(12) STANDARD PATENT (11) Application No. **AU 2012326026 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Peptidomimetic macrocyles

(51) International Patent Classification(s)
C07K 14/00 (2006.01) ***A61K 38/16*** (2006.01)
A61K 38/12 (2006.01)

(21) Application No: **2012326026** (22) Date of Filing: **2012.10.18**

(87) WIPO No: **WO13/059525**

(30) Priority Data

(31) Number	(32) Date	(33) Country
61/548,690	**2011.10.18**	**US**

(43) Publication Date: **2013.04.25**
(44) Accepted Journal Date: **2017.04.13**

(71) Applicant(s)
Aileron Therapeutics, Inc.

(72) Inventor(s)
Kawahata, Noriyuki;Guerlavais, Vincent;Samant, Manoj

(74) Agent / Attorney
Pizzeys Patent and Trade Mark Attorneys Pty Ltd, PO Box 291, WODEN, ACT, 2606, AU

(56) Related Art
Felix A.M. et al. "Synthesis, biological activity and conformational analysis of cyclic GRF analogs" International Journal of Peptide and Protein Research (1998) 32: 441-454
Fry D.C. et al. "Solution Structures of Cyclic and Dicyclic Analogues of Growth Hormone Releasing Factor as Determined by Two-Dimensional NMR and CD Spectroscopies and Constrained Molecular Dynamics" Biopolymers (1992) 32: 649-666
US 2011/0144303 A1

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 April 2013 (25.04.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/059525 A1

(51) International Patent Classification:
A61K 38/12 (2006.01) *C07K 14/00* (2006.01)
A61K 38/16 (2006.01)

(21) International Application Number:
PCT/US2012/060913

(22) International Filing Date:
18 October 2012 (18.10.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/548,690 18 October 2011 (18.10.2011) US

(71) Applicant *(for all designated States except US)*: **AILERON THERAPEUTICS, INC.** [US/US]; 281 Albany Street, Cambridge, MA 02139 (US).

(72) Inventors; and
(71) Applicants *(for US only)*: **KAWAHATA, Noriyuki** [US/US]; 79 Garnet Road, West Roxbury, MA 02132 (US). **GUERLAVAIS, Vincent** [FR/US]; 43 Kenilworth Road, Arlington, MA 02476 (US). **SAMANT, Manoj** [IN/US]; 26 Beacon Street, 32D, Burlington, MA 01803 (US).

(74) Agents: **ORBAI, Lucian** et al.; Wilson Sonsini Goodrich & Rosati, 650 Page Mill Road, Palo Alto, CA 94304-1050 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

WO 2013/059525 A1

(54) Title: PEPTIDOMIMETIC MACROCYLES

(57) Abstract: The present invention provides peptidomimetic macrocycles capable of modulating growth hormone levels and methods of using such macrocycles for the treatment of disease.

PEPTIDOMIMETIC MACROCYCLES

CROSS-REFERENCE

[0001] This application claims the priority benefit of U.S. Provisional Application Serial Nos. 61/548,690 filed October 18, 2011, which is hereby incorporated herein by reference in their entirety.

SEQUENCE LISTING

[0001.1] The instant application contains a Sequence Listing which has been submitted in ASCII format via EFS-Web and is hereby incorporated by reference in its entirety. Said ASCII copy, created on November 2, 2012, is named 35769601.txt and is 225,304 bytes in size.

BACKGROUND OF THE INVENTION

[0002] Human GHRH (Growth Hormone-Releasing Hormone) is a 44-amino-acid peptide whose full biological activity resides in its first 29 amino acids ("GHRH 1-29"). GHRH binds to the GHRH receptor and stimulates pulsatile GH [Growth Hormone] secretion, and with this mechanism of action GHRH represents an alternative to GH therapy in patients with an intact pituitary that may minimize the side effects associated with long-term GH administration. Because the quantity of GH release induced by GHRH is limited by IGF-1 levels, which exert a negative feedback effect, the risk of side effects associated with excessive GH secretion may also be lower with GHRH therapy than with GH therapy. In addition, treatment with GHRH may result in the pituitary secretion of a broader set of GH proteins, and not just the 22-kDa form provided by recombinant human GH, which may also have beneficial effects. Clinically, GHRH has been shown to be safe and effective in increasing GH levels in adults and children, and the growth-promoting effect of GHRH is correlated with the dose and frequency of administration. However, the half-life of GHRH after intravenous injection is only 10–12 min, which has significantly limited its use as a therapeutic agent. Thus there is a clinical need for analogs of GHRH that possess extended half-life *in vivo* that could provide greater therapeutic benefit with an improved (less frequent) dosing regimen.

SUMMARY OF THE INVENTION

[0003] The present invention provides GHRH-derived peptidomimetic macrocycles that are designed to possess improved pharmaceutical properties relative to GHRH. These improved properties include enhanced chemical stability, extended *in vivo* half-life, increased potency and reduced immunogenicity. These peptidomimetic macrocycles are useful to increase circulating levels of GH as a treatment for muscle wasting diseases, lipodystrophies, growth hormone disorders, gastroparesis/short bowel syndrome, and other conditions for which an increase in GH would provide therapeutic benefit.

[0004] Described below are stably cross-linked peptides derived from the GHRH peptide. These cross-linked peptides contain at least two modified amino acids that together form an intramolecular cross-link that can help to stabilize the alpha-helical secondary structures of a portion of GHRH that is thought to be important for agonist activity at the GHRH receptor. Relative to the amino

acid sequence of the wild-type peptide, any amino acid which is not essential to the growth-hormone releasing activity of the peptide may be replaced with any other amino acids, while amino acids which are essential to the growth-hormone releasing activity of the peptide may be replaced only with amino acid analogs which do not substantially decrease said activity.

[0005] Accordingly, a cross-linked polypeptide described herein can have improved biological activity relative to a corresponding polypeptide that is not cross-linked. Without being bound by theory, the GHRH peptidomimetic macrocycles are thought to activate the GHRH receptor, thereby stimulating production and release of growth hormone, which can increase lean muscle mass or reduce adipose tissue (such as abdominal adipose tissue). For example, adipose tissue can be reduced in subjects suffering from obesity, including abdominal obesity. The GHRH peptidomimetic macrocycles described herein can be used therapeutically, for example, to treat muscle wasting diseases that include anorexias, cachexias (such as cancer cachexia, chronic heart failure cachexia, chronic obstructive pulmonary disease cachexia, rheumatoid arthritis cachexia) and sarcopenias, to treat lipodystrophies that include HIV lipodystrophy, to treat growth hormone disorders that include adult and pediatric growth hormone deficiencies, or to treat gastroparesis or short bowel syndrome. Pediatric growth hormone deficiency may be, for example, linked with or associated to idiopathic short stature, SGA (infant small for gestational age), chronic kidney disease, Prader-Willi syndrome Turner syndrome, short stature homeobox (SHOX) gene deficiency, or primary IGF-1 deficiency.

[0006] In one aspect, the present invention provides a peptidomimetic macrocycle comprising an amino acid sequence which is at least about 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, or 99% identical to GHRH 1-44, GHRH 1-29 and/or to an amino acid sequence chosen from the group consisting of the amino acid sequences in Table 1, 2 or 4. Alternatively, an amino acid sequence of said peptidomimetic macrocycle is chosen from the group consisting of the amino acid sequences in Table 1, 2 or 4. The peptidomimetic macrocycle may comprise one, two, three, four, five or more macrocycle-forming linkers, wherein each macrocycle-forming linker connects one amino acid to another amino acid within the peptidomimetic macrocycle. For example, a peptidomimetic macrocycle comprises at least two macrocycle-forming linkers wherein wherein the first of said at least two macrocycle-forming linkers connects a first amino acid to a second amino acid, and the second of said at least two macrocycle-forming linkers connects a third amino acid to a fourth amino acid. In some embodiments, the peptidomimetic macrocycle comprises exactly two macrocycle-forming linkers. In other embodiments, the peptidomimetic macrocycle comprises exactly one macrocycle-forming linker.

[0007] Macrocycle-forming linkers connect any two amino acids which can be crosslinked without impairing the activity of the peptidomimetic macrocycle. In some embodiments, a macrocycle-forming linker connects one of the following pairs of amino acids (numbered with reference to any sequences aligned to GHRH 1-29): 4 and 8; 5 and 12; 8 and 12; 8 and 15; 9 and 16; 12 and

16; 12 and 19; 15 and 22; 18 and 25; 21 and 25; 21 and 28; 22 and 29; 25 and 29. For example, a macrocycle-forming linkers connects of the following pairs of amino acids: 4 and 8; 5 and 12; 12 and 19; 15 and 22; 18 and 25; 21 and 25; 21 and 28. In some embodiments, a first macrocycle-forming linker connects amino acid pairs 4 and 8; 5 and 12; 8 and 12; 8 and 15; 9 and 16; 12 and 16; or 12 and 19; and a second macrocycle-forming linker connects amino acid pairs 15 and 22; 18 and 25; 21 and 25; 21 and 28; 22 and 29; or 25 and 29. For example, the first macrocycle-forming linker connects amino acid pairs 4 and 8; 5 and 12; or 12 and 19; and the second macrocycle-forming linker connects amino acid pairs 15 and 22; 18 and 25; 21 and 25; or 21 and 28. In some embodiments, the first macrocycle-forming linker connects amino acid pairs 4 and 8 and the second macrocycle-forming linker connects amino acid pairs 21 and 25.

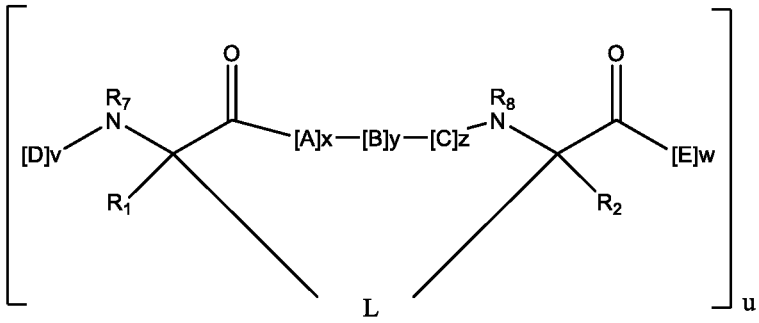
[0008] In some embodiments, a peptidomimetic macrocycle comprises an amino acid sequence which is at least about 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, or 99% identical to GHRH 1-44, GHRH 1-29 and/or to an amino acid sequence chosen from the group consisting of the amino acid sequences in Table 1, 2 or 4, and further comprises a macrocycle-forming linker connecting a first amino acid to a second amino acid, wherein the first and second amino acids are selected from the following pairs of amino acids: 4 and 8; 5 and 12; 8 and 12; 8 and 15; 9 and 16; 12 and 16; 12 and 19; 15 and 22; 18 and 25; 21 and 25; 21 and 28; 22 and 29. For example, the macrocycle-forming linker connects amino acids 12 and 19.

[0009] In some embodiments, a peptidomimetic macrocycle comprises a sequence chosen from the group consisting of the amino acid sequences in Tables 1, 2 or 4, or the amino acid sequence of the peptidomimetic macrocycle is chosen from the group consisting of the amino acid sequences in Tables 1, 2 or 4.

[0010] In some embodiments, the peptidomimetic macrocycle comprises a helix, such as an α-helix or a 3_{10} helix. In other embodiments, the peptidomimetic macrocycle comprises an α,α-disubstituted amino acid. For example, at least one amino acid, or each amino acid, connected by the macrocycle-forming linker is an α,α-disubstituted amino acid.

[0011] In some embodiments, a peptidomimetic macrocycle of the invention comprises a crosslinker linking the α-positions of at least two amino acids.

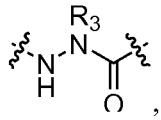
[0012] In some embodiments, the peptidomimetic macrocycle has the formula:



Formula I Formula (I)

wherein:

each A, C, D, and E is independently an amino acid;

B is an amino acid,  , [-NH-L_3-CO-], [-NH-L_3-SO_2-], or [-NH-L_3-];

R_1 and R_2 are independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–;

R_3 is hydrogen, alkyl, alkenyl, alkynyl, arylalkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, cycloalkylalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

L is a macrocycle-forming linker of the formula $–L_1–L_2–$;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker L, form the amino acid sequence of the peptidomimetic macrocycle which is at least about 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, or 99% identical to GHRH 1-44, GHRH 1-29 and/or to an amino acid sequence chosen from the group consisting of the amino acid sequences in Table 1, 2 or 4;

L_1 and L_2 are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4-K-R_4-]_n$, each being optionally substituted with R_5;

each R_4 is alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

each R_5 is independently halogen, alkyl, $-OR_6$, $-N(R_6)_2$, $-SR_6$, $-SOR_6$, $-SO_2R_6$, $-CO_2R_6$, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent;

R_7 is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with a D residue;

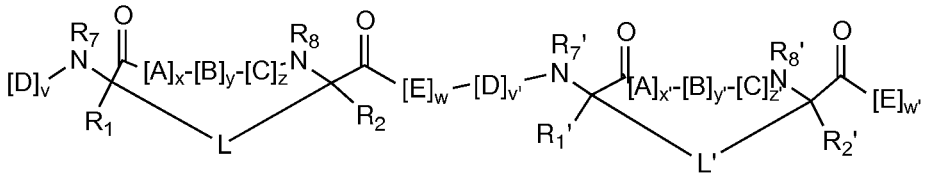
R_8 is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with an E residue;

v and w are independently integers from 1-1000, for example 1-500, 1-200, 1-100, 1-50, 1-40, 1-25, 1-20, 1 to 15, or 1 to 10;

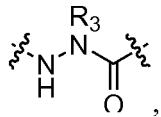
u, x, y and z are independently integers from 0-10, for example u is 1, 2, or 3; and

n is an integer from 1-5. For example, u is 2. In some embodiments, the sum of x+y+z is 2, 3 or 6, for example 3 or 6.

[0013] In some embodiments, the peptidomimetic macrocycle of Formula (I) has the Formula:



wherein each A, C, D, and E is independently an amino acid;

B is an amino acid,  , [-NH-L_3-CO-], [-NH-L_3-SO_2-], or [-NH-L_3-];

L' is a macrocycle-forming linker of the formula –L_1'–L_2'–;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linkers L and L', form the amino acid sequence of the peptidomimetic macrocycle;

R_1' and R_2' are independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–;

L_1' and L_2' are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or [-R_4-K-R_4-]$_n$, each being optionally substituted with R_5;

each K is independently O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

R_7' is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with a D residue;

R_8' is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with an E residue;

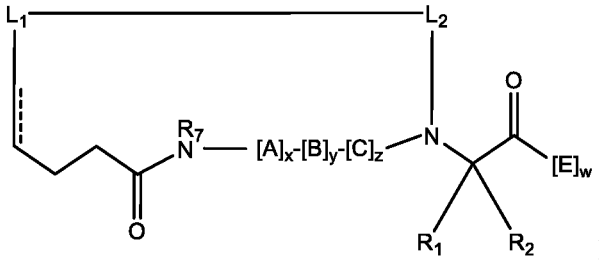
v' and w' are independently integers from 1-1000, for example 1-500, 1-200, 1-100, 1-50, 1-40, 1-25, 1-20, 1 to 15, or 1 to 10;

x', y' and z' are independently integers from 0-10; and

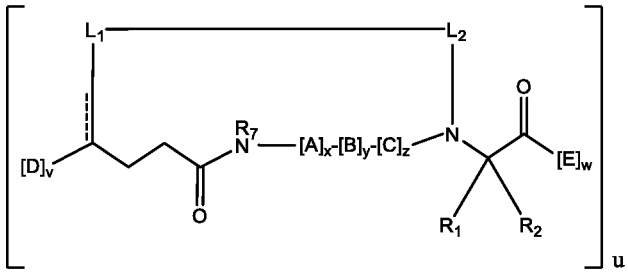
n is an integer from 1-5. In some embodiments, the sum of x'+y'+z' is 2, 3 or 6, for example 3 or 6.

[0014] In some embodiments of any of the peptidomimetic macrocycles described herein, each K is O, S, SO, SO_2, CO, or CO_2.

[0015] In other embodiments, the peptidomimetic macrocycle may comprise a crosslinker linking a backbone amino group of a first amino acid to a second amino acid within the peptidomimetic macrocycle. For example, the invention provides peptidomimetic macrocycles of the Formula (II) or (IIa):



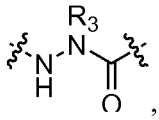
Formula (II)



Formula (IIa)

wherein:

each A, C, D, and E is independently an amino acid;

B is an amino acid,  , [-NH-L_3-CO-], [-NH-L_3-SO_2-], or [-NH-L_3-];

R_1 and R_2 are independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–, or part of a cyclic structure with an E residue;

R_3 is hydrogen, alkyl, alkenyl, alkynyl, arylalkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, cycloalkylalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

L_1 and L_2 are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4-K-R_4-]_n$, each being optionally substituted with R_5;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker -L_1-L_2-, form the amino acid sequence of the peptidomimetic macrocycle which is at least about 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, or 99% identical to GHRH 1-44, GHRH 1-29 and/or to an amino acid sequence chosen from the group consisting of the amino acid sequences in Table 1, 2 or 4;

each R_4 is alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

each R_5 is independently halogen, alkyl, -OR_6, -$N(R_6)_2$, -SR_6, -SOR_6, -SO_2R_6, -CO_2R_6, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent;

R_7 is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

v and w are independently integers from 1-1000, for example 1-500, 1-200, 1-100, 1-50, 1-40, 1-25, 1-20, 1 to 15, or 1 to 10;

u, x, y and z are independently integers from 0-10, for example u is 1-3; and

n is an integer from 1-5.

[0016] Also provided herein is a peptidomimetic macrocycle comprising an amino acid sequence of Formula:

X1-X2-X3-X4-X5-X6-X7-X8-X9-X10-X11-X12-X13-X14-X15-X16-X17-X18-X19-X20-X21-X22-X23-X24-X25-X26-X27-X28-X29 (SEQ ID NO: 1)

wherein:

X1 is Tyr or His;

X2 is Ala, D-Ala, or Val;

X3 is Asp;

X4 is Ala or a crosslinked amino acid;

X5 is Ile;

X6 is Phe;

X7 is Thr;

X8 is Gln, Asn, or a crosslinked amino acid;

X9 is Ser or a crosslinked amino acid;

X10 is Tyr;

X11 is Arg, Ala or Gln;

X12 is Lys, Ala, Gln or a crosslinked amino acid;

X13 is Val or Ile;

X14 is Leu;

X15 is Gly, Ala or a crosslinked amino acid;

X16 is Gln, Glu or a crosslinked amino acid;

X17 is Leu;

X18 is Ser, Tyr or a crosslinked amino acid;

X19 is Ala or a crosslinked amino acid;

X20 is Arg or Gln;

X21 is Lys, Gln or a crosslinked amino acid;

X22 is Leu, Ala, or a crosslinked amino acid;

X23 is Leu;

X24 is Gln, Glu or His;

X25 is Asp, Glu or a crosslinked amino acid;

X26 is Ile;

X27 is Met, Ile, Leu or Nle;

X28 is Ser or a crosslinked amino acid;

X29 is Arg, Ala, Gln or a crosslinked amino acid;

wherein the peptidomimetic macrocycle comprises at least one macrocycle-forming linker connecting at least one pair of amino acids selected from X1-X29;

L is a macrocycle-forming linker of the formula $–L_1–L_2–$;

L_1 and L_2 are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4-K-R_4-]_n$, each being optionally substituted with R_5;

each R_4 is alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is O, S, SO, SO_2, CO, or CO_2;

each R_5 is independently halogen, alkyl, $-OR_6$, $-N(R_6)_2$, $-SR_6$, $-SOR_6$, $-SO_2R_6$, $-CO_2R_6$, a fluorescent moiety, a radioisotope or a therapeutic agent; and

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent.

[0017] For example, the polypeptide comprises at least one, or at least two, macrocycle-forming linkers which connect one of the following pairs of amino acids: X4 and X8; X5 and X12; X8 and X12; X8 and X15; X9 and X16; X12 and X16; X12 and X19; X15 and X22; X18 and X25; X21 and X25; X21 and X28; X22 and X29; X25 and X29. For example, each macrocycle-forming linker connects one of the following pairs of amino acids: X4 and X8; X5 and X12; X12 and X19; X15 and X22; X18 and X25; X21 and X25; X21 and X28.

[0018] In some embodiments, peptidomimetic macrocycles comprise a macrocycle-forming linker of Formula $–L_1-L_2-$, wherein L_1 and L_2 are independently alkylene, alkenylene or alkynylene. For example, L_1 and L_2 are independently C_3-C_{10} alkylene or alkenylene, or C_3-C_6 alkylene or alkenylene.

[0019] In some embodiments, R_1 and R_2 are independently H or alkyl, for example methyl.

[0020] Additionally, the invention provides a method of increasing the circulating level of growth hormone (GH) in a subject, a method of increasing lean muscle mass in a subject, and a method of reducing adipose tissue (such as abdominal adipose tissue) in a subject comprising administering to the subject a peptidomimetic macrocycle of the invention. For example, subjects suffering from obesity, including abdominal obesity, are treated using a peptidomimetic macrocycle of the invention. The invention also provides a method of treating muscle wasting diseases that include anorexias, cachexias (such as cancer cachexia, chronic heart failure cachexia, chronic obstructive pulmonary disease cachexia, rheumatoid arthritis cachexia) and sarcopenias, a method of treating lipodystrophies that include HIV lipodystrophy, a method of treating growth hormone disorders that include adult and pediatric growth hormone deficiencies,

or a method of treating gastroparesis or short bowel syndrome. Pediatric growth hormone deficiency may be, for example, linked with or associated to idiopathic short stature, SGA (infant small for gestational age), chronic kidney disease, Prader-Willi syndrome Turner syndrome, short stature homeobox (SHOX) gene deficiency, or primary IGF-1 deficiency. The invention also provides a method of treating muscle wasting diseases, lipodystrophies, growth hormone disorders or gastroparesis/short bowel syndrome in a subject by administering an agonist of the GHRH receptor, such as an analog of GHRH, wherein the agonist is administered no more frequently than once daily, no more frequently than every other day, no more frequently than twice weekly, no more frequently than weekly, or no more frequently than every other week. The invention also provides a method of increasing the circulating level of growth hormone (GH) in a subject by administering an agonist of the GHRH receptor, such as an analog of GHRH, wherein the agonist is administered no more frequently than once daily, no more frequently than every other day, no more frequently than twice weekly, no more frequently than weekly, or no more frequently than every other week.

INCORPORATION BY REFERENCE

[0021] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings of which:

[0023] **FIGURES 1A and 1B** show improved stabilities to trypsin proteolysis of the peptidomimetic macrocycles of the invention.

[0024] **FIGURE 2** shows improved serum stabilities of the peptidomimetic macrocycles of the invention.

[0025] **FIGURES 3 and 3a** show GHRH receptor agonist activities measured by cAMP release and trypsin half-lives of the peptidomimetic macrocycles of the invention. For cAMP values, "+" represents values greater than 50 nM; "++" represents values between 10-50 nM; "+++" represents values between 1-10 nM; "++++" represents values lower than 1 nM. For trypsin half-lives, "+" represents values lower than 50 min.; "++" represents values between 50-100 min.; "+++" represents values between 100-200 min.; "++++" represents values greater than 200 min.; and "NT" signifies "not tested". Figure 3 discloses SEQ ID NOS 89-131, respectively, in order of appearance. Figure 3a discloses SEQ ID NOS 132-137, respectively, in order of appearance.

[0026] **FIGURE 4** shows the result of a plasma PK study performed with peptidomimetic macrocycle SP-1.

[0027] **FIGURE 5** shows the result of a plasma PK study performed with peptidomimetic macrocycle SP-8.

[0028] **FIGURE 6** shows the result of a plasma PK study performed with peptidomimetic macrocycle SP-6.

[0029] **FIGURE 7** shows the result of a plasma PK study performed with peptidomimetic macrocycle SP-21.

[0030] **FIGURE 8** shows the result of a plasma PK study performed with peptidomimetic macrocycle SP-32.

[0031] **FIGURE 9** shows the result of a plasma PK study performed with peptidomimetic macrocycles SP-1, SP-6, SP-8, SP-21, and SP-32.

[0032] **FIGURE 10** shows stimulation of growth hormone production by peptidomimetic macrocycle SP-8.

[0033] **FIGURE 11** shows growth hormone release (AUC) induced by sermorelin in comparison to peptidomimetic macrocycles SP-1, SP-6, SP-8, SP-21, and SP-32.

DETAILED DESCRIPTION OF THE INVENTION

[0034] As used herein, the term "macrocycle" refers to a molecule having a chemical structure including a ring or cycle formed by at least 9 covalently bonded atoms.

[0035] As used herein, the term "peptidomimetic macrocycle" or "crosslinked polypeptide" refers to a compound comprising a plurality of amino acid residues joined by a plurality of peptide bonds and at least one macrocycle-forming linker which forms a macrocycle between a first naturally-occurring or non-naturally-occurring amino acid residue (or analog) and a second naturally-occurring or non-naturally-occurring amino acid residue (or analog) within the same molecule. Peptidomimetic macrocycle include embodiments where the macrocycle-forming linker connects the α carbon of the first amino acid residue (or analog) to the α carbon of the second amino acid residue (or analog). The peptidomimetic macrocycles optionally include one or more non-peptide bonds between one or more amino acid residues and/or amino acid analog residues, and optionally include one or more non-naturally-occurring amino acid residues or amino acid analog residues in addition to any which form the macrocycle. A "corresponding uncrosslinked polypeptide" when referred to in the context of a peptidomimetic macrocycle is understood to relate to a polypeptide of the same length as the macrocycle and comprising the equivalent natural amino acids of the wild-type sequence corresponding to the macrocycle.

[0036] As used herein, the term "stability" refers to the maintenance of a defined secondary structure in solution by a peptidomimetic macrocycle of the invention as measured by circular dichroism, NMR or another biophysical measure, or resistance to proteolytic degradation *in vitro* or *in vivo*. Non-limiting examples of secondary structures contemplated in this invention are α-helices, 3_{10} helices, β-turns, and β-pleated sheets.

