from unsubstituted aryl; unsubstituted heteroaryl; aryl substituted with a halogen; heteroaryl substituted with a halogen; or C_1 - C_{20} alkyl substituted with a halogen, unsubstituted aryl, aryl substituted with a halogen, unsubstituted heteroaryl, or heteroaryl substituted with a halogen. R^4 may also be methyl or ethyl. In some embodiments, R^4 is an amino acid side chain.

30 **[0083]** L^2 may be a bond, $-C(O)-$, $-O(CH_2)_k-$, $-C(O)NR^6-$, $-NH-$, $-C(O)O-$, $-S-$, $-S(O)-$, $-S(O)_2-$, substituted or unsubstituted C_1 - C_{20} alkylene, or substituted or unsubstituted 2 to 20 membered heteroalkylene. R^6 may be a hydrogen, substituted or unsubstituted C_1 - C_{20} alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or unsubstituted C_3 - C_7 (e.g. C_5 - C_7) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. In some embodiments, L^2 is selected from a bond, $-C(O)-$, $-C(O)NR^6-$, $-C(O)O-$, 35

-S(O)₂-, substituted or unsubstituted C₁-C₂₀ alkylene, or substituted or unsubstituted 2 to 20 membered heteroalkylene. In other embodiments, L² is -C(O)-, -C(O)NR⁶-, -C(O)O-, or -S(O)₂-.

[0084] R⁶ may be a hydrogen or substituted or unsubstituted C₁-C₂₀ alkyl. R⁶ may also be 5 hydrogen or unsubstituted C₁-C₂₀ alkyl. Alternatively, R⁶ is selected from hydrogen or unsubstituted C₁-C₄ alkyl.

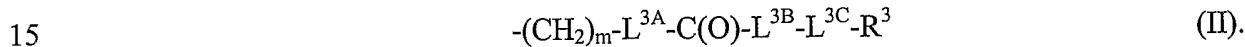
[0085] R² may be selected from substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or unsubstituted 2 to 20 membered cycloalkyl, substituted or unsubstituted 5 to 7 membered heterocycloalkyl, substituted or 10 unsubstituted aryl, substituted or unsubstituted heteroaryl, or -L⁶-Y. R² may also be substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. Alternatively, R² is a unsubstituted aryl; aryl substituted with a halogen or unsubstituted C₁-C₁₀ alkyl; unsubstituted heteroaryl; heteroaryl substituted with a halogen or unsubstituted 15 C₁-C₁₀ alkyl; or C₁-C₂₀ alkyl substituted with a halogen, unsubstituted aryl, aryl substituted with a halogen, unsubstituted heteroaryl, or heteroaryl substituted with a halogen. In some embodiments, R² is an unsubstituted C₁-C₂₀ alkyl, unsubstituted 2 to 20 membered heteroalkyl, substituted or unsubstituted aryl, or unsubstituted heteroaryl. In other embodiments, R² is an unsubstituted C₁-C₄ alkyl, unsubstituted furanyl, unsubstituted 20 phenyl, unsubstituted pyridinyl, unsubstituted thiazolyl, furanyl substituted with a substituted or unsubstituted C₁-C₂₀ alkyl, phenyl substituted with a substituted or unsubstituted C₁-C₂₀ alkyl, pyridinyl substituted with substituted or unsubstituted C₁-C₂₀ alkyl, or thiazolyl substituted with substituted or unsubstituted C₁-C₂₀ alkyl.

[0086] Alternatively, R² is an unsubstituted C₁-C₄ alkyl, unsubstituted furanyl, 25 unsubstituted phenyl, unsubstituted pyridinyl, furanyl substituted with an unsubstituted C₁-C₁₀ alkyl, phenyl substituted with an unsubstituted C₁-C₁₀ alkyl, pyridinyl substituted with an unsubstituted C₁-C₁₀ alkyl, or thiazolyl substituted with an unsubstituted C₁-C₁₀ alkyl. R² may also be selected from unsubstituted C₁-C₄ alkyl, unsubstituted furanyl, unsubstituted phenyl, unsubstituted pyridinyl, furanyl substituted with an unsubstituted C₁-C₄ alkyl, 30 phenyl substituted with an unsubstituted C₁-C₄ alkyl, pyridinyl substituted with an unsubstituted C₁-C₄ alkyl, or thiazolyl substituted with an unsubstituted C₁-C₄ alkyl.

[0087] L^3 may be a bond, -C(O)-, -O-, -C(O)NR⁷-, -N(R⁷)-, -C(O)O-, -S-, -S(O)-, -S(O)₂-, -NR⁷-C(O)-NR⁸-, -NR⁷-C(O)-O-, substituted or unsubstituted C₁-C₂₀ alkylene, or substituted or unsubstituted 2 to 20 membered heteroalkylene. R⁷ and R⁸ may be independently selected from hydrogen, substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or unsubstituted C₃-C₇ (e.g. C₅-C₇) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0088] L^3 may also be selected from substituted or unsubstituted alkylene, or substituted or unsubstituted heteroalkylene. Alternatively, L^3 may be selected from substituted or unsubstituted C₁-C₂₀ alkylene, or substituted or unsubstituted 2 to 20 membered heteroalkylene. In some embodiments, L^3 is a C₁-C₂₀ alkylene substituted with an oxo, or unsubstituted C₁-C₂₀ alkyl; or 2 to 20 membered heteroalkylene substituted with an oxo, or unsubstituted C₁-C₂₀ alkyl.

[0089] In an exemplary embodiment, -L³-R³ of Formula (I) has the formula:



[0090] In Formula (II), the symbol "m" is an integer from 0 to 10.

[0091] L^{3A} is selected from a bond, -N(R¹²)-, -O-, or -C(R¹³)(R¹⁴)-. R¹² is a hydrogen, or unsubstituted C₁-C₂₀ alkyl. R¹³ and R¹⁴ may independently be selected from hydrogen, unsubstituted C₁-C₂₀ alkyl, -OR¹⁵, or -NR¹⁶R¹⁷. R¹⁵, R¹⁶ and R¹⁷ are, independently, 20 hydrogen or unsubstituted C₁-C₂₀ alkyl.

[0092] L^{3B} is a bond, -N(R¹⁸)-, -C(R¹⁹)(R²⁰)-, or -O-. R¹⁸ may be selected from hydrogen, or unsubstituted C₁-C₂₀ alkyl. R¹⁹ and R²⁰ are independently hydrogen, unsubstituted C₁-C₂₀ alkyl, -OR²¹, or -NR²²R²³, C₁-C₂₀ alkyl substituted with -OR²¹, or N₃. R²¹, R²² and R²³ are independently hydrogen, or unsubstituted C₁-C₂₀ alkyl. L^{3C} is a bond, unsubstituted C₁-C₂₀ alkylene, or unsubstituted 2 to 20 membered heteroalkylene.

[0093] In some embodiments, m is an integer from 1 to 10, one of R¹³ or R¹⁴ is hydrogen, one of R¹⁹ or R²⁰ is hydrogen, or L^{3C} is C₁-C₂₀ alkylene.

[0094] In some embodiments, R³ is a substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. The symbol m may be 0. L^{3A} may be -N(R¹²)-. L^{3B} may be

$-C(R^{19})(R^{20})-$. L^{3C} may be unsubstituted C_1 - C_5 alkylene. R^{12} may be hydrogen. R^{19} may be hydrogen. L^{3C} may be methylene.

5 [0095] In other embodiments, R^3 is a substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. The symbol m may be 1. L^{3B} may be $-N(R^{18})-$. L^{3C} may be unsubstituted C_1 - C_5 alkylene. R^{18} may be hydrogen. L^{3C} may be methylene.

10 [0096] In an exemplary embodiment, the symbol "m" is 0. R^{12} , R^{13} , R^{14} , and R^{19} may be hydrogen. R^{18} may be hydrogen or unsubstituted C_1 - C_{20} alkyl. R^{20} may be hydrogen, unsubstituted C_1 - C_8 alkyl, $-OR^{21}$, or $-NR^{22}R^{23}$. R^{21} , R^{22} , and R^{23} , independently, may be hydrogen, or unsubstituted C_1 - C_8 alkyl. L^{3C} may be an unsubstituted C_1 - C_8 alkylene.

15 [0097] In some embodiments, $-L^3-R^3$ may also be selected from: $-NH-C(O)-CHR^{19}-CH_2-R^3$; $-NH-C(O)-O-CH_2-R^3$; $-NH-C(O)-NH-CH_2-R^3$; $-CH_2-C(O)-NH-CH_2-R^3$; $-CH_2-C(O)-CHR^{19}-CH_2-R^3$; $-CH_2-C(O)-O-CH_2-R^3$; or $-O-C(O)-NH-CH_2-R^3$. R^{15} is hydrogen or unsubstituted C_1 - C_{20} alkyl.

20 [0098] In an exemplary embodiment, R^3 is selected from substituted or unsubstituted C_1 - C_{20} alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or unsubstituted C_3 - C_7 (e.g. C_5 - C_7) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or $-L^6-Y$. R^3 may also be selected from substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or substituted or unsubstituted heterocycloalkyl. Alternatively, R^3 is a substituted or unsubstituted 5 membered heteroaryl, or substituted or unsubstituted 5 membered heterocycloalkyl.

25 [0099] In some embodiments, R^3 is selected from an unsubstituted heteroaryl; an unsubstituted heterocycloalkyl; a heteroaryl substituted with halogen, $-CF_3$, $-OH$, $-NH_2$, $-CN$, unsubstituted C_1 - C_{20} alkyl, or unsubstituted 2 to 20 membered heteroalkyl; or heterocycloalkyl substituted with oxo, or unsubstituted C_1 - C_{20} alkyl. In other embodiments, R^3 is an unsubstituted aryl; unsubstituted heteroaryl; aryl substituted with a halogen; heteroaryl substituted with a halogen; or C_1 - C_{20} alkyl substituted with a halogen, unsubstituted aryl, aryl substituted with a halogen, unsubstituted heteroaryl, or heteroaryl substituted with a halogen.

[0100] In another exemplary embodiment, R³ is selected from a substituted or unsubstituted pyrazolyl, substituted or unsubstituted furanyl, substituted or unsubstituted imidazolyl, substituted or unsubstituted isoxazolyl, substituted or unsubstituted oxadiazolyl, substituted or unsubstituted oxazolyl, substituted or unsubstituted pyrrolyl, substituted or unsubstituted pyridyl, substituted or unsubstituted pyrimidyl, substituted or unsubstituted pyridazinyl, substituted or unsubstituted thiazolyl, substituted or unsubstituted triazolyl, substituted or unsubstituted thienyl, substituted or unsubstituted dihydrothieno-pyrazolyl, substituted or unsubstituted thianaphthetyl, substituted or unsubstituted carbazolyl, substituted or unsubstituted benzimidazolyl, substituted or unsubstituted benzothienyl, substituted or unsubstituted benzofuranyl, substituted or unsubstituted indolyl, substituted or unsubstituted quinolinyl, substituted or unsubstituted benzotriazolyl, substituted or unsubstituted benzothiazolyl, substituted or unsubstituted benzooxazolyl, substituted or unsubstituted benzimidazolyl, substituted or unsubstituted isoquinolinyl, substituted or unsubstituted isoindolyl, substituted or unsubstituted acridinyl, substituted or unsubstituted benzoisazolyl, or substituted or unsubstituted dimethylhydantoin.

[0101] In some exemplary embodiments, R³ is substituted or unsubstituted pyrazolyl, substituted or unsubstituted oxazolyl, substituted or unsubstituted thiazolyl, or substituted or unsubstituted furanyl. In other exemplary embodiments, R³ is selected from a substituted or unsubstituted 1-pyrazolyl, substituted or unsubstituted 4-oxazolyl, substituted or unsubstituted 2-oxazolyl, substituted or unsubstituted 2-thiazolyl, or substituted or unsubstituted 2-furanyl.

[0102] R³ may also be selected from a 1-pyrazolyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2 to 20 membered heteroalkyl; 4-oxazolyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2 to 20 membered heteroalkyl; 2-oxazolyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2 to 20 membered heteroalkyl; 2-thiazolyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2 to 20 membered heteroalkyl; or 2-furanyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2 to 20 membered heteroalkyl.

[0103] Alternatively, R³ may be one of the following: 1-pyrazolyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 6 membered heteroalkyl; 4-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 6 membered heteroalkyl; 2-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 6 membered

heteroalkyl; 2-thiazolyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 6 membered heteroalkyl; or 2-furanyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 6 membered heteroalkyl.

5 [0104] R³ may also be one of: 1-pyrazolyl substituted with an unsubstituted C₁-C₅ alkyl (e.g. at the 3 position, the 5 position, or the 3 and 5 position); 4-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl (e.g. at the 2 position, the 5-position, or the 2 and 5 position); 2-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl (e.g. at the 4 position); 2-thiazolyl substituted with an unsubstituted C₁-C₅ alkyl (e.g. at the 4 position); or 2-furanyl substituted with an unsubstituted C₁-C₅ alkyl (e.g. at the 5 position).

10 [0105] In an exemplary embodiment, L⁵ is a bond, -C(O)-, substituted or unsubstituted C₁-C₂₀ alkylene, or substituted or unsubstituted 2 to 20 membered heteroalkylene. L⁵ may be selected from a bond, -C(O)-, substituted or unsubstituted C₁-C₂₀ alkylene, or substituted or unsubstituted 2 to 10 membered heteroalkylene. L⁵ may also be selected from a bond; unsubstituted C₁-C₁₀ alkylene; unsubstituted 2 to 10 membered heteroalkylene; C₁-C₁₀ 15 alkylene substituted with an oxo, unsubstituted C₁-C₁₀ alkyl, or unsubstituted 2 to 10 membered heteroalkyl; or 2 to 10 membered heteroalkylene substituted with an oxo, unsubstituted C₁-C₁₀ alkyl, or unsubstituted 2 to 10 membered heteroalkyl.

[0106] In another exemplary embodiment, -L⁵-R⁵ has the formula



20 [0107] The symbol "q" is an integer from 0 to 5. R²⁴ and R²⁵ are independently selected from a hydrogen, substituted or unsubstituted C₁-C₁₀ alkyl, substituted or unsubstituted 2 to 10 membered heteroalkyl, substituted or unsubstituted C₃-C₇ (e.g. C₅-C₇) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heterocycloalkyl, or substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. R⁵ may be selected from substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted 2 to 20 membered 25 heteroalkyl, substituted or unsubstituted C₃-C₇ (e.g. C₅-C₇) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heteroalkyl, substituted or unsubstituted 2 to 20 membered heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or -L⁶-Y. In some embodiments, one of R²⁴ or R²⁵ is hydrogen.

30 [0108] In some embodiments, R⁵ is -NR²⁹R³⁰. R²⁴, R²⁵, R²⁹, and R³⁰ may independently be selected from hydrogen and substituted or unsubstituted C₁-C₁₀ alkyl. The symbol q may

be 1 or 2. R²⁵, R²⁹, and R³⁰ may also independently be unsubstituted C₁-C₅ alkyl. R²⁴ may also be hydrogen.

[0109] In some embodiments, R⁵ is -S(O)_tR³². The symbol t may represent 2. R³² may be substituted or unsubstituted C₁-C₁₀ alkyl. L⁵ may be substituted or unsubstituted C₁-C₁₀ alkylene. R³² may also be unsubstituted C₁-C₅ alkyl. L⁵ may also be unsubstituted C₁-C₅ alkylene.

[0110] In an exemplary embodiment, R²⁴ is hydrogen. R²⁵ may be selected from an unsubstituted C₁-C₁₀ alkyl, unsubstituted C₃ to C₇ (e.g. C₅ to C₇) cycloalkyl, unsubstituted aryl, C₅ to C₇ cycloalkyl substituted with a C₁-C₅ unsubstituted alkyl, or aryl substituted with a C₁-C₅ unsubstituted alkyl.

[0111] R⁵ may be selected from a substituted or unsubstituted C₁-C₁₀ alkyl, substituted or unsubstituted 2 to 10 membered heteroalkyl, substituted or unsubstituted C₃-C₇ (e.g. C₅-C₇) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heteroalkyl, substituted or unsubstituted 2 to 10 membered heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or -L⁶-Y. Alternatively, R⁵ is selected from unsubstituted aryl; unsubstituted heteroaryl; aryl substituted with a halogen; heteroaryl substituted with a halogen; or C₁-C₂₀ alkyl substituted with a halogen.

[0112] In some exemplary embodiments, R⁵ is an unsubstituted C₁-C₁₀ alkyl; unsubstituted 2 to 10 membered heteroalkyl; unsubstituted C₃-C₇ (e.g. C₅-C₇) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heteroalkyl; unsubstituted 2 to 10 membered heterocycloalkyl; unsubstituted aryl; unsubstituted heteroaryl; C₁-C₁₀ alkyl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 5 membered heteroalkyl; 2 to 10 membered heteroalkyl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 5 membered heteroalkyl; C₅-C₇ cycloalkyl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 5 membered heteroalkyl; 5 to 7 membered heterocycloalkyl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 5 membered heteroalkyl; aryl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 5 membered heteroalkyl; or heteroaryl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 5 membered heteroalkyl.

[0113] In other exemplary embodiments, R⁵ is an unsubstituted C₁-C₁₀ alkyl; or heteroaryl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅ alkyl, or

unsubstituted 2 to 5 membered heteroalkyl. R^5 may also be selected from unsubstituted C_1 - C_5 alkyl; unsubstituted pyridinyl; or pyridinyl substituted with an unsubstituted C_1 - C_5 alkyl.

[0114] R^{11} may be a hydrogen, substituted or unsubstituted alkyl, or substituted or unsubstituted heteroalkyl. R^{11} may also be a hydrogen, unsubstituted C_1 - C_{20} alkyl, unsubstituted 2 to 20 membered heteroalkyl, C_1 - C_{20} alkyl substituted with a halogen, or 2 to 20 membered heteroalkyl substituted with a halogen. In another exemplary embodiment, R^{11} is a hydrogen, unsubstituted C_1 - C_{20} alkyl, unsubstituted 2 to 20 membered heteroalkyl, C_1 - C_{20} alkyl substituted with a fluorine or chlorine, or 2 to 20 membered heteroalkyl substituted with a fluorine or chlorine.

[0115] R^{10A} and R^{10B} may be independently selected from a hydrogen, substituted or unsubstituted C_1 - C_{20} alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or unsubstituted C_3 - C_8 cycloalkyl, substituted or unsubstituted 5 to 7 membered heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or $-L^6-Y$. R^{10A} and R^{10B} may also be independently selected from a hydrogen, substituted or unsubstituted C_1 - C_8 alkyl, substituted or unsubstituted 2 to 8 membered heteroalkyl, substituted or unsubstituted C_3 - C_7 (e.g. C_5 - C_7) cycloalkyl, substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, or $-L^6-Y$.

[0116] In another exemplary embodiment, R^{10A} and R^{10B} are independently selected from a hydrogen, unsubstituted C_1 - C_8 alkyl, unsubstituted 2 to 8 membered heteroalkyl, unsubstituted C_5 - C_7 cycloalkyl, unsubstituted 5 to 7 membered heterocycloalkyl, unsubstituted aryl, or unsubstituted heteroaryl.

[0117] R^{10A} is optionally joined with R^2 to form a substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. In an exemplary embodiment, R^{10A} is optionally joined with R^2 to form a substituted or unsubstituted C_3 - C_8 cycloalkyl, substituted or unsubstituted 5 to 6 membered heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl. In another exemplary embodiment, R^{10A} is optionally joined with R^2 to form an unsubstituted C_3 - C_8 cycloalkyl, unsubstituted 5 to 6 membered heterocycloalkyl, unsubstituted aryl, or unsubstituted heteroaryl.

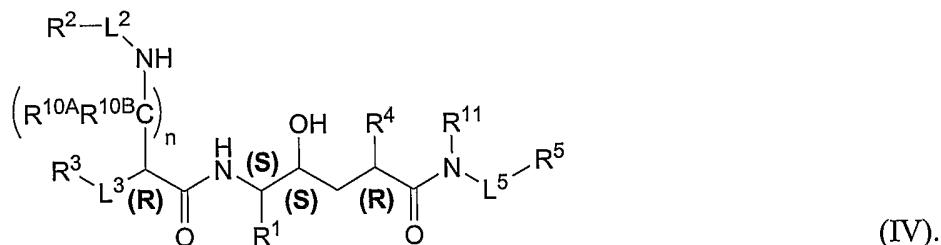
[0118] In some embodiments, R^{36} and R^{37} are hydrogen or substituted or unsubstituted C_1 - C_{10} alkyl. R^{36} and R^{37} may also be hydrogen or unsubstituted C_1 - C_5 alkyl.

[0119] L^6 may be selected from a bond, $-OP(OH)_2O-$, $-C(O)OR^{26}-$, $-C(O)NHR^{27}-$, $-S(O)_2NHR^{28}-$, substituted or unsubstituted C_1-C_{20} alkylene, substituted or unsubstituted 2 to 20 membered heteroalkylene, substituted or unsubstituted 3-8 membered cycloalkylene, substituted or unsubstituted 3 to 8 membered heterocycloalkylene, substituted or unsubstituted arylene, substituted or unsubstituted heteroarylene, or peptidyl linker. R^{26} , R^{27} , and R^{28} may independently be selected from substituted or unsubstituted C_1-C_{20} alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or unsubstituted 3-8 membered cycloalkyl, substituted or unsubstituted 3 to 8 membered heterocycloalkyl, substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

[0120] In an exemplary embodiment, 0, 1, 2 or 3 of R^1 , R^2 , R^3 , R^4 , R^5 , R^{10A} , R^{10B} , and R^{11} may be $-L^6-Y$. In some exemplary embodiments, 0 or 1 of R^1 , R^2 , R^3 , R^4 , R^5 , R^{10A} , R^{10B} , and R^{11} may be $-L^6-Y$. In other exemplary embodiments, R^1 , R^2 , R^3 , R^4 , R^5 , R^{10A} , R^{10B} , and R^{11} may not be $-L^6-Y$.

[0121] Y may be a peptidyl carrier moiety. The peptidyl carrier moiety may be capable of transporting the compound of Formula (I) across the blood brain barrier of a mammal. Alternatively, the peptidyl carrier moiety may be capable of binding to a blood brain barrier receptor. The peptidyl carrier moiety may also be derived from an HIV tat protein, a peptide comprising an oligo-D-arginine residue, an antibody, or an antibody fragment. Carrier moieties are described in detail below.