[0037] As used herein, the term "helical stability" refers to the maintenance of α helical structure by a peptidomimetic macrocycle of the invention as measured by circular dichroism or NMR. For example, in some embodiments, the peptidomimetic macrocycles of the invention exhibit at least a 1.25, 1.5, 1.75 or 2-fold increase in α-helicity as determined by circular dichroism compared to a corresponding uncrosslinked macrocycle.

[0038] The term "amino acid" refers to a molecule containing both an amino group and a carboxyl group. Suitable amino acids include, without limitation, both the D-and L-isomers of the naturally-occurring amino acids, as well as non-naturally occurring amino acids prepared by organic synthesis or other metabolic routes. The term amino acid, as used herein, includes without limitation, α-amino acids, natural amino acids, non-natural amino acids, and amino acid analogs.

[0039] The term "α-amino acid" refers to a molecule containing both an amino group and a carboxyl group bound to a carbon which is designated the α-carbon.

[0040] The term "β-amino acid" refers to a molecule containing both an amino group and a carboxyl group in a β configuration.

[0041] The term "naturally occurring amino acid" refers to any one of the twenty amino acids commonly found in peptides synthesized in nature, and known by the one letter abbreviations A, R, N, C, D, Q, E, G, H, I, L, K, M, F, P, S, T, W, Y and V.

[0042] The following table shows a summary of the properties of natural amino acids:

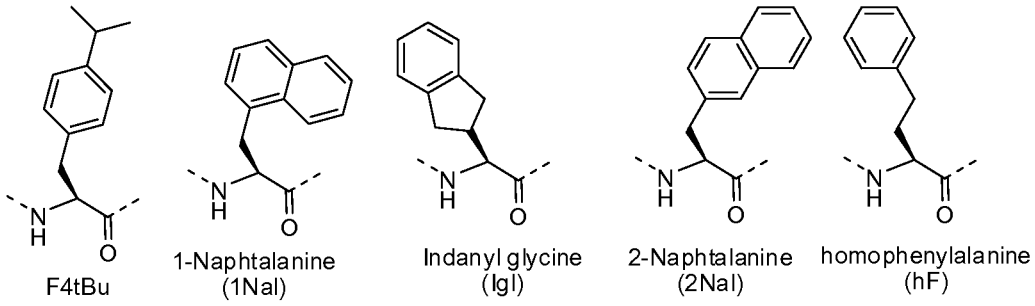
Amino Acid	3-Letter Code	1-Letter Code	Side-chain Polarity	Side-chain charge (pH 7.4)	Hydropathy Index
Alanine	Ala	A	nonpolar	neutral	1.8
Arginine	Arg	R	polar	positive	−4.5
Asparagine	Asn	N	polar	neutral	−3.5
Aspartic acid	Asp	D	polar	negative	−3.5
Cysteine	Cys	C	polar	neutral	2.5
Glutamic acid	Glu	E	polar	negative	−3.5
Glutamine	Gln	Q	polar	neutral	−3.5
Glycine	Gly	G	nonpolar	neutral	−0.4
Histidine	His	H	polar	positive(10%) neutral(90%)	−3.2
Isoleucine	Ile	I	nonpolar	neutral	4.5
Leucine	Leu	L	nonpolar	neutral	3.8
Lysine	Lys	K	polar	positive	−3.9
Methionine	Met	M	nonpolar	neutral	1.9

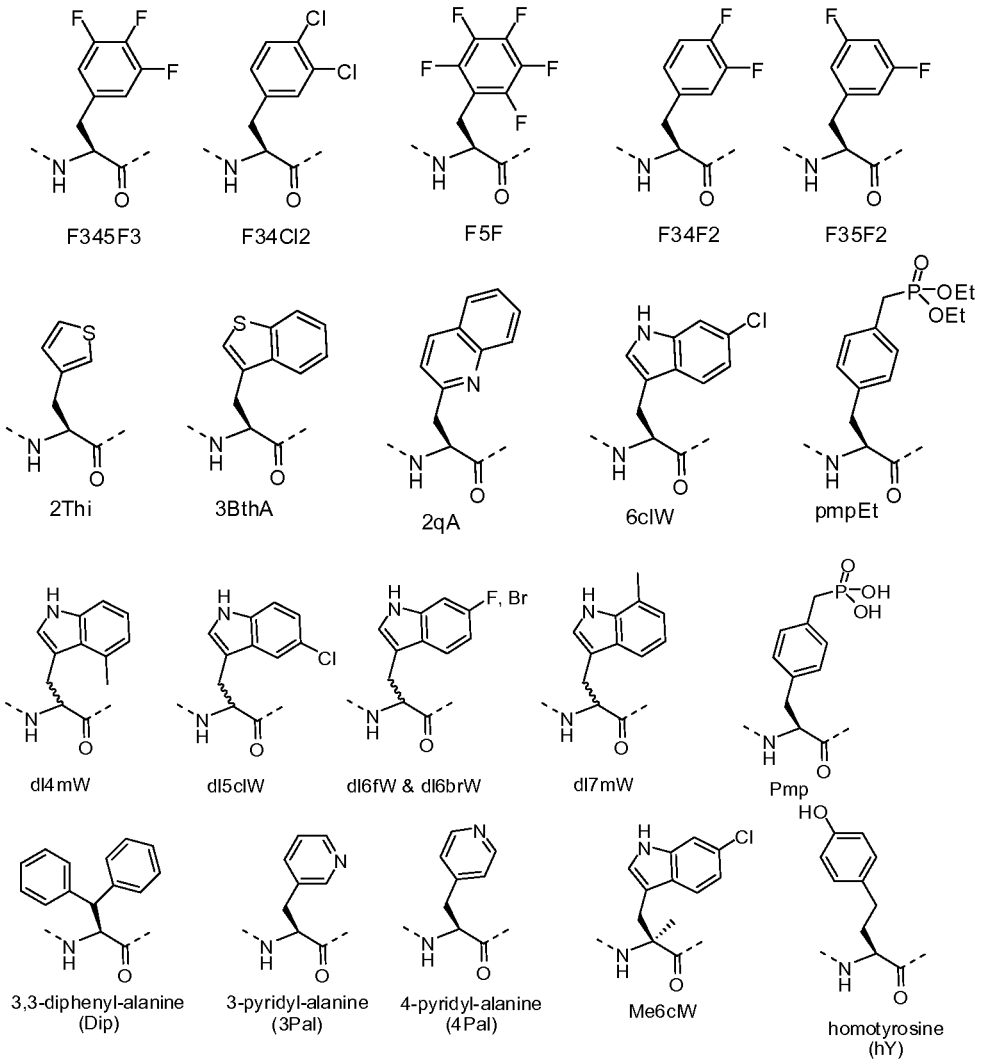
Phenylalanine	Phe	F	nonpolar	neutral	2.8
Proline	Pro	P	nonpolar	neutral	−1.6
Serine	Ser	S	polar	neutral	−0.8
Threonine	Thr	T	polar	neutral	−0.7
Tryptophan	Trp	W	nonpolar	neutral	−0.9
Tyrosine	Tyr	Y	polar	neutral	−1.3
Valine	Val	V	nonpolar	neutral	4.2

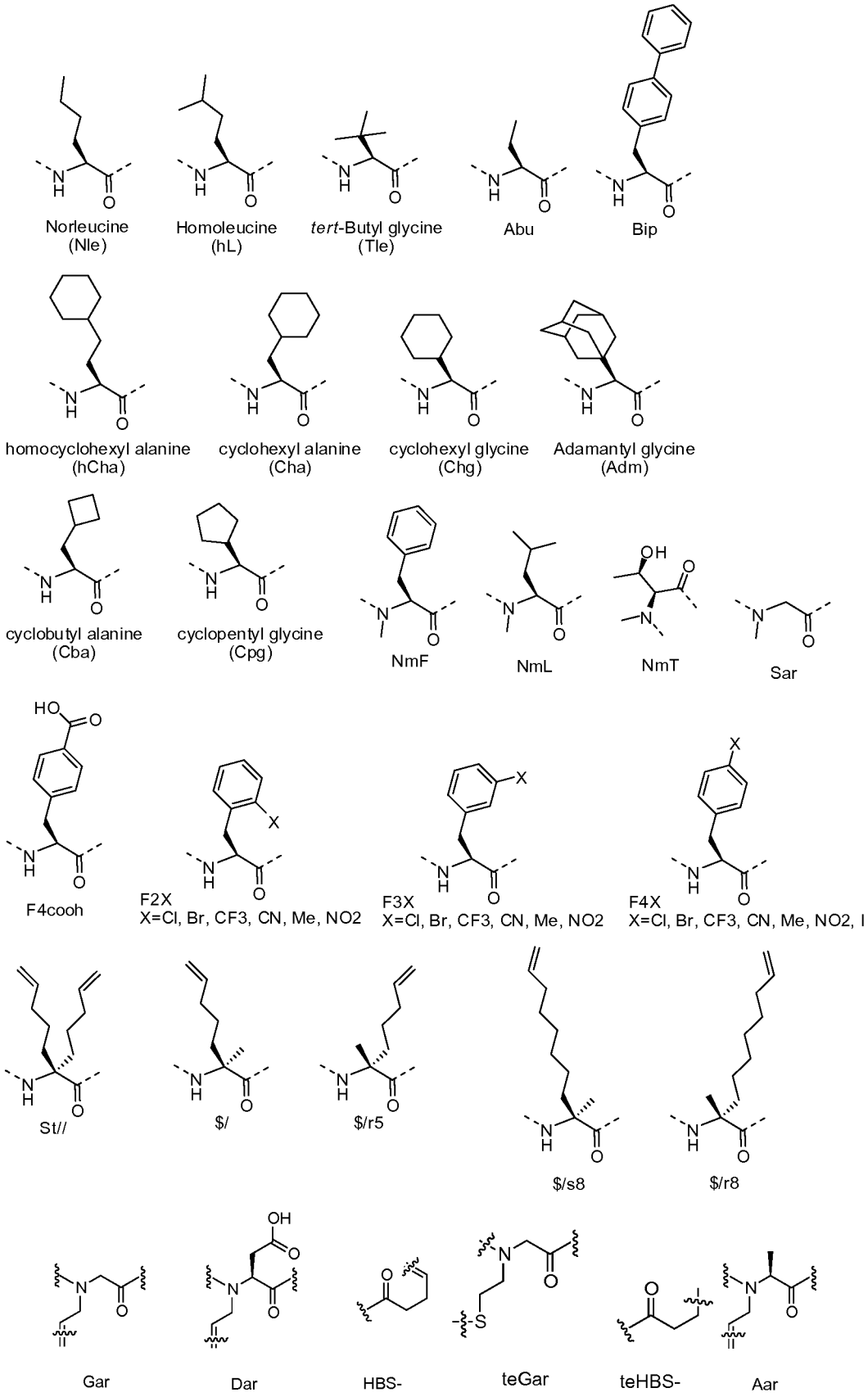
[0043] "Hydrophobic amino acids" include small hydrophobic amino acids and large hydrophobic amino acids. "Small hydrophobic amino acid" are glycine, alanine, proline, and analogs thereof. "Large hydrophobic amino acids" are valine, leucine, isoleucine, phenylalanine, methionine, tryptophan, and analogs thereof. "Polar amino acids" are serine, threonine, asparagine, glutamine, cysteine, tyrosine, and analogs thereof. "Charged amino acids" are lysine, arginine, histidine, aspartate, glutamate, and analogs thereof.

[0044] The term "amino acid analog" refers to a molecule which is structurally similar to an amino acid and which can be substituted for an amino acid in the formation of a peptidomimetic macrocycle. Amino acid analogs include, without limitation, β-amino acids and amino acids where the amino or carboxy group is substituted by a similarly reactive group (*e.g.*, substitution of the primary amine with a secondary or tertiary amine, or substitution of the carboxy group with an ester).

[0045] The term "non-natural amino acid" refers to an amino acid which is not one of the the twenty amino acids commonly found in peptides synthesized in nature, and known by the one letter abbreviations A, R, N, C, D, Q, E, G, H, I, L, K, M, F, P, S, T, W, Y and V. Non-natural amino acids or amino acid analogs include, without limitation, structures according to the following:




F345F3
F34Cl2
F5F
F34F2
F35F2
2Thi
3BthA
2qA
6clW
pmpEt
dl4mW
dl5clW
dl6fW & dl6brW
dl7mW
Pmp
3,3-diphenyl-alanine
(Dip)
3-pyridyl-alanine
(3Pal)
4-pyridyl-alanine
(4Pal)
Me6clW
homotyrosine
(hY)
Amf
Aml
Amr
Ams
Amw
Ac3c
Ac5c
Ac6c
Aib



[0046] Amino acid analogs include β-amino acid analogs. Examples of β-amino acid analogs include, but are not limited to, the following: cyclic β-amino acid analogs; β – alanine; (R) - β –

phenylalanine; (R) - 1,2,3,4 - tetrahydro - isoquinoline - 3 - acetic acid; (R) - 3 - amino - 4 - (1 - naphthyl) - butyric acid; (R) - 3 - amino - 4 - (2,4 - dichlorophenyl)butyric acid; (R) - 3 - amino - 4 - (2 - chlorophenyl) - butyric acid; (R) - 3 - amino - 4 - (2 - cyanophenyl) - butyric acid; (R) - 3 - amino - 4 - (2 - fluorophenyl) - butyric acid; (R) - 3 - amino - 4 - (2 - furyl) - butyric acid; (R) - 3 - amino - 4 - (2 - methylphenyl) - butyric acid; (R) - 3 - amino - 4 - (2 - naphthyl) - butyric acid; (R) - 3 - amino - 4 - (2 - thienyl) - butyric acid; (R) - 3 - amino - 4 - (2 - trifluoromethylphenyl) - butyric acid; (R) - 3 - amino - 4 - (3,4 - dichlorophenyl)butyric acid; (R) - 3 - amino - 4 - (3,4 - difluorophenyl)butyric acid; (R) - 3 - amino - 4 - (3 - benzothienyl) - butyric acid; (R) - 3 - amino - 4 - (3 - chlorophenyl) - butyric acid; (R) - 3 - amino - 4 - (3 - cyanophenyl) - butyric acid; (R) - 3 - amino - 4 - (3 - fluorophenyl) - butyric acid; (R) - 3 - amino - 4 - (3 - methylphenyl) - butyric acid; (R) - 3 - amino - 4 - (3 - pyridyl) - butyric acid; (R) - 3 - amino - 4 - (3 - thienyl) - butyric acid; (R) - 3 - amino - 4 - (3 - trifluoromethylphenyl) - butyric acid; (R) - 3 - amino - 4 - (4 - bromophenyl) - butyric acid; (R) - 3 - amino - 4 - (4 - chlorophenyl) - butyric acid; (R) - 3 - amino - 4 - (4 - cyanophenyl) - butyric acid; (R) - 3 - amino - 4 - (4 - fluorophenyl) - butyric acid; (R) - 3 - amino - 4 - (4 - iodophenyl) - butyric acid; (R) - 3 - amino - 4 - (4 - methylphenyl) - butyric acid; (R) - 3 - amino - 4 - (4 - nitrophenyl) - butyric acid; (R) - 3 - amino - 4 - (4 - pyridyl) - butyric acid; (R) - 3 - amino - 4 - (4 - trifluoromethylphenyl) - butyric acid; (R) - 3 - amino - 4 - pentafluoro - phenylbutyric acid; (R) - 3 - amino - 5 - hexenoic acid; (R) - 3 - amino - 5 - hexynoic acid; (R) - 3 - amino - 5 - phenylpentanoic acid; (R) - 3 - amino - 6 - phenyl - 5 - hexenoic acid; (S) - 1,2,3,4 - tetrahydro - isoquinoline - 3 - acetic acid; (S) - 3 - amino - 4 - (1 - naphthyl) - butyric acid; (S) - 3 - amino - 4 - (2,4 - dichlorophenyl)butyric acid; (S) - 3 - amino - 4 - (2 - chlorophenyl) - butyric acid; (S) - 3 - amino - 4 - (2 - cyanophenyl) - butyric acid; (S) - 3 - amino - 4 - (2 - fluorophenyl) - butyric acid; (S) - 3 - amino - 4 - (2 - furyl) - butyric acid; (S) - 3 - amino - 4 - (2 - methylphenyl) - butyric acid; (S) - 3 - amino - 4 - (2 - naphthyl) - butyric acid; (S) - 3 - amino - 4 - (2 - thienyl) - butyric acid; (S) - 3 - amino - 4 - (2 - trifluoromethylphenyl) - butyric acid;

(S) - 3 - amino - 4 - (3,4 - dichlorophenyl)butyric acid; (S) - 3 - amino - 4 - (3,4 - difluorophenyl)butyric acid; (S) - 3 - amino - 4 - (3 - benzothienyl) - butyric acid; (S) - 3 - amino - 4 - (3 - chlorophenyl) - butyric acid; (S) - 3 - amino - 4 - (3 - cyanophenyl) - butyric acid; (S) - 3 - amino - 4 - (3 - fluorophenyl) - butyric acid; (S) - 3 - amino - 4 - (3 - methylphenyl) - butyric acid; (S) - 3 - amino - 4 - (3 - pyridyl) - butyric acid; (S) - 3 - amino - 4 - (3 - thienyl) - butyric acid; (S) - 3 - amino - 4 - (3 - trifluoromethylphenyl) - butyric acid; (S) - 3 - amino - 4 - (4 - bromophenyl) - butyric acid; (S) - 3 - amino - 4 - (4 - chlorophenyl) - butyric acid; (S) - 3 - amino - 4 - (4 - cyanophenyl) - butyric acid; (S) - 3 - amino - 4 - (4 - fluorophenyl) - butyric acid; (S) - 3 - amino - 4 - (4 - iodophenyl) - butyric acid; (S) - 3 - amino - 4 - (4 - methylphenyl) - butyric acid; (S) - 3 - amino - 4 - (4 - nitrophenyl) - butyric acid; (S) - 3 - amino - 4 - (4 - pyridyl) - butyric acid; (S) - 3 - amino - 4 - (4 - trifluoromethylphenyl) - butyric acid; (S) - 3 - amino - 4 -

pentafluoro - phenylbutyric acid; (S) - 3 - amino - 5 - hexenoic acid; (S) - 3 - amino - 5 - hexynoic acid; (S) - 3 - amino - 5 - phenylpentanoic acid; (S) - 3 - amino - 6 - phenyl - 5 - hexenoic acid; 1,2,5,6 - tetrahydropyridine - 3 - carboxylic acid; 1,2,5,6 - tetrahydropyridine - 4 - carboxylic acid; 3 - amino - 3 - (2 - chlorophenyl) - propionic acid; 3 - amino - 3 - (2 - thienyl) - propionic acid; 3 - amino - 3 - (3 - bromophenyl) - propionic acid; 3 - amino - 3 - (4 - chlorophenyl) - propionic acid; 3 - amino - 3 - (4 - methoxyphenyl) - propionic acid; 3 - amino - 4,4,4 - trifluoro - butyric acid; 3 - aminoadipic acid; D- β – phenylalanine; β – leucine; L - β – homoalanine; L - β - homoaspartic acid γ - benzyl ester; L - β - homoglutamic acid δ - benzyl ester; L - β – homoisoleucine; L - β – homoleucine; L - β – homomethionine; L - β – homophenylalanine; L - β – homoproline; L - β – homotryptophan; L - β – homovaline; L - Nω - benzyloxycarbonyl - β – homolysine; Nω - L - β – homoarginine; O - benzyl - L - β – homohydroxyproline; O - benzyl - L - β – homoserine; O - benzyl - L - β – homothreonine; O - benzyl - L - β – homotyrosine; γ - trityl - L - β – homoasparagine; (R) - β – phenylalanine; L - β - homoaspartic acid γ - t - butyl ester; L - β - homoglutamic acid δ - t - butyl ester; L - Nω - β – homolysine; Nδ - trityl - L - β – homoglutamine; Nω - 2,2,4,6,7 - pentamethyl - dihydrobenzofuran - 5 - sulfonyl - L - β – homoarginine; O - t - butyl - L - β - homohydroxy – proline; O - t - butyl - L - β – homoserine; O - t - butyl - L - β – homothreonine; O - t - butyl - L - β – homotyrosine; 2- aminocyclopentane carboxylic acid; and 2-aminocyclohexane carboxylic acid.

[0047] Amino acid analogs include analogs of alanine, valine, glycine or leucine. Examples of amino acid analogs of alanine, valine, glycine, and leucine include, but are not limited to, the following: α – methoxyglycine; α - allyl - L – alanine; α - aminoisobutyric acid; α - methyl – leucine; β - (1 - naphthyl) - D – alanine; β - (1 - naphthyl) - L – alanine; β - (2 - naphthyl) - D – alanine; β - (2 - naphthyl) - L – alanine; β - (2 - pyridyl) - D – alanine; β - (2 - pyridyl) - L – alanine; β - (2 - thienyl) - D – alanine; β - (2 - thienyl) - L – alanine; β - (3 - benzothienyl) - D – alanine; β - (3 - benzothienyl) - L – alanine; β - (3 - pyridyl) - D – alanine; β - (3 - pyridyl) - L – alanine; β - (4 - pyridyl) - D – alanine; β - (4 - pyridyl) - L – alanine; β - chloro - L – alanine; β - cyano - L – alanin; β - cyclohexyl - D – alanine; β - cyclohexyl - L – alanine; β - cyclopenten - 1 - yl - alanine; β - cyclopentyl – alanine; β - cyclopropyl - L - Ala – OH • dicyclohexylammonium salt; β - t - butyl - D – alanine; β - t - butyl - L – alanine; γ - aminobutyric acid; L - α,β - diaminopropionic acid; 2,4 - dinitro – phenylglycine; 2,5 - dihydro - D – phenylglycine; 2 - amino - 4,4,4 - trifluorobutyric acid; 2 - fluoro – phenylglycine; 3 - amino - 4,4,4 - trifluoro - butyric acid; 3 - fluoro – valine; 4,4,4 - trifluoro – valine; 4,5 - dehydro - L - leu – OH • dicyclohexylammonium salt; 4 - fluoro - D – phenylglycine; 4 - fluoro - L – phenylglycine; 4 - hydroxy - D – phenylglycine; 5,5,5 - trifluoro – leucine; 6 - aminohexanoic acid; cyclopentyl - D - Gly – OH • dicyclohexylammonium salt; cyclopentyl - Gly – OH • dicyclohexylammonium salt; D - α,β - diaminopropionic acid; D - α - aminobutyric acid; D - α - t – butylglycine; D - (2 -

thienyl)glycine; D - (3 - thienyl)glycine; D - 2 - aminocaproic acid; D - 2 – indanylglycine; D – allylglycine•dicyclohexylammonium salt; D – cyclohexylglycine; D – norvaline; D – phenylglycine; β - aminobutyric acid; β - aminoisobutyric acid; (2 - bromophenyl)glycine; (2 - methoxyphenyl)glycine; (2 - methylphenyl)glycine; (2 - thiazoyl)glycine; (2 - thienyl)glycine; 2 - amino - 3 - (dimethylamino) - propionic acid; L - α,β - diaminopropionic acid; L - α - aminobutyric acid; L - α - t – butylglycine; L - (3 - thienyl)glycine; L - 2 - amino - 3 - (dimethylamino) - propionic acid; L - 2 - aminocaproic acid dicyclohexyl - ammonium salt; L - 2 – indanylglycine; L - allylglycine•dicyclohexyl ammonium salt; L – cyclohexylglycine; L – phenylglycine; L – propargylglycine; L – norvaline; N - α - aminomethyl - L – alanine; D - α,γ - diaminobutyric acid; L - α,γ - diaminobutyric acid; β - cyclopropyl - L – alanine; (N - β - (2,4 - dinitrophenyl)) - L - α,β - diaminopropionic acid; (N - β - 1 - (4,4 - dimethyl - 2,6 - dioxocyclohex - 1 - ylidene)ethyl) - D - α,β - diaminopropionic acid; (N - β - 1 - (4,4 - dimethyl - 2,6 - dioxocyclohex - 1 - ylidene)ethyl) - L - α,β - diaminopropionic acid; (N - β - 4 - methyltrityl) - L - α,β - diaminopropionic acid; (N - β - allyloxycarbonyl) - L - α,β - diaminopropionic acid; (N - γ - 1 - (4,4 - dimethyl - 2,6 - dioxocyclohex - 1 - ylidene)ethyl) - D - α,γ - diaminobutyric acid; (N - γ - 1 - (4,4 - dimethyl - 2,6 - dioxocyclohex - 1 - ylidene)ethyl) - L - α,γ - diaminobutyric acid; (N - γ - 4 - methyltrityl) - D - α,γ - diaminobutyric acid; (N - γ - 4 - methyltrityl) - L - α,γ - diaminobutyric acid; (N - γ - allyloxycarbonyl) - L - α,γ - diaminobutyric acid; D - α,γ - diaminobutyric acid; 4,5 - dehydro - L – leucine; cyclopentyl - D - Gly – OH; cyclopentyl - Gly – OH; D – allylglycine; D – homocyclohexylalanine; L - 1 – pyrenylalanine; L - 2 - aminocaproic acid; L – allylglycine; L – homocyclohexylalanine; and N - (2 - hydroxy - 4 - methoxy - Bzl) - Gly – OH.