[0122] In some embodiments, the inhibitors of the present invention have a stereochemical configuration as shown below in Formula (IV).



[0123] In Formula (IV), L^2 , L^3 , L^5 , R^1 , R^2 , R^3 , R^4 , R^5 , R^{11} , R^{10A} , R^{10B} , and n are as defined above in the discussion of the compounds of Formula (I).

[0124] As described above, $-L^3-R^3$ is $-CH_2-C(O)-CHR^{19}-CH_2-R^3$. In some embodiments, the stereochemical configuration is as shown below in Formula (IV):



[0125] In Formula (V), R³ and R¹⁹ are as defined above in the discussion of -L³-R³ and the compounds of Formula (I).

[0126] In some embodiments, each substituted group described above in the compounds of Formulae (I)-(V) is substituted with at least one substituent group. More specifically, in some embodiments, each substituted alkyl, substituted heteroalkyl, substituted cycloalkyl, substituted heterocycloalkyl, substituted aryl, substituted heteroaryl, substituted alkylene, substituted heteroalkylene, substituted cycloalkylene, substituted, substituted heteroalkylene, substituted arylene, and/or substituted heteroarylene described above in the compounds of Formulae (I)-(VIII) are substituted with at least one substituent group. In other embodiments, at least one or all of these groups are substituted with at least one size-limited substituent group. Alternatively, at least one or all of these groups are substituted with at least one lower substituent group.

[0127] In other embodiments of the compounds of Formulae (I)-(V), each substituted or unsubstituted alkyl is a substituted or unsubstituted C₁-C₂₀ alkyl, each substituted or unsubstituted heteroalkyl is a substituted or unsubstituted 2 to 20 membered heteroalkyl, each substituted or unsubstituted cycloalkyl is a substituted or unsubstituted C₃-C₈ cycloalkyl, each substituted or unsubstituted heterocycloalkyl is a substituted or unsubstituted 3 to 8 membered heterocycloalkyl, each substituted or unsubstituted alkylene is a substituted or unsubstituted C₁-C₂₀ alkylene, each substituted or unsubstituted heteroalkylene is a substituted or unsubstituted 2 to 20 membered heteroalkylene, each substituted or unsubstituted cycloalkylene is a substituted or unsubstituted C₃-C₈ cycloalkylene, each substituted or unsubstituted heterocycloalkylene is a substituted or unsubstituted 3 to 8 membered heterocycloalkylene.

[0128] In some embodiments, each substituted or unsubstituted alkyl is a substituted or unsubstituted C₁-C₈ alkyl, each substituted or unsubstituted heteroalkyl is a substituted or unsubstituted 2 to 8 membered heteroalkyl, each substituted or unsubstituted cycloalkyl is a substituted or unsubstituted C₃-C₇ (e.g. C₅-C₇) cycloalkyl, each substituted or unsubstituted heterocycloalkyl is a substituted or unsubstituted 3 to 7 (e.g. 5 to 7) membered heterocycloalkyl, each substituted or unsubstituted alkylene is a substituted or unsubstituted C₁-C₈ alkylene, and/or each substituted or unsubstituted heteroalkylene is a substituted or unsubstituted 2 to 8 membered heteroalkylene.

[0129] In another embodiment, the compounds of the present invention include any of the compounds Table 1.

Carrier Moieties

[0130] In copending U.S. Application No. 20040121947, and International Application No. PCT/US02/34324 (Publication No. WO 03/039454), which are herein incorporated by reference for all purposes, isostere β -secretase inhibitors with and without a carrier moiety were shown to effectively reduce A β production in tg2576 mice expressing the Swedish mutation of the human amyloid precursor protein (Hsiao, K., *et al.*, *Science* 274, 99-102 (1996)). Thus, one of skill in the art will recognize that the compounds of the invention may be administered with or without a carrier moiety.

[0131] A "carrier moiety," as used herein, refers to a chemical moiety covalently or non-covalently attached to a β -secretase inhibitor compound of the invention that enhances the ability of the compound to traverse the blood-brain barrier (BBB). The β -secretase inhibitors of the invention may be attached or conjugated to the carrier moiety by covalent interactions (e.g., peptide bonds) or by non-covalent interactions (e.g., ionic bonds, hydrogen bonds, van der Waals attractions).

[0132] The blood-brain barrier is a permeability barrier that exists between the extracellular fluid in the brain and the blood in the capillary lumen. The barrier stems from structural differences between the capillaries in the brain and capillaries found in other tissues. Most significant among the structural differences of brain capillaries are the tight junctions between endothelial cells. These specialized tight junctions create a very high trans-endothelial electrical resistance of 1500-2000 ohms/cm² compared to 3-33 ohms/cm²

in capillary endothelial cells lying outside the brain, reducing the aqueous based paracellular diffusion observed in other organs (Brightman, M. in Bradbury MWB (ed)

25 *Physiology and Pharmacology of the blood-brain barrier. Handbook of experimental pharmacology* 103, Springer-Verlag, Berlin, (1992); Lo, E.H., *et al.*, *Brain Res. Rev.*, 38:140-148, (2001)). Thus, in some embodiments, the compounds of the present invention are covalently attached to a carrier moiety (represented by the symbol Y in the formulae above).

30 [0133] Any appropriate carrier moiety may be used in the present invention. Useful carrier moieties include, for example, lipophilic carrier moieties, enzymatic substrate carrier

moieties, peptidyl carrier moieties, and nanoparticle carrier moieties. Carrier moieties may also include an oligosaccharide unit or other molecule linked to the compound by phosphoester or lipid-ester or other hydrolyzable bonds which are cleaved by glycosidases, phosphatases, esterases, lipases, or other hydrolases in the lysosomes and endosomes. The 5 carrier moieties may contain guanidine, amino, or imidazole functional groups.

Lipophilic Carrier Moieties

[0134] Lipophilic carrier moieties increase the overall lipophilicity of a compound, thereby aiding in passage through the BBB. Lipophilicity can be quantified using any suitable approach known in the art. For example, the partition coefficient between octanol 10 and water ($\log P_{o/w}$) may be measured thereby indicating the degree of lipophilicity. In some embodiments, the lipophilic carrier moiety has a $\log P_{o/w}$ of 1.5-2.5. Lipophilic carrier moieties are widely known in the art and are discussed in detail, for example, in Lambert, D.M., *Eur J Pharm Sci.*, 11:S15-27 (2000). Exemplary lipophilic carrier moieties used to increase the lipophilicity of a compound include modified and unmodified 15 diglycerides, fatty acids, and phospholipids.

[0135] Some lipophilic carrier moieties undergo enzyme mediated oxidation after traversing the BBB, resulting in a hydrophilic membrane impermeable form of the carrier moiety that remains trapped behind the BBB (Bodor et al., *Pharmacol Ther* 76:1-27 (1997); Bodor et al., *American Chemical Society*, Washington, DC pp317-337 (1995); Chen et al., *J 20 Med Chem* 41:3773-3781 (1998); Wu et al., *J Pharm Pharmacol* 54:945-950 (2002)). Exemplary lipophilic carrier moieties that undergo enzyme mediated oxidation include 1,4-dihydrotrigonelline (Palomino et al., *J Med Chem*, 32:622-625 (1989)); alkyl phosphonate carrier moieties that have been successfully used to transport testosterone and zidovudine across the blood-brain barrier (Somogyi, G., et al., *Int J Pharm*, 166:15-26 (1998)); and the 25 lipophilic dihydropyridine carrier moieties that are enzymatically oxidized to the ionic pyridinium salt (Bodor et al., *Science*, 214(18):1370-1372 (1981)).

Peptidyl Carrier Moieties

[0136] Peptidyl carrier moieties are moieties partially or wholly composed of a peptide (including polypeptides, proteins, antibodies, and antibody fragments) used to aid in the 30 transport of compounds across the BBB (Wu et al., *J Clin Invest* 100:1804-1812 (1997); U.S. Pat. No. 4,801,575; Pardridge et al., *Adv Drug Deliv Rev*, 36:299-321 (1999)).

[0137] Peptidyl carrier moieties may interact with specific peptide transport systems, receptors, or ligands, that target the corresponding ligand or receptor on an endothelial cell of the BBB. Specific transport systems may include either carrier-mediated or receptor-mediated transport across the BBB (U.S. Pat. App. No. 20040110928). Exemplary peptidyl 5 carrier moieties include insulin (Pardridge et al., *Nat Rev Drug Discov*, 1:131-139 (2002)); small peptides such as enkephalin, thyrotropin-releasing hormone, arginine-vassopressin (Bergley, *J Pharm Pharmacol*, 48:136-146 (1996)), Banks et al., *Peptides*, 13:1289-1294 (1992)), Han et al., *AAPS Pharm. Si.*, 2:E6 (2000)); chimeric peptides such as those described in WO-A-89/10134; amino acid derivatives such as those disclosed in U.S. Pat. 10 App. No. 20030216589; tat peptide (Schwarze, S.R., et al., *Science* 285:1569-1572 (1999); polyarginine peptide (Wender, P.A., et al., *Proc. Natl. Acad. Sci. USA* 97:13003-13008 (2000)); insulin-like-growth factor-1; insulin-like-growth factor-2; transferrin; leptin; low-density lipoprotein (Pardridge, *Nat. Rev. Drug Discov.* 1:131-139 (2002); Colma et al., *Pharm. Res.* 17:266-274 (2000); Pardridge, *Endocrine Rev*, 7:314-330 (1986); Golden, et 15 al., *J Clin Invest*, 99:14-18 (1997); Bickel et al., *Adv. Drug Deliv. Rev.* 46(1-3):247-79 (2001)); and basic fibroblast growth factor (bFGF) (U.S. Pat. App. No. 20040102369).

[0138] Copending U.S. Application No. 20040121947, and International Application No. PCT/US02/34324 (Publication No. WO 03/039454), disclose that confocal microscopic images of cells incubated with a fluorescent tat-conjugated isosteric β -secretase inhibitor 20 showed uneven distribution inside cells. Some high fluorescence intensity was associated with the endosome and lysosome intracellular vesicular structures. This indicated that the tat carrier moiety may have been modified by proteases within the lysosome or endosome resulting in an inhibitor that was unable to exit the lysosomal or endosomal compartment. Lysosomes and endosomes contain many proteases, including hydrolase such as cathepsins 25 A, B, C, D, H and L. Some of these are endopeptidase, such as cathepsins D and H. Others are exopeptidases, such as cathepsins A and C, with cathepsin B capable of both endo- and exopeptidase activity. The specificities of these proteases are sufficiently broad to hydrolyze a tat peptide away from the inhibitor compound, thus, hydrolyzing the carrier peptide away from the isosteric inhibitor. Thus, it has been shown that tat and other carrier 30 peptides may be particularly useful for specific delivery of isosteric inhibitors to lysosomes and endosomes. When administered to a mammal by a mechanism such as injections, the conjugated compound will penetrate cells and permeate to the interior of lysosomes and

endosomes. The proteases in lysosomes and endosomes will then hydrolyze tat, thereby preventing to escape from lysosomes and endosomes.

[0139] The carrier peptide may be tat or other basic peptides, such as oligo-L-arginine, that are hydrolyzable by lysosomal and endosomal proteases. Specific peptide bonds susceptible for the cleavage of lysosomal or endosomal proteases may be installed, thereby facilitating the removal of the carrier compound from the inhibitor. For example, dipeptides Phe-Phe, Phe-Leu, Phe-Tyr and others are cleaved by cathepsin D.

[0140] In one embodiment, the peptidyl carrier molecule includes cationic functional groups, such as the tat-peptide (Schwarze, S.R., *et al.*, *Science* 285: 1569-1572 (1999)), or nine arginine residues (Wender, P. A., *et al.*, *Proc. Natl. Acad. Sci. USA* 97:13003-13008 (2000)). Useful cationic functional groups include, for example, guanidine, amino, and imidazole functional groups. Thus, cationic functional groups also include amino acid side chains such as side chains of lysine, arginine, and histidine residues. In some embodiments, the peptidyl carrier molecule may include from 1-10 cationic functional groups. When a compound of the invention is conjugated or attached to a carrier moiety, the resulting conjugate may be referred to herein as a “Carrier Peptide-Inhibitor” conjugate or “CPI.” The CPI conjugate can be administered to an *in vitro* sample or to a mammal thereby serving as a transport vehicle for a compound or compounds of the invention into a cell in an *in vitro* sample or in a mammal. The carrier moieties and CPI conjugates result in an increase in the ability of the compounds of the invention to effectively penetrate cells and the blood brain barrier to inhibit memapsin 2 from cleaving APP to subsequently generate A β .

[0141] Adsorptive-mediated transcytosis (AME) provides an alternative mechanism whereby peptidyl carrier moieties may cross the BBB. AME differs from other forms of transcytosis in that the initial binding of the carrier moiety to the luminal plasma membrane is mediated through either electrostatic interactions with anionic sites, or specific interactions with sugar residues. Uptake through AME is determined by the C-terminal structure and basicity of the carrier moiety. Exemplary adsorptive peptidyl carrier moieties include peptides and proteins with basic isoelectric points (cationic proteins), and some lectins (glycoprotein binding proteins). See Tamai, I., *et al.*, *J. Pharmacol. Exp. Ther.* 280:410-415 (1997); Kumagai, A. K., *et al.*, *J. Biol. Chem.* 262: 15214-15219 (1987).

[0142] Peptidyl carrier moieties also include antibody carrier moieties. Antibody carrier moieties are carrier moieties that include an antibody or fragment thereof. Typically, the antibody or antibody fragment is, or is derived from, a monoclonal antibody. Antibody carrier moieties bind to cellular receptors, or transporters expressed on the luminal surface of brain capillary endothelial cells (U.S. Patent App No. 20040101904). Exemplary antibodies, or fragments thereof, include MAb 83-14 that binds to the human insulin receptor (Pardridge et al., *Pharm Res.* 12:807-816 (1995)); anti-transferrin antibody (Li, J.Y., et al., *Protein Engineering* 12:787-796 (1999)); and monoclonal antibodies that mimic an endogenous protein or peptide which is known to cross the BBB as discussed above.

10 Nanoparticle Carrier Moieties

[0143] Nanoparticle carrier moieties are solid colloidal carriers generally less than a micron in diameter or length. The compound may be encapsulated in, adsorbed onto, or covalently linked to the surface of the nanoparticle carrier moiety. Nanoparticle carrier moieties have been used to successfully deliver a variety of compounds to the brain, including hexapeptide dalagrin, an enkephalin analog; loperamide; tubocerarine; and doxorubicin (Ambikanandan, et al., *J. Pharm Pharmaceut Sci* 6(2):252-273 (2003)). In addition to aiding transport into the brain, nonionic detergents such as polysorbate-80, which can be used to coat the nanoparticle, may be used to inhibit the efflux pump. Zordan-Nudo, T., et al., *Cancer Res.* 53:5994-6000 (1993). Exemplary materials for the manufacture of nanoparticle carrier moieties include polyalkylcyanoacrylate (PACA) (Bertling et al., *Biotechnol. Appl. Biochem.* 13: 390-405 (1991)); polybutylcyanoacrylate (PBCA) (Chavany et al., *Pharm. Res.* 9: 441-449 (1992)); polybutylcyanoacrylate with the peptide-drug complex absorbed onto the surface and coated with polysorbate 80 (Kreuter, J., et al., *Brain Res.* 674:171-174 (1995), Kreuter, J., *Adv Drug Deliv Rev.* 47:65-81, 2001), Kreuter, J., *Curr Med Chem.* 2:241-249 (2002)); polyisohexylcyanoacrylate (PIHCA) (Chavany et al., *Pharm. Res.* 11: 1370-1378 (1994)); polyhexylcyanoacrylate (PHCA) (Zobel et al., *Antisense Nucleic Acid Drug Dev.* 7:483-493 (1997)); and PEGylated polycyanoacrylate (Pilar, C., et al., *Pharm Res* 18(8):1157-1166 (2001)).

25 **Linker Moieties**

[0144] Linker moieties may be used to attach the carrier moiety to the β -secretase inhibitors of the present invention (represented by the symbol L^6). For example, steric hinderance between the compound and the carrier can be prevented using polymer

technology (e.g. PEGylation) in conjunction with the linker molecule to introduce a long spacer arm (Yoshikawa, T., et al., *J Pharmacol Exp Ther*, 263:897–903, 1992). Linker moieties may be cleavable or non-cleavable.

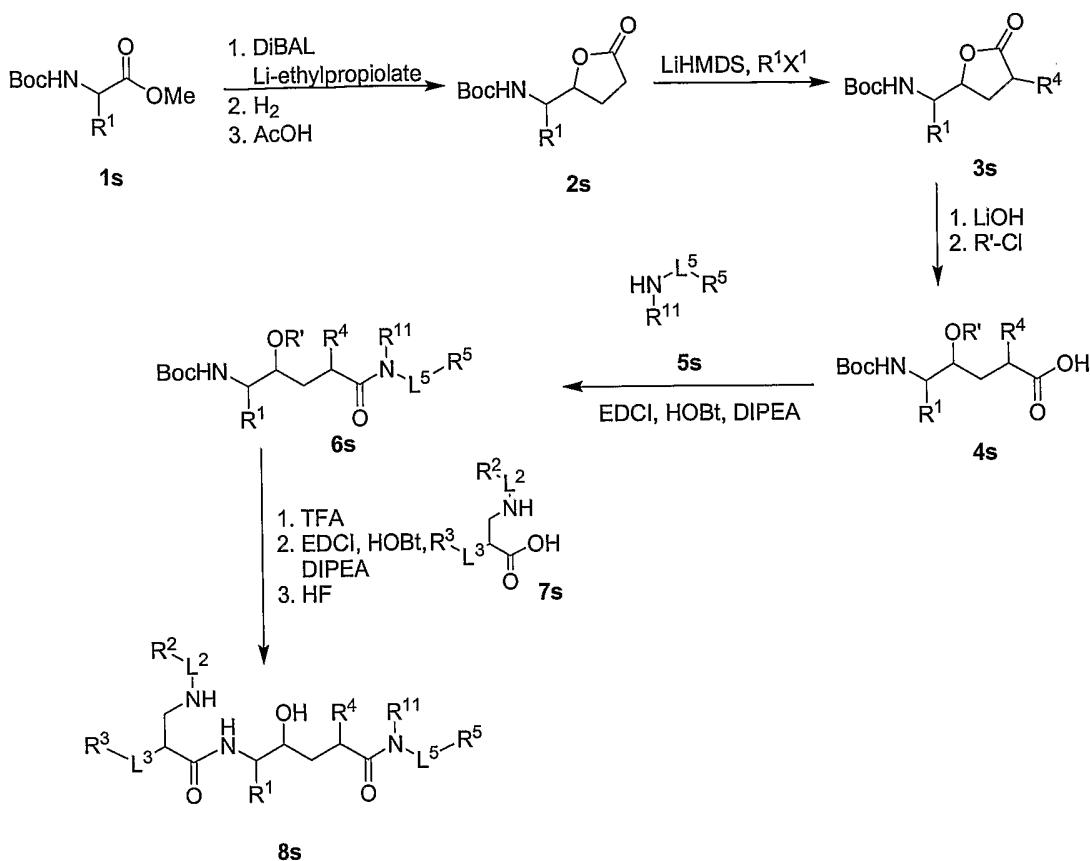
[0145] Cleavable linker molecules include a cleavable moiety. Any appropriate cleavable moiety is useful in the present invention, including for example, phosphoesters, esters, disulfides, and the like. Cleavable moieties also include those moieties capable of being cleaved by biological enzymes, such as peptidases, glycosidases, phosphatases, esterases, lipases, or other hydrolases. Cleavable linker molecules are especially useful where the carrier moiety interferes with the biological activity of the compound. Exemplary cleavable linker molecules include N-succinimidyl-3-2-pyridyldithiopropionate (SPDP), or N-hydrosuccinimide (NHS).

[0146] Non-cleavable linker molecules are those that involve the attachment of a carrier moiety to the compound through a linkage that is generally stable to biological conditions and enzymes.. Non-cleavable linker molecules are typically used when the carrier moiety does not interfere with the biological activity of the compound. Exemplary non-cleavable linker molecules include thio-ether (e.g., m-maleimidobenzoyl N-hydroxysuccinimide ester (MBS)); amide (e.g., N-hydrosuccinimide (NHS-XX-); extended amide (e.g., N-hydrosuccinimide polyethylene glycol (NHS-PEG); and extended hydrazide linkages (e.g., hydrazide-PEG-biotin-); avidin-biotin; and PEG linkers (Ambikanandan et al., *J. Pharm Pharmaceut Sci* 6(2):252-273 (2003); Pardridge, *Adv Drug Deliv Rev*, 36:299–321 (1999); U.S. Pat. No. 6,287,792).

Exemplary Syntheses

[0147] The compounds of the invention are synthesized by an appropriate combination of generally well known synthetic methods. Techniques useful in synthesizing the compounds of the invention are both readily apparent and accessible to those of skill in the relevant art. The discussion below is offered to illustrate certain of the diverse methods available for use in assembling the compounds of the invention. However, the discussion is not intended to define the scope of reactions or reaction sequences that are useful in preparing the compounds of the present invention.

Scheme 1



[0148] In Scheme 1, R^1 , R^2 , R^3 , R^4 , R^5 , R^{11} , L^2 , L^3 , and L^5 are as defined above in the discussion of the inhibitors of the present invention. X' is a halogen (e.g. iodide, chloride or bromide) and R' is a hydroxyl protecting group (e.g. TBDMS, TBS). Those of skill in the art will understand how to protect a particular functional group, such as a hydroxyl or amine, from interfering with a chosen set of reaction conditions. For examples of useful protecting groups, *See Greene et al., PROTECTIVE GROUPS IN ORGANIC SYNTHESIS*, John Wiley & Sons, New York, 1991.

[0149] In the above scheme, the methyl ester **1s** is cyclized to the corresponding lactone **2s** followed by substitution with the halogenated R^1 group to yield the substituted lactone **3s**. Ring opening and protection of the resulting hydroxyl group yields the protected isostere fragment **4s**. Amide coupling of the **4s** ester and **5s** free amine yields the corresponding N-terminal extended isostere **6s**. Acid deprotection of the **6s** Boc amino group followed by amide coupling to the **7s** ester yields the amino isostere **8s**.