[0048] Amino acid analogs include analogs of arginine or lysine. Examples of amino acid analogs of arginine and lysine include, but are not limited to, the following: citrulline; L - 2 - amino - 3 - guanidinopropionic acid; L - 2 - amino - 3 - ureidopropionic acid; L – citrulline; $Lys(Me)_2$ – OH; $Lys(N_3)$ – OH; Nδ - benzyloxycarbonyl - L – ornithine; Nω - nitro - D – arginine; Nω - nitro - L – arginine; α - methyl – ornithine; 2,6 - diaminoheptanedioic acid; L – ornithine; (Nδ - 1 - (4,4 - dimethyl - 2,6 - dioxo - cyclohex - 1 - ylidene)ethyl) - D – ornithine; (Nδ - 1 - (4,4 - dimethyl - 2,6 - dioxo - cyclohex - 1 - ylidene)ethyl) - L – ornithine; (Nδ - 4 - methyltrityl) - D – ornithine; (Nδ - 4 - methyltrityl) - L – ornithine; D – ornithine; L – ornithine; Arg(Me)(Pbf) – OH; $Arg(Me)_2$ – OH (asymmetrical); Arg(Me)2 - OH (symmetrical); Lys(ivDde) – OH; Lys(Me)2 - OH • HCl; Lys(Me3) - OH chloride; Nω - nitro - D – arginine; and Nω - nitro - L – arginine.

[0049] Amino acid analogs include analogs of aspartic or glutamic acids. Examples of amino acid analogs of aspartic and glutamic acids include, but are not limited to, the following: α - methyl - D - aspartic acid; α - methyl - glutamic acid; α - methyl - L - aspartic acid; γ - methylene - glutamic acid; (N - γ - ethyl) - L – glutamine; [N - α - (4 - aminobenzoyl)] - L - glutamic acid; 2,6 - diaminopimelic acid; L - α - aminosuberic acid; D - 2 - aminoadipic acid; D - α - aminosuberic

acid; α - aminopimelic acid; iminodiacetic acid; L - 2 - aminoadipic acid; threo - β - methyl - aspartic acid; γ - carboxy - D - glutamic acid γ,γ - di - t - butyl ester; γ - carboxy - L - glutamic acid γ,γ - di - t - butyl ester; Glu(OAll) – OH; L - Asu(OtBu) – OH; and pyroglutamic acid.

[0050] Amino acid analogs include analogs of cysteine and methionine. Examples of amino acid analogs of cysteine and methionine include, but are not limited to, Cys(farnesyl) – OH, Cys(farnesyl) – OMe, α - methyl – methionine, Cys(2 - hydroxyethyl) – OH, Cys(3 - aminopropyl) – OH, 2 - amino - 4 - (ethylthio)butyric acid, buthionine, buthioninesulfoximine, ethionine, methionine methylsulfonium chloride, selenomethionine, cysteic acid, [2 - (4 - pyridyl)ethyl] - DL – penicillamine, [2 - (4 - pyridyl)ethyl] - L – cysteine, 4 - methoxybenzyl - D – penicillamine, 4 - methoxybenzyl - L – penicillamine, 4 - methylbenzyl - D - penicillamine, 4 - methylbenzyl - L – penicillamine, benzyl-D-cysteine, benzyl – L – cysteine, benzyl – DL – homocysteine, carbamoyl – L – cysteine, carboxyethyl – L – cysteine, carboxymethyl – L – cysteine, diphenylmethyl – L – cysteine, ethyl – L – cysteine, methyl – L – cysteine, t-butyl – D – cysteine, trityl – L-homocysteine, trityl – D – penicillamine, cystathionine, homocystine, L-homocystine, (2-aminoethyl) – L – cysteine, seleno – L – cystine, cystathionine, Cys(StBu) – OH, and acetamidomethyl - D – penicillamine.

[0051] Amino acid analogs include analogs of phenylalanine and tyrosine. Examples of amino acid analogs of phenylalanine and tyrosine include β - methyl – phenylalanine, β – hydroxyphenylalanine, α - methyl - 3 - methoxy - DL – phenylalanine, α - methyl - D – phenylalanine, α - methyl - L – phenylalanine, 1,2,3,4 - tetrahydroisoquinoline - 3 - carboxylic acid, 2,4 - dichloro – phenylalanine, 2 - (trifluoromethyl) – D -phenylalanine, 2 - (trifluoromethyl) - L – phenylalanine, 2 - bromo - D – phenylalanine, 2 - bromo - L – phenylalanine, 2 - chloro - D – phenylalanine, 2 - chloro - L – phenylalanine, 2 - cyano - D – phenylalanine, 2 - cyano - L – phenylalanine, 2 - fluoro - D – phenylalanine, 2 - fluoro - L – phenylalanine, 2 - methyl - D – phenylalanine, 2 - methyl - L – phenylalanine, 2 - nitro - D – phenylalanine, 2 - nitro - L – phenylalanine, 2;4;5 - trihydroxy – phenylalanine, 3,4,5 - trifluoro - D – phenylalanine, 3,4,5 - trifluoro - L – phenylalanine, 3,4 - dichloro - D – phenylalanine, 3,4 - dichloro - L – phenylalanine, 3,4 - difluoro - D – phenylalanine, 3,4 - difluoro - L – phenylalanine, 3,4 - dihydroxy - L – phenylalanine, 3,4 - dimethoxy - L – phenylalanine, 3,5,3' - triiodo - L – thyronine, 3,5 - diiodo - D – tyrosine, 3,5 - diiodo - L – tyrosine, 3,5 - diiodo - L – thyronine, 3 - (trifluoromethyl) - D – phenylalanine, 3 - (trifluoromethyl) - L – phenylalanine, 3 - amino - L – tyrosine, 3 - bromo - D – phenylalanine, 3 - bromo - L – phenylalanine, 3 – chloro – D – phenylalanine, 3 – chloro – L – phenylalanine, 3 - chloro - L – tyrosine, 3 - cyano - D – phenylalanine, 3 - cyano - L – phenylalanine, 3 - fluoro - D – phenylalanine, 3 - fluoro - L – phenylalanine, 3 - fluoro – tyrosine, 3 - iodo - D – phenylalanine, 3 - iodo - L – phenylalanine, 3 - iodo - L – tyrosine, 3 - methoxy - L – tyrosine, 3 - methyl - D – phenylalanine, 3 - methyl - L – phenylalanine, 3 - nitro - D – phenylalanine, 3 - nitro - L – phenylalanine, 3 - nitro - L – tyrosine,

4 - (trifluoromethyl) - D – phenylalanine, 4 - (trifluoromethyl) - L – phenylalanine, 4 - amino - D – phenylalanine, 4 - amino - L – phenylalanine, 4 - benzoyl - D – phenylalanine, 4 - benzoyl - L – phenylalanine, 4 - bis(2 - chloroethyl)amino - L – phenylalanine, 4 - bromo - D – phenylalanine, 4 - bromo - L – phenylalanine, 4 - chloro - D – phenylalanine, 4 - chloro - L – phenylalanine, 4 - cyano - D – phenylalanine, 4 - cyano - L – phenylalanine, 4 - fluoro - D – phenylalanine, 4 - fluoro - L – phenylalanine, 4 - iodo - D – phenylalanine, 4 - iodo - L – phenylalanine, homophenylalanine, thyroxine, 3,3 – diphenylalanine, thyronine, ethyl-tyrosine, and methyl-tyrosine.

[0052] Amino acid analogs include analogs of proline. Examples of amino acid analogs of proline include, but are not limited to, 3,4-dehydro-proline, 4-fluoro-proline, cis-4-hydroxy-proline, thiazolidine-2-carboxylic acid, and trans-4-fluoro-proline.

[0053] Amino acid analogs include analogs of serine and threonine. Examples of amino acid analogs of serine and threonine include, but are not limited to, 3 - amino - 2 - hydroxy - 5 - methylhexanoic acid, 2 - amino - 3 - hydroxy - 4 - methylpentanoic acid, 2 - amino - 3 - ethoxybutanoic acid, 2 - amino - 3 - methoxybutanoic acid, 4 - amino - 3 - hydroxy - 6 - methylheptanoic acid, 2 - amino - 3 - benzyloxypropionic acid, 2 - amino - 3 - benzyloxypropionic acid, 2 - amino - 3 - ethoxypropionic acid, 4 - amino - 3 - hydroxybutanoic acid, and α–methylserine.

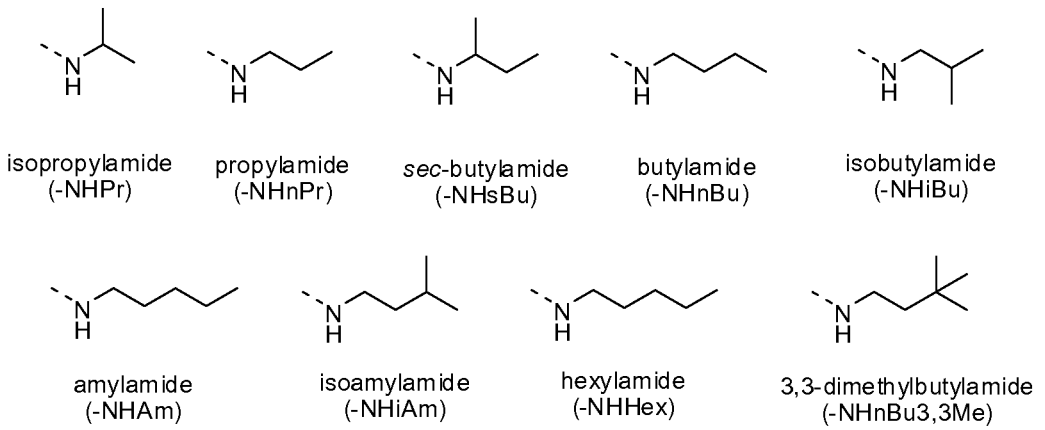
[0054] Amino acid analogs include analogs of tryptophan. Examples of amino acid analogs of tryptophan include, but are not limited to, the following: α - methyl - tryptophan; β - (3 - benzothienyl) - D - alanine; β - (3 - benzothienyl) - L - alanine; 1 - methyl - tryptophan; 4 - methyl - tryptophan; 5 - benzyloxy - tryptophan; 5 - bromo - tryptophan; 5 - chloro - tryptophan; 5 - fluoro - tryptophan; 5 - hydroxy - tryptophan; 5 - hydroxy - L - tryptophan; 5 - methoxy - tryptophan; 5 - methoxy - L - tryptophan; 5 - methyl - tryptophan; 6 - bromo - tryptophan; 6 - chloro - D - tryptophan; 6 - chloro - tryptophan; 6 - fluoro - tryptophan; 6 - methyl - tryptophan; 7 - benzyloxy - tryptophan; 7 - bromo - tryptophan; 7 - methyl - - tryptophan; D - 1,2,3,4 - tetrahydro - norharman - 3 - carboxylic acid; 6 - methoxy - 1,2,3,4 - tetrahydronorharman - 1 - carboxylic acid; 7 - azatryptophan; L - 1,2,3,4 - tetrahydro - norharman - 3 - carboxylic acid; 5 - methoxy - 2 - methyl - tryptophan; and 6 - chloro - L - tryptophan.

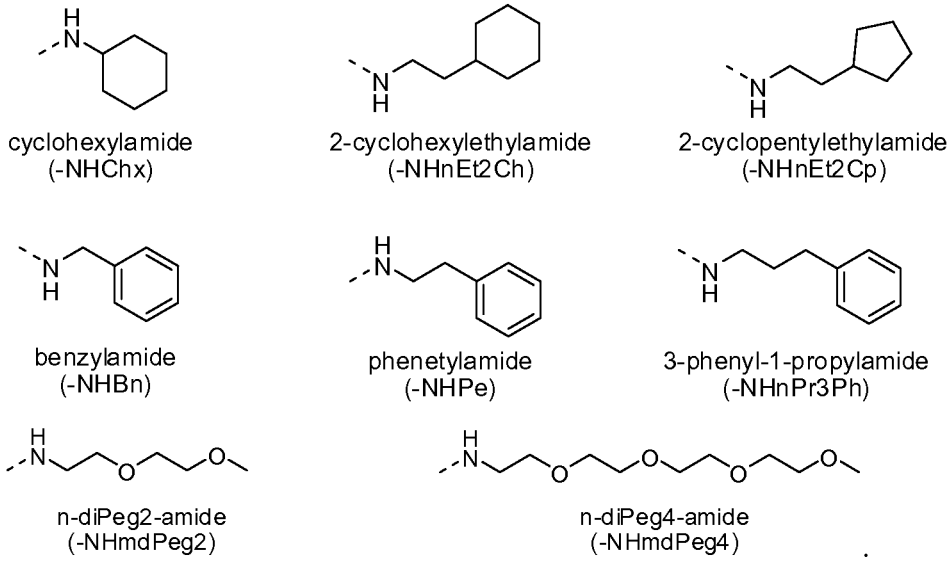
[0055] In some embodiments, amino acid analogs are racemic. In some embodiments, the D isomer of the amino acid analog is used. In some embodiments, the L isomer of the amino acid analog is used. In other embodiments, the amino acid analog comprises chiral centers that are in the R or S configuration. In still other embodiments, the amino group(s) of a β-amino acid analog is substituted with a protecting group, *e.g.*, tert-butyloxycarbonyl (BOC group), 9-fluorenylmethyloxycarbonyl (FMOC), tosyl, and the like. In yet other embodiments, the carboxylic acid functional group of a β-amino acid analog is protected, *e.g.*, as its ester derivative. In some embodiments the salt of the amino acid analog is used.

[0056] A "non-essential" amino acid residue is a residue that can be altered from the wild-type sequence of a polypeptide without abolishing or substantially abolishing its essential biological or biochemical activity (*e.g.*, receptor binding or activation). An "essential" amino acid residue is a residue that, when altered from the wild-type sequence of the polypeptide, results in abolishing or substantially abolishing the polypeptide's essential biological or biochemical activity.

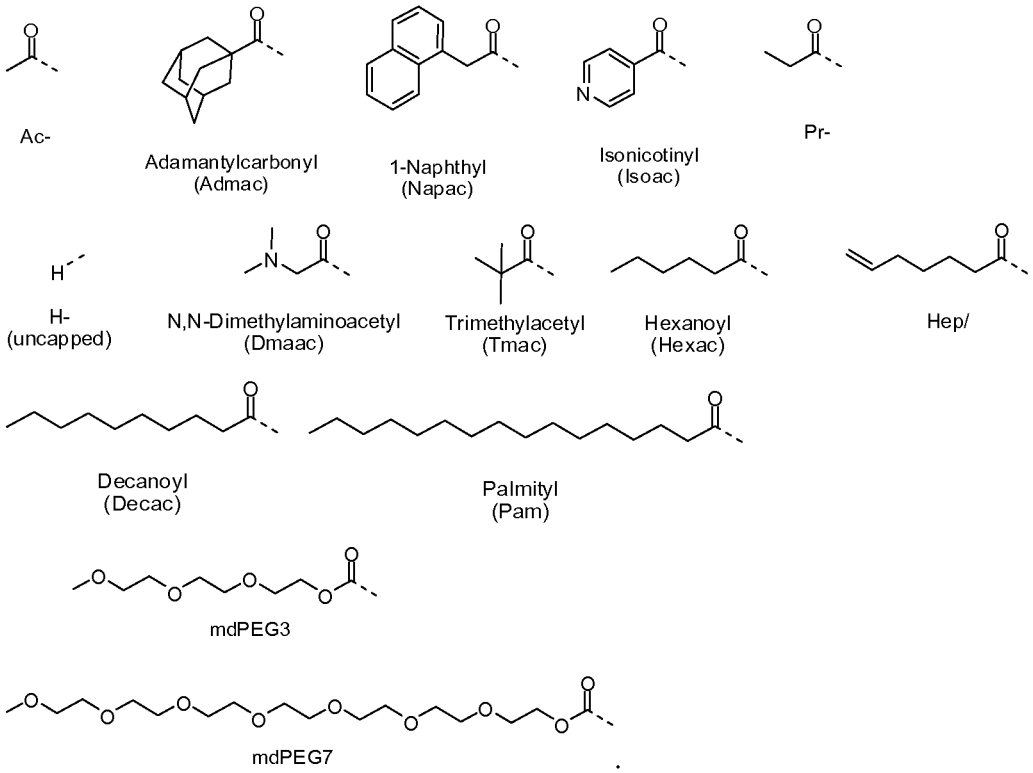
[0057] A "conservative amino acid substitution" is one in which the amino acid residue is replaced with an amino acid residue having a similar side chain. Families of amino acid residues having similar side chains have been defined in the art. These families include amino acids with basic side chains (*e.g.*, K, R, H), acidic side chains (*e.g.*, D, E), uncharged polar side chains (*e.g.*, G, N, Q, S, T, Y, C), nonpolar side chains (*e.g.*, A, V, L, I, P, F, M, W), beta-branched side chains (*e.g.*, T, V, I) and aromatic side chains (*e.g.*, Y, F, W, H). Thus, a predicted nonessential amino acid residue in a polypeptide, for example, is replaced with another amino acid residue from the same side chain family. Other examples of acceptable substitutions are substitutions based on isosteric considerations (e.g. norleucine for methionine) or other properties (e.g. 2-thienylalanine for phenylalanine).

[0058] The term "capping group" refers to the chemical moiety occurring at either the carboxy or amino terminus of the polypeptide chain of the subject peptidomimetic macrocycle. The capping group of a carboxy terminus includes an unmodified carboxylic acid (ie –COOH) or a carboxylic acid with a substituent. For example, the carboxy terminus can be substituted with an amino group to yield a carboxamide at the C-terminus. Various substituents include but are not limited to primary and secondary amines, including pegylated secondary amines. Representative secondary amine capping groups for the C-terminus include:





[0059] The capping group of an amino terminus includes an unmodified amine (ie $-NH_2$) or an amine with a substituent. For example, the amino terminus can be substituted with an acyl group to yield a carboxamide at the N-terminus. Various substituents include but are not limited to substituted acyl groups, including C_1-C_6 carbonyls, C_7-C_{30} carbonyls, and pegylated carbamates. Representative capping groups for the N-terminus include:



[0060] The term "member" as used herein in conjunction with macrocycles or macrocycle-forming linkers refers to the atoms that form or can form the macrocycle, and excludes substituent or side chain atoms. By analogy, cyclodecane, 1,2-difluoro-decane and 1,3-dimethyl cyclodecane are all considered ten-membered macrocycles as the hydrogen or fluoro substituents or methyl side chains do not participate in forming the macrocycle.

[0061] The symbol "  " when used as part of a molecular structure refers to a single bond or a *trans* or *cis* double bond.

[0062] The term "amino acid side chain" refers to a moiety attached to the α-carbon (or another backbone atom) in an amino acid. For example, the amino acid side chain for alanine is methyl, the amino acid side chain for phenylalanine is phenylmethyl, the amino acid side chain for cysteine is thiomethyl, the amino acid side chain for aspartate is carboxymethyl, the amino acid side chain for tyrosine is 4-hydroxyphenylmethyl, etc. Other non-naturally occurring amino acid side chains are also included, for example, those that occur in nature (*e.g.*, an amino acid metabolite) or those that are made synthetically (*e.g.*, an α,α di-substituted amino acid).

[0063] The term "α,α di-substituted amino" acid refers to a molecule or moiety containing both an amino group and a carboxyl group bound to a carbon (the α-carbon) that is attached to two natural or non-natural amino acid side chains.

[0064] The term "polypeptide" encompasses two or more naturally or non-naturally-occurring amino acids joined by a covalent bond (*e.g.*, an amide bond). Polypeptides as described herein include full length proteins (*e.g.*, fully processed proteins) as well as shorter amino acid sequences (*e.g.*, fragments of naturally-occurring proteins or synthetic polypeptide fragments).

[0065] The term "macrocyclization reagent" or "macrocycle-forming reagent" as used herein refers to any reagent which may be used to prepare a peptidomimetic macrocycle of the invention by mediating the reaction between two reactive groups. Reactive groups may be, for example, an azide and alkyne, in which case macrocyclization reagents include, without limitation, Cu reagents such as reagents which provide a reactive Cu(I) species, such as CuBr, CuI or CuOTf, as well as Cu(II) salts such as $Cu(CO_2CH_3)_2$, $CuSO_4$, and $CuCl_2$ that can be converted in situ to an active Cu(I) reagent by the addition of a reducing agent such as ascorbic acid or sodium ascorbate. Macrocyclization reagents may additionally include, for example, Ru reagents known in the art such as $Cp^*RuCl(PPh_3)_2$, $[Cp^*RuCl]_4$ or other Ru reagents which may provide a reactive Ru(II) species. In other cases, the reactive groups are terminal olefins. In such embodiments, the macrocyclization reagents or macrocycle-forming reagents are metathesis catalysts including, but not limited to, stabilized, late transition metal carbene complex catalysts such as Group VIII transition metal carbene catalysts. For example, such catalysts are Ru and Os metal centers having a +2 oxidation state, an electron count of 16 and pentacoordinated. In other examples, catalysts have W or Mo centers. Various catalysts are disclosed in Grubbs et al., "Ring Closing Metathesis and Related Processes in Organic Synthesis" Acc. Chem. Res. 1995, 28, 446-452, and U.S. Pat. No. 5,811,515; U.S. Pat. No. 7,932,397; U.S. Application No. 2011/0065915; U.S. Application No. 2011/0245477; Yu et al., "Synthesis of Macrocyclic Natural Products by Catalyst-Controlled Stereoselective Ring-Closing Metathesis," Nature 2011, 479, 88; and Peryshkov et al., "Z-Selective Olefin Metathesis Reactions Promoted by Tungsten Oxo Alkylidene Complexes," J. Am. Chem. Soc. 2011, 133, 20754. In yet other cases, the reactive

groups are thiol groups. In such embodiments, the macrocyclization reagent is, for example, a linker functionalized with two thiol-reactive groups such as halogen groups.

[0066] The term "halo" or "halogen" refers to fluorine, chlorine, bromine or iodine or a radical thereof.

[0067] The term "alkyl" refers to a hydrocarbon chain that is a straight chain or branched chain, containing the indicated number of carbon atoms. For example, C_1-C_{10} indicates that the group has from 1 to 10 (inclusive) carbon atoms in it. In the absence of any numerical designation, "alkyl" is a chain (straight or branched) having 1 to 20 (inclusive) carbon atoms in it.

[0068] The term "alkylene" refers to a divalent alkyl (*i.e.*, -R-).

[0069] The term "alkenyl" refers to a hydrocarbon chain that is a straight chain or branched chain having one or more carbon-carbon double bonds. The alkenyl moiety contains the indicated number of carbon atoms. For example, C_2-C_{10} indicates that the group has from 2 to 10 (inclusive) carbon atoms in it. The term "lower alkenyl" refers to a C_2-C_6 alkenyl chain. In the absence of any numerical designation, "alkenyl" is a chain (straight or branched) having 2 to 20 (inclusive) carbon atoms in it.

[0070] The term "alkynyl" refers to a hydrocarbon chain that is a straight chain or branched chain having one or more carbon-carbon triple bonds. The alkynyl moiety contains the indicated number of carbon atoms. For example, C_2-C_{10} indicates that the group has from 2 to 10 (inclusive) carbon atoms in it. The term "lower alkynyl" refers to a C_2-C_6 alkynyl chain. In the absence of any numerical designation, "alkynyl" is a chain (straight or branched) having 2 to 20 (inclusive) carbon atoms in it.

[0071] The term "aryl" refers to a 6-carbon monocyclic or 10-carbon bicyclic aromatic ring system wherein 0, 1, 2, 3, or 4 atoms of each ring are substituted by a substituent. Examples of aryl groups include phenyl, naphthyl and the like. The term "arylalkoxy" refers to an alkoxy substituted with aryl.

[0072] "Arylalkyl" refers to an aryl group, as defined above, wherein one of the aryl group's hydrogen atoms has been replaced with a C_1-C_5 alkyl group, as defined above. Representative examples of an arylalkyl group include, but are not limited to, 2-methylphenyl, 3-methylphenyl, 4-methylphenyl, 2-ethylphenyl, 3-ethylphenyl, 4-ethylphenyl, 2-propylphenyl, 3-propylphenyl, 4-propylphenyl, 2-butylphenyl, 3-butylphenyl, 4-butylphenyl, 2-pentylphenyl, 3-pentylphenyl, 4-pentylphenyl, 2-isopropylphenyl, 3-isopropylphenyl, 4-isopropylphenyl, 2-isobutylphenyl, 3-isobutylphenyl, 4-isobutylphenyl, 2-sec-butylphenyl, 3-sec-butylphenyl, 4-sec-butylphenyl, 2-t-butylphenyl, 3-t-butylphenyl and 4-t-butylphenyl.

[0073] "Arylamido" refers to an aryl group, as defined above, wherein one of the aryl group's hydrogen atoms has been replaced with one or more -C(O)NH_2 groups. Representative examples of an arylamido group include 2-C(O)NH2-phenyl, 3-C(O)NH_2-phenyl, 4-C(O)NH_2-phenyl, 2-C(O)NH_2-pyridyl, 3-C(O)NH_2-pyridyl, and 4-C(O)NH_2-pyridyl,

[0074] "Alkylheterocycle" refers to a C_1-C_5 alkyl group, as defined above, wherein one of the C_1-C_5 alkyl group's hydrogen atoms has been replaced with a heterocycle. Representative examples of an alkylheterocycle group include, but are not limited to, -CH_2CH_2-morpholine, -CH_2CH_2-piperidine, -$CH_2CH_2CH_2$-morpholine, and -$CH_2CH_2CH_2$-imidazole.

[0075] "Alkylamido" refers to a C_1-C_5 alkyl group, as defined above, wherein one of the C_1-C_5 alkyl group's hydrogen atoms has been replaced with a -$C(O)NH_2$ group. Representative examples of an alkylamido group include, but are not limited to, -CH_2-$C(O)NH_2$, -CH_2CH_2-$C(O)NH_2$, -$CH_2CH_2CH_2C(O)NH_2$, -$CH_2CH_2CH_2CH_2C(O)NH_2$, -$CH_2CH_2CH_2CH_2CH_2C(O)NH_2$, -$CH_2CH(C(O)NH_2)CH_3$, -$CH_2CH(C(O)NH_2)CH_2CH_3$, -$CH(C(O)NH_2)CH_2CH_3$, -$C(CH_3)_2CH_2C(O)NH_2$, –$CH_2$-$CH_2$–NH-C(O)-$CH_3$, –$CH_2$-$CH_2$–NH-C(O)-$CH_3$-CH3, and –$CH_2$-$CH_2$–NH-C(O)-$CH=CH_2$.

[0076] "Alkanol" refers to a C_1-C_5 alkyl group, as defined above, wherein one of the C_1-C_5 alkyl group's hydrogen atoms has been replaced with a hydroxyl group. Representative examples of an alkanol group include, but are not limited to, -CH_2OH, -CH_2CH_2OH, -$CH_2CH_2CH_2OH$, -$CH_2CH_2CH_2CH_2OH$, -$CH_2CH_2CH_2$ CH_2CH_2OH, -$CH_2CH(OH)CH_3$, -$CH_2CH(OH)CH_2CH_3$, -$CH(OH)CH_3$ and -$C(CH_3)_2CH_2OH$.

[0077] "Alkylcarboxy" refers to a C_1-C_5 alkyl group, as defined above, wherein one of the C_1-C_5 alkyl group's hydrogen atoms has been replaced with a --COOH group. Representative examples of an alkylcarboxy group include, but are not limited to, -CH_2COOH, -CH_2CH_2COOH, -$CH_2CH_2CH_2COOH$, -$CH_2CH_2CH_2CH_2COOH$, -$CH_2CH(COOH)CH_3$, -$CH_2CH_2CH_2CH_2CH_2COOH$, -$CH_2CH(COOH)CH_2CH_3$, -$CH(COOH)CH_2CH_3$ and -$C(CH_3)_2CH_2COOH$.

[0078] The term "cycloalkyl" as employed herein includes saturated and partially unsaturated cyclic hydrocarbon groups having 3 to 12 carbons, preferably 3 to 8 carbons, and more preferably 3 to 6 carbons, wherein the cycloalkyl group additionally is optionally substituted. Some cycloalkyl groups include, without limitation, cyclopropyl, cyclobutyl, cyclopentyl, cyclopentenyl, cyclohexyl, cyclohexenyl, cycloheptyl, and cyclooctyl.

[0079] The term "heteroaryl" refers to an aromatic 5-8 membered monocyclic, 8-12 membered bicyclic, or 11-14 membered tricyclic ring system having 1-3 heteroatoms if monocyclic, 1-6 heteroatoms if bicyclic, or 1-9 heteroatoms if tricyclic, said heteroatoms selected from O, N, or S (*e.g.*, carbon atoms and 1-3, 1-6, or 1-9 heteroatoms of O, N, or S if monocyclic, bicyclic, or tricyclic, respectively), wherein 0, 1, 2, 3, or 4 atoms of each ring are substituted by a substituent. Examples of heteroaryl groups include pyridyl, furyl or furanyl, imidazolyl, benzimidazolyl, pyrimidinyl, thiophenyl or thienyl, quinolinyl, indolyl, thiazolyl, and the like.

[0080] The term "heteroarylalkyl" or the term "heteroaralkyl" refers to an alkyl substituted with a heteroaryl. The term "heteroarylalkoxy" refers to an alkoxy substituted with heteroaryl.

[0081] The term "heteroarylalkyl" or the term "heteroaralkyl" refers to an alkyl substituted with a heteroaryl. The term "heteroarylalkoxy" refers to an alkoxy substituted with heteroaryl.

[0082] The term "heterocyclyl" refers to a nonaromatic 5-8 membered monocyclic, 8-12 membered bicyclic, or 11-14 membered tricyclic ring system having 1-3 heteroatoms if monocyclic, 1-6 heteroatoms if bicyclic, or 1-9 heteroatoms if tricyclic, said heteroatoms selected from O, N, or S (*e.g.*, carbon atoms and 1-3, 1-6, or 1-9 heteroatoms of O, N, or S if monocyclic, bicyclic, or tricyclic, respectively), wherein 0, 1, 2 or 3 atoms of each ring are substituted by a substituent. Examples of heterocyclyl groups include piperazinyl, pyrrolidinyl, dioxanyl, morpholinyl, tetrahydrofuranyl, and the like.

[0083] The term "substituent" refers to a group replacing a second atom or group such as a hydrogen atom on any molecule, compound or moiety. Suitable substituents include, without limitation, halo, hydroxy, mercapto, oxo, nitro, haloalkyl, alkyl, alkaryl, aryl, aralkyl, alkoxy, thioalkoxy, aryloxy, amino, alkoxycarbonyl, amido, carboxy, alkanesulfonyl, alkylcarbonyl, and cyano groups.

[0084] In some embodiments, the compounds of this invention contain one or more asymmetric centers and thus occur as racemates and racemic mixtures, single enantiomers, individual diastereomers and diastereomeric mixtures. All such isomeric forms of these compounds are included in the present invention unless expressly provided otherwise. In some embodiments, the compounds of this invention are also represented in multiple tautomeric forms, in such instances, the invention includes all tautomeric forms of the compounds described herein (*e.g.*, if alkylation of a ring system results in alkylation at multiple sites, the invention includes all such reaction products). All such isomeric forms of such compounds are included in the present invention unless expressly provided otherwise. All crystal forms of the compounds described herein are included in the present invention unless expressly provided otherwise.

[0085] As used herein, the terms "increase" and "decrease" mean, respectively, to cause a statistically significantly (*i.e.*, $p < 0.1$) increase or decrease of at least 5%.

[0086] As used herein, the recitation of a numerical range for a variable is intended to convey that the variable is equal to any of the values within that range. Thus, for a variable which is inherently discrete, the variable is equal to any integer value within the numerical range, including the end-points of the range. Similarly, for a variable which is inherently continuous, the variable is equal to any real value within the numerical range, including the end-points of the range. As an example, and without limitation, a variable which is described as having values between 0 and 2 takes the values 0, 1 or 2 if the variable is inherently discrete, and takes the values 0.0, 0.1, 0.01, 0.001, or any other real values ≥ 0 and ≤ 2 if the variable is inherently continuous.

[0087] As used herein, unless specifically indicated otherwise, the word "or" is used in the inclusive sense of "and/or" and not the exclusive sense of "either/or."

[0088] The term "on average" represents the mean value derived from performing at least three independent replicates for each data point.

[0089] The term "biological activity" encompasses structural and functional properties of a macrocycle of the invention. Biological activity is, for example, structural stability, alpha-helicity, affinity for a target, resistance to proteolytic degradation, cell penetrability, intracellular stability, *in vivo* stability, or any combination thereof.

[0090] The details of one or more particular embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

[0091] In some embodiments, the peptide sequences are derived from a GHRH peptide. For example, the peptide sequences are derived from human GHRH (1-29) or human GHRH (1-44).

[0092] A non-limiting exemplary list of suitable GHRH peptides for use in the present invention is given in Table 1 and Table 2 below. In Tables 1 and 2, all peptides possess a free amino terminus (shown as H-) and all peptides possess an carboxamide terminus (shown as –NH2). X residues form cross-links to one other X residue, Z residues form cross-links to one other Z residue, and XX residues form cross-links with two other X residues. In Tables 1 and 2, amino acid A2 is either L-Ala or D-Ala, A8 is either L-Asn or L-Gln, A15 is either L-Ala or Gly, and A27 is either L-Nle or L-Leu.

TABLE 1 (SEQ ID NOS 2-74, respectively, in order of appearance)

H-Y-A2-D-X-IFT-X-SYRKVL-A15-QLSAR-Z-LLQ-Z-I-A27-SR-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-A15-QLSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-DAIFT-X-SYR-X-VL-A15-QLSAR-Z-LLQ-Z-I-A27-SR-NH2
H-Y-A2-DAIFT-X-SYR-X-VL-A15-QLSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-DAIFT-A8-SY-X-KVL-X-QLSAR-Z-LLQ-Z-I-A27-SR-NH2
H-Y-A2-DAIFT-A8-SY-X-KVL-X-QLSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-X-LSAR-Z-LLQ-Z-I-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-X-LSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-D-X-IFT-A8-SY-X-KVL-A15-QLSARKLLQDI-A27-SR-NH2
H-Y-A2-DA-X-FT-A8-SYR-X-VL-A15-QLSARKLLQDI-A27-SR-NH2
H-Y-A2-DAI-X-T-A8-SYRK-X-L-A15-QLSARKLLQDI-A27-SR-NH2
H-Y-A2-DAIF-X-A8-SYRKV-X-A15-QLSARKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-X-SYRKVL-X-QLSARKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-X-YRKVL-A15-X-LSARKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-S-X-RKVL-A15-Q-X-SARKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SY-X-KVL-A15-QL-X-ARKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-QLS-X-RKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRK-X-L-A15-QLSA-X-KLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKV-X-A15-QLSAR-X-LLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-X-QLSARK-X-LQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-X-LSARKL-X-QDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-Q-X-SARKLL-X-DI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-QL-X-ARKLLQ-X-I-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-QLS-X-RKLLQD-X-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-QLSA-X-KLLQDI-X-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-QLSAR-X-LLQDI-A27-X-R-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-QLSARK-X-LQDI-A27-S-X-NH2
H-Y-A2-D-X-IFT-A8-SY-X-KVL-A15-QLSAR-Z-LLQ-Z-I-A27-SR-NH2

H-Y-A2-D-X-IFT-A8-SY-X-KVL-A15-QLSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-DA-X-FT-A8-SYR-X-VL-A15-QLSAR-Z-LLQ-Z-I-A27-SR-NH2
H-Y-A2-DA-X-FT-A8-SYR-X-VL-A15-QLSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-DAI-X-T-A8-SYRK-X-L-A15-QLSAR-Z-LLQ-Z-I-A27-SR-NH2
H-Y-A2-DAI-X-T-A8-SYRK-X-L-A15-QLSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-DAIF-X-A8-SYRKV-X-A15-QLSAR-Z-LLQ-Z-I-A27-SR-NH2
H-Y-A2-DAIF-X-A8-SYRKV-X-A15-QLSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-DAIFT-X-SYRKVL-X-QLSAR-Z-LLQ-Z-I-A27-SR-NH2
H-Y-A2-DAIFT-X-SYRKVL-X-QLSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-DAIFT-A8-X-YRKVL-A15-X-LSARKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-DAIFT-A8-X-YRKVL-A15-X-LSAR-Z-LLQ-Z-I-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-QLS-X-RKLLQ-Z-I-A27-S-Z-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-Z-QLSARK-Z-LQDI-A27-SR-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-A15-QL-Z-ARKLLQ-Z-I-A27-SR-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-A15-QLSAR-Z-LLQDI-A27-Z-R-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-A15-QLSARK-Z-LQDI-A27-S-Z-NH2
H-Y-A2-DAIFT-X-SYR-X-VL-Z-QLSARK-Z-LQDI-A27-SR-NH2
H-Y-A2-DAIFT-X-SYR-X-VL-A15-QL-Z-ARKLLQ-Z-I-A27-SR-NH2
H-Y-A2-DAIFT-X-SYR-X-VL-A15-QLSAR-Z-LLQDI-A27-Z-R-NH2
H-Y-A2-DAIFT-X-SYR-X-VL-A15-QLSARK-Z-LQDI-A27-S-Z-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-X-LSAR-Z-LLQDI-A27-Z-R-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-X-LSARK-Z-LQDI-A27-S-Z-NH2
H-Y-A2-DAIFT-A8-SY-X-KVL-X-QLSAR-Z-LLQDI-A27-Z-R-NH2
H-Y-A2-DAIFT-A8-SY-X-KVL-X-QLSARK-Z-LQDI-A27-S-Z-NH2
H-Y-A2-D-X-IFT-XX-SYR-X-VL-A15-QLSARKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-X-SYR-XX-VL-A15-X-LSARKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-XX-LSA-X-KLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-QLSAR-X-LLQ-XX-I-A27-S-X-NH2
H-Y-A2-D-X-IFT-XX-SYRKVL-X-QLSARKLLQDI-A27-SR-NH2
H-Y-A2-D-X-IFT-A8-SY-XX-KVL-X-QLSARKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-X-SYR-XX-VL-A15-QLS-X-RKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-X-SYRKVL-XX-QLS-X-RKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-X-YRKVL-A15-XX-LSA-X-KLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-X-YRK-XX-L-A15-QLSA-X-KLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-QLS-XX-RKL-X-QDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-XX-LSARKL-X-QDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-X-LSARKL-XX-QDI-X-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-X-LSA-XX-KLLQDI-X-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-QL-X-ARK-XX-LQDI-A27-S-X-NH2
H-Y-A2-DAIFT-A8-SYRKVL-A15-QL-X-ARKLLQ-XX-I-A27-S-X-NH2
H-Y-A2-D-X-IFT-A8-SY-XX-KVL-A15-QL-X-ARKLLQDI-A27-SR-NH2
H-Y-A2-DAIFT-X-SYRKVL-XX-QLSARK-X-LQDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-X-YRKVL-A15-XX-LSARKL-X-QDI-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15-QLS-XX-RKLLQD-X-A27-SR-NH2
H-Y-A2-DAIFT-A8-SYRKVL-X-QLSARK-XX-LQDI-A27-S-X-NH2

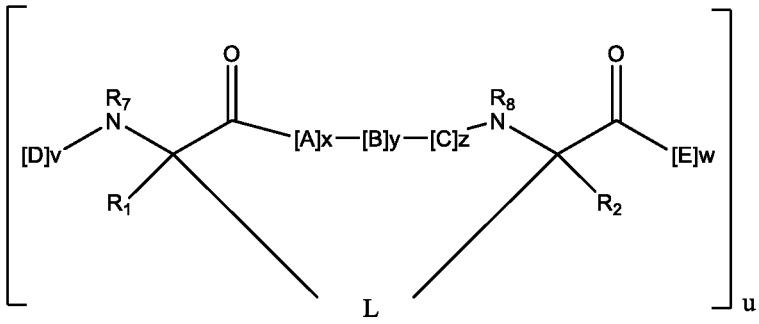
TABLE 2 (SEQ ID NOS 75-88, respectively, in order of appearance)

H-Y-A2-D-X-IFT-X-SYRKVL-A15-QLSAR-Z-LLQ-Z-I-A27-SRQQGESNQERGARARL-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-A15-QLSARKLLQ-Z-I-A27-S-Z-QQGESNQERGARARL-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-Z-QLSARK-Z-LQDI-A27-SRQQGESNQERGARARL-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-A15-QL-Z-ARKLLQ$I-A27-SRQQGESNQERGARARL-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-A15-QLSAR-Z-LLQDI-A27--Z-RQQGESNQERGARARL-NH2
H-Y-A2-D-X-IFT-X-SYRKVL-A15-QLSARK-Z-LQDI-A27-S-Z-QQGESNQERGARARL-NH2
H-Y-A2-DAIFT-X-SYR-X-VL-A15-QLSAR-Z-LLQ-Z-I-A27-SRQQGESNQERGARARL-NH2

H-Y-A2-DAIFT-X-SYR-X-VL-A15-QLSARKLLQ-Z-I-A27-S-Z-QQGESNQERGARARL-NH2
H-Y-A2-DAIFT-A8-SY-X-KVL-X-QLSAR-Z-LLQ-Z-I-A27-SRQQGESNQERGARARL-NH2
H-Y-A2-DAIFT-A8-SY-X-KVL-X-QLSARKLLQ-Z-I-A27-S-Z-QQGESNQERGARARL-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15--X-LSAR-Z-LLQ-Z-I-A27-SRQQGESNQERGARARL-NH2
H-Y-A2-DAIFT-A8-SYR-X-VL-A15--X-LSARKLLQ-Z-I-A27-S-Z-QQGESNQERGARARL-NH2
H-Y-A2-DAIFT-X-SYRKVL-X-QLSAR-Z-LLQ-Z-I-A27-SRQQGESNQERGARARL-NH2
H-Y-A2-DAIFT-X-SYRKVL-X-QLSARKLLQ-Z-I-A27-S-Z-QQGESNQERGARARL-NH2

Peptidomimetic Macrocycles of the Invention

[0093] In some embodiments, a peptidomimetic macrocycle of the invention has the Formula (I):

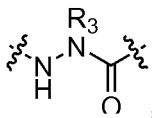


Formula I Formula (I)

wherein:

each A, C, D, and E is independently an amino acid (including natural or non-natural amino acids and amino acid analogs) and the terminal D and E independently optionally include a capping group;

B is an amino acid (including natural or non-natural amino acids and amino acid analogs),



, [-NH-L_3-CO-], [-NH-L_3-SO_2-], or [-NH-L_3-];

R_1 and R_2 are independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–;

R_3 is hydrogen, alkyl, alkenyl, alkynyl, arylalkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, cycloalkylalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

L is a macrocycle-forming linker of the formula –L_1–L_2–;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker L, form the amino acid sequence of the peptidomimetic macrocycle which is at least about 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, or 99% identical to GHRH 1-44, GHRH 1-29 and/or to an amino acid sequence chosen from the group consisting of the amino acid sequences in Table 1, 2 or 4;

L_1 and L_2 are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or [-R_4-K-R_4-]$_n$, each being optionally substituted with R_5;

each R_4 is alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

each R_5 is independently halogen, alkyl, $-OR_6$, $-N(R_6)_2$, $-SR_6$, $-SOR_6$, $-SO_2R_6$, $-CO_2R_6$, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent;

R_7 is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with a D residue;

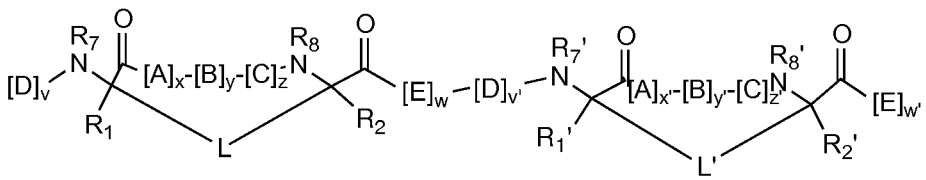
R_8 is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with an E residue;

v and w are independently integers from 1-1000, for example 1-500, 1-200, 1-100, 1-50, 1-40, 1-25, 1-20, 1 to 15, or 1 to 10;

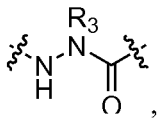
u, x, y and z are independently integers from 0-10, for example u is 1, 2, or 3; and

n is an integer from 1-5, for example 1. For example, u is 2. In some embodiments, the sum of x+y+z is 2, 3 or 6, for example 3 or 6.

[0094] In some embodiments, the peptidomimetic macrocycle of Formula (I) has the Formula:



wherein each A, C, D, and E is independently an amino acid;

B is an amino acid,  , [-NH-L_3-CO-], [-NH-L_3-SO_2-], or [-NH-L_3-];

L' is a macrocycle-forming linker of the formula $-L_1'-L_2'-$;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linkers L and L', form the amino acid sequence of the peptidomimetic macrocycle;

R_1' and R_2' are independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–;

L_1' and L_2' are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4-K-R_4-]_n$, each being optionally substituted with R_5;

each K is independently O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

R_7' is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with a D residue;

R_8' is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with an E residue;

v' and w' are independently integers from 1-1000, for example 1-500, 1-200, 1-100, 1-50, 1-40, 1-25, 1-20, 1 to 15, or 1 to 10;

x', y' and z' are independently integers from 0-10; and

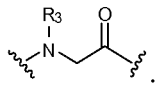
n is an integer from 1-5. In some embodiments, the sum of x'+y'+z' is 2, 3 or 6, for example 3 or 6.

[0095] In some embodiments of any of the peptidomimetic macrocycles described herein, each K is O, S, SO, SO_2, CO, or CO_2.

[0096] In one example, at least one of R_1 and R_2 is alkyl, unsubstituted or substituted with halo–. In another example, both R_1 and R_2 are independently alkyl, unsubstituted or substituted with halo–. In some embodiments, at least one of R_1 and R_2 is methyl. In other embodiments, R_1 and R_2 are methyl.

[0097] In some embodiments of the invention, the sum of the sum of x+y+z is at least 3, and/or the sum of x'+y'+z' is at least 3. In other embodiments of the invention, the sum of the sum of x+y+z is 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 (for example 2, 3 or 6) and/or the sum of x'+y'+z' is 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 (for example 2, 3 or 6).

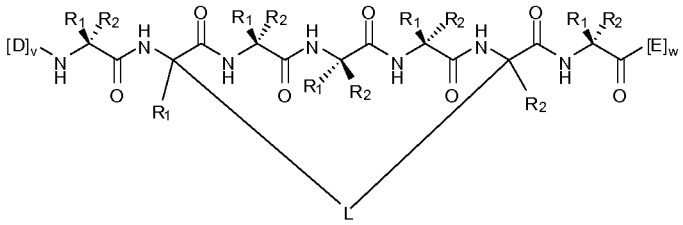
[0098] Each occurrence of A, B, C, D or E in a macrocycle or macrocycle precursor of the invention is independently selected. For example, a sequence represented by the formula $[A]_x$, when x is 3, encompasses embodiments where the amino acids are not identical, e.g. Gln–Asp–Ala as well as embodiments where the amino acids are identical, e.g. Gln–Gln–Gln. This applies for any value of x, y, or z in the indicated ranges. Similarly, when u is greater than 1, each compound of the invention may encompass peptidomimetic macrocycles which are the same or different. For example, a compound of the invention may comprise peptidomimetic macrocycles comprising different linker lengths or chemical compositions.

[0099] In some embodiments, the peptidomimetic macrocycle of the invention comprises a secondary structure which is an α-helix and R_8 is –H, allowing intrahelical hydrogen bonding. In some embodiments, at least one of A, B, C, D or E is an α,α-disubstituted amino acid. In one example, B is an α,α-disubstituted amino acid. For instance, at least one of A, B, C, D or E is 2-aminoisobutyric acid. In other embodiments, at least one of A, B, C, D or E is  .

[00100] In other embodiments, the length of the macrocycle-forming linker L as measured from a first Cα to a second Cα is selected to stabilize a desired secondary peptide structure, such as an α-helix

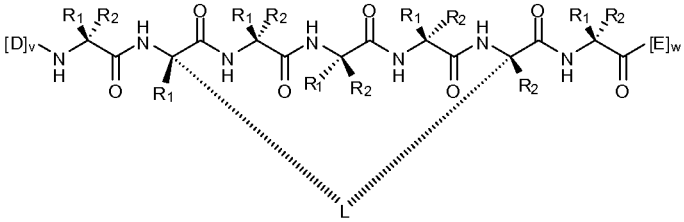
formed by residues of the peptidomimetic macrocycle including, but not necessarily limited to, those between the first Cα to a second Cα.

[00101] In one embodiment, the peptidomimetic macrocycle of Formula (I) is:

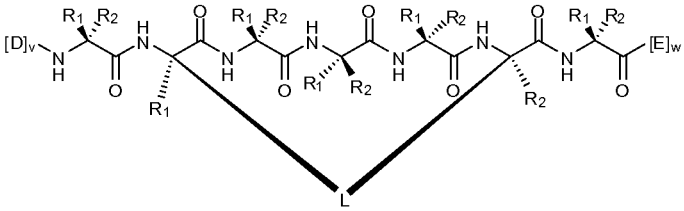


[00102] wherein each R_1 and R_2 is independently independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–.