Beta-Secretase Inhibitor Activity

[0150] To develop useful β -secretase inhibitors, candidate inhibitors capable of selectively decreasing memapsin 2 activity may be identified *in vitro* and subsequently tested for their ability to reduce the production of A β . The activity of the inhibitor 5 compounds can be assayed utilizing methods known in the art and/or those methods presented herein.

[0151] Compounds that decrease memapsin 2 activity may be identified and tested using biologically active memapsin 2, either recombinant or naturally occurring. Memapsin 2 can be found in native cells, isolated *in vitro*, or co-expressed or expressed in a cell. Measuring 10 the reduction in the memapsin 2 activity in the presence of an inhibitor relative to the activity in the absence of the inhibitor may be performed using a variety of methods well-known in the art.

[0152] For example, the compounds may be tested for their ability to cause a detectable decrease in hydrolysis of a β -secretase site of a peptide in the presence of memapsin 2. 15 These data can be expressed, for example, as K_i , K_i apparent, Vi/Vo , or percentage inhibition. K_i is the inhibition equilibrium constant which indicates the ability of compounds to inhibit a given enzyme (such as memapsin 2, memapsin 1, and/or cathepsin D). Numerically lower K_i values indicate a higher affinity of the compounds of the invention for the enzyme. The K_i value is independent of the substrate, and converted from 20 K_i apparent.

[0153] K_i apparent is determined in the presence of substrate according to established techniques (see, for example, Bieth, J., *Bayer-Symposium V: Proteinase Inhibitors*, pp. 463-469, Springer-Verlag, Berlin (1994)). The standard error for the K_i apparent is the error from the nonlinear regression of the Vi/Vo data measured at different concentrations of the 25 compounds of the invention (e.g., between about 10 nM to about 1000 nM) employing well-known techniques (see, for example, Bieth, J., *Bayer-Symposium V: Proteinase Inhibitors*, pp. 463-469, Springer-Verlag, Berlin (1994), Ermolieff, J., *et al.*, *Biochemistry* 39:12450-12456 (2000), the teachings of which are incorporated herein by reference in their entirety). Vi/Vo depicts the ratio of initial conversion velocities of an enzyme substrate (Ermolieff, *et* 30 *al.*, *Biochemistry* 40:12450-12456 (2000)) by an enzyme in the absence (Vo) or presence (Vi) of an inhibitor. A Vi/Vo value of 1.0 indicates that a compound does not inhibit the

enzyme. A Vi/V_o value less than 1.0 indicates that a compound of the invention inhibits enzyme activity.

[0154] Once compounds are identified that are capable of reducing the hydrolysis of a β -secretase site of a peptide in the presence of memapsin 2, the compounds may be further tested for their ability to selectively inhibit memapsin 2 relative to other enzymes.

5 Typically, the other enzyme is a peptide hydrolase, such as memapsin 1 or cathepsin D. Compounds that decrease cathepsin D activity or memapsin 1 activity are tested using biologically active enzyme, either recombinant or naturally occurring. Cathepsin D or memapsin 1 activity can be found in native cells, isolated *in vitro*, or co-expressed or 10 expressed in a cell. Inhibition by a compound of the invention is measured using standard *in vitro* or *in vivo* assays such as those well known in the art or as otherwise described herein.

[0155] For example, selectivity may be measured by determining the extent to which memapsin 2 hydrolyzes a substrate peptide compared to the extent to which the same 15 compound inhibits memapsin 1 and/or cathepsin D cleaving of a β -secretase site of a substrate peptide. Exemplary substrate peptides are useful in determining the activity of memapsin 2 includes APP and derivatives thereof, such as FS-2 (Bachem Americas, Torrance, CA). Exemplary substrate peptides are useful in determining the activity of memapsin 1 and cathepsin D include, for example, peptides with the sequence 20 ELDLA¹VEFWH²DR. These data can be expressed, for example, as K_i, K_i apparent, Vi/V_o, or percentage inhibition and depict the inhibition of a compound for memapsin 2 activity relative to memapsin 1 or cathepsin D activity. For example, if the K_i of a reaction between 25 an inhibitor compound of the invention and memapsin 1 or cathepsin D is 1000 and the K_i of a reaction between an inhibitor compound of the invention and memapsin 2 is 100, the inhibitor compound inhibits the β -secretase activity of memapsin 2 ten fold, relative to memapsin 1.

[0156] Compounds demonstrating the ability to cause a detectable decrease in hydrolysis 30 of a β -secretase site of a peptide in the presence of memapsin 2 (or, in addition, selectivity of action toward memapsin 2), may be tested in cell models or animal models for their ability to cause a detectable decrease in the amount or production of β -amyloid protein (A β). For example, isosteric inhibitors of memapsin 2 have been tested for their ability to decrease A β production in cultured cells (coping U.S. Application No. 20040121947,

and International Application No. PCT/US02/34324 (Publication No. WO 03/039454)).

Briefly, inhibitors may be added to a culture of cells (e.g. human embryonic kidney (HEK293) cells, HeLa cells, Chinese hamster ovary cells, or neuroblastoma line M17 cells) stably transfected with a nucleic acid constructs that encode human APP Swedish mutant

5 (or London mutation or double mutant) and, if needed, a nucleic acid construct encoding human memapsin 2. Immunoprecipitation of A β followed by SDS-gel electrophoresis allows detection and quantitation of the amount of A β produced in the presence and absence of inhibitor.

10 [0157] In addition to cell cultures, animal models may be used to test inhibitors of memapsin 2 for their ability to decrease A β production. For example, an animal (e.g. tg2576 mice) expressing the Swedish mutation of the human amyloid precursor protein (Hsiao, K., *et al.*, *Science* 274, 99-102 (1996) may be injected intraperitoneally with an inhibitor. The plasma may then be collected and A β levels determined by capture ELISA (BioSource International, Camarillo, CA).

15 [0158] The presence of inhibitors in organs of animal models or within cellular compartments may be ascertained using a fluorescent tag conjugated to the inhibitor and visualization via confocal microscopy (copending U.S. Application No. 20040121947, and International Application No. PCT/US02/34324 (Publication No. WO 03/039454)).

20 [0159] The sample obtained from the mammal can be a fluid sample, such as a plasma or serum sample; or can be a tissue sample, such as a brain biopsy. The amount of β -amyloid protein or a decrease in the production of β -amyloid protein can be measured using standard techniques (e.g. western blotting and ELISA assays).

25 [0160] Further examples of assays for identifying memapsin 2- β -secretase inhibitors are set forth in the Examples section below. Other methods for assaying the activity of memapsin 2, memapsin 1, and cathepsin D and the activity of agents that decrease the activity of these enzymes are known in the art. The selection of appropriate assay methods is well within the capabilities of those of skill in the art.

Pharmaceutical Compositions

30 [0161] In another aspect, the present invention provides pharmaceutical compositions comprising a memapsin 2 β -secretase inhibitor compound of the invention or a memapsin

2 β -secretase inhibitor compound in combination with a pharmaceutically acceptable carrier. The pharmaceutical compositions include optical isomers, diastereomers, or pharmaceutically acceptable salts of the inhibitors disclosed herein. The memapsin 2 β -secretase inhibitor included in the pharmaceutical composition may be covalently attached 5 to a carrier moiety, as described above. Alternatively, the memapsin 2 β -secretase inhibitor included in the pharmaceutical composition is not covalently linked to a carrier moiety.

[0162] A "pharmaceutically suitable carrier," as used herein refers to pharmaceutical excipients, for example, pharmaceutically, physiologically, acceptable organic, or inorganic carrier substances suitable for enteral or parenteral application which do not deleteriously react with the extract. Suitable pharmaceutically acceptable carriers include water, salt 10 solutions (such as Ringer's solution), alcohols, oils, gelatins and carbohydrates such as lactose, amylose or starch, fatty acid esters, hydroxymethylcellulose, and polyvinyl pyrrolidine. Such preparations can be sterilized and, if desired, mixed with auxiliary agents such as lubricants, preservatives, stabilizers, wetting agents, emulsifiers, salts for 15 influencing osmotic pressure, buffers, coloring, and/or aromatic substances and the like which do not deleteriously react with the compounds of the invention.

[0163] The compounds of the invention can be administered alone or can be coadministered to the patient. Coadministration is meant to include simultaneous or sequential administration of the compounds individually or in combination (more than one 20 compound). Thus, the preparations can also be combined, when desired, with other active substances (e.g. to reduce metabolic degradation).

Formulations

[0164] The β -secretase inhibitors of the present invention can be prepared and administered in a wide variety of oral, parenteral and topical dosage forms. Thus, the 25 compounds of the present invention can be administered by injection (e.g. intravenously, intramuscularly, intracutaneously, subcutaneously, intraduodenally, or intraperitoneally). Also, the compounds described herein can be administered by inhalation, for example, intranasally. Additionally, the compounds of the present invention can be administered 30 transdermally. It is also envisioned that multiple routes of administration (e.g., intramuscular, oral, transdermal) can be used to administer the compounds of the invention. Accordingly, the present invention also provides pharmaceutical compositions comprising a

pharmaceutically acceptable carrier or excipient and one or more compounds of the invention.

[0165] For preparing pharmaceutical compositions from the compounds of the present invention, pharmaceutically acceptable carriers can be either solid or liquid. Solid form 5 preparations include powders, tablets, pills, capsules, cachets, suppositories, and dispersible granules. A solid carrier can be one or more substance, which may also act as diluents, flavoring agents, binders, preservatives, tablet disintegrating agents, or an encapsulating material.

[0166] In powders, the carrier is a finely divided solid, which is in a mixture with the 10 finely divided active component. In tablets, the active component is mixed with the carrier having the necessary binding properties in suitable proportions and compacted in the shape and size desired.

[0167] The powders and tablets preferably contain from 5% to 70% of the active 15 compound. Suitable carriers are magnesium carbonate, magnesium stearate, talc, sugar, lactose, pectin, dextrin, starch, gelatin, tragacanth, methylcellulose, sodium carboxymethylcellulose, a low melting wax, cocoa butter, and the like. The term "preparation" is intended to include the formulation of the active compound with 20 encapsulating material as a carrier providing a capsule in which the active component with or without other carriers, is surrounded by a carrier, which is thus in association with it. Similarly, cachets and lozenges are included. Tablets, powders, capsules, pills, cachets, and 25 lozenges can be used as solid dosage forms suitable for oral administration.

[0168] For preparing suppositories, a low melting wax, such as a mixture of fatty acid 25 glycerides or cocoa butter, is first melted and the active component is dispersed homogeneously therein, as by stirring. The molten homogeneous mixture is then poured into convenient sized molds, allowed to cool, and thereby to solidify.

[0169] Liquid form preparations include solutions, suspensions, and emulsions, for example, water or water/propylene glycol solutions. For parenteral injection, liquid 30 preparations can be formulated in solution in aqueous polyethylene glycol solution.

[0170] When parenteral application is needed or desired, particularly suitable admixtures for the compounds of the invention are injectable, sterile solutions, preferably oily or aqueous solutions, as well as suspensions, emulsions, or implants, including suppositories.

In particular, carriers for parenteral administration include aqueous solutions of dextrose, saline, pure water, ethanol, glycerol, propylene glycol, peanut oil, sesame oil, polyoxyethylene-block polymers, and the like. Ampules are convenient unit dosages. The compounds of the invention can also be incorporated into liposomes or administered via 5 transdermal pumps or patches. Pharmaceutical admixtures suitable for use in the present invention are well-known to those of skill in the art and are described, for example, in *Pharmaceutical Sciences* (17th Ed., Mack Pub. Co., Easton, PA) and WO 96/05309, the teachings of both of which are hereby incorporated by reference.

10 [0171] Aqueous solutions suitable for oral use can be prepared by dissolving the active component in water and adding suitable colorants, flavors, stabilizers, and thickening agents as desired. Aqueous suspensions suitable for oral use can be made by dispersing the finely divided active component in water with viscous material, such as natural or synthetic gums, resins, methylcellulose, sodium carboxymethylcellulose, and other well-known suspending agents.

15 [0172] Also included are solid form preparations, which are intended to be converted, shortly before use, to liquid form preparations for oral administration. Such liquid forms include solutions, suspensions, and emulsions. These preparations may contain, in addition to the active component, colorants, flavors, stabilizers, buffers, artificial and natural sweeteners, dispersants, thickeners, solubilizing agents, and the like.

20 [0173] The pharmaceutical preparation is preferably in unit dosage form. In such form the preparation is subdivided into unit doses containing appropriate quantities of the active component. The unit dosage form can be a packaged preparation, the package containing discrete quantities of preparation, such as packeted tablets, capsules, and powders in vials or ampoules. Also, the unit dosage form can be a capsule, tablet, cachet, or lozenge itself, or it 25 can be the appropriate number of any of these in packaged form.

[0174] The quantity of active component in a unit dose preparation may be varied or adjusted from 0.1 mg to 10000 mg, more typically 1.0 mg to 1000 mg, most typically 10 mg to 500 mg, according to the particular application and the potency of the active component. The composition can, if desired, also contain other compatible therapeutic agents.

30 [0175] Some compounds may have limited solubility in water and therefore may require a surfactant or other appropriate co-solvent in the composition. Such co-solvents include: Polysorbate 20, 60 and 80; Pluronic F-68, F-84 and P-103; cyclodextrin; polyoxyl 35 castor

oil; or other agents known to those skilled in the art. Such co-solvents are typically employed at a level between about 0.01 % and about 2% by weight.

[0176] Viscosity greater than that of simple aqueous solutions may be desirable to decrease variability in dispensing the formulations, to decrease physical separation of components of a suspension or emulsion of formulation and/or otherwise to improve the formulation. Such viscosity building agents include, for example, polyvinyl alcohol, polyvinyl pyrrolidone, methyl cellulose, hydroxy propyl methylcellulose, hydroxyethyl cellulose, carboxymethyl cellulose, hydroxy propyl cellulose, chondroitin sulfate and salts thereof, hyaluronic acid and salts thereof, combinations of the foregoing, and other agents known to those skilled in the art. Such agents are typically employed at a level between about 0.01% and about 2% by weight. Determination of acceptable amounts of any of the above adjuvants is readily ascertained by one skilled in the art.

[0177] The compositions of the present invention may additionally include components to provide sustained release and/or comfort. Such components include high molecular weight, anionic mucomimetic polymers, gelling polysaccharides and finely-divided drug carrier substrates. These components are discussed in greater detail in U.S. Pat. Nos. 4,911,920; 5,403,841; 5,212,162; and 4,861,760. The entire contents of these patents are incorporated herein by reference in their entirety for all purposes.

Effective Dosages

[0178] Pharmaceutical compositions provided by the present invention include compositions wherein the active ingredient is contained in a therapeutically effective amount, *i.e.*, in an amount effective to achieve its intended purpose. The actual amount effective for a particular application will depend, *inter alia*, on the condition being treated. For example, when administered in methods to treat Alzheimer's disease, such compositions will contain an amount of active ingredient effective to achieve the desired result (e.g. decreasing β -secretase activity or β -amyloid production). Determination of a therapeutically effective amount of a compound of the invention is well within the capabilities of those skilled in the art, especially in light of the detailed disclosure herein.

[0179] The dosage and frequency (single or multiple doses) administered to a mammal can vary depending upon a variety of factors, including a disease that results in increased activity of memapsin 2 or increased accumulation of β -amyloid protein, whether the

mammal suffers from another disease, and its route of administration; size, age, sex, health, body weight, body mass index, and diet of the recipient; nature and extent of symptoms of the disease being treated (e.g., Alzheimer's disease), kind of concurrent treatment, complications from the disease being treated or other health-related problems. Other 5 therapeutic regimens or agents can be used in conjunction with the methods and compounds of Applicants' invention. Adjustment and manipulation of established dosages (e.g., frequency and duration) are well within the ability of those skilled in the art.

[0180] For any compound described herein, the therapeutically effective amount can be initially determined from cell culture assays. Target concentrations will be those 10 concentrations of active compound(s) that are capable of reducing the activity of memapsin 2 activity, as measured using the methods described herein or known in the art.

[0181] As is well known in the art, therapeutically effective amounts for use in humans can also be determined from animal models. For example, a dose for humans can be formulated to achieve a concentration that has been found to be effective in animals. The 15 dosage in humans can be adjusted by monitoring memapsin 2 inhibition and adjusting the dosage upwards or downwards, as described above. Adjusting the dose to achieve maximal efficacy in humans based on the methods described above and other methods as are well-known in the art is well within the capabilities of the ordinarily skilled artisan.

[0182] Dosages may be varied depending upon the requirements of the patient and the 20 compound being employed. The dose administered to a patient, in the context of the present invention should be sufficient to effect a beneficial therapeutic response in the patient over time. The size of the dose also will be determined by the existence, nature, and extent of any adverse side-effects. Determination of the proper dosage for a particular situation is within the skill of the practitioner. Generally, treatment is initiated with smaller dosages 25 which are less than the optimum dose of the compound. Thereafter, the dosage is increased by small increments until the optimum effect under circumstances is reached. In one embodiment of the invention, the dosage range is 0.001% to 10% w/v. In another embodiment, the dosage range is 0.1% to 5% w/v.

[0183] Dosage amounts and intervals can be adjusted individually to provide levels of the 30 administered compound effective for the particular clinical indication being treated. This will provide a therapeutic regimen that is commensurate with the severity of the individual's disease state.

[0184] Utilizing the teachings provided herein, an effective prophylactic or therapeutic treatment regimen can be planned which does not cause substantial toxicity and yet is entirely effective to treat the clinical symptoms demonstrated by the particular patient. This planning should involve the careful choice of active compound by considering factors such 5 as compound potency, relative bioavailability, patient body weight, presence and severity of adverse side effects, preferred mode of administration and the toxicity profile of the selected agent.

Toxicity

[0185] The ratio between toxicity and therapeutic effect for a particular compound is its 10 therapeutic index and can be expressed as the ratio between LD₅₀ (the amount of compound lethal in 50% of the population) and ED₅₀ (the amount of compound effective in 50% of the population). Compounds that exhibit high therapeutic indices are preferred. Therapeutic index data obtained from cell culture assays and/or animal studies can be used in formulating a range of dosages for use in humans. The dosage of such compounds 15 preferably lies within a range of plasma concentrations that include the ED₅₀ with little or no toxicity. The dosage may vary within this range depending upon the dosage form employed and the route of administration utilized. See, *e.g.* Fingl *et al.*, *In: THE PHARMACOLOGICAL BASIS OF THERAPEUTICS*, Ch.1, p.1, 1975. The exact formulation, route 20 of administration and dosage can be chosen by the individual physician in view of the patient's condition and the particular method in which the compound is used.

Methods of Reducing the Activity of Memapsin 2 Beta-Secretase

[0186] In another aspect of the present invention, the β -secretase inhibitor compounds of the invention can be employed in methods to decrease memapsin 2 activity, decrease 25 hydrolysis of a β -secretase site of a memapsin 2 substrate, and/or decrease the accumulation of β -amyloid protein relative to the amount of memapsin 2 activity, hydrolysis of a β -secretase site, and accumulation of β -amyloid protein, respectively, in the absence of the β -secretase inhibitor.

[0187] In an exemplary embodiment, a method of reducing memapsin 2 activity is provided. The method includes contacting a memapsin 2 with an effective amount (i.e. in 30 an amount effective to achieve its intended purpose) of β -secretase inhibitor compound of the present invention. The memapsin 2 may be contacted in any appropriate environment.

The memapsin 2 activity is decreased relative the amount of activity in the absence of β -secretase inhibitor.

[0188] In another exemplary embodiment, a method is provided of selectively reducing memapsin 2 activity using an effective amount of an inhibitor of the present invention.

5 Selective reduction of the activity of memapsin 2 means that memapsin 2 is not only reduced relative to its activity in the absence of inhibitor, but is reduced to a greater extent as compared to the reduction in activity due to inhibitor action against another peptide hydrolase. For example, as described above, the reduction in activity of an enzyme may be expressed in terms of the inhibitory constant (K_i). Where an inhibitor selectively reduces 10 the activity of memapsin 2, the K_i of the reaction between an inhibitor compound of the invention and memapsin 2 is less than the K_i of the reaction between an inhibitor compound of the invention and another peptide hydrolase.

[0189] In an exemplary embodiment, the K_i of the reaction between an inhibitor compound of the invention and memapsin 2 is at least 2 times less than the K_i of the 15 reaction between an inhibitor compound of the invention and another peptide hydrolase. In another exemplary embodiment, the K_i of the reaction between an inhibitor compound of the invention and memapsin 2 is at least 10 times less than the K_i of the reaction between an inhibitor compound of the invention and another peptide hydrolase. In another exemplary embodiment, the K_i of the reaction between an inhibitor compound of the invention and 20 memapsin 2 is at least 100 times less than the K_i of the reaction between an inhibitor compound of the invention and another peptide hydrolase. In another exemplary embodiment, the K_i of the reaction between an inhibitor compound of the invention and memapsin 2 is at least 1000 times less than the K_i of the reaction between an inhibitor compound of the invention and another peptide hydrolase. In another exemplary embodiment, the K_i of the reaction between an inhibitor compound of the invention and 25 memapsin 2 is at least 10000 times less than the K_i of the reaction between an inhibitor compound of the invention and another peptide hydrolase.

[0190] In some related embodiments, the inhibitor selectively reduces the activity of memapsin 2 as compared to memapsin 1. In other related embodiments, the inhibitor 30 selectively reduces the activity of memapsin 2 as compared to cathepsin D.

[0191] Thus, the present invention provides methods of selectively reducing the activity of memapsin 2. The method includes contacting a memapsin 2 with a β -secretase inhibitor

compound of the present invention. In a related embodiment, the method includes contacting the memapsin 2 with a β -secretase inhibitor in the presence of memapsin 1. In an alternative related embodiment, the method includes contacting the memapsin 2 with a β -secretase inhibitor in the presence of cathepsin D. In yet another related embodiment, the 5 method includes contacting the memapsin 2 with a β -secretase inhibitor in the presence of cathepsin D and memapsin 1.

[0192] In some embodiments, the activity of memapsin-2 β -secretase may be determined by measuring the hydrolysis of a β -secretase site of a β -secretase substrate. Thus, the present invention also relates to a method of decreasing the hydrolysis of a β -secretase site 10 of a β -secretase substrate by contacting a memapsin 2 with a β -secretase inhibitor compound of the present invention. In some embodiments, the hydrolysis of a β -secretase site is decreased relative the amount of hydrolysis in the absence of the inhibitor. In other embodiments, the hydrolysis is selectively reduced as compared to hydrolysis by memapsin 1 and/or cathepsin D. Thus, a method of selectively decreasing hydrolysis of a β -secretase 15 site of a β -amyloid precursor protein relative to memapsin 1 and/or cathepsin D in a sample is provided. The method includes contacting a memapsin 2 with a β -secretase inhibitor compound of the present invention.

[0193] In another embodiment, the present invention relates to a method of decreasing the amount of β -amyloid protein in a sample by contacting the memapsin 2 with an inhibitor 20 compound of the present invention. The amount of β -amyloid protein in a sample is decreased relative the amount of β -amyloid protein in the sample in the absence of the inhibitor. Thus, the accumulation of β -amyloid protein is thereby decreased.

[0194] Memapsin 2 may be contacted in any suitable environment or any suitable sample. For example, memapsin 2 may be contacted *in vitro*, within a cell, or within a mammal. 25 Typically, *in vitro* solutions are selected such that the components do not substantially interfere with the enzymatic activity of memapsin 2 (e.g. aqueous solutions). In some embodiments, the *in vitro* solution includes a biological sample, such as a mammalian sample. Exemplary mammalian samples include plasma or serum samples and tissue samples, such as a brain biopsy. Any appropriate cell or cellular sample may be selected in 30 which to contact the memapsin 2 with the inhibitor. The cell may contain endogenous memapsin 2 or recombinant memapsin 2 as previously described (copending U.S. Application No. 20040121947, and International Application No. PCT/US02/34324

(Publication No. WO 03/039454)). Exemplary cells include human embryonic kidney (HEK293) cells, HeLa cells, Chinese hamster ovary cells, or neuroblastoma line M17 cells Hela cells, 293 cells. In an exemplary embodiment, the compounds of the invention are administered to a mammal to inhibit the hydrolysis of a β -secretase site of a β -amyloid precursor protein (e.g. a mouse, rabbit or human).

Methods of Treating Alzheimer's Disease

10 [0195] In another aspect of the present invention, the β -secretase inhibitor compounds of the invention can be employed in the treatment of diseases or conditions associated with β -secretase activity, hydrolysis of a β -secretase site of a β -amyloid precursor protein, and/or β -amyloid protein accumulation. Typically, a mammal is treated for the disease or condition. In an exemplary embodiment, the disease is Alzheimer's disease.

15 [0196] Thus, in some embodiments, the invention provides a method of treating Alzheimer's disease in a mammal comprising the step of administering to the mammal an effective amount of the β -secretase inhibitors of the invention. The mammals treated with the inhibitors may be human primates, nonhuman primates and/or non-human mammals (e.g., rodents, canines). In one embodiment, the mammal is administered a compound of the invention that reduces β -secretase activity (inhibits memapsin 1 and memapsin 2 activity). In another embodiment, the mammal is administered a compound that selectively reduces memapsin 2 activity. In a related embodiment, the compound has minimal or no effect on reducing memapsin 1 activity. Therefore, the present invention also provides a 20 method of treating Alzheimer's disease in a subject in need thereof, the method comprising administering to the subject a β -secretase inhibitor compound. In an exemplary embodiment, the β -secretase inhibitor compound is part of a pharmaceutical formulation, as described above.

25 [0197] The inhibitor compounds of the invention can be employed in the treatment of diseases or conditions associated with β -secretase activity, which can halt, reverse or diminish the progression of the disease or condition, in particular Alzheimer's disease. In addition to compounds that decrease memapsin 2 activity, compounds that selectively reduce memapsin 2 activity are useful to treat diseases or conditions or biological processes 30 association with memapsin 2 activity rather than diseases or conditions or biological

processes associated with both memapsin 2 activity and another peptide hydrolase (such as cathepsin D or memapsin 1).

[0198] For example, both memapsin 1 and memapsin 2 cleave amyloid precursor protein (APP) at a β -secretase site to form β -amyloid protein (also referred to herein as A β or β -amyloid protein). Thus, both memapsin 1 and memapsin 2 have β -secretase activity (Hussain, I., *et al.*, *J. Biol. Chem.* 276:23322-23328 (2001)). However, the β -secretase activity of memapsin 1 is significantly less than the β -secretase activity of memapsin 2 (Hussain, I., *et al.*, *J. Biol. Chem.* 276:23322-23328 (2001)). Memapsin 2 is localized in the brain, and pancreas, and other tissues (Lin, X., *et al.*, *Proc. Natl. Acad. Sci. USA* 97:1456-1460 (2000)) and memapsin 1 is localized preferentially in placentae (Lin, X., *et al.*, *Proc. Natl. Acad. Sci. USA* 97:1456-1460 (2000)). Alzheimer's disease is associated with the accumulation of A β in the brain as a result of cleaving of APP by β -secretase (also referred to herein as memapsin 2, ASP2 and BACE). Thus, methods employing the compounds which selectively inhibit memapsin 2 activity relative to memapsin 1 activity may be important in the treatment of memapsin 2-related diseases, such as Alzheimer's disease. Selective inhibition of memapsin 2 activity makes the compounds of the invention suitable drug candidates for use in the treatment of Alzheimer's disease.

Methods of Administering Beta-Secretase Inhibitors to the CNS

[0199] The inhibitor compounds of the present invention may be administered to the CNS through either invasive or non-invasive methods. Non-invasive methods of administration include those methods that do not require the use of a mechanical or physical means to breach the integrity of the blood-brain barrier. Typically, non-invasive methods include the use of immunoliposomes, blood-brain barrier disruption (BBBD), or the olfactory pathway.

[0200] Immunoliposomes are liposomes with antibodies or antibody fragments that bind to receptors or transporters expressed on brain capillary endothelial cells attached to the surface of the liposome. An exemplary immunoliposome combines polymer (e.g. PEGylation) technology with that of chimeric peptide technology. For example, the β -secretase inhibitor may be packaged into a unilamellar lipid vesicle containing a PEG²⁰⁰⁰ derivative that contains a reactive groups at one end, for attachment to a complimentary reactive group of an antibody or fragment thereof. Complimentary reactive groups are well known in the art and, include, for example, amine and activated carboxylic acids, thiols and

maleimides, and the like (Ambikanandan et al., *J. Pharm Pharmaceut Sci* 6(2):252-273 (2003); Huwyler et al., *Proc. Natl. Acad. Sci. USA*, 93:14164-14169 (1996); and Huwyler et al., *J Pharmol Exp Ther.* 282:1541-1546 (1997); and U.S. Pat. No. 6,372,250).

[0201] Blood-brain barrier disruption is a temporal loss of the integrity of the tight

5 junctions between endothelial cells that comprise the blood brain barrier. Typically, the compound is administered via systemic or intercarotid injection in conjunction with transient blood-brain barrier disruption (BBBD). Exemplary agents useful for inducing BBBD include solvents such as dimethyl sulfoxide (DMSO); ethanol (EtOH); metals (e.g. aluminum); X-irradiation; induction of pathological conditions (e.g. hypertension, 10 hypercapnia, hypoxia, or ischemia); anti-neoplastic agents (e.g. VP-16, cisplatin, hydroxyurea, flurouracil and etoposide); or concurrent systemic administration of the convulsant drug metrazol and the anti-convulsant drug pentobarbital (Ambikanandan et al., *J. Pharm Pharmaceut Sci* 6(2):252-273 (2003)); vasoactive leukotrienes (Black et al., *J Neurosurg*, 81(5):745-751 (1994)); intracarotid infusion of bradykinin, histamine, or the 15 synthetic bradykinin analog RMP-7 (Miller et al., *Science* 297:1116-1118 (2002), Matsukado, et al., *Neurosurgery* 39:125-133 (1996), Abbott, et al., *Mol Med Today* 2:106-113 (1996), Emerich et al., *Clin Pharmacokinet* 40:105-123 (2001)); hyaluronidase (U. S. Pat App No. 20030215432, Kreil, et al. *Protein Sci.*, 4(9):1666-1669 (1995)); and intercarotid injection of inert hypertonic solutions such as mannitol, or arabinose (Neuwelt, 20 E.A., et al., in Neuwelt EA (ed), *Implications of the Blood Brain Barrier and its Manipulation: Clinical Aspects*. Vol. 2, Plenum Press, New York, (1989), Neuwelt, et al., *J Nucl Med*, 35:1831-1841 (1994), Neuwelt et al., *Pediatr Neurosurg* 21:16-22 (1994), Kroll et al., *Neurosurg*, 42:1083-1099 (1998), Rapoport, *Cell Mol Neurobiol* 20:217-230 (2000), and Doran et al., *Neurosurg* 36:965-970, (1995)).

25 [0202] Olfactory pathway administration is the intranasal delivery of the compound to the olfactory nerves in the upper third of the nasal passages. After intranasal delivery, the compound is transported back along the sensory olfactory neurons to yield significant concentrations in the cerebral spinal fluid (CSF) and olfactory bulb (Thorne et al., *Brain Res*, 692(1-2):278-282 (1995); Thorne et al., *Clin Pharmacokinet* 40:907-946 (2001); Illum,

30 *Drug Discov Today* 7:1184-1189 (2002); U.S. Pat. 6,180,603; U.S. Pat. 6,313,093; and U.S. Pat App No. 20030215398).

[0203] Invasive methods of administration are those methods that involve a physical breach of the blood-brain barrier typically through a mechanical or physical means to introduce the compound into the CSF, or directly into the parenchyma of the brain. Typically, invasive methods of administration may include injection or surgical 5 implantation of the compound.

[0204] In injection methods, a needle is used to physically breach the BBB and deliver the compound directly into the CSF. Exemplary injection methods include intraventricular, intrathecal, or intralumbar routes of administration and may also involve infusion of the compound through a reservoir external to the body (Krewson et al., *Brain Res* 680:196-206 10 (1995); Harbaugh et al., *Neurosurg.* 23(6):693-698 (1988); Huang et al., *J Neurooncol* 45:9-17 (1999); Bobo et al., *Proc Natl Acad Sci USA* 91:2076-2082 (1994); Neuwalt et al., *Neurosurg.* 38(4):1129-1145 (1996)).

[0205] In surgical implantation methods, the compound is placed directly into the parenchyma of the brain. Exemplary surgical implantation methods may include 15 incorporation of the compound into a polyanhydride wafer placed directly into the interstitium of the brain (Brem et al., *Sci Med* 3(4):1-11 (1996); Brem et al., *J Control Release* 74:63-67 (2001)).

Crystallized Complexes

[0206] In another aspect, the present invention provides a crystallized complex containing 20 a memapsin 2 protein and a β -secretase inhibitor of the present invention. Memapsin 2 proteins useful in forming co-crystals with isostere compounds (e.g. memapsin 2 protein fragments, transmembrane proteins, etc.) have been previously discussed in detail (copending U.S. Application No. 20040121947, and International Application No. PCT/US02/34324 (Publication No. WO 03/039454)). These memapsin 2 proteins are 25 equally useful in forming crystallized complexes with β -secretase inhibitors of the present invention.

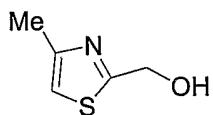
[0207] The crystallized complex may be formed employing techniques described in copending U.S. Application No. 20040121947, and International Application No. PCT/US02/34324 (Publication No. WO 03/039454). Briefly, a nucleic acid construct 30 encoding the protein is generated, is expressed in a host cell, such as a mammalian host cell (e.g., Hela cell, 293 cell) or a bacterial host cell (e.g., *E. coli*), is purified and is crystallized

with a compound or compounds of the invention. The diffraction resolution limit of the crystallized protein can be determined, for example, by x-ray diffraction or neutron diffraction techniques.

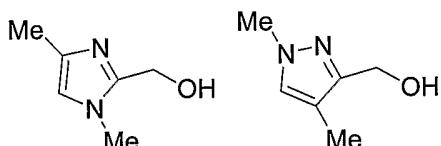
[0208] In an exemplary embodiment, the crystallized protein may have an x-ray diffraction resolution limit not greater than about 4.0 \AA . The crystallized protein may also have an x-ray diffraction resolution limit not greater than about 4.0 \AA , about 3.5 \AA , about 3.0 \AA , about 2.5 \AA , about 2.0 \AA , about 1.5 \AA , about 1.0 \AA , or about 0.5 \AA . In some embodiments, the crystallized protein may also have an x-ray diffraction resolution limit not greater than about 2 \AA . The diffraction resolution limit of the crystallized protein can be determined 10 employing standard x-ray diffraction techniques.

[0209] In an other exemplary embodiment, the β -secretase inhibitor of the crystallized complex is in association with said protein at an S_3' binding pocket, an S_4' binding pocket and/or an S_4 binding pocket. S_3' , S_4' , and S_4 binding pockets are discussed in detail in copending U.S. Application No. 20040121947, and International Application No. 15 PCT/US02/34324 (Publication No. WO 03/039454).

[0210] The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding equivalents of the features shown and described, or portions thereof, it being recognized that various modifications are possible within the scope of the 20 invention claimed. Moreover, any one or more features of any embodiment of the invention may be combined with any one or more other features of any other embodiment of the invention, without departing from the scope of the invention. For example, the features of the β -secretase inhibitors of the present invention are equally applicable to the methods of treating disease states and/or the pharmaceutical compositions described herein. All 25 publications, patents, and patent applications cited herein are hereby incorporated by reference in their entirety for all purposes.

EXAMPLES**Example 1: Synthesis of Heterocycle Alcohols****Example 1.1: Methylthiazole Methanol**

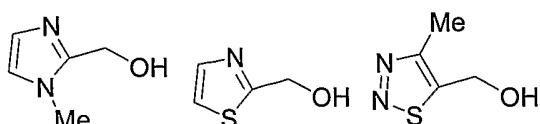
5 [0211] Methylthiazole (1.0 g, 10.1 mmol) in THF at -78°C was treated with n-BuLi (1.6 M, 7.56 mL) for 30 min, DMF (1.4 mL, 18.2 mmol) was added dropwise. The resulting reaction mixture was warmed to r.t. After the starting material was disappeared (by TLC), the reaction mixture was re-cooled to 0°C and LAH (0.69 g, 18.5 mmol) was added. The mixture was warmed to r.t. and stirred for 1 h, the reaction was quenched with aqueous 10 NH_4Cl , diluted with EtOAc. The organic solution was separated, extracted twice with EtOAc, dried with Na_2SO_4 , and concentrated. The residue was purified with flash chromatography to give the corresponding alcohol as a light yellow oil. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 6.89 (s, 1 H); 4.95 (s, 2 H); 2.48 (s, 3 H).

Example 1.2: Dimethylimidizolyl Methanol and Dimethylpyrazolyl Methanol

15 [0212] Methylimidazole (5 g, 60.89 mmol) was treated with trimethyl phosphate (3.41 g, 24.36 mmol) and diisopropyl ethylamine at 150°C for 6 h. The resulting mixture was dissolved in benzene and the solution was stirred with 30% aqueous potassium hydroxide. Evaporation of the solvent from the organic layer and flash chromatography of the residue 20 afforded dimethylimidazole as white solid. Following the same procedure the dimethylpyrazine was also made.

[0213] Using the procedure of preparation of methylthiazole methanol in Example 1.1, the alcohols were made from the corresponding dimethyl species. Dimethylimidazolyl methanol was a white solid. Dimethylpyrazolyl methanol was a light yellow oil. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 7.24 (s, 1 H); 4.65 (s, 2 H); 3.89 (s, 3 H); 2.07 (s, 3 H).

Example 1.3: Methylimidizolyl Methanol, Thiazole Methanol, Methyl Thiodiazolyl Methanol



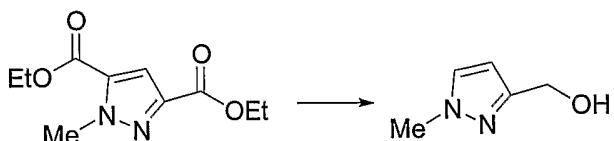
[0214] Aldehyde (100 mg, 0.91 mmol) in diethyl ether at 0 °C was added lithium aluminium hydride (51.7 mg, 1.36 mmol), then the resulting mixture was warmed to r.t. After 1 h, the reaction was quenched with $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ and stirred for a couple of hours. The organic solution was filtrated. The residue was purified with flash chromatography to give the corresponding alcohol as a white solid. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 6.86 (m, 2 H); 4.57 (s, 2 H); 3.88 (br, 1 H); 3.65 (s, 3 H).

[0215] Same as the above procedure to prepare the thiazolyl methanol, a light yellow oil. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 6.86 (m, 2 H); 4.57 (s, 2 H); 3.88 (br, 1 H); 3.65 (s, 3 H).

[0216] Methyl thiodiazolyl methanol, a light yellow oil. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 5.05 (s, 2 H); 2.68 (s, 3 H).

[0217] Thiazolyl methanol, a light yellow oil. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 7.77 (d, 1 H); 7.35 (d, 1 H); 4.99 (s, 2 H).

Example 1.4: Methyldiazolyl Methanol



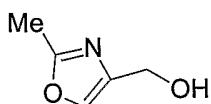
[0218] Diethyl pyrazoledicarboxylate (2.0 g, 9.42 mmol) in THF at 0 °C was added NaH (60% in mineral oil, 0.42 g, 10.37 mmol) portionwise. The resulting mixture was warmed to r.t. and stirred overnight. The reaction was quenched with saturated aqueous NH_4Cl carefully. The mixture was diluted with EtOAc , separated, and extracted with EtOAc twice. The combined organic layers were dried over Na_2SO_4 , concentrated, and purified by flash chromatography to afford the product as a colorless oil.

[0219] The above diester (1.0 g, 4.42 mmol) was dissolved in MeOH , a solution of KOH in MeOH (0.28 g of KOH in 2.5 mL of MeOH) was added, and the mixture was stirred at r.t. for 24 h. After removal of solvent under reduced pressure at low temperature, the residue was dissolved in water and neutralized with aqueous HCl (1M solution). Extraction of the

mixture with CHCl_3 three times afforded the crude product after concentration of the combined organic layers. Without further purification the crude above product was heated to 210 °C for 30 min. to provide a dark brown oil, which was purified by flash chromatography to give the ester.

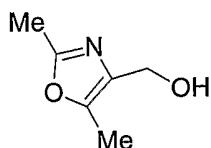
5 [0220] The ester was reduced to corresponding alcohol by LAH. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 7.32 (s, 1 H); 6.25 (s, 1 H); 4.68 (s, 2 H); 3.88 (s, 3 H); 2.74 (br, 1 H).

Example 1.5: Methylloxazolyl Methanol



[0221] A suspension of ethyl acetamide hydrochloride (0.87 g, 7.1 mmol) in DCM at 0 °C 10 was treated with serine ethyl ester hydrochloride (1 g, 5.9 mmol) and triethylamine (0.82 mL, 5.9 mmol) and the reaction mixture allowed to r.t. After 24 h, the reaction was quenched with water, and the layers were separated. The aqueous layer was extracted with DCM twice, the combined organic layers was concentrated to give a crude product. Without further purification the crude product was treated with DBU/CCl₄/Py (6.6 mL/15 mL/22.5 mL) in acetonitrile. After 3 h, the solvent was removed in vacuo, the residue was dissolved 15 in EtOAc, washed with water for three times. The organic layer was dried over Na_2SO_4 , concentrated and the residue was purified by flash chromatography to afford the pure ester, which was reduced by LAH to get the desired alcohol. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 7.51 (s, 1 H); 4.58 (s, 2 H); 2.48 (s, 3 H).

20 Example 1.6: Dimethyloxazolyl Methanol

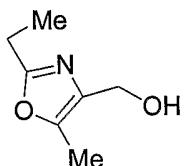


[0222] Sodium nitrite (12.2 g, 0.18 mol) in water was added dropwise to a solution of ethyl acetoacetate (19.5 mL, 0.15 mol) in glacial acetic acid at r.t. for 1h. The resulting mixture was stirred for further 1 h at r.t, 80 mL of water added, and stirring continued for 2 25 h. The reaction mixture was extracted with ether for three times, washed with aqueous NaHCO_3 , water and brine. The organic layer was dried, concentrated to afford the crude product. Without further purification, the crude product (6.5 g, 40.8 mmol) in a mixture of

acetic anhydrous (19.3 mL, 0.21 mol), acetic acid (58 mL), and 210 mg of Pd/C (10% w/w) was hydrogenated at 50 Psi pressure for 1.5 h. The catalyst and solvent were removed and the residue was triturated with hexanes to give ethyl N-acetylacetooacetate as solid, m.p. 38-40 °C.

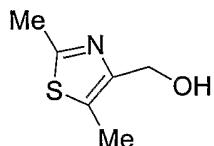
5 [0223] The above solid product (3.3 g, 17.6 mmol) was treated with thionyl chloride (1.3 mL, 17.6 mmol) in dry benzene at r.t. The mixture was warmed to 30 °C for 1 h, and for 30 min under water-pump vacuum. The residue was diluted with EtOAc and washed with aqueous NaHCO₃, water, and brine. The organic layer was dried, concentrated to give the crude product as a brown oil, which was further reduced by LAH to provide the desired 10 alcohol as a light yellow solid. ¹H-NMR: (300 MHz, CDCl₃), δ: 4.51 (s, 2 H); 2.58 (s, 3 H); 2.43 (s, 3 H), 2.31 (s, 3 H).

[0224] A similar procedure was used to prepare the corresponding ethyl heterocycle:



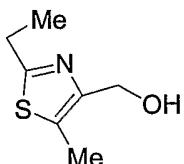
¹H-NMR: (300 MHz, CDCl₃), δ: 4.51 (s, 2 H); 2.75 (m, 2 H); 2.31 (s, 3 H); 1.33 (m, 3 H).