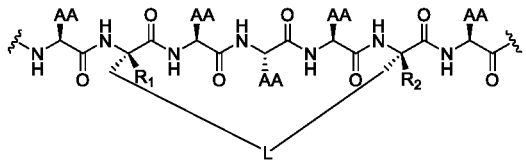
[00103] In related embodiments, the peptidomimetic macrocycle comprises a structure of Formula (I) which is:

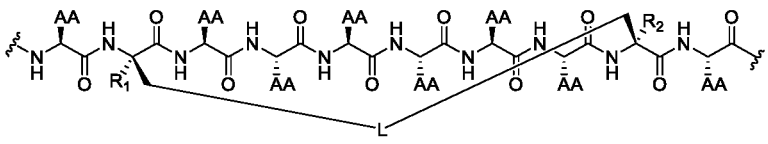


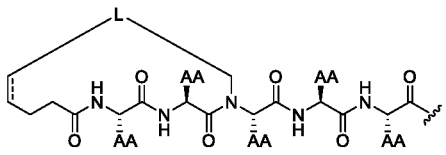
or

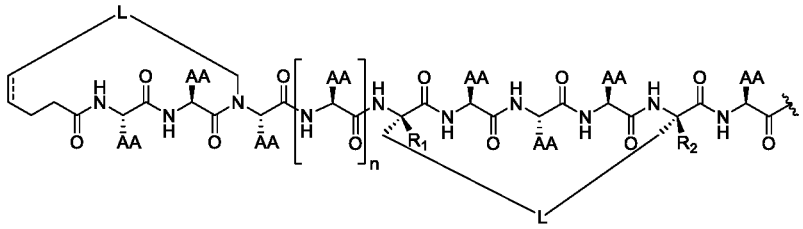


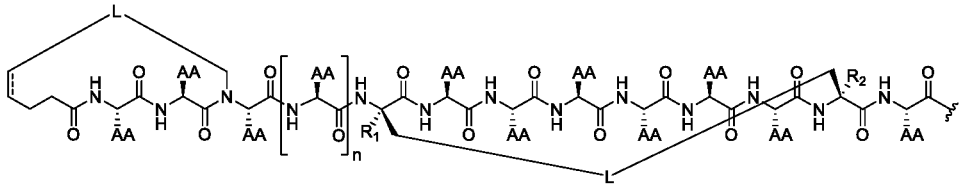
[00104] In other embodiments, the peptidomimetic macrocycle of Formula (I) is a compound of any of the formulas shown below:

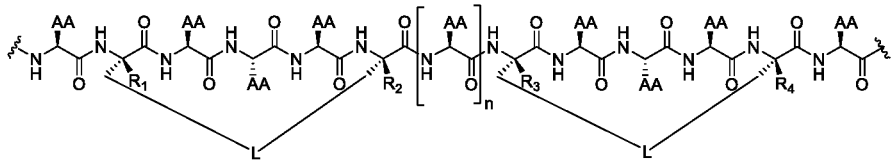


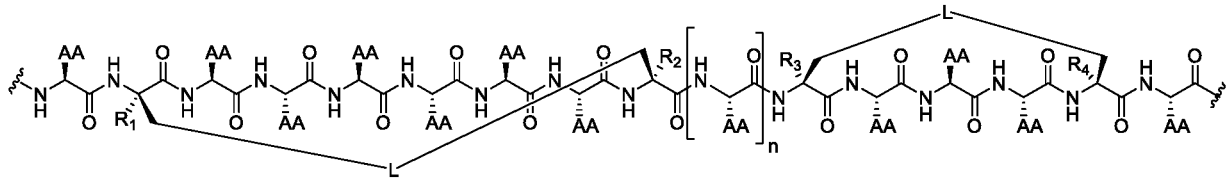


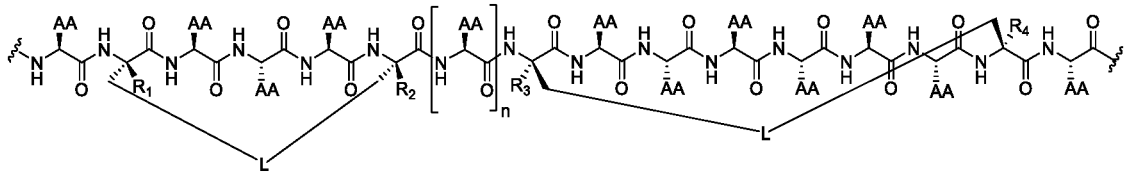


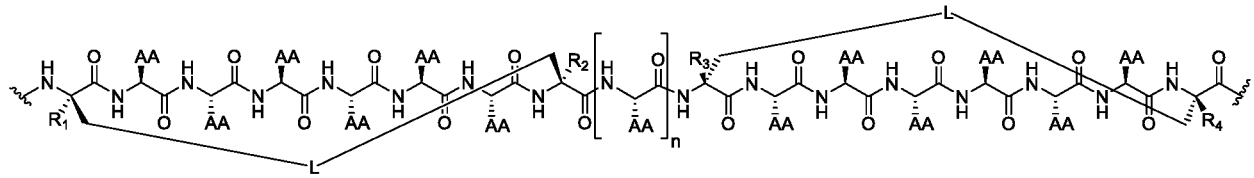


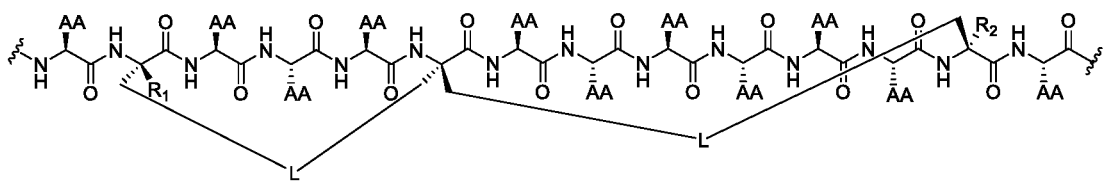


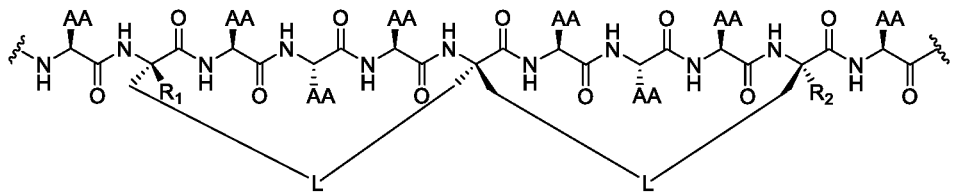


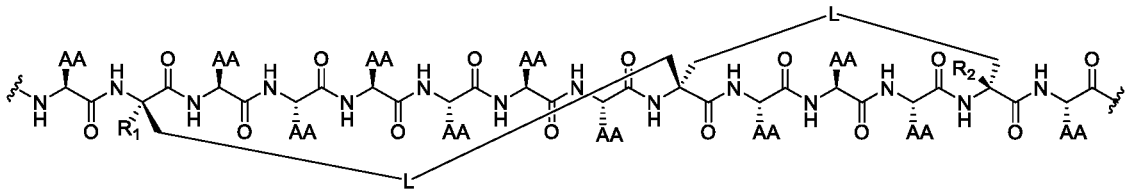


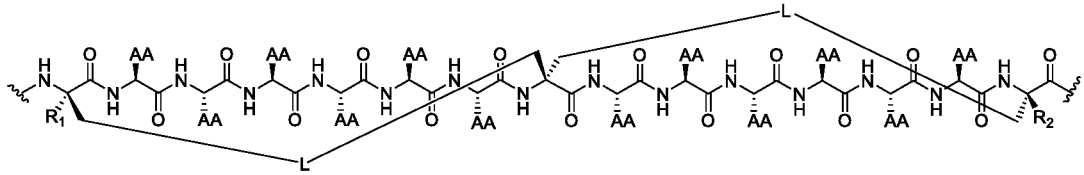






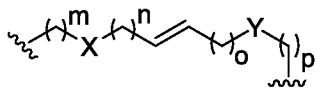




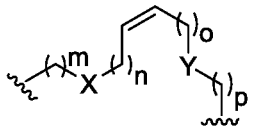


wherein "AA" represents any natural or non-natural amino acid side chain and "〰" is $[D]_v$, $[E]_w$ as defined above, and n is an integer between 0 and 20, 50, 100, 200, 300, 400 or 500. In some embodiments, the substituent "n" shown in the preceding paragraph is 0. In other embodiments, the substituent "n" shown in the preceding paragraph is less than 50, 40, 30, 20, 10, or 5.

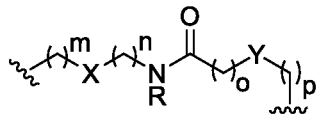
[00105] Exemplary embodiments of the macrocycle-forming linker L are shown below.



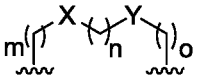
where X, Y = $-CH_2-$, O, S, or NH
m, n, o, p = 0-10



where X, Y = $-CH_2-$, O, S, or NH
m, n, o, p = 0-10



where X, Y = $-CH_2-$, O, S, or NH
m, n, o, p = 0-10
R = H, alkyl, other substituent



where X, Y = $-CH_2-$, O, S, or NH
m, n, o = 0-10

[00106] In other embodiments, D and/or E in the compound of Formula I are further modified in order to facilitate cellular uptake. In some embodiments, lipidating or PEGylating a peptidomimetic macrocycle facilitates cellular uptake, increases bioavailability, increases blood circulation, alters pharmacokinetics, decreases immunogenicity and/or decreases the needed frequency of administration.

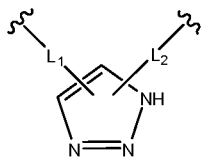
[00107] In other embodiments, at least one of [D] and [E] in the compound of Formula I represents a moiety comprising an additional macrocycle-forming linker such that the peptidomimetic macrocycle comprises at least two macrocycle-forming linkers. In a specific embodiment, a peptidomimetic macrocycle comprises two macrocycle-forming linkers.

[00108] In the peptidomimetic macrocycles of the invention, any of the macrocycle-forming linkers described herein may be used in any combination with any of the sequences shown in Tables 1-3 and also with any of the R– substituents indicated herein.

[00109] In some embodiments, the peptidomimetic macrocycle comprises at least one α-helix motif. For example, A, B and/or C in the compound of Formula I include one or more α-helices. As a general matter, α-helices include between 3 and 4 amino acid residues per turn. In some embodiments, the α-helix of the peptidomimetic macrocycle includes 1 to 5 turns and, therefore, 3 to 20 amino acid residues. In specific embodiments, the α-helix includes 1 turn, 2 turns, 3 turns, 4 turns, or 5 turns. In some embodiments, the macrocycle-forming linker stabilizes an α-helix motif included within the peptidomimetic macrocycle. Thus, in some embodiments, the length of the macrocycle-forming linker L from a first Cα to a second Cα is selected to increase the stability of an α-helix. In some embodiments, the macrocycle-forming linker spans from 1 turn to 5 turns of the α-helix. In some embodiments, the macrocycle-forming linker spans approximately 1 turn, 2 turns, 3 turns, 4 turns, or 5 turns of the α-helix. In some embodiments, the length of the macrocycle-forming linker is approximately 5 Å to 9 Å per turn of the α-helix, or approximately 6 Å to 8 Å per turn of the α-helix. Where the macrocycle-forming linker spans approximately 1 turn of an α-helix, the length is equal to approximately 5 carbon-carbon bonds to 13 carbon-carbon bonds, approximately 7 carbon-carbon bonds to 11 carbon-carbon bonds, or approximately 9 carbon-carbon bonds. Where the macrocycle-forming linker spans approximately 2 turns of an α-helix, the length is equal to approximately 8 carbon-carbon bonds to 16 carbon-carbon bonds, approximately 10 carbon-carbon bonds to 14 carbon-carbon bonds, or approximately 12 carbon-carbon bonds. Where the macrocycle-forming linker spans approximately 3 turns of an α-helix, the length is equal to approximately 14 carbon-carbon bonds to 22 carbon-carbon bonds, approximately 16 carbon-carbon bonds to 20 carbon-carbon bonds, or approximately 18 carbon-carbon bonds. Where the macrocycle-forming linker spans approximately 4 turns of an α-helix, the length is equal to approximately 20 carbon-carbon bonds to 28 carbon-carbon bonds, approximately 22 carbon-carbon bonds to 26 carbon-carbon bonds, or approximately 24 carbon-carbon bonds. Where the macrocycle-forming linker spans approximately 5 turns of an α-helix, the length is equal to approximately 26 carbon-carbon bonds to 34 carbon-carbon bonds, approximately 28 carbon-carbon bonds to 32 carbon-carbon bonds, or approximately 30 carbon-carbon bonds. Where the macrocycle-forming linker spans approximately 1 turn of an α-helix, the linkage contains approximately 4 atoms to 12 atoms, approximately 6 atoms to 10 atoms, or approximately 8 atoms. Where the macrocycle-forming linker spans approximately 2 turns of the α-helix, the linkage contains approximately 7 atoms to 15 atoms, approximately 9 atoms to 13 atoms, or approximately 11 atoms. Where the macrocycle-forming linker spans approximately 3 turns of the α-helix, the linkage contains approximately 13 atoms to 21 atoms, approximately 15 atoms to 19 atoms, or approximately 17

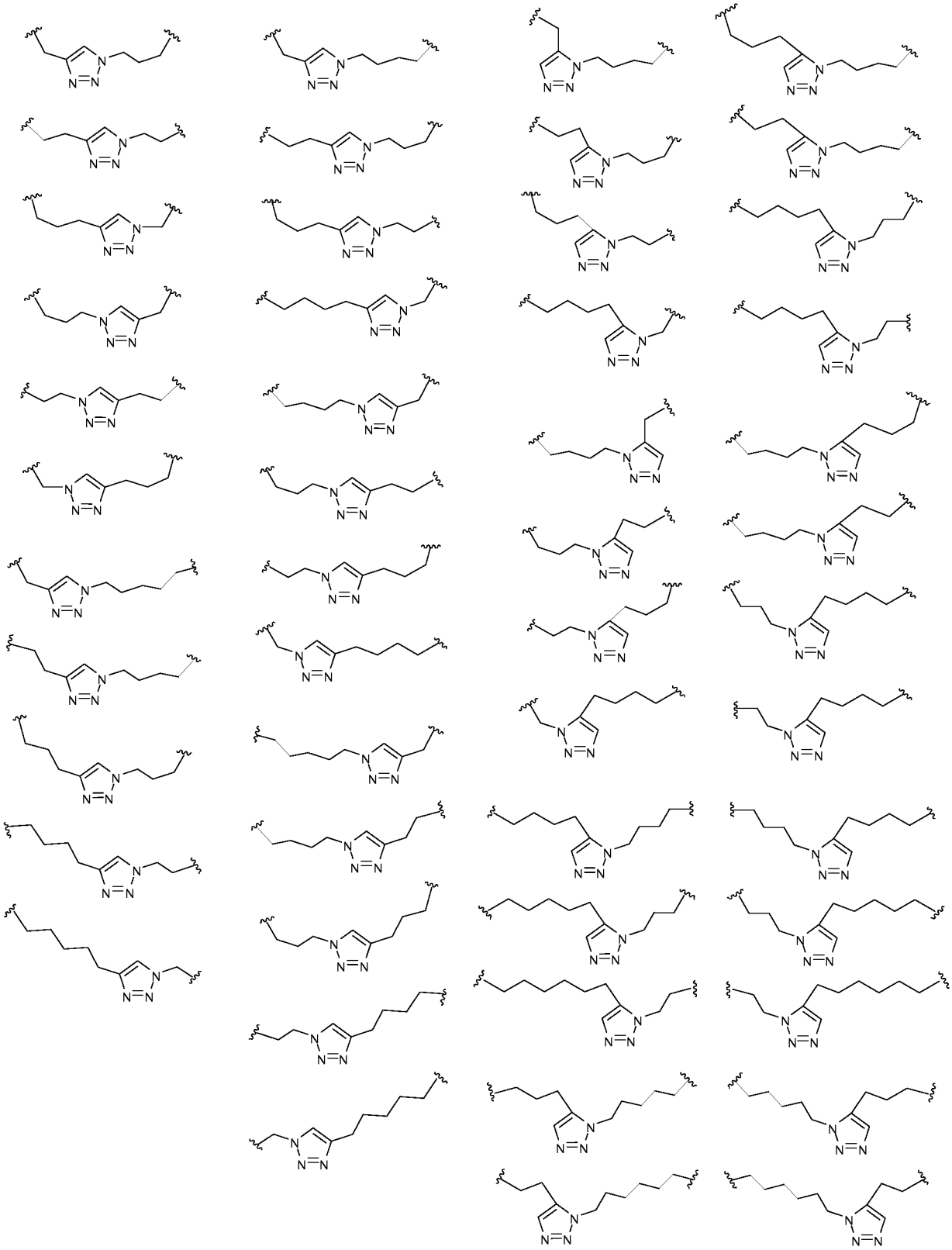
atoms. Where the macrocycle-forming linker spans approximately 4 turns of the α-helix, the linkage contains approximately 19 atoms to 27 atoms, approximately 21 atoms to 25 atoms, or approximately 23 atoms. Where the macrocycle-forming linker spans approximately 5 turns of the α-helix, the linkage contains approximately 25 atoms to 33 atoms, approximately 27 atoms to 31 atoms, or approximately 29 atoms. Where the macrocycle-forming linker spans approximately 1 turn of the α-helix, the resulting macrocycle forms a ring containing approximately 17 members to 25 members, approximately 19 members to 23 members, or approximately 21 members. Where the macrocycle-forming linker spans approximately 2 turns of the α-helix, the resulting macrocycle forms a ring containing approximately 29 members to 37 members, approximately 31 members to 35 members, or approximately 33 members. Where the macrocycle-forming linker spans approximately 3 turns of the α-helix, the resulting macrocycle forms a ring containing approximately 44 members to 52 members, approximately 46 members to 50 members, or approximately 48 members. Where the macrocycle-forming linker spans approximately 4 turns of the α-helix, the resulting macrocycle forms a ring containing approximately 59 members to 67 members, approximately 61 members to 65 members, or approximately 63 members. Where the macrocycle-forming linker spans approximately 5 turns of the α-helix, the resulting macrocycle forms a ring containing approximately 74 members to 82 members, approximately 76 members to 80 members, or approximately 78 members.

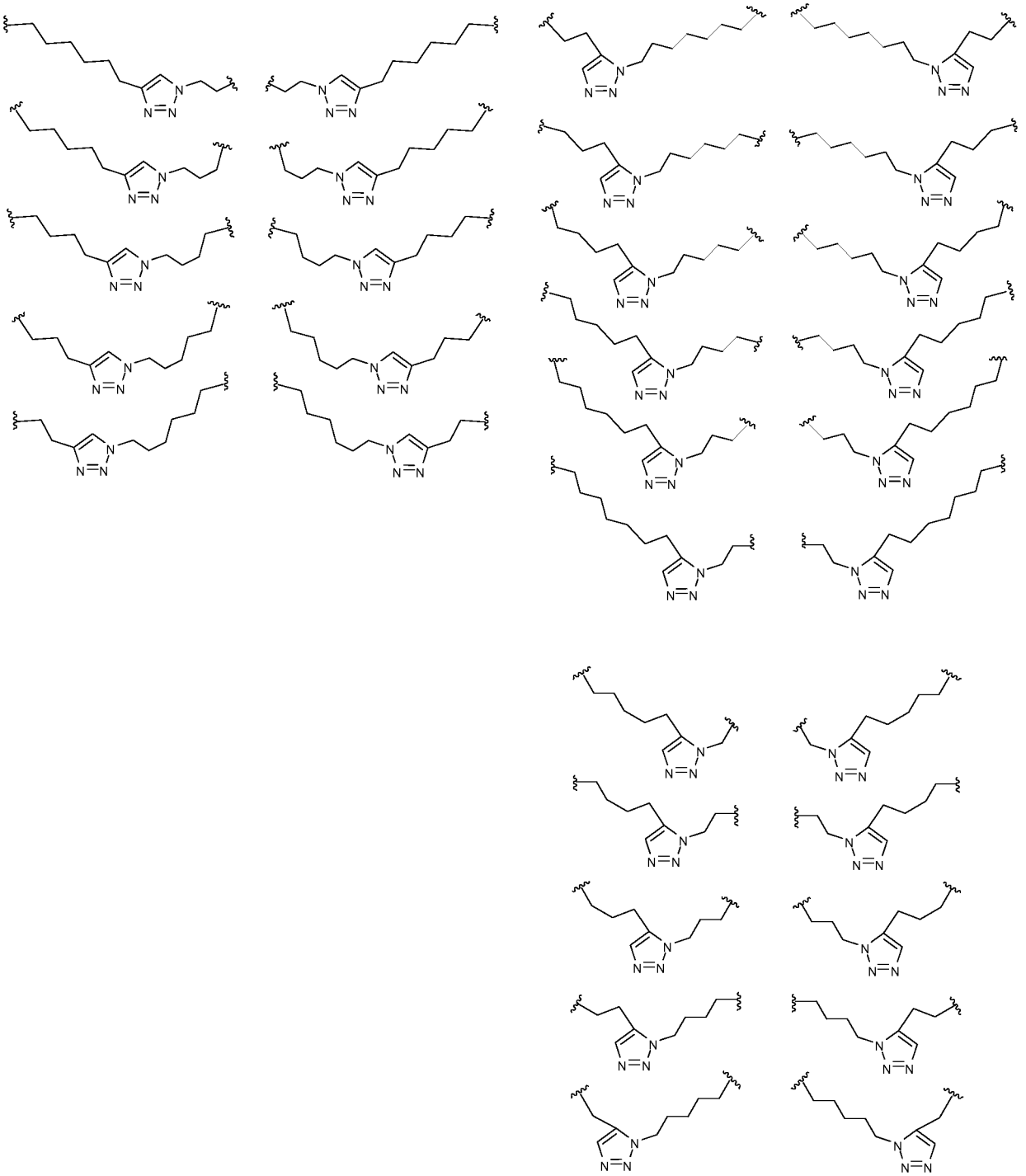
[00110] In some embodiments, L is a macrocycle-forming linker of the formula



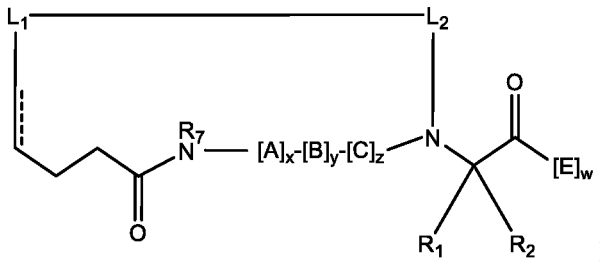
;

[00111] Exemplary embodiments of such macrocycle-forming linkers L are shown below.

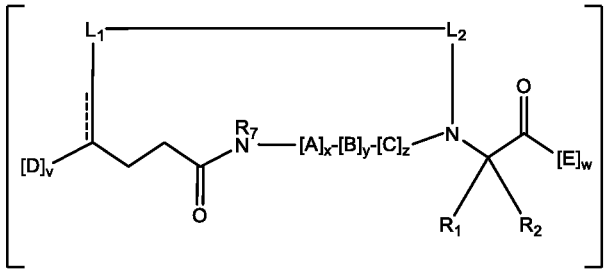




[00112] In other embodiments, the invention provides peptidomimetic macrocycles of Formula (II) or (IIa):



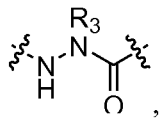
Formula (II)



Formula (IIa)

wherein:

each A, C, D, and E is independently an amino acid;

B is an amino acid,  , [-NH-L_3-CO-], [-NH-L_3-SO_2-], or [-NH-L_3-];

R_1 and R_2 are independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–, or part of a cyclic structure with an E residue;

R_3 is hydrogen, alkyl, alkenyl, alkynyl, arylalkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, cycloalkylalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

L_1 and L_2 are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4-K-R_4-]_n$, each being optionally substituted with R_5;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker -L_1-L_2-, form the amino acid sequence of the peptidomimetic macrocycle which is at least about 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, or 99% identical to GHRH 1-44, GHRH 1-29 and/or to an amino acid sequence chosen from the group consisting of the amino acid sequences in Table 1, 2 or 4;

each R_4 is alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

each R_5 is independently halogen, alkyl, -OR_6, -$N(R_6)_2$, -SR_6, -SOR_6, -SO_2R_6, -CO_2R_6, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent;

R_7 is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

v and w are independently integers from 1-1000, for example 1-100;

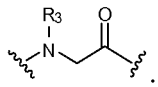
u, x, y and z are independently integers from 0-10, for example u is 1-3; and

n is an integer from 1-5.

[00113] In one example, at least one of R_1 and R_2 is alkyl, unsubstituted or substituted with halo–. In another example, both R_1 and R_2 are independently alkyl, unsubstituted or substituted with halo–.

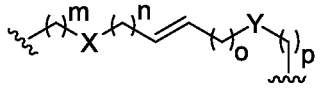
In some embodiments, at least one of R_1 and R_2 is methyl. In other embodiments, R_1 and R_2 are methyl.

[00114] In some embodiments of the invention, the sum of x+y+z is at least 1. In other embodiments of the invention, the sum of x+y+z is at least 2. In other embodiments of the invention, the sum of x+y+z is 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10. Each occurrence of A, B, C, D or E in a macrocycle or macrocycle precursor of the invention is independently selected. For example, a sequence represented by the formula $[A]_x$, when x is 3, encompasses embodiments where the amino acids are not identical, e.g. Gln–Asp–Ala as well as embodiments where the amino acids are identical, e.g. Gln–Gln–Gln. This applies for any value of x, y, or z in the indicated ranges.

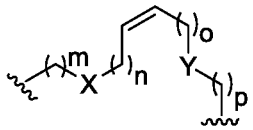
[00115] In some embodiments, the peptidomimetic macrocycle of the invention comprises a secondary structure which is an α-helix and R_8 is –H, allowing intrahelical hydrogen bonding. In some embodiments, at least one of A, B, C, D or E is an α,α-disubstituted amino acid. In one example, B is an α,α-disubstituted amino acid. For instance, at least one of A, B, C, D or E is 2-aminoisobutyric acid. In other embodiments, at least one of A, B, C, D or E is  .

[00116] In other embodiments, the length of the macrocycle-forming linker $-L_1-L_2-$ as measured from a first Cα to a second Cα is selected to stabilize a desired secondary peptide structure, such as an α-helix formed by residues of the peptidomimetic macrocycle including, but not necessarily limited to, those between the first Cα to a second Cα.

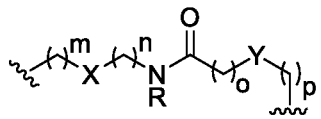
[00117] Exemplary embodiments of the macrocycle-forming linker $-L_1-L_2-$ are shown below.



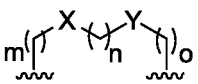
where X, Y = $-CH_2-$, O, S, or NH
m, n, o, p = 0-10



where X, Y = $-CH_2-$, O, S, or NH
m, n, o, p = 0-10



where X, Y = $-CH_2-$, O, S, or NH
m, n, o, p = 0-10
R = H, alkyl, other substituent



where X, Y = $-CH_2-$, O, S, or NH
m, n, o = 0-10

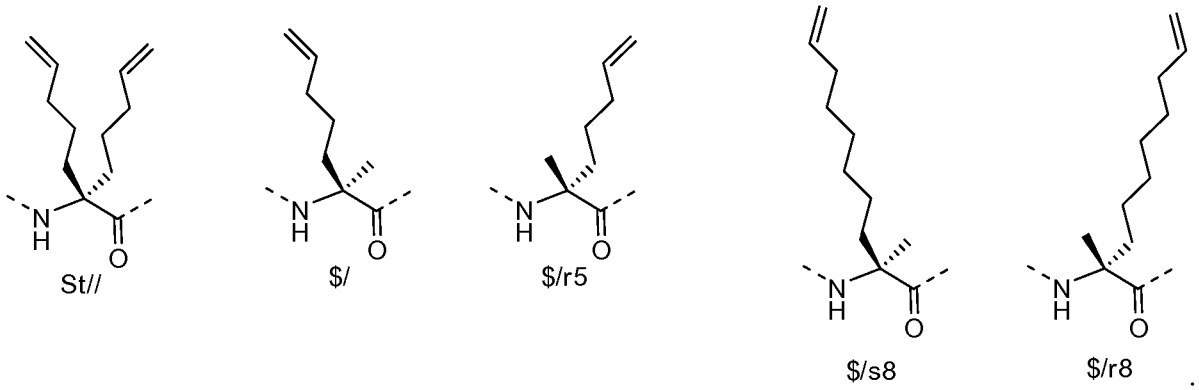
[00118] Examples of peptidomimetic macrocycles of Formula (II) are shown in Table 4 and include SP-85, SP-86, SP-87, SP-88, SP-91, and SP-92.

Preparation of Peptidomimetic Macrocycles

[00119] Peptidomimetic macrocycles of the invention may be prepared by any of a variety of methods known in the art. For example, any of the residues indicated by "X", "Z" or "XX" in Tables 1, 2

or 4 may be substituted with a residue capable of forming a crosslinker with a second residue in the same molecule or a precursor of such a residue.