15 **Example 1.7: Dimethylthiazolyl Methanol**



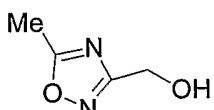
[0225] A mixture of ethyl N-acetylacetooacetate (3.6 g, 19.3 mmol) and phosphorus pentasulfide (4.3 g, 9.6 mmol) in toluene was heated to 75 °C for 2 h. The reaction mixture was diluted with EtOAc and quenched with water. The organic layer was separated. The aqueous layer was extracted with EtOAc. The combined organic layers were washed with brine, dried, and concentrated to give the crude ester, which was reduced with LAH without further purification to provide the desired alcohol. ¹H-NMR: (300 MHz, CDCl₃), δ: 4.64 (s, 2 H); 3.75 (br, 3 H); 2.64 (s, 3 H), 2.42 (s, 3 H).

[0226] A similar procedure was used to prepare the corresponding ethyl heterocycle:



[0227] Same procedure as above was used to prepare the alcohol. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 4.65 (s, 2 H); 2.98 (m, 2 H); 2.43 (s, 3 H); 1.36 (m, 3 H).

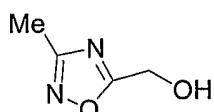
Example 1.8: Methylloxazazimidizolyl Methanol



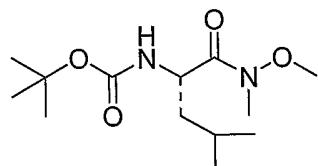
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[0228] Ethyl chlorooximinoacetate (2 g) in 80 mL of dry diethyl ether was treated with dry ammonia gas at 0 °C. The precipitated ammonium chloride was filtered with suction and the filtrate was evaporated under reduced pressure to give the product, m.p. 96-97 °C. This compound (1 g) was treated with acetic anhydrous (1.1 mL) in pyridine at reflux condition 10 for 1 h. The solvent was removed and the residue was dissolved in CHCl_3 . The organic layer was washed with water, aqueous NaHCO_3 , and brine, dried and concentrated to give the crude product, which was reduced to desired alcohol with NaBH_4 in methanol. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 4.78 (s, 2 H); 2.63 (s, 3 H).

[0229] The procedure below was used to produce the following methylloxazazimidizolyl 15 methanol:

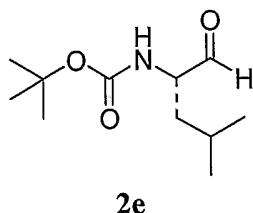


[0230] Acetamide oxime (0.95 g, 12.8 mmol) in THF was added NaH (60% in mineral oil, 0.62 g, 15.4 mmol) at r.t. The mixture was then heated up to 80 °C for 10 min and TEMOM protected ethyl glycolate was added. The resulting was heated at this temperature 20 for 2 h. The solvent was removed and the residue was diluted CHCl_3 and washed with water and brine. The solvent was removed and the residue was purified with flash chromatography to give the product, which was deprotected with TFA to provide the desired alcohol as a white solid. $^1\text{H-NMR}$: (300 MHz, CDCl_3), δ : 4.90 (s, 2 H); 2.43 (s, 3 H).

Example 2: Preparation of Exemplary Beta-Secretase Inhibitor Compounds**Example 2.1: Synthesis of N-(*tert*-Butoxycarbonyl)-L-leucine-N'-methoxy-N'-methylamide:****1e**

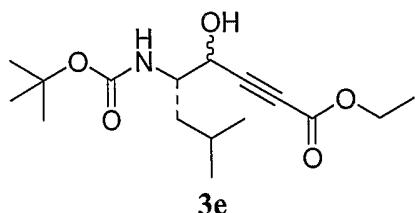
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[0231] To a stirred solution of N,O-dimethylhydroxylamine hydrochloride (5.52 g, 56.6 mmol) in dry dichloromethane (25 mL) under a N₂ atmosphere at 0 °C, was added N-methylpiperidine (6.9 mL, 56.6 mmol) dropwise. The resulting mixture was stirred at 0 °C for 30 minutes. In a separate flask, commercially available N-(*t*-butyloxycarbonyl)-L-leucine (11.9 g, 51.4 mmol) was dissolved in a mixture of tetrahydrofuran (THF) (45 mL) and dichloromethane (180 mL) under a N₂ atmosphere. The resulting solution was cooled to -20 °C. To this solution was added 1-methylpiperidine (6.9 mL, 56.6 mmol) followed by isobutyl chloroformate (7.3 mL, 56.6 mmol) dropwise. The resulting mixture was stirred for 5 minutes at -20 °C and the above solution of N,O-dimethyl-hydroxylamine was added dropwise. The reaction mixture was stirred at -20 °C for 30 minutes followed by warming to room temperature. The reaction was quenched with water and the layers were separated. The aqueous layer was extracted with CH₂Cl₂ (3 times). The combined organic layers were washed with 10% citric acid, saturated sodium bicarbonate, brine, dried over Na₂SO₄ and concentrated under reduced pressure. Flash column chromatography (25% ethyl acetate (EtOAc) in hexanes) yielded 1 (13.8 g, 97%). [α]_D²³ -23 (c 1.5, MeOH); ¹H-NMR (400 MHZ, CDCl₃) δ 5.06 (d, 1H, J = 9.1 Hz), 4.70 (m, 1H), 3.82 (s, 3H), 3.13 (s, 3H), 1.70 (m, 1H), 1.46-1.36 (m, 2H) 1.41 (s, 9H), 0.93 (dd, 6H, J = 6.5, 14.2 Hz); ¹³C-NMR (100 MHZ, CDCl₃) δ 173.9, 155.6, 79.4, 61.6, 48.9, 42.1, 32.1, 28.3, 24.7, 23.3, 21.5; IR (neat) 3326, 2959, 2937, 2871, 1710, 1666, 1502, 1366, 1251, 1046 cm⁻¹; HRMS m/z (M+H)⁺ calc'd for C₁₃H₂₇N₂O₄ 275.1971, found 275.1964.

Example 2.2: Synthesis of N-(*tert*-Butoxycarbonyl)-L-Leucinal

5 [0232] To a stirred suspension of lithium aluminum hydride (LAH) (770 mg, 20.3 mmol) in diethyl ether (60 mL) at -40 °C under N₂ atmosphere, was added dropwise a solution of 1e (5.05 g, 18.4 mmol) in diethyl ether (20 mL). The resulting reaction mixture was stirred for 30 minutes followed by quenching with 10% aqueous NaHSO₄ (30 mL) and warming to room temperature for 30 minutes. This solution was filtered and the filter cake was washed 10 with diethyl ether (two times). The combined organic layers were washed with saturated sodium bicarbonate, brine, dried over MgSO₄ and concentrated under reduced pressure to afford 2e (3.41 g) which was used immediately without further purification. Crude ¹H-NMR (400 MHZ, CDCl₃) δ 9.5 (s, 1H), 4.9 (s, 1H), 4.2 (m, 1H), 1.8-1.6 (m, 2H), 1.44 (s, 9H), 1.49-1.39 (m, 1H), 0.96 (dd, 6H, J = 2.7, 6.5 Hz).

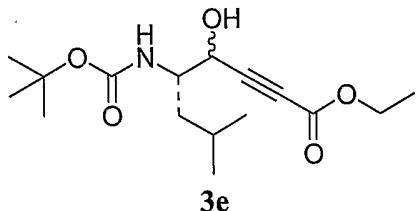
15 **Example 2.3: Synthesis of Ethyl (4S,5S)-and (4R,5S)-5-[(*tert*-Butoxycarbonyl)amino]-4-hydroxy-7- methyloct-2-ynoate**



20 [0233] To a stirred solution of ethyl propiolate (801 mL) in THF (2 mL) at -78 °C was added a 1.0 M solution of lithium hexamethyldisilazide (7.9mL) dropwise over a 5 minutes period. The mixture was stirred for 30 min, after which N-(*tert*-butoxycarbonyl)-L-leucinal 2e (or N-Boc-L-leucinal) (1.55 g, 7.2 mmol) in 8 mL of dry THF was added. The resulting mixture was stirred at -78 °C for 30 minutes. The reaction was quenched with saturated aqueous NH₄Cl at -78 °C followed by warming to room temperature. Brine was added and the layers were separated. The organic layer was dried over Na₂SO₄ and concentrated under reduced pressure. Flash column chromatography (15% EtOAc in hexanes) yielded a mixture of acetylenic alcohols 3e (68%). ¹H-NMR (300 MHZ, CDCl₃) δ 4.64 (d, 1H, J = 9.0 Hz), 4.44 (br s, 1H), 4.18 (m, 2H), 3.76 (m, 1H), 1.63 (m, 1H), 1.43-1.31 (m, 2H), 1.39

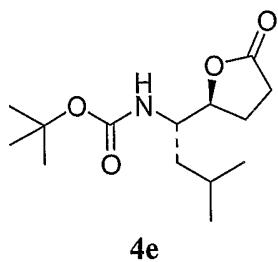
(s, 9H), 1.29-1.18 (m, 3H), 0.89 (m, 6H); IR (neat) 3370, 2957, 2925, 2854, 1713, 1507, 1367, 1247, 1169, 1047 cm^{-1} .

Example 2.3A: Alternative synthesis of Ethyl (4S,5S)-and (4R,5S)-5-[(tert-Butoxycarbonyl)amino]-4-hydroxy-7- methyloct-2-ynoate



[0234] To a stirred solution of DIBAL-H (1.5M in toluene, 28 mL, 42.0 mmol) at -78 °C under argon atmosphere was added of Boc-Valine methyl ester (5.0g, 20.4 mmol) in toluene (25 mL) dropwise over 25 min (solution A). To a separate solution of LiHMDS (1.0M in 10 tetrahydrofuran, 31 mL, 31.0 mmol) at -78 °C under argon atmosphere was added ethylpropiolate (3.1 mL, 30.6 mmol) dropwise over 5 min (solution B). After stirring at -78 °C for 80 min solution A was transferred quickly via cannulae to solution B. After stirring and additional 15 min at -78 °C the solution was allowed to warm to room temperature. After stirring an additional 3 h at room temperature, the reaction mixture was cooled to -10 15 °C and quenched with acetic acid (7.5 mL) and stirred for 20 min. The mixture was allowed to warm to room temperature and poured into a mixture of 50 mL ethyl acetate and 50 mL 10% citric acid and stirred for 1 h. The layers were separated and the organic layer washed with H_2O (2x), brine, dried with Na_2SO_4 , and concentrated to yield a crude oil which was purified by flash column chromatography (20% ethyl acetate in hexanes) to provide **3e** 20 (2.0g, 31%). ^1H NMR identical to above procedure.

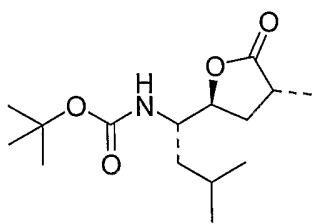
Example 2.4: (5S,1'S)-5-[1'-(tert-Butoxycarbonyl)amino]-3'-methylbutyl]dihydrofuran -2(3H)-one (4)



[0235] To a stirred solution of **3e** (1.73 g, 5.5 mmol) in methanol (MeOH) (20 mL) was 25 added 10% Pd/C (1.0 g). The resulting mixture was placed under a hydrogen balloon and

stirred for 1 hour. After this period, the reaction was filtered through a pad of Celite and the filtrate was concentrated under reduced pressure. The residue was dissolved in toluene (20 mL) and acetic acid (100 mL). The resulting mixture was refluxed for 6 oursfollowed by cooling to room temperature and concentrating under reduced pressure. Flash column chromatography (40% diethyl ether in hexanes) yielded **4e** (0.94 g, 62.8 mmol) and less than 5% of its diastereomer. Lactone 4: M.p. 74-75 °C; $[\alpha]_D^{23}$ -33.0 (c 1.0, MeOH); lit. (Fray, A. H., *et al.*, *J. Org. Chem.* 51:4828-4833 (1986)) $[\alpha]_D^{23}$ -33.8 (c 1.0, MeOH); ^1H -NMR (400 MHZ, CDCl_3) δ 4.50-4.44 (m, 2H), 3.84-3.82 (m, 1H), 2.50 (t, 2H, J = 7.8 Hz), 2.22-2.10 (m, 2H), 1.64-1.31 (m, 3H), 1.41 (s, 9H), 0.91 (dd, 6H, J = 2.2, 6.7 Hz); ^{13}C -NMR (75 MHZ, CDCl_3) δ 177.2, 156.0, 82.5, 79.8, 51.0, 42.2, 28.6, 28.2, 24.7, 24.2, 23.0, 21.9; IR (neat) 2956, 2918, 2859, 1774, 1695, 1522, 1168 cm^{-1} ; mass (EI) m/z 294 ($\text{M}^+ + \text{Na}$); HRMS: m/z (M+Na)⁺ calc'd for $\text{C}_{14}\text{H}_{25}\text{NO}_4\text{Na}$, 294.1681, found 294.1690.

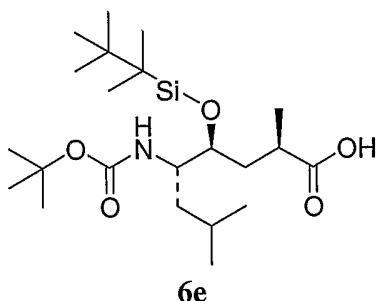
Example 2.5: Synthesis of (3R,5S,1'S)-5-[1'-(*tert*-Butoxycarbonyl)amino]-3'-methylbutyl]-3-meth yl-(3H)-dihydrofuran-2-one



[0236] To a stirred solution of lactone **4e** (451.8 mg, 1.67 mmol) in THF (8 mL) at -78°C under a N_2 atmosphere, was added dropwise lithium hexamethyldisilazide (3.67 mL, 1.0 M in THF, 3.67 mmol). The resulting mixture was stirred at -78 °C for 30 minutes. Methyl iodide (MeI) (228 mL) was added dropwise and the resulting mixture was stirred at -78°C for 20 minutes. The reaction was quenched with saturated aqueous NH_4Cl and allowed to warm to room temperature. The reaction mixture was concentrated under reduced pressure and the residue was extracted with EtOAc (three times). The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure. Flash column chromatography (15% EtOAc in hexanes) yielded **5e** (0.36 g, 76%). The stereochemistry of C_2 -methyl group was assigned based upon NOESY and COSY experiments. Irradiation of the C_2 -methyl group exhibited 6% NOE with the C_3 α -proton and 5% NOE with the C_4 -proton. The α - and β -protons of C_3 were assigned by 2 D-NMR. $[\alpha]_D^{23}$ -19.3 (c 0.5, CHCl_3); ^1H -NMR (300 MHZ, CDCl_3) δ 4.43 (t, 1 H, J = 6.3 Hz), 4.33 (d,

1H, $J = 9.6$ Hz), 3.78 (m, 1H), 2.62 (m, 1H), 2.35 (m, 1H), 1.86 (m, 1H), 1.63-1.24 (m, 3H), 1.37 (s, 9H), 1.21 (d, 3H, $J = 7.5$ Hz), 0.87 (dd, 6H, $J = 2.6, 6.7$ Hz); ^{13}C -NMR (75 MHZ, CDCl_3) δ 180.4, 156.0, 80.3, 79.8, 51.6, 41.9, 34.3, 32.5, 28.3, 24.7, 23.0, 21.8, 16.6; IR (neat) 2962, 2868, 1764, 1687, 1519, 1272, 1212, 1008 cm^{-1} ; HRMS: m/z (M+Na) $^+$ calc'd for $\text{C}_{15}\text{H}_{27}\text{NO}_4\text{Na}$, 308.1838, found 308.1828.

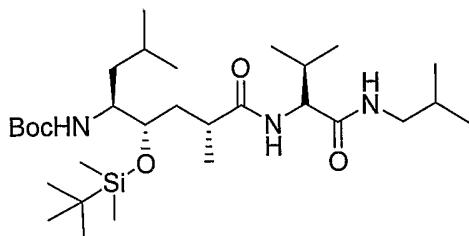
Example 2.6: Synthesis of (2R,4S,5S)-5-[(*tert*-Butoxycarbonyl)amino]-4-[(*tert*-butyldimethylsilyl)-oxy]-2,7-methyloctanoic acid



10 [0237] To a stirred solution of lactone **5e** (0.33 g, 1.17 mmol) in a mixture of THF and water (5:1; 6 mL) was added LiOH·H₂O (0.073 g, 1.8 equiv). The resulting mixture was stirred at room temperature for 1 hour. The volatiles were removed under reduced pressure and the remaining solution was cooled to 0 °C and acidified with 25% aqueous citric acid to pH 3. The resulting acidic solution was extracted with EtOAc three times. The combined organic layers were washed with brine, dried over Na₂SO₄ and concentrated under reduced pressure to yield the corresponding hydroxy acid (330 mg) as a white foam. This hydroxy acid was used directly for the next reaction without further purification. To the above hydroxy acid (330 mg, 1.1 mmol) in dimethylformamide (DMF) was added imidazole (1.59 g, 23.34 mmol) and *tert*-butyldimethylchlorosilane (1.76 g, 11.67 mmol). The resulting mixture was stirred at room temperature for 24 hours. MeOH (4 mL) was added and the mixture was stirred for an additional 1 hour. The mixture was acidified with 25% aqueous citric acid to pH 3 and was extracted with EtOAc three times. The combined extracts were washed with water, brine, dried over Na₂SO₄ and concentrated under reduced pressure. Flash column chromatography (35% EtOAc in hexanes) yielded **6e** (0.44 g, 90%). M.p. 121-123 °C; $[\alpha]_D^{23} -40.0$ (c 0.13, CHCl₃); ^1H -NMR (400 MHZ, DMSO-*d*⁶, 343 K) δ 6.20 (br s, 1H), 3.68 (m, 1H), 3.51 (br s, 1H), 2.49-2.42 (m, 1H), 1.83 (t, 1H, $J = 10.1$ Hz), 1.56 (m, 1H), 1.37 (s, 9H), 1.28-1.12 (m, 3H), 1.08 (d, 3H, $J = 7.1$ Hz), 0.87 (d, 3H, $J = 6.1$ Hz) 0.86 (s, 9H), 0.82 (d, 3H, $J = 6.5$ Hz), 0.084 (s, 3H), 0.052 (s, 3H); IR (neat) 3300-3000,

2955, 2932, 2859, 1711 cm^{-1} ; HRMS: m/z (M+Na)⁺ calc'd for C₂₁H₄₃NO₅NaSi, 440.2808, found 440.2830.

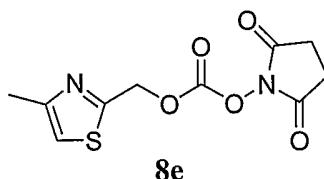
Example 2.7: Synthesis of Leucine-Alanine-Valine Inhibitor Precursor



7e

[0238] The Leucine-Alanine-Valine Inhibitor Precursor 7e was produced by coupling 6e with Valine-N-iBu amide under standard EDCI/HOBt conditions as follows: to a stirred solution of Leucine-Alanine isostere 6e (0.55 g, 1.3 mmol) in dichloromethane (20 mL) was added HOBt (0.20 g, 1.6 mmol) and EDCI (0.28 g, 1.6 mmol). To this mixture was added a solution of N-Boc-Valine-N'-iBu (0.44 mL, 1.6 mmol) which was pretreated with TFA in DCM for 30 minutes and concentrated under reduced pressure, and DIPEA (1.2 mL, 6.7 mmol) in dichloromethane (10 mL). The resulting mixture was stirred at room temperature for 15h under argon followed by quenching with NaHCO₃. The layers were separated and the aqueous layer was extracted with CHCl₃ (2 × 20 mL). The combined organic layer was dried with Na₂SO₄ and concentrated under reduced pressure. The resulting residue was purified by flash column chromatography (2% methanol in CHCl₃) to provide 7e (0.69g, 75%). ¹H NMR (300 MHz, CDCl₃ + CD₃OD): δ 4.54 (d, 1H), 4.09 (t, 1H), 3.64-3.80 (m, 2H), 2.98-3.20 (m, 2H), 2.50-2.63 (m, 1H), 2.06-2.21 (m, 1H), 1.20-1.88 (m, 6H), 1.47 (s, 9H), 1.13 (d, 3H, J = 6.3 Hz), 0.85-1.01 (m, 27H), 0.08-0.15 (m, 6H).

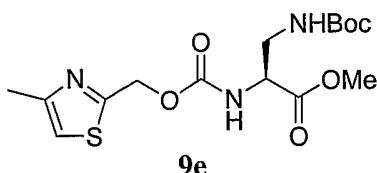
Example 2.8: Synthesis of Heterocycle Mixed Carbonate



[0239] To a stirred solution of 4-methyl thiazole methanol (0.47 g, 3.6 mmol) in CH₃CN (15 mL) was added triethylamine (1.5 mL, 11 mmol) and N,N'-disuccinimidyl carbonate (1.12 g, 4.4 mmol). The resulting mixture was stirred at room temperature for 15 h and was concentrated under reduced pressure. The residue was dissolved in EtOAc and saturated NaHCO₃. The layers were separated and the aqueous layer was extracted with EtOAc (2 ×

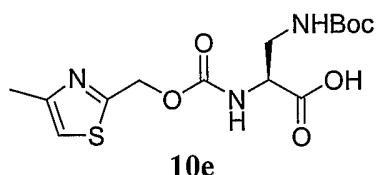
20 mL). The combined organic layer was washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure to provide mixed carbonate **8e** (955 mg, 97%) which was used for next step without further purification.

Example 2.9: Synthesis of Heterocycle Boc-Amine Ester

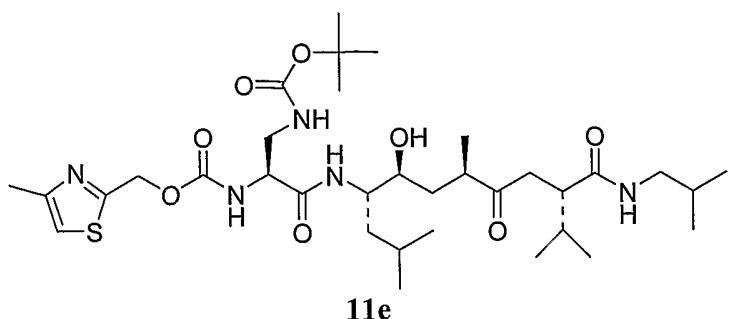


[0240] To a stirred solution of H-Dap(Boc)-OMe·HCl (481 mg, 1.89 mmol) in CH_2Cl_2 (10 mL) was added triethylamine (1.1 mL, 7.6 mmol) and a solution of mixed carbonate **8e** (0.51 g, 1.89 mmol) in CH_2Cl_2 (5 mL). The resulting mixture was stirred at room temperature for 15 h and was quenched with saturated NaHCO_3 . The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (2×20 mL). The combined organic layer was washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure. The resulting oil was purified by column chromatography (40% EtOAc in hexanes) to provide 15 **9e** (518.1 mg, 67%) as a colorless oil.

Example 2.10: Synthesis of Heterocycle Boc-Amine Acid



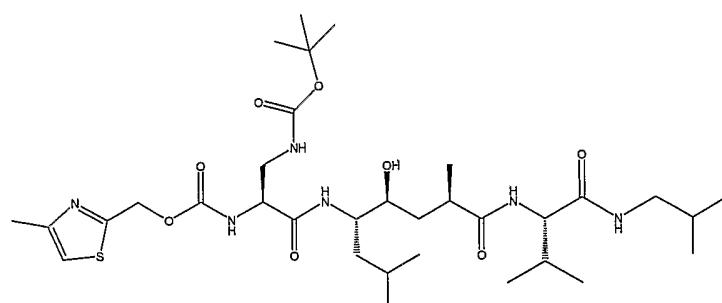
[0241] The above ester **9e** (25.9 mg, 0.07 mmol) was dissolved in THF (3 mL) and 1N LiOH (1 mL) was added. The resulting mixture was stirred for 30 min and was concentrated under reduced pressure. The solution was acidified carefully to pH 3 by 1N HCl and extracted with EtOAc (2×10 mL). The combined organic layer was washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure to provide acid **10e** as a yellow oil which was used for next step without further purification.

Example 2.11: Synthesis of Exemplary Isostere

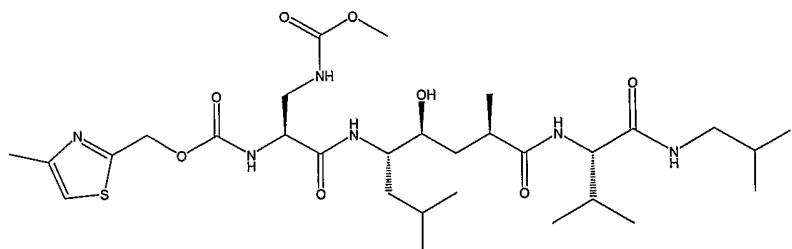
5 [0242] To a stirred solution of acid **10e** (24 mg, 0.07 mmol) in CH_2Cl_2 (3 mL) was added HOBt (11.2 mg 0.08 mmol) and EDCI (15.8 mg, 0.08 mmol), and a solution of amine **7e** (39 mg, 0.08 mmol) (pretreated with TFA in DCM and dried under reduced pressure, DIPEA (0.05 mL, 0.29 mmol), and dichloromethane (2 mL)) and N,N-diisopropylethylamine (61 μ L, 0.35 mmol) in CH_2Cl_2 (2 mL). The resulting mixture was stirred at room temperature for 15 h and quenched with water. The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (2×10 mL). The combined organic layer was washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure. The resulting oil was dissolved in THF (3 mL) and aqueous HF (48%, 15 drops) was added. The mixture was stirred for 30 min and was quenched with saturated aqueous NaHCO_3 . The 10 layers were separated and the aqueous layer was extracted with EtOAc (2×10 mL). The combined organic layer was washed with brine, dried with Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography (5% MeOH/CHCl₃) to provide the product (13.2 mg) as a solid. ¹H NMR (CDCl_3) δ 6.90 (s, 1H), 5.30 (s, 2H), 4.23-4.25 (m, 1H), 3.99-4.03 (m, 1H), 3.83 (m, 1H), 3.44-3.49 (m, 2H), 3.31-3.39 (m, 1H), 3.05-3.12 (m, 1H), 2.92-2.98 (m, 1H), 2.56-2.63 (m, 1H), 2.42 (s, 3H), 1.98-2.05 (m, 1H), 1.61-1.79 (m, 2H), 1.47-1.54 (m, 3H), 1.40 (s, 9H), 1.26-1.34 (m, 1H), 1.09 (d, 3H, J=6.9Hz), 0.84-0.92 (m, 18H).

15

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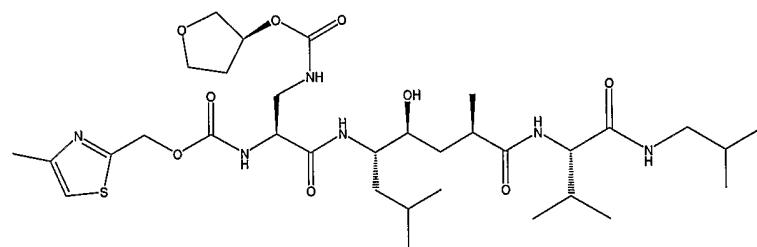
Example 3: Physical Properties of Exemplary Compounds:

[0243] 6.90 (s, 1H), 5.30 (s, 2H), 4.23-4.25 (m, 1H), 3.99-4.03 (m, 1H), 3.83 (m, 1H), 3.44-3.49 (m, 2H), 3.31-3.39 (m, 1H), 3.05-3.12 (m, 1H), 2.92-2.98 (m, 1H), 2.56-2.63 (m, 1H), 2.42 (s, 3H), 1.98-2.05 (m, 1H), 1.61-1.79 (m, 2H), 1.47-1.54 (m, 3H), 1.40 (s, 9H), 1.26-1.34 (m, 1H), 1.09 (d, 3H, $J=6.9\text{Hz}$), 0.84-0.92 (m, 18H).



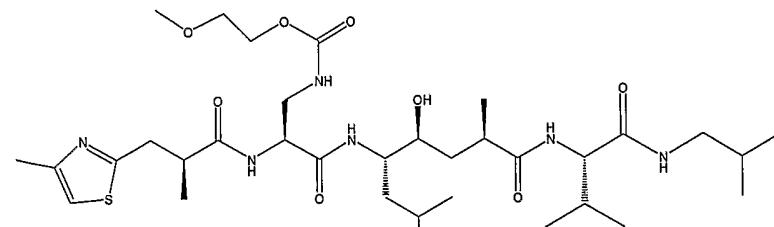
5

[0244] 6.90 (s, 1H), 5.30 (s, 2H), 4.24-4.29 (m, 1H), 4.00 (m, 1H), 3.81-3.85 (m, 1H), 3.63 (s, 3H), 3.44-3.52 (m, 3H), 3.04-3.12 (m, 1H), 2.93-2.96 (m, 1H), 2.56-2.62 (m, 1H), 2.42 (s, 3H), 1.96-2.02 (m, 1H), 1.62-1.80 (m, 2H), 1.42-1.50 (m, 3H), 1.28-1.34 (m, 1H), 1.09 (d, 3H, $J=6.9\text{Hz}$), 0.84-0.91 (m, 18H).



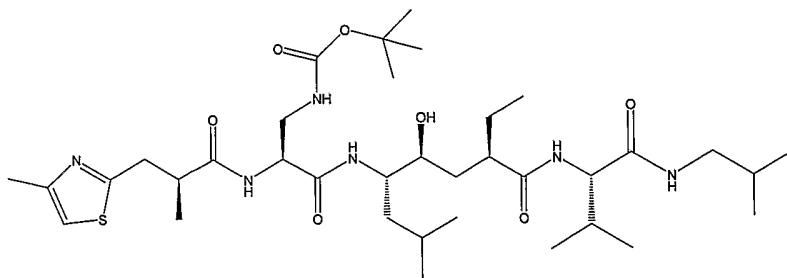
10

[0245] 6.90 (s, 1H), 5.28 (s, 2H), 5.18-5.19 (m, 1H), 4.22-4.25 (m, 1H), 3.98-4.03 (m, 1H), 3.76-3.87 (m, 4H), 3.43-3.51 (m, 2H), 3.22-3.39 (m, 1H), 3.02-3.11 (m, 1H), 2.89-2.97 (m, 1H), 2.55-2.60 (m, 1H), 2.40 (s, 3H), 2.06-2.18 (m, 1H), 1.94-2.01 (m, 2H), 1.60-1.76 (m, 2H), 1.28-1.52 (m, 5H), 1.08 (d, 3H, $J=6.9\text{Hz}$), 0.83-0.90 (m, 18H).

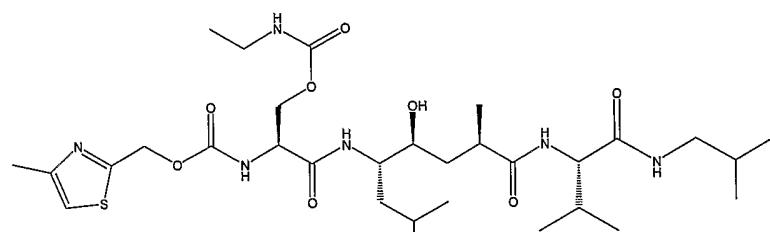


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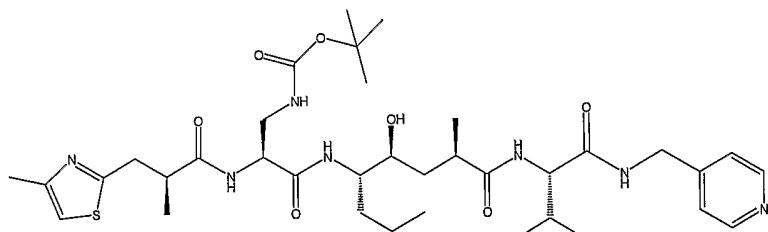
[0246] ^1H NMR (300 MHz, $\text{CDCl}_3+\text{CD}_3\text{OD}$): δ 0.80-0.95 (18H, m), 1.12 (3H, d, $J=6.9\text{ Hz}$), 1.21 (3H, d, $J=6.9\text{ Hz}$), 1.14-1.35 (2H, m), 1.62-1.82 (3H, m), 1.94-2.10 (1H, m), 2.39 (3H, s), 2.57-2.70 (3H, m), 2.80-2.89 (1H, m), 2.92-3.04 (2H, m), 3.06-3.14 (1H, m), 3.24-3.33 (1H, m), 3.37 (3H, s), 3.41-3.51 (2H, m), 3.56 (2H, d, $J=4.2\text{ Hz}$), 3.74-3.83 (1H, m), 4.02 (1H, d, $J=7.8\text{ Hz}$), 4.12-4.22 (2H, m), 4.43 (1H, d, $J=5.1\text{ Hz}$), 6.73 (1H, d, s).



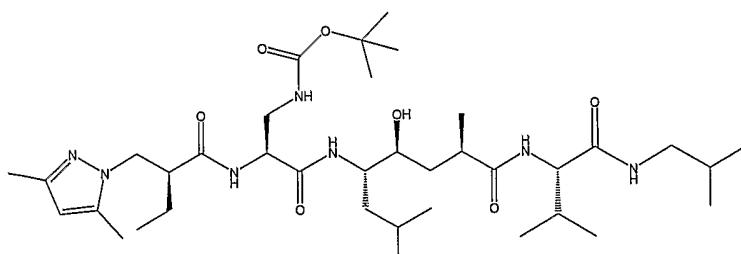
[0247] ^1H NMR (300 MHz, $\text{CDCl}_3+\text{CD}_3\text{OD}$): δ 0.88 (21H, m), 1.22 (6H, m), 1.41 (9H, s), 1.58-1.81 (6H, m), 2.04 (1H, m), 2.43 (4H, s), 2.88-3.12 (9H, m), 3.29-3.43 (4H, m), 3.76 (1H, m), 4.03 (1H, d, $J=8.1$ Hz), 4.38 (1H, m), 6.82 (1H, s).



5 [0248] 6.89 (s, 1H), 5.27 (s, 2H), 4.33-4.36 (m, 1H), 4.22-4.26 (m, 1H), 4.11-4.17 (m, 1H), 3.96-3.99 (m, 1H), 3.79-3.86 (m, 1H), 3.42-3.50 (m, 2H), 3.10-3.18 (m, 2H), 2.88-2.96 (m, 1H), 2.52-2.56 (m, 1H), 2.38 (s, 3H), 1.94-2.00 (m, 1H), 1.56-1.78 (m, 2H), 1.38-1.52 (m, 3H), 1.20-1.30 (m, 2H), 1.05-1.09 (m, 5H), 0.82-0.88 (m, 18H).

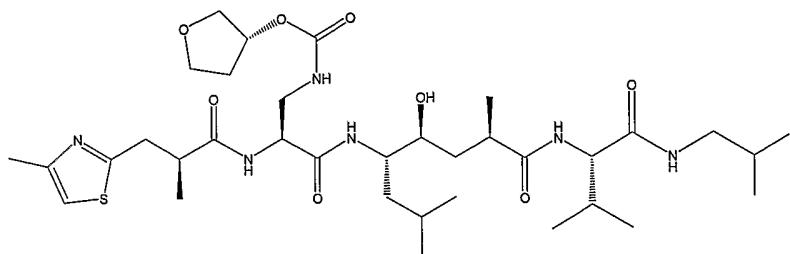


10 [0249] ^1H NMR (300 MHz, $\text{CDCl}_3+\text{CD}_3\text{OD}$): δ 0.10-1.00 (12H, m), 1.10 (3H, d, $J=6.4$ Hz), 1.19 (3H, d, $J=6.6$ Hz), 1.40 (9H, s), 1.36-1.56 (2H, m), 1.60-1.74 (1H, m), 2.00-2.12 (1H, m), 2.38 (3H, s), 2.54-2.64 (1H, m), 2.78-2.90 (1H, m), 2.90-3.10 (3H, m), 3.22-3.34 (1H, m), 3.34-3.48 (3H, m), 3.72-3.86 (1H, m), 4.04-4.12 (1H, m), 4.30-4.38 (1H, m), 4.38-4.45 (2H, m), 6.73 (1H, d, $J=0.9$ Hz), 7.23 (2H, d, $J=5.7$ Hz), 8.46 (2H, d, $J=4.8$ Hz).

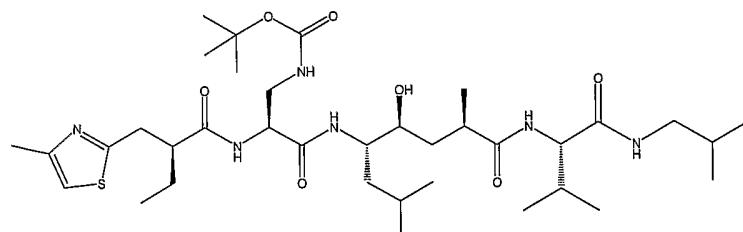


[0250] ^1H NMR (300 MHz, $\text{CDCl}_3+\text{CD}_3\text{OD}$): δ 0.80-0.94 (21H, m), 1.08 (3H, d, $J=6.6$ Hz), 1.38 (9H, s), 1.18-1.80 (4H, m), 1.19-2.06 (1H, m), 2.15 (3H, s), 2.16 (3H, s), 2.50-2.64 (1H, m), 2.66-

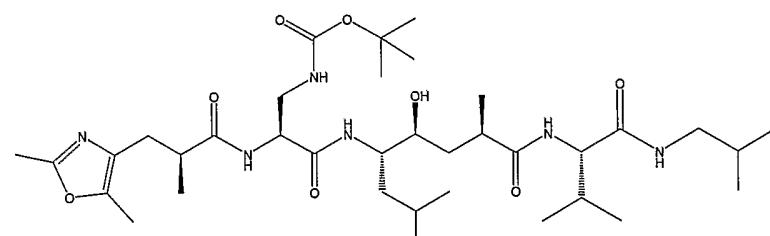
2.80 (1H, m), 2.86-2.96 (1H, m), 3.02-3.10 (1H, m), 3.20-3.42 (6H, m), 3.70-3.80(1H, m), 3.80-3.90(1H, m), 3.98 (1H, d, $J=8.1$ Hz), 4.05-4.13 (1H, m), 4.30-4.38 (2H, m), 5.70 (1H, s).



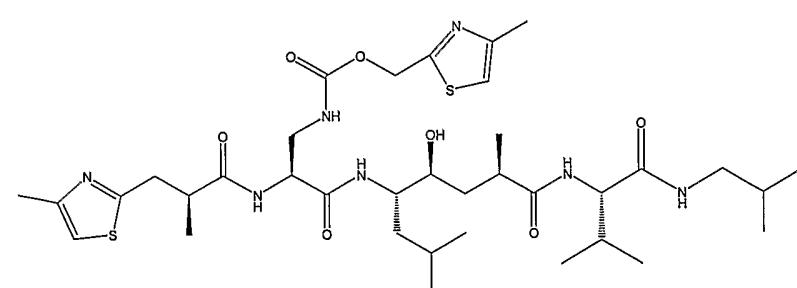
[0251] ^1H NMR (300 MHz, $\text{CDCl}_3+\text{CD}_3\text{OD}$): δ 0.76-0.92 (18H, m), 1.05 (3H, d, $J=6.9$ Hz), 1.13 (3H, d, $J=6.6$ Hz), 1.18-1.76 (6H, m), 1.84-2.00 (2H, m), 2.00-2.14 (1H, m), 2.33 (3H, d, $J=1.2$ Hz), 2.48-2.62 (1H, m), 2.70-2.84 (1H, m), 2.84-3.20 (3H, m), 3.38-3.52 (5H, m), 3.60-3.80(5H, m), 3.90-4.12(1H, m), 4.62-4.90 (1H, m), 5.20-5.38 (1H, m), 6.70(1H, d, $J=0.9$ Hz).



[0252] ^1H NMR (300 MHz, $\text{CDCl}_3+\text{CD}_3\text{OD}$): δ 0.80-0.97 (21H, m), 1.11 (3H, d, $J=7.2$ Hz), 1.41 (9H, s), 1.20-1.80 (8H, m), 1.96-2.08 (1H, m), 2.39 (3H, d, $J=1.2$ Hz), 2.56-2.72 (2H, m), 2.90-3.18 (3H, m), 3.20-3.30 (1H, m), 3.32-3.48 (3H, m), 3.72-3.84(1H, m), 3.96-4.06(1H, m), 4.38-4.46 (1H, m), 6.73(1H, d, $J=0.9$ Hz).



[0253] ^1H NMR (300 MHz, $\text{CDCl}_3+\text{CD}_3\text{OD}$): δ 0.78-0.88 (18H, m), 1.04 (3H, d, $J=6.9$ Hz), 1.34 (9H, s), 1.14-1.46 (5H, m), 1.54-1.76 (2H, m), 1.84-2.02 (1H, m), 2.10 (3H, s), 2.29 (3H, s), 2.24-2.40 (2H, m), 2.40-2.60 (3H, m), 2.82-2.92 (1H, m), 2.98-3.06 (1H, m), 3.22-3.42 (4H, m), 3.60-3.80(1H, m), 3.94 (1H, d, $J=8.1$ Hz), 4.26-4.34 (1H, m).

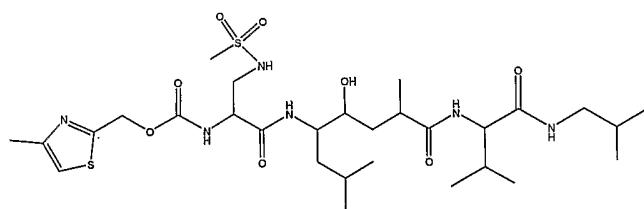


[0254] ^1H NMR (300 MHz, $\text{CDCl}_3 + \text{CD}_3\text{OD}$): δ 0.76-0.92 (18H, m), 1.03 (3H, d, $J=6.9$ Hz), 1.13 (3H, d, $J=6.9$ Hz), 1.00-1.80 (6H, m), 1.88-2.02 (1H, m), 2.34 (3H, s), 2.38 (1H, s), 2.40-2.62 (1H, m), 2.64-2.86 (2H, m), 2.85-3.10 (2H, m), 3.16-3.28 (1H, m), 3.36-3.50 (3H, m), 3.68-3.82 (1H, m), 3.80-4.02 (1H, m), 4.38-4.48 (1H, m), 5.24 (2H, s), 6.69 (1H, s), 6.85 (1H, s).

5 **Example 4: Inhibition of Memapsin 2 Beta-Secretase Activity**

[0255] Potency of compounds were determined by measurement of their inhibition of memapsin 2 activity toward a fluorescent substrate. Kinetic inhibition experiment were performed using the procedure as described in Ermolieff, *et al.* (*Biochemistry* 39:12450-12456 (2000), the teachings of which are incorporated hereby in their entirety). Briefly, 10 assays were performed at pH 4, 37 °C, by pre-incubation of memapsin 2 enzyme with compound for 20 minutes. Activity measure was initiated by addition of a fluorogenic substrate FS-2 (Bachem Americas, Torrance, CA). Fluorescent signal increase over time was measured as a rate of hydrolysis of the peptide substrate. Inhibition of hydrolytic rate was expressed relative to uninhibited controls and fit to a model for tight-binding inhibitors 15 (J. Bieth, in “Proteinase Inhibitors”, Bayer Symposium V, 463-469, 1974). The results are presented in Table 1 below.