[00120] Various methods to effect formation of peptidomimetic macrocycles are known in the art. For example, the preparation of peptidomimetic macrocycles of Formula I is described in Schafmeister et al., J. Am. Chem. Soc. 122:5891-5892 (2000); Schafmeister & Verdine, J. Am. Chem. Soc. 122:5891 (2005); Walensky et al., Science 305:1466-1470 (2004); US Patent No. 7,192,713 and PCT application WO 2008/121767. The α,α-disubstituted amino acids and amino acid precursors disclosed in the cited references may be employed in synthesis of the peptidomimetic macrocycle precursor polypeptides. For example, the "S5-olefin amino acid" is (S)-α-(2'-pentenyl) alanine and the "R8 olefin amino acid" is (R)-α-(2'-octenyl) alanine. Following incorporation of such amino acids into precursor polypeptides, the terminal olefins are reacted with a metathesis catalyst, leading to the formation of the peptidomimetic macrocycle. In various embodiments, the following amino acids may be employed in the synthesis of the peptidomimetic macrocycle:



[00121] In some embodiments, x+y+z is 3, and and A, B and C are independently natural or non-natural amino acids. In other embodiments, x+y+z is 6, and and A, B and C are independently natural or non-natural amino acids.

[00122] In some embodiments, the contacting step is performed in a solvent selected from the group consisting of protic solvent, aqueous solvent, organic solvent, and mixtures thereof. For example, the solvent may be chosen from the group consisting of H_2O, THF, THF/H_2O, tBuOH/H_2O, DMF, DIPEA, CH_3CN or CH_2Cl_2, $ClCH_2CH_2Cl$ or a mixture thereof. The solvent may be a solvent which favors helix formation.

[00123] Alternative but equivalent protecting groups, leaving groups or reagents are substituted, and certain of the synthetic steps are performed in alternative sequences or orders to produce the desired compounds. Synthetic chemistry transformations and protecting group methodologies (protection and deprotection) useful in synthesizing the compounds described herein include, for example, those such as described in Larock, Comprehensive Organic Transformations, VCH Publishers (1989); Greene and Wuts, Protective Groups in Organic Synthesis, 2d. Ed. , John

Wiley and Sons (1991); Fieser and Fieser, Fieser and Fieser's Reagents for Organic Synthesis, John Wiley and Sons (1994); and Paquette, ed., Encyclopedia of Reagents for Organic Synthesis, John Wiley and Sons (1995), and subsequent editions thereof.

[00124] The peptidomimetic macrocycles disclosed herein are made, for example, by chemical synthesis methods, such as described in Fields *et al.*, Chapter 3 in Synthetic Peptides: A User's Guide, ed. Grant, W. H. Freeman & Co., New York, N. Y., 1992, p. 77. Hence, for example, peptides are synthesized using the automated Merrifield techniques of solid phase synthesis with the amine protected by either tBoc or Fmoc chemistry using side chain protected amino acids on, for example, an automated peptide synthesizer (*e.g.*, Applied Biosystems (Foster City, CA), Model 430A, 431, or 433).

[00125] One manner of producing the peptidomimetic precursors and peptidomimetic macrocycles described herein uses solid phase peptide synthesis (SPPS). The C-terminal amino acid is attached to a cross-linked polystyrene resin *via* an acid labile bond with a linker molecule. This resin is insoluble in the solvents used for synthesis, making it relatively simple and fast to wash away excess reagents and by-products. The N-terminus is protected with the Fmoc group, which is stable in acid, but removable by base. Side chain functional groups are protected as necessary with base stable, acid labile groups.

[00126] Longer peptidomimetic precursors are produced, for example, by conjoining individual synthetic peptides using native chemical ligation. Alternatively, the longer synthetic peptides are biosynthesized by well known recombinant DNA and protein expression techniques. Such techniques are provided in well-known standard manuals with detailed protocols. To construct a gene encoding a peptidomimetic precursor of this invention, the amino acid sequence is reverse translated to obtain a nucleic acid sequence encoding the amino acid sequence, preferably with codons that are optimum for the organism in which the gene is to be expressed. Next, a synthetic gene is made, typically by synthesizing oligonucleotides which encode the peptide and any regulatory elements, if necessary. The synthetic gene is inserted in a suitable cloning vector and transfected into a host cell. The peptide is then expressed under suitable conditions appropriate for the selected expression system and host. The peptide is purified and characterized by standard methods.

[00127] The peptidomimetic precursors are made, for example, in a high-throughput, combinatorial fashion using, for example, a high-throughput polychannel combinatorial synthesizer (*e.g.*, Thuramed TETRAS multichannel peptide synthesizer from CreoSalus, Louisville, KY or Model Apex 396 multichannel peptide synthesizer from AAPPTEC, Inc., Louisville, KY).

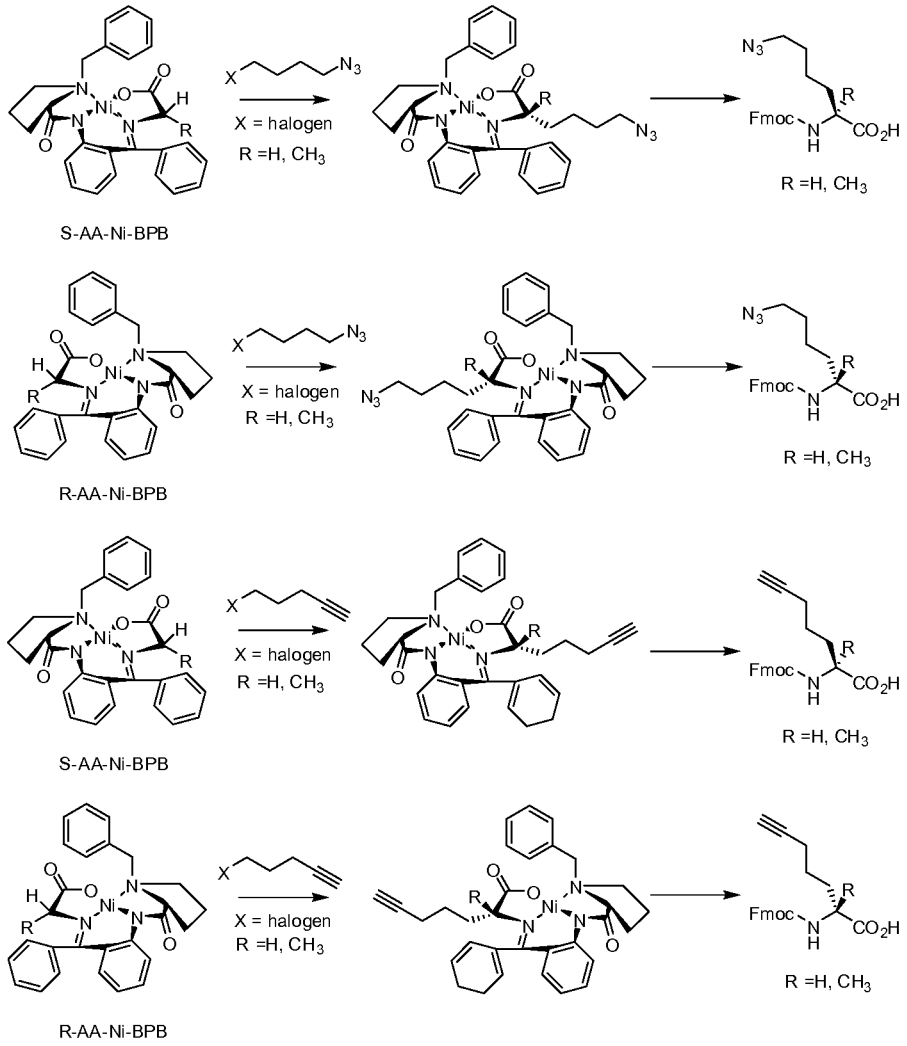
[00128] In some embodiments, the peptidomimetic macrocyles of the invention comprise triazole macrocycle-forming linkers. For example, the synthesis of such peptidomimetic macrocycles involves a multi-step process that features the synthesis of a peptidomimetic precursor containing an azide moiety and an alkyne moiety; followed by contacting the peptidomimetic precursor with

a macrocyclization reagent to generate a triazole-linked peptidomimetic macrocycle. Such a process is described, for example, in US Application 12/037,041, filed on February 25, 2008. Macrocycles or macrocycle precursors are synthesized, for example, by solution phase or solid-phase methods, and can contain both naturally-occurring and non-naturally-occurring amino acids. See, for example, Hunt, "The Non-Protein Amino Acids" in Chemistry and Biochemistry of the Amino Acids, edited by G.C. Barrett, Chapman and Hall, 1985.

[00129] In some embodiments, an azide is linked to the α-carbon of a residue and an alkyne is attached to the α-carbon of another residue. In some embodiments, the azide moieties are azido-analogs of amino acids L-lysine, D-lysine, alpha-methyl-L-lysine, alpha-methyl-D-lysine, L-ornithine, D-ornithine, alpha-methyl-L-ornithine or alpha-methyl-D-ornithine. In another embodiment, the alkyne moiety is L-propargylglycine. In yet other embodiments, the alkyne moiety is an amino acid selected from the group consisting of L-propargylglycine, D-propargylglycine, (S)-2-amino-2-methyl-4-pentynoic acid, (R)-2-amino-2-methyl-4-pentynoic acid, (S)-2-amino-2-methyl-5-hexynoic acid, (R)-2-amino-2-methyl-5-hexynoic acid, (S)-2-amino-2-methyl-6-heptynoic acid, (R)-2-amino-2-methyl-6-heptynoic acid, (S)-2-amino-2-methyl-7-octynoic acid, (R)-2-amino-2-methyl-7-octynoic acid, (S)-2-amino-2-methyl-8-nonynoic acid and (R)-2-amino-2-methyl-8-nonynoic acid.

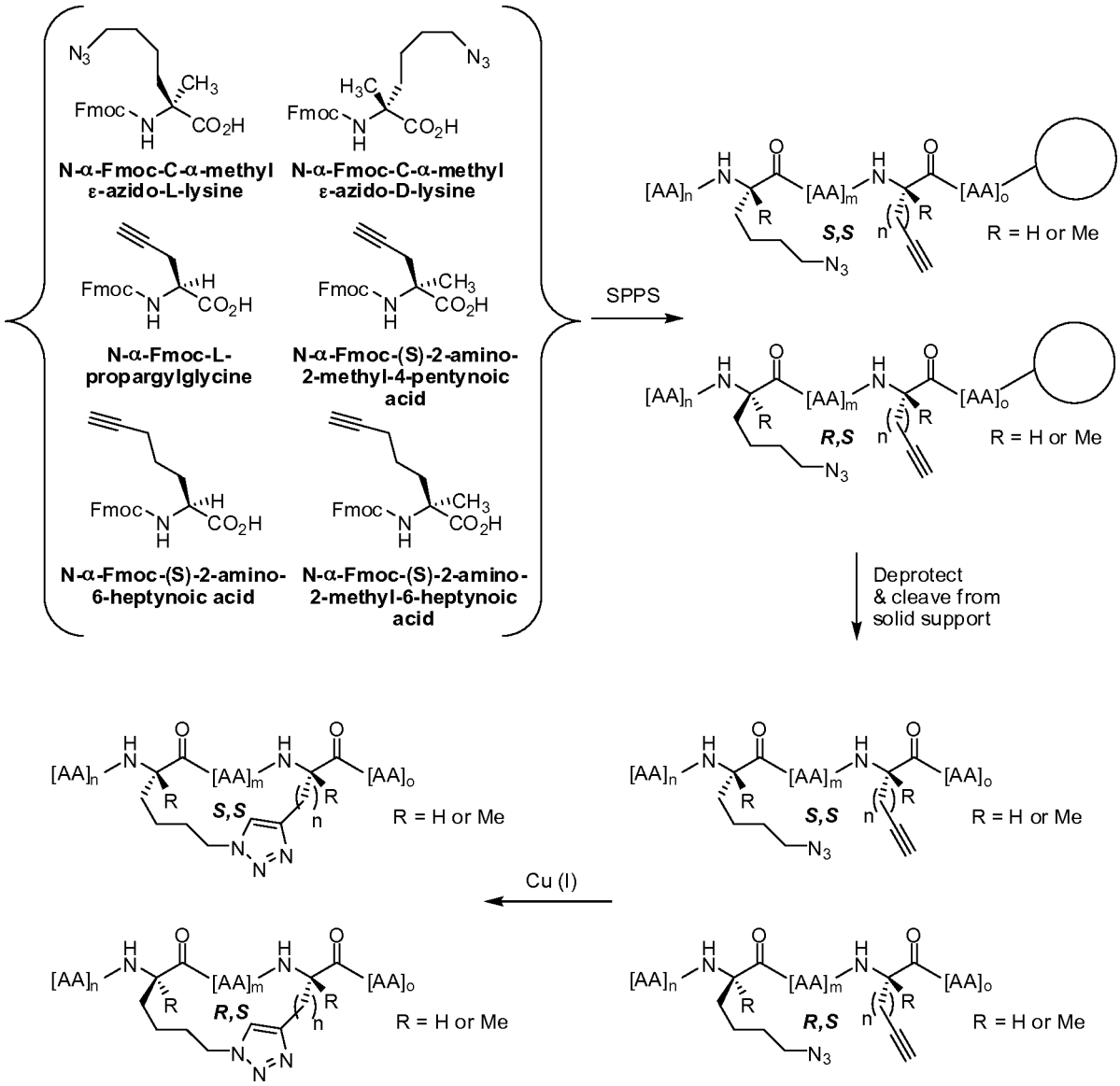
[00130] The following synthetic schemes are provided solely to illustrate the present invention and are not intended to limit the scope of the invention, as described herein. To simplify the drawings, the illustrative schemes depict azido amino acid analogs ε-azido-α-methyl-L-lysine and ε-azido-α-methyl-D-lysine, and alkyne amino acid analogs L-propargylglycine, (S)-2-amino-2-methyl-4-pentynoic acid, and (S)-2-amino-2-methyl-6-heptynoic acid. Thus, in the following synthetic schemes, each R_1, R_2, R_7 and R_8 is -H; each L_1 is $-(CH_2)_4-$; and each L_2 is $-(CH_2)-$. However, as noted throughout the detailed description above, many other amino acid analogs can be employed in which R_1, R_2, R_7, R_8, L_1 and L_2 can be independently selected from the various structures disclosed herein.

[00131] Synthetic Scheme 1:



[00132] Synthetic Scheme 1 describes the preparation of several compounds of the invention. Ni(II) complexes of Schiff bases derived from the chiral auxiliary (S)-2-[N-(N'-benzylprolyl)amino]benzophenone (BPB) and amino acids such as glycine or alanine are prepared as described in Belokon *et al.* (1998), *Tetrahedron Asymm.* 9:4249-4252. The resulting complexes are subsequently reacted with alkylating reagents comprising an azido or alkynyl moiety to yield enantiomerically enriched compounds of the invention. If desired, the resulting compounds can be protected for use in peptide synthesis.

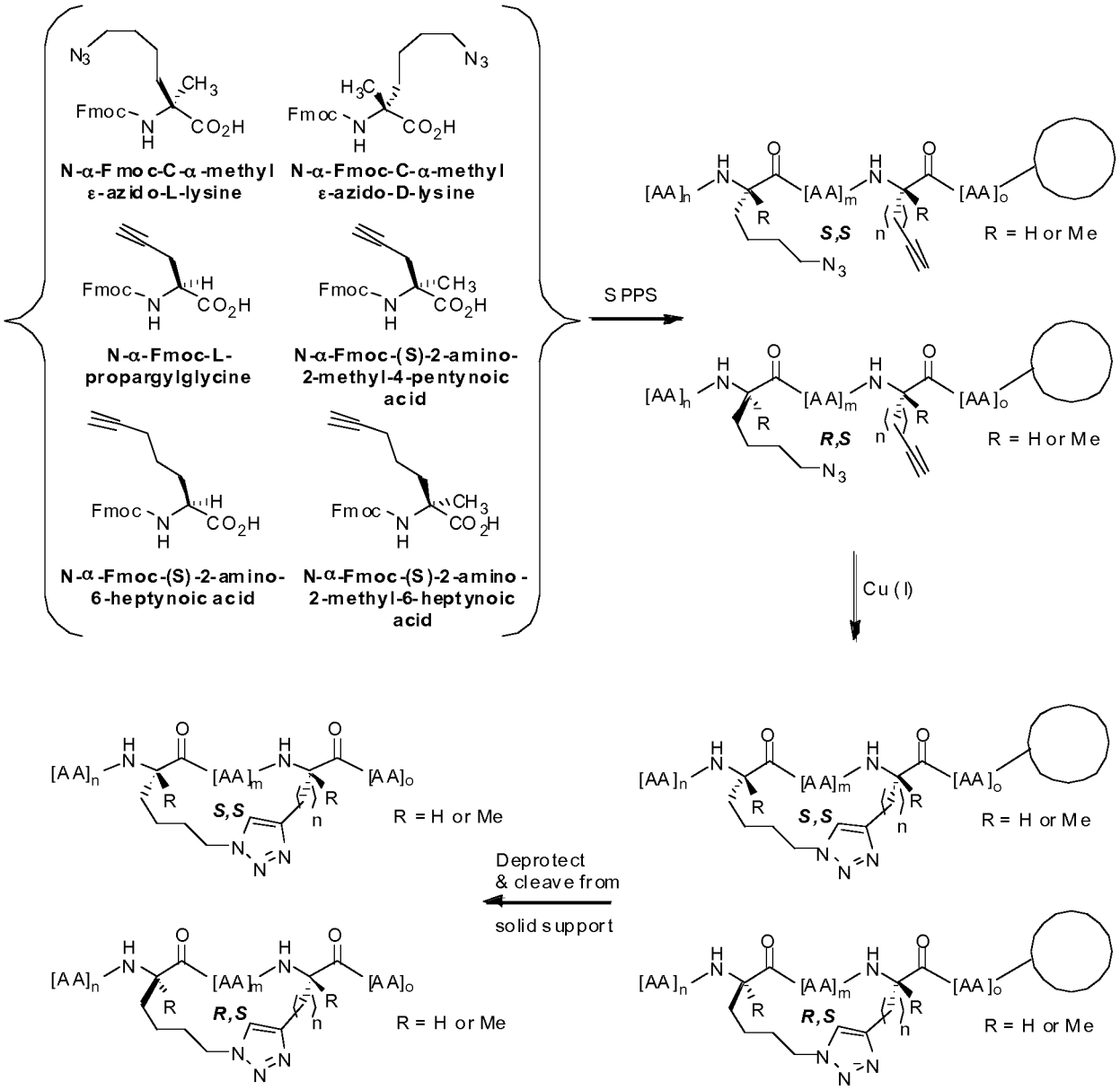
[00133] Synthetic Scheme 2:



[00134] In the general method for the synthesis of peptidomimetic macrocycles shown in Synthetic Scheme 2, the peptidomimetic precursor contains an azide moiety and an alkyne moiety and is synthesized by solution-phase or solid-phase peptide synthesis (SPPS) using the commercially available amino acid N-α-Fmoc-L-propargylglycine and the N-α-Fmoc-protected forms of the amino acids (S)-2-amino-2-methyl-4-pentynoic acid, (S)-2-amino-6-heptynoic acid, (S)-2-amino-2-methyl-6-heptynoic acid, N-methyl-ε-azido-L-lysine, and N-methyl-ε-azido-D-lysine. The peptidomimetic precursor is then deprotected and cleaved from the solid-phase resin by standard conditions (*e.g.*, strong acid such as 95% TFA). The peptidomimetic precursor is reacted as a crude mixture or is purified prior to reaction with a macrocyclization reagent such as a Cu(I) in organic or aqueous solutions (Rostovtsev *et al.* (2002), *Angew. Chem. Int. Ed.* 41:2596-2599; Tornoe *et al.* (2002), *J. Org. Chem.* 67:3057-3064; Deiters *et al.* (2003), *J. Am. Chem. Soc.* 125:11782-11783; Punna *et al.* (2005), *Angew. Chem. Int. Ed.* 44:2215-2220). In one embodiment, the triazole forming reaction is performed under conditions that favor α-helix

formation. In one embodiment, the macrocyclization step is performed in a solvent chosen from the group consisting of H_2O, THF, CH_3CN, DMF , DIPEA, tBuOH or a mixture thereof. In another embodiment, the macrocyclization step is performed in DMF. In some embodiments, the macrocyclization step is performed in a buffered aqueous or partially aqueous solvent.

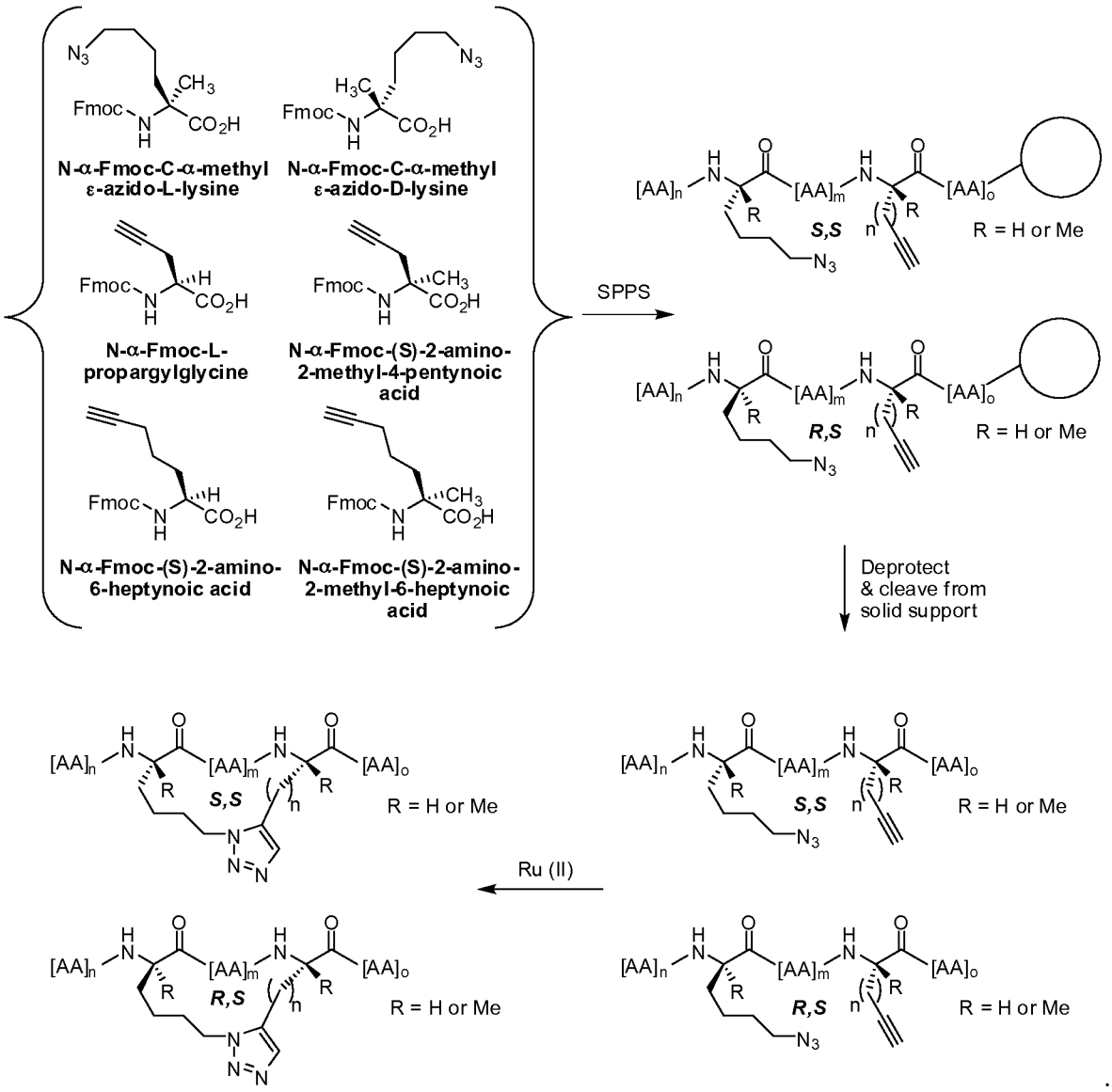
[00135] Synthetic Scheme 3:



[00136] In the general method for the synthesis of peptidomimetic macrocycles shown in Synthetic Scheme 3, the peptidomimetic precursor contains an azide moiety and an alkyne moiety and is synthesized by solid-phase peptide synthesis (SPPS) using the commercially available amino acid N-α-Fmoc-L-propargylglycine and the N-α-Fmoc-protected forms of the amino acids (S)-2-amino-2-methyl-4-pentynoic acid, (S)-2-amino-6-heptynoic acid, (S)-2-amino-2-methyl-6-heptynoic acid, N-methyl-ε-azido-L-lysine, and N-methyl-ε-azido-D-lysine. The peptidomimetic

precursor is reacted with a macrocyclization reagent such as a Cu(I) reagent on the resin as a crude mixture (Rostovtsev *et al.* (2002), *Angew. Chem. Int. Ed.* 41:2596-2599; Tornoe *et al.* (2002), *J. Org. Chem.* 67:3057-3064; Deiters *et al.* (2003), *J. Am. Chem. Soc.* 125:11782-11783; Punna *et al.* (2005), *Angew. Chem. Int. Ed.* 44:2215-2220). The resultant triazole-containing peptidomimetic macrocycle is then deprotected and cleaved from the solid-phase resin by standard conditions (*e.g.*, strong acid such as 95% TFA). In some embodiments, the macrocyclization step is performed in a solvent chosen from the group consisting of CH_2Cl_2, $ClCH_2CH_2Cl$, DMF, THF, NMP, DIPEA, 2,6-lutidine, pyridine, DMSO, H_2O or a mixture thereof. In some embodiments, the macrocyclization step is performed in a buffered aqueous or partially aqueous solvent.

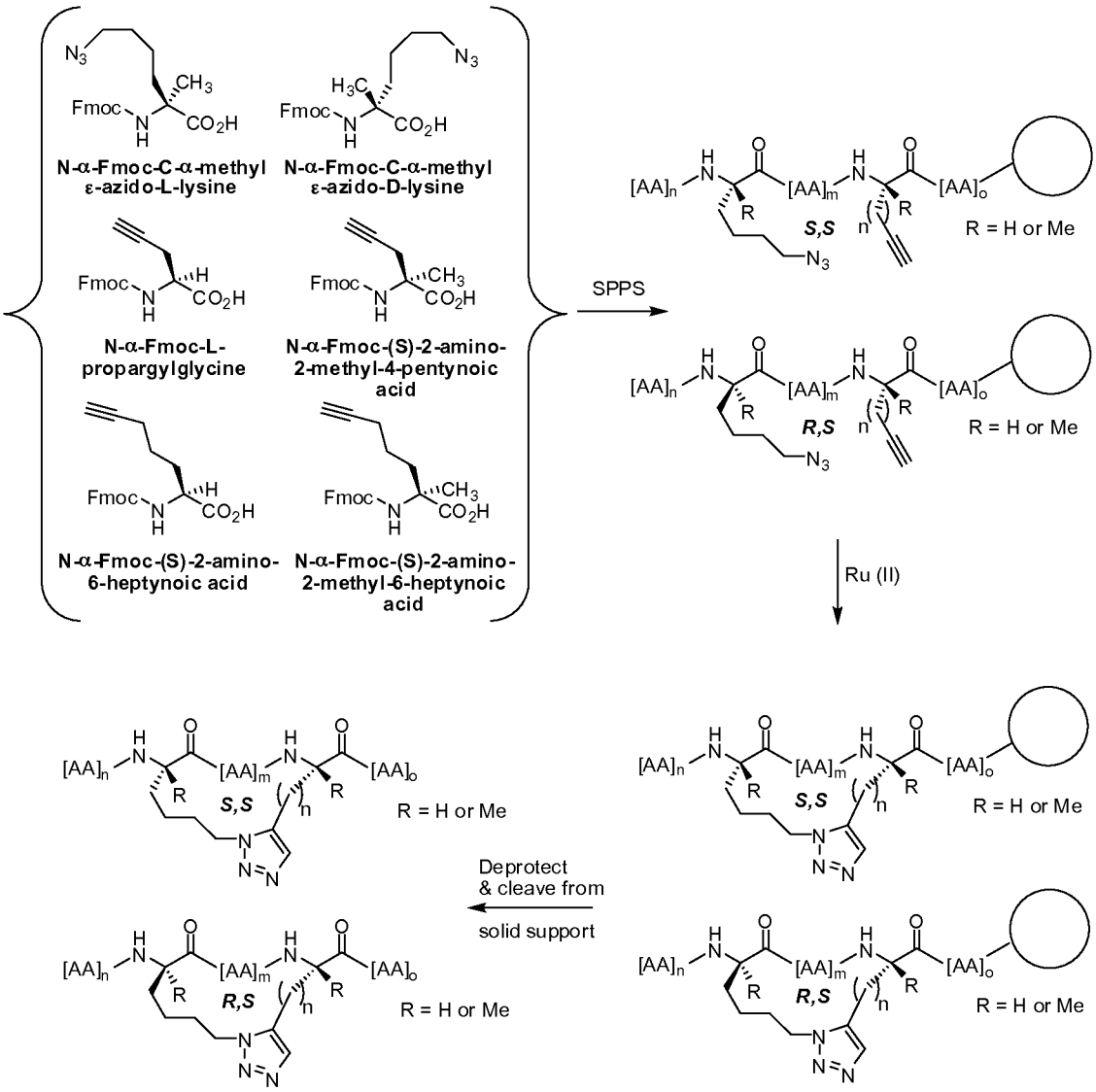
[00137] Synthetic Scheme 4:



[00138] In the general method for the synthesis of peptidomimetic macrocycles shown in Synthetic Scheme 4, the peptidomimetic precursor contains an azide moiety and an alkyne moiety and is

synthesized by solution-phase or solid-phase peptide synthesis (SPPS) using the commercially available amino acid N-α-Fmoc-L-propargylglycine and the N-α-Fmoc-protected forms of the amino acids (S)-2-amino-2-methyl-4-pentynoic acid, (S)-2-amino-6-heptynoic acid, (S)-2-amino-2-methyl-6-heptynoic acid, N-methyl-ε-azido-L-lysine, and N-methyl-ε-azido-D-lysine. The peptidomimetic precursor is then deprotected and cleaved from the solid-phase resin by standard conditions (*e.g.*, strong acid such as 95% TFA). The peptidomimetic precursor is reacted as a crude mixture or is purified prior to reaction with a macrocyclization reagent such as a Ru(II) reagents, for example $Cp^*RuCl(PPh_3)_2$ or $[Cp^*RuCl]_4$ (Rasmussen *et al.* (2007), *Org. Lett.* 9:5337-5339; Zhang *et al.* (2005), *J. Am. Chem. Soc.* 127:15998-15999). In some embodiments, the macrocyclization step is performed in a solvent chosen from the group consisting of DMF, CH_3CN and THF.

[00139] Synthetic Scheme 5:



[00140] In the general method for the synthesis of peptidomimetic macrocycles shown in Synthetic Scheme 5, the peptidomimetic precursor contains an azide moiety and an alkyne moiety and is

synthesized by solid-phase peptide synthesis (SPPS) using the commercially available amino acidN-α-Fmoc-L-propargylglycine and the N-α-Fmoc-protected forms of the amino acids (S)-2-amino-2-methyl-4-pentynoic acid, (S)-2-amino-6-heptynoic acid, (S)-2-amino-2-methyl-6-heptynoic acid, N-methyl-ε-azido-L-lysine, and N-methyl-ε-azido-D-lysine. The peptidomimetic precursor is reacted with a macrocyclization reagent such as a Ru(II) reagent on the resin as a crude mixture. For example, the reagent can be $Cp^*RuCl(PPh_3)_2$ or $[Cp^*RuCl]_4$ (Rasmussen *et al.* (2007), *Org. Lett.* 9:5337-5339; Zhang *et al.* (2005), *J. Am. Chem. Soc.* 127:15998-15999). In some embodiments, the macrocyclization step is performed in a solvent chosen from the group consisting of CH_2Cl_2, $ClCH_2CH_2Cl$, CH_3CN, DMF, and THF.

[00141] The present invention contemplates the use of non-naturally-occurring amino acids and amino acid analogs in the synthesis of the peptidomimetic macrocycles described herein. Any amino acid or amino acid analog amenable to the synthetic methods employed for the synthesis of stable triazole containing peptidomimetic macrocycles can be used in the present invention. For example, L-propargylglycine is contemplated as a useful amino acid in the present invention. However, other alkyne-containing amino acids that contain a different amino acid side chain are also useful in the invention. For example, L-propargylglycine contains one methylene unit between the α-carbon of the amino acid and the alkyne of the amino acid side chain. The invention also contemplates the use of amino acids with multiple methylene units between the α-carbon and the alkyne. Also, the azido-analogs of amino acids L-lysine, D-lysine, alpha-methyl-L-lysine, and alpha-methyl-D-lysine are contemplated as useful amino acids in the present invention. However, other terminal azide amino acids that contain a different amino acid side chain are also useful in the invention. For example, the azido-analog of L-lysine contains four methylene units between the α-carbon of the amino acid and the terminal azide of the amino acid side chain. The invention also contemplates the use of amino acids with fewer than or greater than four methylene units between the α-carbon and the terminal azide. Table 3 shows some amino acids useful in the preparation of peptidomimetic macrocycles disclosed herein.

TABLE 3

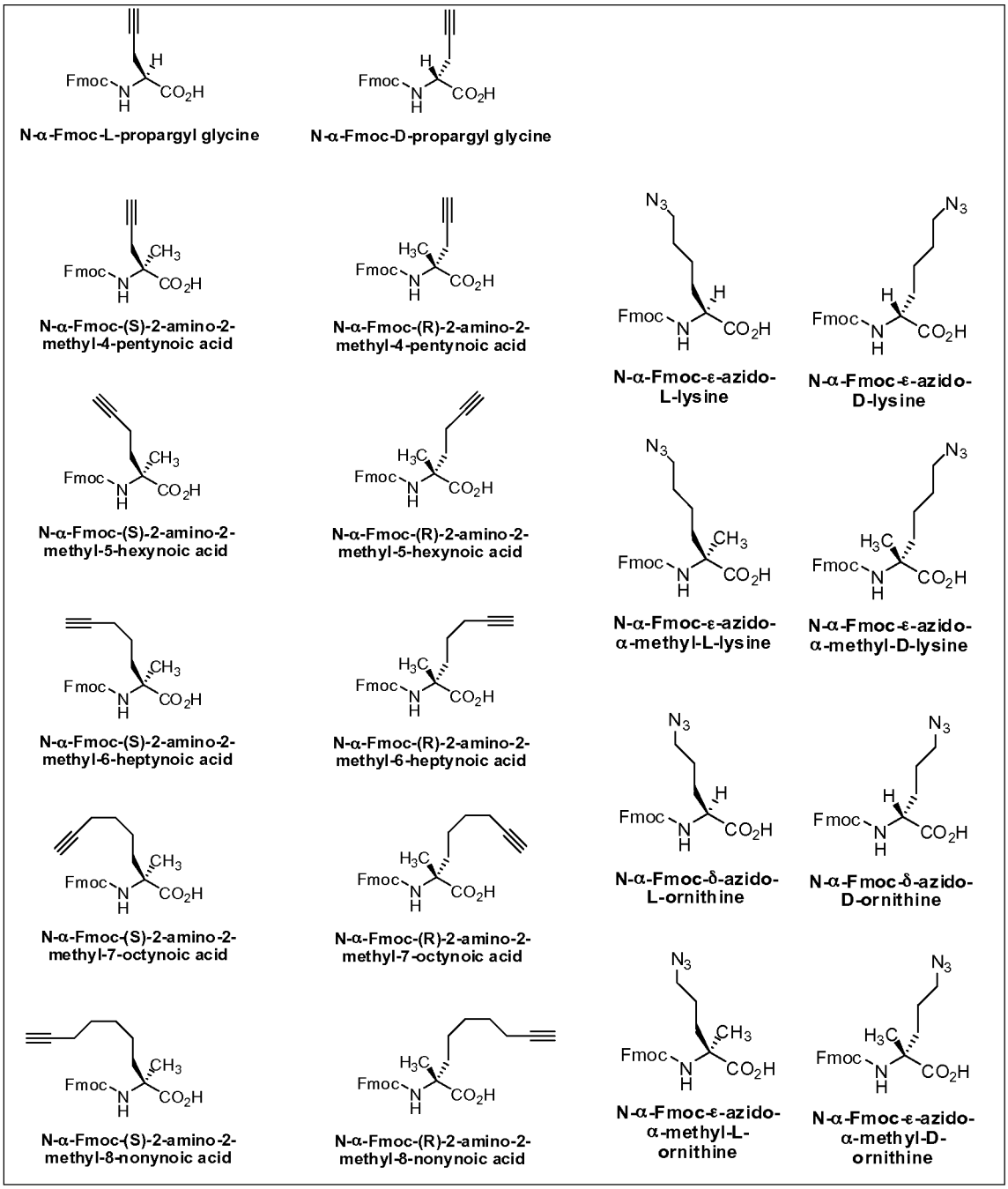


Table 3 shows exemplary amino acids useful in the preparation of peptidomimetic macrocycles disclosed herein.

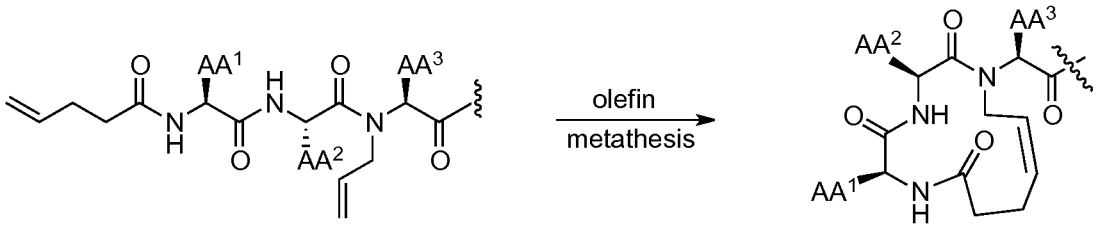
[00142] In some embodiments the amino acids and amino acid analogs are of the D-configuration. In other embodiments they are of the L-configuration. In some embodiments, some of the amino acids and amino acid analogs contained in the peptidomimetic are of the D-configuration while some of the amino acids and amino acid analogs are of the L-configuration. In some embodiments the amino acid analogs are α,α-disubstituted, such as α-methyl-L-propargylglycine, α-methyl-D-propargylglycine, ε-azido-alpha-methyl-L-lysine, and ε-azido-alpha-methyl-D-lysine. In some embodiments the amino acid analogs are N-alkylated, *e.g.*, N-methyl-L-

propargylglycine, N-methyl-D-propargylglycine, N-methyl-ε-azido-L-lysine, and N-methyl-ε-azido-D-lysine.

[00143] In some embodiments, the –NH moiety of the amino acid is protected using a protecting group, including without limitation -Fmoc and -Boc. In other embodiments, the amino acid is not protected prior to synthesis of the peptidomimetic macrocycle.

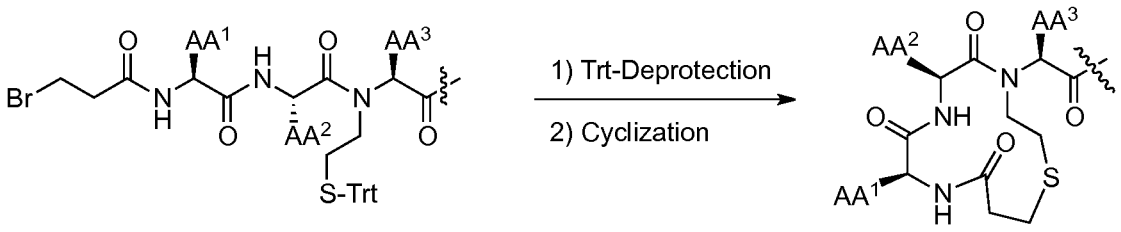
[00144] Additional methods of forming peptidomimetic macrocycles which are envisioned as suitable to perform the present invention include those disclosed by Mustapa, M. Firouz Mohd et al., J. Org. Chem (2003), 68, pp. 8193-8198; Yang, Bin et al. Bioorg Med. Chem. Lett. (2004), 14, pp. 1403-1406; U.S. Patent No. 5,364,851; U.S. Patent No. 5,446,128; U.S. Patent No. 5,824,483; U.S. Patent No. 6,713,280; and U.S. Patent No. 7,202,332. In such embodiments, aminoacid precursors are used containing an additional substituent R- at the alpha position. Such aminoacids are incorporated into the macrocycle precursor at the desired positions, which may be at the positions where the crosslinker is substituted or, alternatively, elsewhere in the sequence of the macrocycle precursor. Cyclization of the precursor is then performed according to the indicated method.

[00145] For example, a peptidomimetic macrocycle of Formula (II) is prepared as indicated:



wherein each AA_1, AA_2, AA_3 is independently an amino acid side chain.

[00146] In other embodiments, a peptidomimetic macrocycle of Formula (II) is prepared as indicated:



wherein each AA_1, AA_2, AA_3 is independently an amino acid side chain.

[00147] In some embodiments, a peptidomimetic macrocycle is obtained in more than one isomer, for example due to the configuration of a double bond within the structure of the crosslinker (*E* vs *Z*). Such isomers can or can not be separable by conventional chromatographic methods. In some embodiments, one isomer has improved biological properties relative to the other isomer. In one embodiment, an *E* crosslinker olefin isomer of a peptidomimetic macrocycle has better solubility, better target affinity, better in vivo or in vitro efficacy, higher helicity, or improved cell permeability relative to its *Z* counterpart. In another embodiment, a *Z* crosslinker olefin isomer of

a peptidomimetic macrocycle has better solubility, better target affinity, better in vivo or in vitro efficacy, higher helicity, or improved cell permeability relative to its *E* counterpart.

Assays

[00148] The properties of the peptidomimetic macrocycles of the invention are assayed, for example, by using the methods described below. In some embodiments, a peptidomimetic macrocycle of the invention has improved biological properties relative to a corresponding polypeptide lacking the substituents described herein.

Assay to Determine α-helicity.

[00149] In solution, the secondary structure of polypeptides with α-helical domains will reach a dynamic equilibrium between random coil structures and α-helical structures, often expressed as a "percent helicity". Thus, for example, alpha-helical domains are predominantly random coils in solution, with α-helical content usually under 25%. Peptidomimetic macrocycles with optimized linkers, on the other hand, possess, for example, an alpha-helicity that is at least two-fold greater than that of a corresponding uncrosslinked polypeptide. In some embodiments, macrocycles of the invention will possess an alpha-helicity of greater than 50%. To assay the helicity of peptidomimetic macrocyles of the invention, the compounds are dissolved in an aqueous solution (e.g. 50 mM potassium phosphate solution at pH 7, or distilled H_2O, to concentrations of 25-50 μM). Circular dichroism (CD) spectra are obtained on a spectropolarimeter (*e.g.*, Jasco J-710) using standard measurement parameters (e.g. temperature, 20°C; wavelength, 190-260 nm; step resolution, 0.5 nm; speed, 20 nm/sec; accumulations, 10; response, 1 sec; bandwidth, 1 nm; path length, 0.1 cm). The α-helical content of each peptide is calculated by dividing the mean residue ellipticity (e.g. [Φ]222obs) by the reported value for a model helical decapeptide (Yang *et al.* (1986), *Methods Enzymol.* 130:208)).

Assay to Determine Melting Temperature (Tm).

[00150] A peptidomimetic macrocycle of the invention comprising a secondary structure such as an α-helix exhibits, for example, a higher melting temperature than a corresponding uncrosslinked polypeptide. Typically peptidomimetic macrocycles of the invention exhibit Tm of > 60°C representing a highly stable structure in aqueous solutions. To assay the effect of macrocycle formation on meltine temperature, peptidomimetic macrocycles or unmodified peptides are dissolved in distilled H_2O (e.g. at a final concentration of 50 μM) and the Tm is determined by measuring the change in ellipticity over a temperature range (e.g. 4 to 95 °C) on a spectropolarimeter (*e.g.*, Jasco J-710) using standard parameters (e.g. wavelength 222nm; step resolution, 0.5 nm; speed, 20 nm/sec; accumulations, 10; response, 1 sec; bandwidth, 1 nm; temperature increase rate: 1°C/min; path length, 0.1 cm).

Protease Resistance Assay.

[00151] The amide bond of the peptide backbone is susceptible to hydrolysis by proteases, thereby rendering peptidic compounds vulnerable to rapid degradation *in vivo*. Peptide helix formation, however, typically buries the amide backbone and therefore may shield it from proteolytic cleavage. The peptidomimetic macrocycles of the present invention may be subjected to *in vitro* trypsin proteolysis to assess for any change in degradation rate compared to a corresponding uncrosslinked polypeptide. For example, the peptidomimetic macrocycle and a corresponding uncrosslinked polypeptide are incubated with trypsin agarose and the reactions quenched at various time points by centrifugation and subsequent HPLC injection to quantitate the residual substrate by ultraviolet absorption at 280 nm. Briefly, the peptidomimetic macrocycle and peptidomimetic precursor (5 mcg) are incubated with trypsin agarose (Pierce) (S/E ~125) for 0, 10, 20, 90, and 180 minutes. Reactions are quenched by tabletop centrifugation at high speed; remaining substrate in the isolated supernatant is quantified by HPLC-based peak detection at 280 nm. The proteolytic reaction displays first order kinetics and the rate constant, k, is determined from a plot of ln[S] versus time (k=-1Xslope).

Ex Vivo Stability Assay.

[00152] Peptidomimetic macrocycles with optimized linkers possess, for example, an *ex vivo* half-life that is at least two-fold greater than that of a corresponding uncrosslinked polypeptide, and possess an *ex vivo* half-life of 12 hours or more. For *ex vivo* serum stability studies, a variety of assays may be used. For example, a peptidomimetic macrocycle and a corresponding uncrosslinked polypeptide (2 mcg) are incubated with fresh mouse, rat and/or human serum (2 mL) at 37°C for 0, 1, 2, 4, 8, and 24 hours. To determine the level of intact compound, the following procedure may be used: The samples are extracted by transferring 100 µl of sera to 2 ml centrifuge tubes followed by the addition of 10 µL of 50 % formic acid and 500µL acetonitrile and centrifugation at 14,000 RPM for 10 min at 4 ± 2°C. The supernatants are then transferred to fresh 2 ml tubes and evaporated on Turbovap under N_2 < 10 psi, 37°C. The samples are reconstituted in 100µL of 50:50 acetonitrile:water and submitted to LC-MS/MS analysis.

In vitro Binding Assays.

[00153] To assess the binding and affinity of peptidomimetic macrocycles and peptidomimetic precursors to acceptor proteins, a fluorescence polarization assay (FPA) isused, for example. The FPA technique measures the molecular orientation and mobility using polarized light and fluorescent tracer. When excited with polarized light, fluorescent tracers (*e.g.*, FITC) attached to molecules with high apparent molecular weights (*e.g.* FITC-labeled peptides bound to a large protein) emit higher levels of polarized fluorescence due to their slower rates of rotation as compared to fluorescent tracers attached to smaller molecules (*e.g.* FITC- labeled peptides that are free in solution).

[00154] For example, fluoresceinated peptidomimetic macrocycles (25 nM) are incubated with the acceptor protein (25- 1000 nM) in binding buffer (140 mM NaCl, 50 mM Tris-HCL, pH 7.4) for 30 minutes at room temperature. Binding activity is measured, for example, by fluorescence polarization on a luminescence spectrophotometer (e.g. Perkin-Elmer LS50B). Kd values may be determined by nonlinear regression analysis using, for example, Graphpad Prism software (GraphPad Software, Inc., San Diego, CA). A peptidomimetic macrocycle of the invention shows, in some instances, similar or lower Kd than a corresponding uncrosslinked polypeptide.

In vitro Displacement Assays To Characterize Antagonists of Peptide-Protein Interactions.

[00155] To assess the binding and affinity of compounds that antagonize the interaction between a peptide and an acceptor protein, a fluorescence polarization assay (FPA) utilizing a fluoresceinated peptidomimetic macrocycle derived from a peptidomimetic precursor sequence is used, for example. The FPA technique measures the molecular orientation and mobility using polarized light and fluorescent tracer. When excited with polarized light, fluorescent tracers (*e.g.*, FITC) attached to molecules with high apparent molecular weights (*e.g.* FITC-labeled peptides bound to a large protein) emit higher levels of polarized fluorescence due to their slower rates of rotation as compared to fluorescent tracers attached to smaller molecules (*e.g.* FITC-labeled peptides that are free in solution). A compound that antagonizes the interaction between the fluoresceinated peptidomimetic macrocycle and an acceptor protein will be detected in a competitive binding FPA experiment.

[00156] For example, putative antagonist compounds (1 nM to 1 mM) and a fluoresceinated peptidomimetic macrocycle (25 nM) are incubated with the acceptor protein (50 nM) in binding buffer (140mM NaCl, 50 mM Tris-HCL, pH 7.4) for 30 minutes at room temperature. Antagonist binding activity ismeasured, for example, by fluorescence polarization on a luminescence spectrophotometer (e.g. Perkin-Elmer LS50B). Kd values may be determined by nonlinear regression analysis using, for example, Graphpad Prism software (GraphPad Software, Inc., San Diego, CA).

[00157] Any class of molecule, such as small organic molecules, peptides, oligonucleotides or proteins can be examined as putative antagonists in this assay.

Assay for Protein-ligand binding by Affinity Selection-Mass Spectrometry

[00158] To assess the binding and affinity of test compounds for proteins, an affinity-selection mass spectrometry assay is used, for example. Protein-ligand binding experiments are conducted according to the following representative procedure outlined for a system-wide control experiment using 1 μM peptidomimetic macrocycle plus 5 μM target protein. A 1 μL DMSO aliquot of a 40 μM stock solution of peptidomimetic macrocycle is dissolved in 19 μL of PBS (Phosphate-buffered saline: 50 mM, pH 7.5 Phosphate buffer containing 150 mM NaCl). The resulting solution is mixed by repeated pipetting and clarified by centrifugation at 10 000g for 10

min. To a 4 μL aliquot of the resulting supernatant is added 4 μL of 10 μM target protein in PBS. Each 8.0 μL experimental sample thus contains 40 pmol (1.5 μg) of protein at 5.0 μM concentration in PBS plus 1 μM peptidomimetic macrocycle and 2.5% DMSO. Duplicate samples thus prepared for each concentration point are incubated for 60 min at room temperature, and then chilled to 4 °C prior to size-exclusion chromatography-LC-MS analysis of 5.0 μL injections. Samples containing a target protein, protein–ligand complexes, and unbound compounds are injected onto an SEC column, where the complexes are separated from non-binding component by a rapid SEC step. The SEC column eluate is monitored using UV detectors to confirm that the early-eluting protein fraction, which elutes in the void volume of the SEC column, is well resolved from unbound components that are retained on the column. After the peak containing the protein and protein–ligand complexes elutes from the primary UV detector, it enters a sample loop where it is excised from the flow stream of the SEC stage and transferred directly to the LC-MS via a valving mechanism. The $(M + 3H)^{3+}$ ion of the peptidomimetic macrocycle is observed by ESI-MS at the expected m/z, confirming the detection of the protein-ligand complex.

Assay for Protein-ligand Kd Titration Experiments.