Table 1

STRUCTURE	M2 Ki	M1 Ki	Cath D Ki	IC50 _microM_
	++	+	+	-
(4-methylthiazol-2-yl)methyl 9-hydroxy-8-isobutyl-14-isopropyl-11,18-dimethyl-2,6,12,15-tetraoxo-3,7,13,16-tetraazanonadecan-5-ylcarbamate	+	+	+	
tert-butyl 3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++	+	++	++
4-hydroxy-N-(1-(isobutylamino)-3-methyl-1-oxobutan-2-yl)-2,7-dimethyl-5-(2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-(methylsulfonamido)propanamido)octanamide	++	-	++	++
5-(3-acetamido-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)propanamido)-4-hydroxy-N-(1-(isobutylamino)-3-methyl-1-oxobutan-2-yl)-2,7-dimethyloctanamide	++	-	+	+

STRUCTURE	M2 Ki	M1 Ki	Cath D Ki	IC50 _microM_
	+	+	+	-
5-(3-amino-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)propanamido)-4-hydroxy-N-(1-isobutylamino)-3-methyl-1-oxobutan-2-yl)-2,7-dimethyloctanamide	+	-	+	+
methy 3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++	++	++	++
tetrahydrofuran-3-yl 3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++	+	++	++
	++	++	++	++
2-methoxyethyl 3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	+	+	+	+
tert-butyl 3-(3-hydroxy-6-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-5-methyl-6-oxo-1-phenylhexan-2-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++	+	++	++
tert-butyl 3-(5-hydroxy-7-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylcarbamoyl)-2-methylnonan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++	++	++	++
tert-butyl 3-(5-hydroxy-2,7-dimethyl-8-(3-methyl-1-oxo-1-(pyridin-4-ylmethylamino)butan-2-ylamino)-8-oxooctan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++	-	+	++
tert-butyl 2-(2-((3,5-dimethyl-1H-pyrazol-1-yl)methyl)butanamido)-3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	++	++	++	++
tetrahydrofuran-3-yl 3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++	+	++	++

STRUCTURE	M2 Ki	M1 Ki	Cath D Ki	IC50 _microM_
tert-butyl 3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-((4-methylthiazol-2-yl)methyl)butanamido)-3-oxopropylcarbamate	++	+	++	++
tert-butyl 3-(3-hydroxy-6-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-1-(4-methoxyphenyl)-5-methyl-6-oxohexan-2-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	-	-	++	
tert-butyl 2-(3-(2,5-dimethyloxazol-4-yl)-2-methylpropanamido)-3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	++	-	++	++
(4-methylthiazol-2-yl)methyl 3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++	+	++	++
tetrahydrofuran-3-yl 2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)-2-methylpropanamido)-3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	++	+	++	+
tert-butyl 2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)-2-(methoxymethoxy)propanamido)-3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	+	-	++	
tert-butyl 2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)-2-methoxypropanamido)-3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	+	-	++	-
tert-butyl 2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)-2-methylpropanamido)-3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	++	+	++	
tert-butyl 3-(8-(1-(2,2-dimethylhydrazinyl)-3-methyl-1-oxobutan-2-ylamino)-5-hydroxy-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++	-	+	++
tert-butyl 3-(1-(3,5-difluorophenyl)-3-hydroxy-6-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-5-methyl-6-oxohexan-2-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	++			+
tert-butyl 2-(2-((3,5-dimethyl-1H-pyrazol-1-yl)methyl)butanamido)-3-(5-hydroxy-2,7-dimethyl-8-(3-methyl-1-oxo-1-(pyridin-2-ylmethylamino)butan-2-ylamino)-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	++			+
tert-butyl 2-(2-((3,5-dimethyl-1H-pyrazol-1-yl)methyl)butanamido)-3-(5-hydroxy-2,7-dimethyl-8-(3-methyl-1-oxo-1-(pyridin-4-ylmethylamino)butan-2-ylamino)-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	++			++
tert-butyl 2-(2-((3,5-dimethyl-1H-pyrazol-1-yl)methyl)butanamido)-3-(5-hydroxy-2,7-dimethyl-8-(3-methyl-1-((4-methylthiazol-2-yl)methylamino)-1-oxobutan-2-ylamino)-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	++			++
2-fluoroethyl 2-(2-((3,5-dimethyl-1H-pyrazol-1-yl)methyl)butanamido)-3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	++		++	+

STRUCTURE	M2 Ki	M1 Ki	Cath D Ki	IC50 _microM_
tert-butyl 2-((3,5-dimethyl-1H-pyrazol-1-yl)methyl)butanamido)-3-(5-hydroxy-2,7-dimethyl-8-(3-methyl-1-oxo-1-(2,2,2-trifluoroethylamino)butan-2-ylamino)-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	++		++	+
tert-butyl 2-((3,5-dimethyl-1H-pyrazol-1-yl)methyl)butanamido)-3-(5-hydroxy-2,7-dimethyl-8-(3-methyl-1-oxo-1-(2,2,2-trifluoroethylamino)butan-2-ylamino)-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	-			+
tert-butyl 3-(5-hydroxy-8-(1-(isobutylsulfonyl)-3-methylbutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-oxopropylcarbamate	-			-
isopropyl 3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-(4-methylthiazol-2-yl)methyl)butanamido)-3-oxopropylcarbamate	++		++	++
tert-butyl 3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-2-(2-(4-methylthiazol-2-yl)methyl)butanamido)-3-oxopropylcarbamate	-			-
4-hydroxy-N-(1-(isobutylamino)-3-methyl-1-oxobutan-2-yl)-5-(3-(methoxy(methyl)amino)-2-(2-(4-methylthiazol-2-yl)methyl)butanamido)propanamido)-2,7-dimethyloctanamide	+			-
tert-butyl 2-(2-azido-3-(3,5-dimethyl-1H-pyrazol-1-yl)propanamido)-3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	+		++	+
tert-butyl 2-(2-amino-3-(3,5-dimethyl-1H-pyrazol-1-yl)propanamido)-3-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-oxopropylcarbamate	+		+	-
4-hydroxy-N-(1-(isobutylamino)-3-methyl-1-oxobutan-2-yl)-2,7-dimethyl-5-(2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-3-(N-methylmethylsulfonamido)propanamido)octanamide	+			+
3-(3-(3,5-dimethyl-1H-pyrazol-1-yl)propanamido)-4-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-4-oxobutanoic acid	+	++		
2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)propanamido)-N1-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)succinamide	+	++	++	
2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)propanamido)-N1-(5-hydroxy-8-(1-(isobutylcarbamoyl)cyclopentylamino)-2,7-dimethyl-8-oxooctan-4-yl)succinamide	-	++		
2-(2-((3,5-dimethyl-1H-pyrazol-1-yl)methyl)butanamido)-N1-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)succinamide	+	++	++	
benzyl 3-(3-(3,5-dimethyl-1H-pyrazol-1-yl)propanamido)-4-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-4-oxobutanoate	++	+		
2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)propanamido)-N1-(5-hydroxy-8-(1-(isobutylamino)-2-methyl-1-oxopropan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)succinamide	-	+		

STRUCTURE	M2 Ki	M1 Ki	Cath D Ki	IC50 _microM_
2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)-2-methylpropanamido)-N1-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)succinamide	+	+		
2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)propanamido)-N1-(5-hydroxy-8-(3-hydroxy-1-(isobutylamino)-1-oxopropan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)succinamide	-	+		
2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)propanamido)-N1-(5-hydroxy-8-(1-(isobutylamino)-4-methoxy-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)succinamide	-	+		
(2,5-dimethyloxazol-4-yl)methyl 9-hydroxy-8-isobutyl-14-isopropyl-11,18-dimethyl-3,6,12,15-tetraoxo-1-(pyridin-4-yl)-2,7,13,16-tetraazanonadecan-5-ylcarbamate	+	+		++
2-(3-(3,5-dimethyl-1H-pyrazol-1-yl)-2-methylpropanamido)-N1-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)succinamide	+	+		
tert-butyl 9-hydroxy-8-isobutyl-14-isopropyl-11,18-dimethyl-1-(4-methylthiazol-2-yl)-3,6,12,15-tetraoxo-2,7,13,16-tetraazanonadecan-5-ylcarbamate	++	+		
2-(2-methoxyethoxy)ethyl 3-(((2,5-dimethyloxazol-4-yl)methoxy)carbonylamino)-4-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-4-oxobutanoate	++	-		++
(4-methylthiazol-2-yl)methyl 4-amino-1-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-1,4-dioxobutan-2-ylcarbamate	+	-		-
(2,5-dimethyloxazol-4-yl)methyl 4-amino-1-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-1,4-dioxobutan-2-ylcarbamate	+	-		++
3-(((2,5-dimethyloxazol-4-yl)methoxy)carbonylamino)-4-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-4-oxobutanoic acid	+	-		++
N1-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)succinamide	+	-		++
(2,5-dimethyloxazol-4-yl)methyl 9-hydroxy-8-isobutyl-14-isopropyl-2,11,18-trimethyl-3,6,12,15-tetraoxo-2,7,13,16-tetraazanonadecan-5-ylcarbamate	+	-		
4-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-3-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)-4-oxobutanoic acid	+	-		+
benzyl 3-(((2,5-dimethyloxazol-4-yl)methoxy)carbonylamino)-4-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-ylamino)-4-oxobutanoate	++	-		++
tert-butyl 9-hydroxy-8-isobutyl-14-isopropyl-11,18-dimethyl-1-(4-methylthiazol-2-yl)-3,6,12,15-tetraoxo-2,7,13,16-tetraazanonadecan-5-ylcarbamate	+	-		

STRUCTURE	M2 Ki	M1 Ki	Cath D Ki	IC50 _microM_
N4-ethyl-N1-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)succinamide	++	-		
N1-(5-hydroxy-8-(1-(isobutylamino)-3-methyl-1-oxobutan-2-ylamino)-2,7-dimethyl-8-oxooctan-4-yl)-N4,N4-dimethyl-2-(2-methyl-3-(4-methylthiazol-2-yl)propanamido)succinamide	+	-	++	

[0256] In Table 1, for Ki, the symbol "++" represents a Ki of less than 100 nM; the symbol "+" represents a Ki of 100 to 600 nM; and the symbol "-" represents a Ki of greater than 600 nM. For IC50, The symbol "++" indicates an IC50 of less than 6 μ M; "+" indicates an IC50 from 6 to 100 μ M; and "-" indicates an IC50 of greater than 100 μ M.

Example 5: Inhibition of Memapsin 1 Beta-Secretase Activity and Cethespin D Activity

[0257] A substrate peptide NH₃-ELDLAVEFWHDR-CO₂ was dissolved at 2 mg/ml in 10% glacial acetic acid and diluted into 0.009 M NaOH to obtain μ M concentration at pH 10 4.1. After equilibration at 37 degrees C, the reactions were initiated by the addition of an aliquot of memapsin 2. Aliquots were removed at time intervals, and combined with an equal volume of MALDI-TOF matrix (α -hydroxycinnamic acid in acetone, 20 mg/ml) and immediately spotted in duplicate onto a stainless-steel MALDI sample plate. MALDI-TOF mass spectrometry was performed on a PE Biosystems Voyager DE instrument at the 15 Molecular Biology Resource Center on campus. The instrument was operated at 25,000 accelerating volts in positive mode with a 150 ns delay. Ions with a mass-to-charge ratio (*m/z*) were detected in the range of 650 - 2000 atomic mass units. Data was analyzed by the Voyager Data Explorer module to obtain ion intensity data for mass species of substrates 20 and corresponding products in a given mixture. Relative product formation was calculated as the ratio of signal intensity of the product to the sum of signal intensities of both product and the corresponding substrate. Relative product formed per unit time was obtained from non-linear regression analysis of the data representing the initial 15% formation of product using the model:

$$1 - e^{-kT},$$

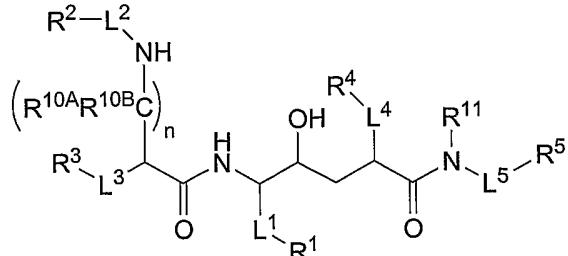
[0258] where k is the relative hydrolytic rate constant and T is time in seconds. Initial rates were expressed relative to uninhibited controls and fit to a tight-binding model of competitive inhibition as above. Results are shown in Table 1 above.

Example 6: Cellular A β IC₅₀ Determinations

5 [0259] The potency of compounds against memapsin 2 activity was determined in a cellular assay of A β production. Compounds that successfully penetrate the cell membrane demonstrate their ability to inhibit memapsin 2 activity in endosomal compartments, thus blocking the production of A β . Chinese hamster ovary cells that over-express human APP695 with the London and Swedish mutations were seeded in multi-well plates at 10%
10 confluence. Compounds were dissolved in DMSO to concentrations near 1 mM, and diluted into culture media to a final concentration near 4 μ M (final 0.4% DMSO). Compounds were diluted serially and applied to cells in multi-well plates 48 h after seeding. Incubation was continued in 5% CO₂ at 37 degrees C for 24 h. Aliquots were removed and assayed for A β ₄₀ content using a sandwich ELISA (BioSource International). Amount of A β ₄₀ over the range
15 of concentration of compounds, relative to control incubations, were fit to a 4-parameter IC₅₀ model. Results are shown in Table 1 above.

WHAT IS CLAIMED IS:

1 1. A compound having the formula:



2

3 wherein

4 n is an integer from 0 to 5;

5 R¹, R³, R⁴, R⁵ are independently -NR²⁹R³⁰, -OR³¹, -C(O)R³², -S(O)_tR³², -N₃,
6 hydrogen, substituted or unsubstituted alkyl, substituted or unsubstituted
7 heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or
8 unsubstituted heterocycloalkyl, substituted or unsubstituted aryl,
9 substituted or unsubstituted heteroaryl, amino acid side chain, or -L⁶-Y,
10 wherein

11 R²⁹ is -C(O)R³³, hydrogen, substituted or unsubstituted alkyl, substituted
12 or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl,
13 substituted or unsubstituted heterocycloalkyl, substituted or
14 unsubstituted aryl, or substituted or unsubstituted heteroaryl,

15 R³² is -NR³⁴R³⁵, hydrogen, substituted or unsubstituted alkyl, substituted
16 or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl,
17 substituted or unsubstituted heterocycloalkyl, substituted or
18 unsubstituted aryl, or substituted or unsubstituted heteroaryl,

19 R³⁴ is independently -NR³⁶R³⁷, hydrogen, substituted or unsubstituted
20 alkyl, substituted or unsubstituted heteroalkyl, substituted or
21 unsubstituted cycloalkyl, substituted or unsubstituted
22 heterocycloalkyl, substituted or unsubstituted aryl, or substituted or
23 unsubstituted heteroaryl, wherein if R¹, R³, R⁴, or R⁵ is -S(O)_tR³²,
24 then R³⁴ is not -NR³⁶R³⁷,

25 R³⁰, R³¹, R³³, R³⁵, R³⁶, and R³⁷ are independently selected from
26 hydrogen, substituted or unsubstituted alkyl, substituted or
27 unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl,

62 L^1 and L^4 are independently a bond, substituted or unsubstituted alkylene, or
63 substituted or unsubstituted heteroalkylene;
64 L^5 is a bond, $-C(O)-$, $-C(O)NH-$, substituted or unsubstituted alkylene, or
65 substituted or unsubstituted heteroalkylene, wherein if R^5 is $-C(O)R^{32}$,
66 $-S(O)R^{32}$, or $-N_3$, then L^5 is a bond, substituted or unsubstituted alkylene,
67 or substituted or unsubstituted heteroalkylene,
68 Y is a carrier moiety; and
69 L^6 is a bond, $-OP(OH)_2O-$, $-C(O)OR^{26}-$, $-C(O)NHR^{27}-$, $-S(O)_2NHR^{28}-$,
70 substituted or unsubstituted alkylene, substituted or unsubstituted
71 heteroalkylene, or a peptidyl linker, wherein
72 R^{26} , R^{27} , and R^{28} are independently selected from substituted or
73 unsubstituted alkyl, substituted or unsubstituted heteroalkyl,
74 cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted
75 or unsubstituted aryl, or substituted or unsubstituted heteroaryl.

- 1 2. The compound of claim 1, wherein n an integer from 0 to 2.
- 1 3. The compound of claim 1, wherein
2 R^1 and R^4 are independently hydrogen, substituted or unsubstituted C_1-C_{20}
3 alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or
4 unsubstituted C_5-C_7 cycloalkyl, substituted or unsubstituted 5 to 7 membered
5 heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl,
6 or $-L^6-Y$.
- 1 4. The compound of claim 1, wherein
2 R^1 and R^4 are independently substituted or unsubstituted C_1-C_{20} alkyl,
3 substituted or unsubstituted 2 to 20 membered heterocycloalkyl, substituted or unsubstituted
4 aryl, or substituted or unsubstituted heteroaryl.
- 1 5. The compound of claim 1, wherein
2 R^1 and R^4 are independently substituted or unsubstituted C_1-C_{20} alkyl,
3 substituted or unsubstituted aryl, or substituted or unsubstituted heteroaryl.
- 1 6. The compound of claim 1, wherein
2 R^1 is substituted or unsubstituted aryl, substituted or unsubstituted
3 heteroaryl, or substituted or unsubstituted C_1-C_8 alkyl; and

4 R⁴ is substituted or unsubstituted aryl, substituted or unsubstituted
5 heteroaryl, or substituted or unsubstituted C₁-C₈ alkyl.

1 7. The compound of claim 1, wherein R¹ is

2 (a) unsubstituted aryl;

3 (b) unsubstituted heteroaryl;

4 (c) aryl substituted with a halogen;

5 (d) heteroaryl substituted with a halogen; or

6 (e) C₁-C₂₀ alkyl substituted with a halogen, unsubstituted aryl, aryl

7 substituted with a halogen, unsubstituted heteroaryl, or heteroaryl substituted with a

8 halogen.

1 8. The compound of claim 1, wherein R⁴ is
2 (a) unsubstituted aryl;
3 (b) unsubstituted heteroaryl;
4 (c) aryl substituted with a halogen;
5 (d) heteroaryl substituted with a halogen; or
6 (e) C₁-C₂₀ alkyl substituted with a halogen, unsubstituted aryl, aryl
7 substituted with a halogen, unsubstituted heteroaryl, or heteroaryl substituted with a
8 halogen.

1 9. The compound of claim 1, wherein
2 R¹ is substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted
3 aryl, or substituted or unsubstituted heteroaryl; and
4 R⁴ is substituted or unsubstituted C₁-C₂₀ alkyl.

1 10. The compound of claim 1, wherein
2 R¹ is C₁-C₅ alkyl substituted with a substituted or unsubstituted phenyl, or
3 substituted or unsubstituted pyridinyl; and
4 R⁴ is unsubstituted C₁-C₈ alkyl.

1 **11.** The compound of claim **10**, wherein R¹ is C₁-C₅ alkyl substituted
2 with:
3 unsubstituted phenyl; unsubstituted pyridinyl; or

4 phenyl substituted with a halogen, OR^{1A}, or unsubstituted (C₁-C₅) alkyl,
5 wherein

6 R^{1A} is hydrogen or unsubstituted (C₁-C₅) alkyl.

1 12. The compound of claim 10, wherein R¹ is methyl substituted with an
2 unsubstituted phenyl, unsubstituted pyridinyl, 3,5-difluorophenyl, 4-hydroxyphenyl, 3-
3 chloro-4-hydroxyphenyl, or 3-chloro-4-methoxyphenyl.

1 13. The compound of claim 1, wherein R¹ is -CH₂-CH(CH₃)-CH₃.

1 14. The compound of claim 1, wherein R⁴ is methyl or ethyl.

1 15. The compound of claim 1, wherein
2 L² is a bond, -C(O)-, -O-(CH₂)_k-, -C(O)NR⁶-, -NH-, -C(O)O-, -S-, -S(O)-,
3 -S(O)₂-, substituted or unsubstituted C₁-C₂₀ alkylene, or substituted or unsubstituted 2 to 20
4 membered heteroalkylene, wherein

5 k is an integer from 0 to 5, and

6 R⁶ is hydrogen, substituted or unsubstituted C₁-C₂₀ alkyl, substituted or
7 unsubstituted C₅-C₇ cycloalkyl, substituted or unsubstituted 2 to 20
8 membered heteroalkyl, substituted or unsubstituted 5 to 7 membered
9 heterocycloalkyl, substituted or unsubstituted aryl, or substituted or
10 unsubstituted heteroaryl; and

11 R² is substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted 2
12 to 20 membered heteroalkyl, substituted or unsubstituted 2 to 20 membered cycloalkyl,
13 substituted or unsubstituted 5 to 7 membered heterocycloalkyl, substituted or unsubstituted
14 aryl, substituted or unsubstituted heteroaryl, or -L⁶-Y.

1 16. The compound of claim 1, wherein

2 L² is a bond, -C(O)-, -C(O)NR⁶-, -C(O)O-, -S(O)₂-, substituted or
3 unsubstituted C₁-C₂₀ alkylene, or substituted or unsubstituted 2 to 20 membered
4 heteroalkylene, wherein R⁶ is hydrogen or substituted or unsubstituted C₁-C₂₀ alkyl; and
5 R² is substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted 2
6 to 20 membered heteroalkyl, substituted or unsubstituted aryl, or substituted or
7 unsubstituted heteroaryl.

1 **17.** The compound of claim **1**, wherein R^2 is
2 (a) unsubstituted aryl;
3 (b) unsubstituted heteroaryl;
4 (c) aryl substituted with a halogen or unsubstituted C_1 - C_{10} alkyl;
5 (d) heteroaryl substituted with a halogen or unsubstituted C_1 - C_{10} alkyl; or
6 (e) C_1 - C_{20} alkyl substituted with a halogen, unsubstituted aryl, aryl
7 substituted with a halogen, unsubstituted heteroaryl, or heteroaryl substituted with a
8 halogen.

1 **18.** The compound of claim **1**, wherein
2 L^2 is $-C(O)-$, $-C(O)NR^6-$, $-C(O)O-$, or $-S(O)_2-$, wherein R^6 is hydrogen or
3 unsubstituted C_1 - C_{20} alkyl;
4 R^2 is unsubstituted C_1 - C_{20} alkyl, unsubstituted 2 to 20 membered heteroalkyl,
5 substituted or unsubstituted aryl, or unsubstituted heteroaryl.

1 **19.** The compound of claim **1**, wherein
2 L^2 is $-C(O)-$, $-C(O)NR^6-$, $-C(O)O-$, or $-S(O)_2-$, wherein R^6 is hydrogen or
3 unsubstituted C_1 - C_4 alkyl; and
4 R^2 is unsubstituted C_1 - C_4 alkyl, unsubstituted furanyl, unsubstituted phenyl,
5 unsubstituted pyridinyl, unsubstituted thiazolyl, furanyl substituted with a substituted or
6 unsubstituted C_1 - C_{20} alkyl, phenyl substituted with a substituted or unsubstituted C_1 - C_{20}
7 alkyl, pyridinyl substituted with substituted or unsubstituted C_1 - C_{20} alkyl, or thiazolyl
8 substituted with an unsubstituted C_1 - C_{20} alkyl.

1 **20.** The compound of claim **19**, wherein
2 R^2 is unsubstituted C_1 - C_4 alkyl, unsubstituted furanyl, unsubstituted phenyl,
3 unsubstituted pyridinyl, furanyl substituted with an unsubstituted C_1 - C_{10} alkyl, phenyl
4 substituted with an unsubstituted C_1 - C_{10} alkyl, pyridinyl substituted with an unsubstituted
5 C_1 - C_{10} alkyl, or thiazolyl substituted with an unsubstituted C_1 - C_{10} alkyl.

1 **21.** The compound of claim **19**, wherein
2 R^2 is unsubstituted C_1 - C_4 alkyl, unsubstituted furanyl, unsubstituted phenyl,
3 unsubstituted pyridinyl, furanyl substituted with an unsubstituted C_1 - C_4 alkyl, phenyl
4 substituted with an unsubstituted C_1 - C_4 alkyl, pyridinyl substituted with an unsubstituted
5 C_1 - C_4 alkyl, or thiazolyl substituted with an unsubstituted C_1 - C_4 alkyl.

1 **22.** The compound of claim 1, wherein

2 L³ is a bond, -C(O)-, -O-, -C(O)NR⁷-, -N(R⁷)-, -C(O)O-, -S-, -S(O)-, -S(O)₂-,

3 -NR⁷-C(O)-NR⁸-, -NR⁷-C(O)-O-, substituted or unsubstituted C₁-C₂₀ alkylene, or

4 substituted or unsubstituted 2 to 20 membered heteroalkylene, wherein

5 R⁷ and R⁸ are independently hydrogen, substituted or unsubstituted C₁-

6 C₂₀ alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl,

7 substituted or unsubstituted C₅-C₇ cycloalkyl, substituted or

8 unsubstituted 5 to 7 membered heterocycloalkyl, substituted or

9 unsubstituted aryl, or substituted or unsubstituted heteroaryl.

1 **23.** The compound of claim 1, wherein

2 L³ is substituted or unsubstituted alkylene, or substituted or unsubstituted

3 heteroalkylene.

1 **24.** The compound of claim 1, wherein

2 L³ is substituted or unsubstituted C₁-C₂₀ alkylene, or substituted or

3 unsubstituted 2 to 20 membered heteroalkylene.

1 **25.** The compound of claim 1, wherein L³ is

2 C₁-C₂₀ alkylene substituted with an oxo, or unsubstituted C₁-C₂₀ alkyl; or

3 2 to 20 membered heteroalkylene substituted with an oxo, or unsubstituted

4 C₁-C₂₀ alkyl.

1 **26.** The compound of claim 1, wherein -L³-R³ has the formula:

2 -(CH₂)_m-L^{3A}-C(O)-L^{3B}-L^{3C}-R³,

3 wherein,

4 m is an integer from 0 to 10;

5 L^{3A} is a bond, -N(R¹²)-, -O-, or -C(R¹³)(R¹⁴)-, wherein

6 R¹² is hydrogen, or unsubstituted C₁-C₂₀ alkyl;

7 R¹³ and R¹⁴ are independently hydrogen, unsubstituted C₁-C₂₀ alkyl,

8 -OR¹⁵, or -NR¹⁶R¹⁷, wherein

9 R¹⁵, R¹⁶ and R¹⁷ are independently hydrogen or unsubstituted C₁-C₂₀

10 alkyl;

11 L^{3B} is a bond, -N(R¹⁸)-, -C(R¹⁹)(R²⁰)-, or -O-, wherein

12 R¹⁸ is hydrogen, or unsubstituted C₁-C₂₀ alkyl;

13 R¹⁹ and R²⁰ are independently hydrogen, unsubstituted C₁-C₂₀ alkyl,
14 -OR²¹, or -NR²²R²³, C₁-C₂₀ alkyl substituted with -OR²¹, or N₃,
15 wherein
16 R²¹, R²² and R²³ are independently hydrogen, or unsubstituted C₁-C₂₀
17 alkyl; and
18 L^{3C} is a bond, unsubstituted C₁-C₂₀ alkylene, or unsubstituted 2 to 20
19 membered heteroalkylene.

1 **27.** The compound of claim **26**, wherein
2 R³ is a substituted or unsubstituted cycloalkyl, substituted or unsubstituted
3 heterocycloalkyl, substituted or unsubstituted aryl, or substituted or
4 unsubstituted heteroaryl,
5 m is 0,
6 L^{3A} is -N(R¹²)-,
7 L^{3B} is -C(R¹⁹)(R²⁰)-,
8 L^{3C} is unsubstituted C₁-C₅ alkylene.

1 **28.** The compound of claim **27**, wherein
2 R¹² is hydrogen,
3 R¹⁹ is hydrogen, and
4 L^{3C} is methylene.

1 **29.** The compound of claim **26**, wherein
2 R³ is a substituted or unsubstituted cycloalkyl, substituted or unsubstituted
3 heterocycloalkyl, substituted or unsubstituted aryl, or substituted or
4 unsubstituted heteroaryl,
5 m is 1,
6 L^{3B} is -N(R¹⁸)-
7 L^{3C} is unsubstituted C₁-C₅ alkylene.

1 **30.** The compound of claim **29**, wherein
2 R¹⁸ is hydrogen, and
3 L^{3C} is methylene.

1 **31.** The compound of claim **26**, wherein -L³-R³ is:
2 -NH-C(O)-CHR¹⁹-CH₂-R³;

3 -NH-C(O)-O-CH₂-R³;
 4 -NH-C(O)-NH-CH₂-R³;
 5 -CH₂-C(O)-NH-CH₂-R³;
 6 -CH₂-C(O)-CHR¹⁹-CH₂-R³;
 7 -CH₂-C(O)-O-CH₂-R³; or
 8 -O-C(O)-NH-CH₂-R³.

1 **32.** The compound of claim 1, wherein R³ is substituted or unsubstituted
2 C₁-C₂₀ alkyl, substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or
3 unsubstituted C₅-C₇ cycloalkyl, substituted or unsubstituted 5 to 7 membered
4 heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl,
5 or -L⁶-Y.

1 **33.** The compound of claim 1, wherein R³ is substituted or unsubstituted
2 aryl, substituted or unsubstituted heteroaryl, or substituted or unsubstituted
3 heterocycloalkyl.

1 34. The compound of claim 1, wherein R^3 is substituted or unsubstituted
2 heteroaryl, or substituted or unsubstituted heterocycloalkyl.

1 36. The compound of claim 1, wherein R³ is
2 unsubstituted heteroaryl; unsubstituted heterocycloalkyl;
3 heteroaryl substituted with a halogen, -CF₃, -OH, -NH₂, -CN, unsubstituted
4 C₁-C₂₀ alkyl, or unsubstituted 2 to 20 membered heteroalkyl; or
5 heterocycloalkyl substituted with oxo, or unsubstituted C₁-C₂₀ alkyl.

1 37. The compound of claim 1, wherein R³ is unsubstituted aryl;
2 unsubstituted heteroaryl; aryl substituted with a halogen; heteroaryl substituted with a
3 halogen; or C₁-C₂₀ alkyl substituted with a halogen, unsubstituted aryl, aryl substituted with
4 a halogen, unsubstituted heteroaryl, or heteroaryl substituted with a halogen.

1 **38.** The compound of claim 1, wherein

2 R³ is substituted or unsubstituted pyrazolyl, substituted or unsubstituted
3 furanyl, substituted or unsubstituted imidazolyl, substituted or unsubstituted isoxazolyl,
4 substituted or unsubstituted oxadiazolyl, substituted or unsubstituted oxazolyl, substituted
5 or unsubstituted pyrrolyl, substituted or unsubstituted pyridyl, substituted or unsubstituted
6 pyrimidyl, substituted or unsubstituted pyridazinyl, substituted or unsubstituted thiazolyl,
7 substituted or unsubstituted triazolyl, substituted or unsubstituted thienyl, substituted or
8 unsubstituted dihydrothieno-pyrazolyl, substituted or unsubstituted thianaphthienyl,
9 substituted or unsubstituted carbazolyl, substituted or unsubstituted benzimidazolyl,
10 substituted or unsubstituted benzothienyl, substituted or unsubstituted benzofuranyl,
11 substituted or unsubstituted indolyl, substituted or unsubstituted quinolinyl, substituted or
12 unsubstituted benzotriazolyl, substituted or unsubstituted benzothiazolyl, substituted or
13 unsubstituted benzooxazolyl, substituted or unsubstituted benzimidazolyl, substituted or
14 unsubstituted isoquinolinyl, substituted or unsubstituted isoindolyl, substituted or
15 unsubstituted acridinyl, substituted or unsubstituted benzoisazolyl, or substituted or
16 unsubstituted dimethylhydantoin.

1 **39.** The compound of claim 1, wherein

2 R³ is substituted or unsubstituted pyrazolyl, substituted or unsubstituted
3 oxazolyl, substituted or unsubstituted thiazolyl, or substituted or unsubstituted furanyl.

1 **40.** The compound of claim 1, wherein

2 R³ is substituted or unsubstituted 1-pyrazolyl, substituted or unsubstituted 4-
3 oxazolyl, substituted or unsubstituted 2-oxazolyl, substituted or unsubstituted 2-thiazolyl, or
4 substituted or unsubstituted 2-furanyl.

1 **41.** The compound of claim 1, wherein R³ is

2 1-pyrazolyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2
3 to 20 membered heteroalkyl;

4 4-oxazolyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2
5 to 20 membered heteroalkyl;

6 2-oxazolyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2
7 to 20 membered heteroalkyl;

8 2-thiazolyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2
9 to 20 membered heteroalkyl; or
10 2-furanyl substituted with an unsubstituted C₁-C₂₀ alkyl, or unsubstituted 2 to
11 20 membered heteroalkyl.

1 **42.** The compound of claim 1, wherein R³ is
2 1-pyrazolyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2
3 to 6 membered heteroalkyl;
4 4-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2
5 to 6 membered heteroalkyl;
6 2-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2
7 to 6 membered heteroalkyl;
8 2-thiazolyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2
9 to 6 membered heteroalkyl; or
10 2-furanyl substituted with an unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to
11 6 membered heteroalkyl.

1 **43.** The compound of claim 1, wherein R³ is
2 1-pyrazolyl substituted with an unsubstituted C₁-C₅ alkyl;
3 4-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl;
4 2-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl;
5 2-thiazolyl substituted with an unsubstituted C₁-C₅ alkyl; or
6 2-furanyl substituted with an unsubstituted C₁-C₅ alkyl.

1 **44.** The compound of claim 1, wherein R³ is:
2 1-pyrazolyl substituted with an unsubstituted C₁-C₅ alkyl at the 3 position,
3 the 5 position, or the 3 and 5 position;
4 4-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl at the 2 position, the
5 5-position, or the 2 and 5 position;
6 2-oxazolyl substituted with an unsubstituted C₁-C₅ alkyl at the 4 position;
7 2-thiazolyl substituted with an unsubstituted C₁-C₅ alkyl at the 4 position; or
8 2-furanyl substituted with an unsubstituted C₁-C₅ alkyl at the 5 position.

1 **45.** The compound of claim 1, wherein

2 L⁵ is a bond, -C(O)-, substituted or unsubstituted C₁-C₂₀ alkylene, or

3 substituted or unsubstituted 2 to 20 membered heteroalkylene; and

4 R⁵ is substituted or unsubstituted C₁-C₂₀ alkyl, substituted or unsubstituted 2

5 to 20 membered heteroalkyl, substituted or unsubstituted C₅-C₇ cycloalkyl, substituted or

6 unsubstituted 5 to 7 membered heteroalkyl, substituted or unsubstituted 2 to 20 membered

7 heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl,

8 or -L⁶-Y.

1 **46.** The compound of claim 1, wherein

2 L⁵ is a bond, -C(O)-, substituted or unsubstituted C₁-C₁₀ alkylene, or

3 substituted or unsubstituted 2 to 10 membered heteroalkylene; and

4 R⁵ is substituted or unsubstituted C₁-C₁₀ alkyl, substituted or unsubstituted 2

5 to 10 membered heteroalkyl, substituted or unsubstituted C₅-C₇ cycloalkyl, substituted or

6 unsubstituted 5 to 7 membered heteroalkyl, substituted or unsubstituted 2 to 10 membered

7 heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl,

8 or -L⁶-Y.

1 **47.** The compound of claim 1, wherein L⁵ is

2 a bond;

3 unsubstituted C₁-C₁₀ alkylene;

4 unsubstituted 2 to 10 membered heteroalkylene;

5 C₁-C₁₀ alkylene substituted with an oxo, unsubstituted C₁-C₁₀ alkyl, or

6 unsubstituted 2 to 10 membered heteroalkyl; or

7 2 to 10 membered heteroalkylene substituted with an oxo, unsubstituted C₁-

8 C₁₀ alkyl, or unsubstituted 2 to 10 membered heteroalkyl.

1 **48.** The compound of claim 1, wherein L⁵ is

2 a bond;

3 unsubstituted C₁-C₁₀ alkylene;

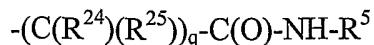
4 unsubstituted 2 to 10 membered heteroalkylene;

5 C₁-C₁₀ alkylene substituted with an oxo or unsubstituted C₁-C₁₀ alkyl; or

6 2 to 10 membered heteroalkylene substituted with an oxo, or unsubstituted

7 C₁-C₁₀ alkyl.

1 **49.** The compound of claim 1, wherein -L⁵-R⁵ has the formula



2 wherein

3 q is an integer from 0 to 5; and

4 R²⁴ and R²⁵ are independently hydrogen, substituted or unsubstituted C₁-C₁₀
5 alkyl, substituted or unsubstituted 2 to 10 membered heteroalkyl,
6 substituted or unsubstituted C₅ to C₇ cycloalkyl, substituted or
7 unsubstituted 5 to 7 membered heterocycloalkyl, or substituted or
8 unsubstituted aryl, or substituted or unsubstituted heteroaryl.

1 **50.** The compound of claim 49, wherein

2 R⁵ is -NR²⁹R³⁰,

3 R²⁴, R²⁵, R²⁹, and R³⁰ are independently selected from hydrogen and
4 substituted or unsubstituted C₁-C₁₀ alkyl, and
5 q is 1 or 2.

1 **51.** The compound of claim 50, wherein R²⁵, R²⁹, and R³⁰ are

2 independently unsubstituted C₁-C₅ alkyl and R²⁴ is hydrogen.

1 **52.** The compound of claim 1, wherein

2 R⁵ is -S(O)_tR³²,

3 t is 2,

4 R³² is substituted or unsubstituted C₁-C₁₀ alkyl, and

5 L⁵ is substituted or unsubstituted C₁-C₁₀ alkylene.

1 **53.** The compound of claim 52, wherein R³² is unsubstituted C₁-C₅ alkyl

2 and L⁵ is unsubstituted C₁-C₅ alkylene.

1 **54.** The compound of claim 49, wherein

2 R²⁴ and R²⁵ are independently hydrogen, substituted or unsubstituted C₁-C₁₀

3 alkyl, substituted or unsubstituted C₅ to C₇ cycloalkyl, or substituted or unsubstituted aryl.

1 **55.** The compound of claim 49, wherein

2 R²⁴ is hydrogen; and

3 R²⁵ is

4 (a) unsubstituted C₁-C₁₀ alkyl, or
5 (b) unsubstituted C₅ to C₇ cycloalkyl, unsubstituted aryl, C₅ to C₇ cycloalkyl
6 substituted with a C₁-C₅ unsubstituted alkyl, or aryl substituted with a C₁-
7 C₅ unsubstituted alkyl.

1 **56.** The compound of claim 49, wherein
2 R²⁴ is hydrogen; and
3 R²⁵ is unsubstituted C₁-C₁₀ alkyl.

1 **57.** The compound of claim 1, wherein R⁵ is unsubstituted aryl;
2 unsubstituted heteroaryl; aryl substituted with a halogen; heteroaryl substituted with a
3 halogen; or C₁-C₂₀ alkyl substituted with a halogen, unsubstituted aryl, aryl substituted with
4 a halogen, unsubstituted heteroaryl, or heteroaryl substituted with a halogen.

1 **58.** The compound of claim 1, wherein R⁵ is
2 unsubstituted C₁-C₁₀ alkyl; unsubstituted 2 to 10 membered heteroalkyl;
3 unsubstituted C₅-C₇ cycloalkyl; unsubstituted 5 to 7 membered heteroalkyl; unsubstituted 2
4 to 10 membered heterocycloalkyl; unsubstituted aryl; unsubstituted heteroaryl;
5 C₁-C₁₀ alkyl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅
6 alkyl, or unsubstituted 2 to 5 membered heteroalkyl;
7 2 to 10 membered heteroalkyl substituted with an -OH, -COOH, halogen,
8 unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 5 membered heteroalkyl;
9 C₅-C₇ cycloalkyl substituted with an -OH, -COOH, halogen, unsubstituted
10 C₁-C₅ alkyl, or unsubstituted 2 to 5 membered heteroalkyl;
11 5 to 7 membered heterocycloalkyl substituted with an -OH, -COOH,
12 halogen, unsubstituted C₁-C₅ alkyl, or unsubstituted 2 to 5 membered heteroalkyl;
13 aryl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅ alkyl, or
14 unsubstituted 2 to 5 membered heteroalkyl; or
15 heteroaryl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅
16 alkyl, or unsubstituted 2 to 5 membered heteroalkyl.

1 **59.** The compound of claim 1, wherein R⁵ is
2 unsubstituted C₁-C₁₀ alkyl; or
3 heteroaryl substituted with an -OH, -COOH, halogen, unsubstituted C₁-C₅
4 alkyl, or unsubstituted 2 to 5 membered heteroalkyl.

1 **60.** The compound of claim 1, wherein R⁵ is
2 unsubstituted C₁-C₅ alkyl; unsubstituted pyridinyl; or
3 pyridinyl substituted with an unsubstituted C₁-C₅ alkyl.

1 **61.** The compound of claim 1, wherein R¹¹ is hydrogen, substituted or
2 unsubstituted alkyl, or substituted or unsubstituted heteroalkyl.

1 **62.** The compound of claim 1, wherein R¹¹ is hydrogen, unsubstituted C₁-
2 C₂₀ alkyl, unsubstituted 2 to 20 membered heteroalkyl, C₁-C₂₀ alkyl substituted with a
3 halogen, or 2 to 20 membered heteroalkyl substituted with a halogen.

1 **63.** The compound of claim 1, wherein R¹¹ is hydrogen, unsubstituted C₁-
2 C₂₀ alkyl, unsubstituted 2 to 20 membered heteroalkyl, C₁-C₂₀ alkyl substituted with a
3 fluorine or chlorine, or 2 to 20 membered heteroalkyl substituted with a fluorine or chlorine.

1 **64.** The compound of claim 1, wherein R³⁶ and R³⁷ are hydrogen or
2 substituted or unsubstituted C₁-C₁₀ alkyl.

1 **65.** The compound of claim 1, wherein R³⁶ and R³⁷ are hydrogen or
2 unsubstituted C₁-C₅ alkyl.

1 **66.** The compound of claim 1, wherein L⁶ is a bond, -OP(OH)₂O-,
2 -C(O)OR²⁶-, -C(O)NHR²⁷-, -S(O)₂NHR²⁸-, substituted or unsubstituted C₁-C₂₀ alkylene,
3 substituted or unsubstituted 2 to 20 membered heteroalkylene, or peptidyl linker, wherein
4 R²⁶, R²⁷, and R²⁸ are independently substituted or unsubstituted C₁-C₂₀ alkyl,
5 substituted or unsubstituted 2 to 20 membered heteroalkyl, substituted or
6 unsubstituted 3-8 membered cycloalkyl, substituted or unsubstituted 3 to
7 8 membered heterocycloalkyl, substituted or unsubstituted aryl, or
8 substituted or unsubstituted heteroaryl.

1 **67.** The compound of claim 1, wherein 0, 1, 2, or 3 groups selected from
2 R¹, R², R³, R⁴, R⁵, R^{10A}, R^{10B}, and R¹¹ are -L⁶-Y.

1 **68.** The compound of claim 1, 0, or 1 of R¹, R², R³, R⁴, R⁵, R^{10A}, R^{10B},
2 and R¹¹ are -L⁶-Y.

1 **69.** The compound of claim 1, wherein R¹, R², R³, R⁴, R⁵, R^{10A}, R^{10B}, and
2 R¹¹ are not -L⁶-Y.

1 **70.** The compound of claim 1, wherein Y is a peptidyl carrier moiety.

1 **71.** The compound of claim 70, wherein said peptidyl carrier moiety is
2 capable of transporting said compound across the blood brain barrier of a mammal.

1 **72.** The compound of claim 70, wherein said peptidyl carrier moiety is
2 capable of binding to a blood brain barrier receptor.

1 **73.** The compound of claim 70, wherein said peptidyl carrier moiety is
2 derived from an HIV tat protein, a peptide comprising an oligo-D-arginine residue, an
3 antibody, or an antibody fragment.

1 **74.** A method of treating Alzheimer's disease in a subject in need thereof,
2 the method comprising administering to the subject an effective amount of the compound of
3 claim 1.

1 **75.** A method of reducing memapsin 2 beta-secretase activity, the method
2 comprising contacting a memapsin 2 beta-secretase with an effective amount of the
3 compound of claim 1.

1 **76.** The method of claim 75, wherein said memapsin 2 beta-secretase is
2 contacted in a cell.

1 **77.** A method of selectively reducing memapsin 2 beta-secretase activity
2 relative to memapsin 1 beta-secretase activity, the method comprising contacting a
3 memapsin 2 beta-secretase with an effective amount of the compound of any one of claim 1
4 in the presence of memapsin 1 beta-secretase.

1 **78.** A method of selectively reducing memapsin 2 beta-secretase activity
2 relative to cathepsin D activity, the method comprising contacting a memapsin 2 beta-
3 secretase with an effective amount of the compound of claim 1 in the presence of cathepsin
4 D.

1 **79.** A method of selectively reducing memapsin 2 beta-secretase activity
2 relative to memapsin 1 beta-secretase activity and cathepsin D activity, the method
3 comprising contacting a memapsin 2 beta-secretase with an effective amount of the
4 compound of claim 1 in the presence of memapsin 1 beta-secretase and cathepsin D.