[00159] To assess the binding and affinity of test compounds for proteins, a protein-ligand Kd titration experiment is performed, for example. Protein-ligand K_d titrations experiments are conducted as follows: 2 μL DMSO aliquots of a serially diluted stock solution of titrant peptidomimetic macrocycle (5, 2.5, ..., 0.098 mM) are prepared then dissolved in 38 μL of PBS. The resulting solutions are mixed by repeated pipetting and clarified by centrifugation at 10 000g for 10 min. To 4.0 μL aliquots of the resulting supernatants is added 4.0 μL of 10 μM target protein in PBS. Each 8.0 μL experimental sample thus contains 40 pmol (1.5 μg) of protein at 5.0 μM concentration in PBS, varying concentrations (125, 62.5, ..., 0.24 μM) of the titrant peptide, and 2.5% DMSO. Duplicate samples thus prepared for each concentration point are incubated at room temperature for 30 min, then chilled to 4 °C prior to SEC-LC-MS analysis of 2.0 μL injections. The $(M + H)^{1+}$, $(M + 2H)^{2+}$, $(M + 3H)^{3+}$, and/or $(M + Na)^{1+}$ ion is observed by ESI-MS; extracted ion chromatograms are quantified, then fit to equations to derive the binding affinity K_d as described in "*A General Technique to Rank Protein-Ligand Binding Affinities and Determine Allosteric vs. Direct Binding Site Competition in Compound Mixtures*." Annis, D. A.; Nazef, N.; Chuang, C. C.; Scott, M. P.; Nash, H. M. *J. Am. Chem. Soc.* **2004**, *126*, 15495-15503; also in "*ALIS: An Affinity Selection-Mass Spectrometry System for the Discovery and Characterization of Protein-Ligand Interactions*" D. A. Annis, C.-C. Chuang, and N. Nazef. In Mass Spectrometry in Medicinal Chemistry. Edited by Wanner K, Höfner G: Wiley-VCH; **2007**:121-184. Mannhold R, Kubinyi H, Folkers G (Series Editors): Methods and Principles in Medicinal Chemistry.

Assay for Competitive Binding Experiments by Affinity Selection-Mass Spectrometry

[00160] To determine the ability of test compounds to bind competitively to proteins, an affiinity selection mass spectrometry assay is performed, for example. A mixture of ligands at 40 μM per component is prepared by combining 2 μL aliquots of 400 μM stocks of each of the three compounds with 14 μL of DMSO. Then, 1 μL aliquots of this 40 μM per component mixture are combined with 1 μL DMSO aliquots of a serially diluted stock solution of titrant peptidomimetic macrocycle (10, 5, 2.5, ..., 0.078 mM). These 2 μL samples are dissolved in 38 μL of PBS. The resulting solutions were mixed by repeated pipetting and clarified by centrifugation at 10 000g for 10 min. To 4.0 μL aliquots of the resulting supernatants is added 4.0 μL of 10 μM target protein in PBS. Each 8.0 μL experimental sample thus contains 40 pmol (1.5 μg) of protein at 5.0 μM concentration in PBS plus 0.5 μM ligand, 2.5% DMSO, and varying concentrations (125, 62.5, ..., 0.98 μM) of the titrant peptidomimetic macrocycle. Duplicate samples thus prepared for each concentration point are incubated at room temperature for 60 min, then chilled to 4 °C prior to SEC-LC-MS analysis of 2.0 μL injections. Additional details on these and other methods are provided in "*A General Technique to Rank Protein-Ligand Binding Affinities and Determine Allosteric vs. Direct Binding Site Competition in Compound Mixtures*." Annis, D. A.; Nazef, N.; Chuang, C. C.; Scott, M. P.; Nash, H. M. *J. Am. Chem. Soc.* **2004**, *126*, 15495-15503; also in "*ALIS: An Affinity Selection-Mass Spectrometry System for the Discovery and Characterization of Protein-Ligand Interactions*" D. A. Annis, C.-C. Chuang, and N. Nazef. In Mass Spectrometry in Medicinal Chemistry. Edited by Wanner K, Höfner G: Wiley-VCH; **2007**:121-184. Mannhold R, Kubinyi H, Folkers G (Series Editors): Methods and Principles in Medicinal Chemistry.

Binding Assays in Intact Cells.

[00161] It is possible to measure binding of peptides or peptidomimetic macrocycles to their natural acceptors in intact cells by immunoprecipitation experiments. For example, intact cells are incubated with fluoresceinated (FITC-labeled) compounds for 4 hrs in the absence of serum, followed by serum replacement and further incubation that ranges from 4-18 hrs. Cells are then pelleted and incubated in lysis buffer (50mM Tris [pH 7.6], 150 mM NaCl, 1% CHAPS and protease inhibitor cocktail) for 10 minutes at 4°C. Extracts are centrifuged at 14,000 rpm for 15 minutes and supernatants collected and incubated with 10 μl goat anti-FITC antibody for 2 hrs, rotating at 4°C followed by further 2 hrs incubation at 4°C with protein A/G Sepharose (50 μl of 50% bead slurry). After quick centrifugation, the pellets are washed in lysis buffer containing increasing salt concentration (*e.g.*, 150, 300, 500 mM). The beads are then re-equilibrated at 150 mM NaCl before addition of SDS-containing sample buffer and boiling. After centrifugation, the supernatants are optionally electrophoresed using 4%-12% gradient Bis-Tris gels followed by transfer into Immobilon-P membranes. After blocking, blots are optionally incubated with an antibody that detects FITC and also with one or more antibodies that detect proteins that bind to the peptidomimetic macrocycle.

Cellular Penetrability Assays.

[00162] To measure the cell penetrability of peptidomimetic macrocycles and corresponding uncrosslinked macrocycle, intact cells are incubated with fluoresceinated peptidomimetic macrocycles or corresponding uncrosslinked macrocycle (10 μM) for 4 hrs in serum free media at 37°C, washed twice with media and incubated with trypsin (0.25%) for 10 min at 37°C. The cells are washed again and resuspended in PBS. Cellular fluorescence is analyzed, for example, by using either a FACSCalibur flow cytometer or Cellomics' KineticScan ® HCS Reader.

In Vivo Stability Assay.

[00163] To investigate the *in vivo* stability of the peptidomimetic macrocycles, the compounds are, for example,administered to mice and/or rats by IV, IP, PO or inhalation routes at concentrations ranging from 0.1 to 50 mg/kg and blood specimens withdrawn at 0', 5', 15', 30', 1 hr, 4 hrs, 8 hrs and 24 hours post-injection. Levels of intact compound in 25 μL of fresh serum are then measured by LC-MS/MS as above.

Clinical Trials.

[00164] To determine the suitability of the peptidomimetic macrocycles of the invention for treatment of humans, clinical trials are performed. For example, patients diagnosed with a muscle wasting disease or lipodystrophy and in need of treatment are selected and separated in treatment and one or more control groups, wherein the treatment group is administered a peptidomimetic macrocycle of the invention, while the control groups receive a placebo or a known GHRH or GH drug. The treatment safety and efficacy of the peptidomimetic macrocycles of the invention can thus be evaluated by performing comparisons of the patient groups with respect to factors such as survival and quality-of-life. In this example, the patient group treated with a peptidomimetic macrocyle show improved long-term survival compared to a patient control group treated with a placebo.

Pharmaceutical Compositions and Routes of Administration

[00165] The peptidomimetic macrocycles of the invention also include pharmaceutically acceptable derivatives or prodrugs thereof. A "pharmaceutically acceptable derivative" means any pharmaceutically acceptable salt, ester, salt of an ester, pro-drug or other derivative of a compound of this invention which, upon administration to a recipient, is capable of providing (directly or indirectly) a compound of this invention. Particularly favored pharmaceutically acceptable derivatives are those that increase the bioavailability of the compounds of the invention when administered to a mammal (*e.g.*, by increasing absorption into the blood of an orally administered compound) or which increases delivery of the active compound to a biological compartment (*e.g.*, the brain or lymphatic system) relative to the parent species. Some

pharmaceutically acceptable derivatives include a chemical group which increases aqueous solubility or active transport across the gastrointestinal mucosa.

[00166] In some embodiments, the peptidomimetic macrocycles of the invention are modified by covalently or non-covalently joining appropriate functional groups to enhance selective biological properties. Such modifications include those which increase biological penetration into a given biological compartment (*e.g.*, blood, lymphatic system, central nervous system), increase oral availability, increase solubility to allow administration by injection, alter metabolism, and alter rate of excretion.

[00167] Pharmaceutically acceptable salts of the compounds of this invention include those derived from pharmaceutically acceptable inorganic and organic acids and bases. Examples of suitable acid salts include acetate, adipate, benzoate, benzenesulfonate, butyrate, citrate, digluconate, dodecylsulfate, formate, fumarate, glycolate, hemisulfate, heptanoate, hexanoate, hydrochloride, hydrobromide, hydroiodide, lactate, maleate, malonate, methanesulfonate, 2-naphthalenesulfonate, nicotinate, nitrate, palmoate, phosphate, picrate, pivalate, propionate, salicylate, succinate, sulfate, tartrate, tosylate and undecanoate. Salts derived from appropriate bases include alkali metal (*e.g.*, sodium), alkaline earth metal (*e.g.*, magnesium), ammonium and N-$(alkyl)_4^+$ salts.

[00168] For preparing pharmaceutical compositions from the compounds of the present invention, pharmaceutically acceptable carriers include either solid or liquid carriers. Solid form preparations include powders, tablets, pills, capsules, cachets, suppositories, and dispersible granules. A solid carrier can be one or more substances, which also acts as diluents, flavoring agents, binders, preservatives, tablet disintegrating agents, or an encapsulating material. Details on techniques for formulation and administration are well described in the scientific and patent literature, see, *e.g.*, the latest edition of Remington's Pharmaceutical Sciences, Maack Publishing Co, Easton PA.

[00169] In powders, the carrier is a finely divided solid, which is in a mixture with the 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.

[00170] Suitable solid excipients are carbohydrate or protein fillers include, but are not limited to sugars, including lactose, sucrose, mannitol, or sorbitol; starch from corn, wheat, rice, potato, or other plants; cellulose such as methyl cellulose, hydroxypropylmethyl-cellulose, or sodium carboxymethylcellulose; and gums including arabic and tragacanth; as well as proteins such as gelatin and collagen. If desired, disintegrating or solubilizing agents are added, such as the cross-linked polyvinyl pyrrolidone, agar, alginic acid, or a salt thereof, such as sodium alginate.

[00171] Liquid form preparations include solutions, suspensions, and emulsions, for example, water or water/propylene glycol solutions. For parenteral injection, liquid preparations can be formulated in solution in aqueous polyethylene glycol solution.

[00172] 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 can be the appropriate number of any of these in packaged form.

[00173] When the compositions of this invention comprise a combination of a peptidomimetic macrocycle and one or more additional therapeutic or prophylactic agents, both the compound and the additional agent should be present at dosage levels of between about 1 to 100%, and more preferably between about 5 to 95% of the dosage normally administered in a monotherapy regimen. In some embodiments, the additional agents are administered separately, as part of a multiple dose regimen, from the compounds of this invention. Alternatively, those agents are part of a single dosage form, mixed together with the compounds of this invention in a single composition.

[00174] In some embodiments, the compositions are present as unit dosage forms that can deliver, for example, from about 0.0001 mg to about 1,000 mg of the peptidomimetic macrocycles, salts thereof, prodrugs thereof, derivatives thereof, or any combination of these. Thus, the unit dosage forms can deliver, for example, in some embodiments, from about 1 mg to about 900 mg, from about 1 mg to about 800 mg, from about 1 mg to about 700 mg, from about 1 mg to about 600 mg, from about 1 mg to about 500 mg, from about 1 mg to about 400 mg, from about 1 mg to about 300 mg, from about 1 mg to about 200 mg, from about 1 mg to about 100 mg, from about 1 mg to about 10 mg, from about 1 mg to about 5 mg, from about 0.1 mg to about 10 mg, from about 0.1 mg to about 5 mg, from about 10 mg to about 1,000 mg, from about 50 mg to about 1,000 mg, from about 100 mg to about 1,000 mg, from about 200 mg to about 1,000 mg, from about 300 mg to about 1,000 mg, from about 400 mg to about 1,000 mg, from about 500 mg to about 1,000 mg, from about 600 mg to about 1,000 mg, from about 700 mg to about 1,000 mg, from about 800 mg to about 1,000 mg, from about 900 mg to about 1,000 mg, from about 10 mg to about 900 mg, from about 100 mg to about 800 mg, from about 200 mg to about 700 mg, or from about 300 mg to about 600 mg of the peptidomimetic macrocycles, salts thereof, prodrugs thereof, derivatives thereof, or any combination of these.

[00175] In some embodiments, the compositions are present as unit dosage forms that can deliver, for example, about 1 mg, about 2 mg, about 3 mg, about 4 mg, about 5 mg, about 6 mg, about 7 mg, about 8 mg, about 9 mg, about 10 mg, about 20 mg, about 30 mg, about 40 mg, about 50 mg, about 60 mg, about 70 mg, about 80 mg, about 90 mg, about 100 mg, about 150 mg, about 200 mg, about 250 mg, about 300 mg, about 350 mg, about 400 mg, about 500 mg, about 600 mg, about 700 mg, about 800 mg, or about 800 mg of peptidomimetic macrocycles, salts thereof, prodrugs thereof, derivatives thereof, or any combination of these.

[00176] Suitable routes of administration include, but are not limited to, oral, intravenous, rectal, aerosol, parenteral, ophthalmic, pulmonary, transmucosal, transdermal, vaginal, otic, nasal, and topical administration. In addition, by way of example only, parenteral delivery includes intramuscular, subcutaneous, intravenous, intramedullary injections, as well as intrathecal, direct intraventricular, intraperitoneal, intralymphatic, and intranasal injections.

[00177] In certain embodiments, a composition as described herein is administered in a local rather than systemic manner, for example, via injection of the compound directly into an organ. In specific embodiments, long acting formulations are administered by implantation (for example subcutaneously or intramuscularly) or by intramuscular injection. Furthermore, in other embodiments, the drug is delivered in a targeted drug delivery system, for example, in a liposome coated with organ-specific antibody. In such embodiments, the liposomes are targeted to and taken up selectively by the organ. In yet other embodiments, the compound as described herein is provided in the form of a rapid release formulation, in the form of an extended release formulation, or in the form of an intermediate release formulation. In yet other embodiments, the compound described herein is administered topically.

[00178] In another embodiment, compositions described herein are formulated for oral administration. Compositions described herein are formulated by combining a peptidomimetic macrocycle with, e.g., pharmaceutically acceptable carriers or excipients. In various embodiments, the compounds described herein are formulated in oral dosage forms that include, by way of example only, tablets, powders, pills, dragees, capsules, liquids, gels, syrups, elixirs, slurries, suspensions and the like.

[00179] In certain embodiments, pharmaceutical preparations for oral use are obtained by mixing one or more solid excipient with one or more of the peptidomimetic macrocycles described herein, optionally grinding the resulting mixture, and processing the mixture of granules, after adding suitable auxiliaries, if desired, to obtain tablets or dragee cores. Suitable excipients are, in particular, fillers such as sugars, including lactose, sucrose, mannitol, or sorbitol; cellulose preparations such as: for example, maize starch, wheat starch, rice starch, potato starch, gelatin, gum tragacanth, methylcellulose, microcrystalline cellulose, hydroxypropylmethylcellulose, sodium carboxymethylcellulose; or others such as: polyvinylpyrrolidone (PVP or povidone) or calcium phosphate. In specific embodiments, disintegrating agents are optionally added. Disintegrating agents include, by way of example only, cross-linked croscarmellose sodium, polyvinylpyrrolidone, agar, or alginic acid or a salt thereof such as sodium alginate.

[00180] In one embodiment, dosage forms, such as dragee cores and tablets, are provided with one or more suitable coating. In specific embodiments, concentrated sugar solutions are used for coating the dosage form. The sugar solutions, optionally contain additional components, such as by way of example only, gum arabic, talc, polyvinylpyrrolidone, carbopol gel, polyethylene glycol, and/or titanium dioxide, lacquer solutions, and suitable organic solvents or solvent mixtures.

Dyestuffs and/or pigments are also optionally added to the coatings for identification purposes. Additionally, the dyestuffs and/or pigments are optionally utilized to characterize different combinations of active compound doses.

[00181] In certain embodiments, therapeutically effective amounts of at least one of the peptidomimetic macrocycles described herein are formulated into other oral dosage forms. Oral dosage forms include push-fit capsules made of gelatin, as well as soft, sealed capsules made of gelatin and a plasticizer, such as glycerol or sorbitol. In specific embodiments, push-fit capsules contain the active ingredients in admixture with one or more filler. Fillers include, by way of example only, lactose, binders such as starches, and/or lubricants such as talc or magnesium stearate and, optionally, stabilizers. In other embodiments, soft capsules, contain one or more active compound that is dissolved or suspended in a suitable liquid. Suitable liquids include, by way of example only, one or more fatty oil, liquid paraffin, or liquid polyethylene glycol. In addition, stabilizers are optionally added.

[00182] In other embodiments, therapeutically effective amounts of at least one of the peptidomimetic macrocycles described herein are formulated for buccal or sublingual administration. Formulations suitable for buccal or sublingual administration include, by way of example only, tablets, lozenges, or gels. In still other embodiments, the peptidomimetic macrocycles described herein are formulated for parenertal injection, including formulations suitable for bolus injection or continuous infusion. In specific embodiments, formulations for injection are presented in unit dosage form (*e.g.*, in ampoules) or in multi-dose containers. Preservatives are, optionally, added to the injection formulations. In still other embodiments, pharmaceutical compositions are formulated in a form suitable for parenteral injection as a sterile suspensions, solutions or emulsions in oily or aqueous vehicles. Parenteral injection formulations optionally contain formulatory agents such as suspending, stabilizing and/or dispersing agents. In specific embodiments, pharmaceutical formulations for parenteral administration include aqueous solutions of the active compounds in water-soluble form. In additional embodiments, suspensions of the active compounds are prepared as appropriate oily injection suspensions. Suitable lipophilic solvents or vehicles for use in the pharmaceutical compositions described herein include, by way of example only, fatty oils such as sesame oil, or synthetic fatty acid esters, such as ethyl oleate or triglycerides, or liposomes. In certain specific embodiments, aqueous injection suspensions contain substances which increase the viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol, or dextran. Optionally, the suspension contains suitable stabilizers or agents which increase the solubility of the compounds to allow for the preparation of highly concentrated solutions. Alternatively, in other embodiments, the active ingredient is in powder form for constitution with a suitable vehicle, *e.g.*, sterile pyrogen-free water, before use.

[00183] Pharmaceutical compositions herein can be administered, for example, once or twice or three or four or five or six times per day, or once or twice or three or four or five or six times per week,

and can be administered, for example, for a day, a week, a month, 3 months, six months, a year, five years, or for example ten years.

Methods of Use

[00184] In one aspect, the present invention provides novel peptidomimetic macrocycles that are useful in competitive binding assays to identify agents which bind to the natural ligand(s) of the proteins or peptides upon which the peptidomimetic macrocycles are modeled. For example, in the GHRH system, labeled peptidomimetic macrocycles based on GHRH can be used in a binding assay along with small molecules that competitively bind to the GHRH receptor. Competitive binding studies allow for rapid *in vitro* evaluation and determination of drug candidates specific for the GHRH system. Such binding studies may be performed with any of the peptidomimetic macrocycles disclosed herein and their binding partners.

[00185] The invention further provides for the generation of antibodies against the peptidomimetic macrocycles. In some embodiments, these antibodies specifically bind both the peptidomimetic macrocycle and the precursor peptides, such as GHRH, to which the peptidomimetic macrocycles are related. Such antibodies, for example, disrupt the native protein-protein interactions, for example, between GHRH and the GHRH receptor.

[00186] In another aspect, the present invention provides methods to activate the GHRH receptor, thereby stimulating production and release of growth hormone, which in turn can increase lean muscle mass or reduce adipose tissue, for example visceral and/or abdominal adipose tissue. In some embodiments, subject suffering from obesity, for example abdominal obesity, are treated using pharmaceutical compositions of the invention. See, e.g. Makimura et al., J. Clin. Endocrinol. Metab. 2009, 94(12): 5131-5138, which is hereby incorporated by reference.

[00187] In yet another aspect, the present invention provides methods for treating muscle wasting diseases that include anorexias, cachexias (such as cancer cachexia, chronic heart failure cachexia, chronic obstructive pulmonary disease cachexia, rheumatoid arthritis cachexia) and sarcopenias, methods for treating lipodystrophies that include HIV lipodystrophy, methods for treating growth hormone disorders that include adult and pediatric growth hormone deficiencies, or methods for treating gastroparesis or short bowel syndrome. These methods comprise administering an effective amount of a compound of the invention to a warm blooded animal, including a human. In some embodiments, a pharmaceutical composition provided herein used in the treatment of muscle wasting diseases is administered no more frequently than once daily, no more frequently than every other day, no more frequently than twice weekly, no more frequently than weekly, or no more frequently than every other week.

[00188] In some embodiments, provided herein are methods for treating adult growth hormone deficiencies. Such deficiencies may be cause, for example, by damage or injury to the pituitary gland or the hypothalamus. Frequently, adult-onset growth hormone deficiency is caused by pituitary tumors or treatment of such tumors, for example by cranial irradiation. Adult growth

hormone deficiency may also be caused by a reduced blood supply to the pituitary gland. In some embodiments, a pharmaceutical composition of the invention used in treatment of adult growth hormone deficiency is administered no more frequently than once daily, no more frequently than every other day, no more frequently than twice weekly, no more frequently than weekly, or no more frequently than every other week.

[00189] In some embodiments, provided herein are methods for treating pediatric growth hormone deficiencies. Growth hormone deficiency in children is often idiophathic. However, possible causes include mutations in genes including GHRHR or GH1, congenital malformations involving the pituitary (such as septo-optic dysplasia or posterior pituitary ectopia), chronic kidney disease, intracranial tumors (e.g. in or near the sella turcica, such as craniopharyngioma), damage to the pituitary from radiation therapy to the cranium (for cancers such as leukemia or brain tumors), surgery, trauma or intracranial disease (e.g. hydrocephalus), autoimmune inflammation (hypophysitis), ischemic or hemorrhagic infarction from low blood pressure (Sheehan syndrome) or hemorrhage pituitary apoplexy. Growth hormone deficiency is observed in congenital diseases such as Prader-Willi syndrome, Turner syndrome, or short stature homeobox gene (SHOX) deficiency, idiopathic short stature, or in infants who are small for gestational age. In some embodiments, a composition of the invention used in treatment of pediatric growth hormone deficiency is administered no more frequently than once daily, no more frequently than every other day, no more frequently than twice weekly, no more frequently than weekly, or no more frequently than every other week.

[00190] As used herein, the term "treatment" is defined as the application or administration of a therapeutic agent to a patient, or application or administration of a therapeutic agent to an isolated tissue or cell line from a patient, who has a disease, a symptom of disease or a predisposition toward a disease, with the purpose to cure, heal, alleviate, relieve, alter, remedy, ameliorate, improve or affect the disease, the symptoms of disease or the predisposition toward disease.

[00191] In some embodiments, the invention provides peptidomimetic macrocycles and methods of use as described in the items below.

Item 1. A peptidomimetic macrocycle comprising an amino acid sequence which is at least about 60% identical to an amino acid sequence chosen from the group consisting of the amino acid sequences in Tables 1, 2 or 4.

Item 2. The peptidomimetic macrocycle of item 1, wherein the amino acid sequence of said peptidomimetic macrocycle is at least about 80% identical to an amino acid sequence chosen from the group consisting of the amino acid sequences in Tables 1, 2 or 4.

Item 3. The peptidomimetic macrocycle of item 1, wherein the amino acid sequence of said peptidomimetic macrocycle is at least about 90% identical to an amino acid sequence chosen from the group consisting of the amino acid sequences in Tables 1, 2 or 4.

Item 4. The peptidomimetic macrocycle of item 1, wherein the amino acid sequence of said peptidomimetic macrocycle is chosen from the group consisting of the amino acid sequences in Tables 1, 2 or 4.

Item 5. The peptidomimetic macrocycle of item 1, wherein the peptidomimetic macrocycle comprises a helix.

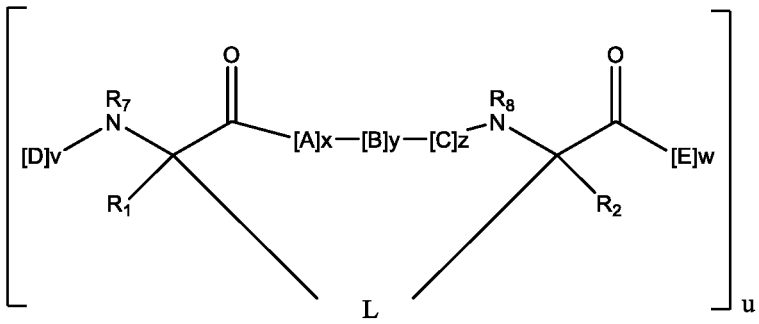
Item 6. The peptidomimetic macrocycle of item 1, wherein the peptidomimetic macrocycle comprises an α-helix.

Item 7. The peptidomimetic macrocycle of item 1, wherein the peptidomimetic macrocycle comprises an α,α-disubstituted amino acid.

Item 8. The peptidomimetic macrocycle of item 1, wherein the peptidomimetic macrocycle comprises a crosslinker linking the α-positions of at least two amino acids.

Item 9. The peptidomimetic macrocycle of item 8, wherein at least one of said two amino acids is an α,α-disubstituted amino acid.

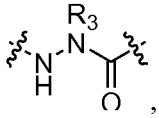
Item 10. The peptidomimetic macrocycle of item 8, wherein the peptidomimetic macrocycle has the formula:



Formula I Formula (I)

wherein:

each A, C, D, and E is independently a natural or non-natural amino acid;

B is a natural or non-natural amino acid, amino acid analog,  , [-NH-L_3-CO-], [-NH-L_3-SO_2-], or [-NH-L_3-];

R_1 and R_2 are independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–;

R_3 is hydrogen, alkyl, alkenyl, alkynyl, arylalkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, cycloalkylalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

L is a macrocycle-forming linker of the formula –L_1–L_2–;

L_1 and L_2 are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or [-R_4-K-R_4-]$_n$, each being optionally substituted with R_5;

each R_4 is alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

each R_5 is independently halogen, alkyl, $-OR_6$, $-N(R_6)_2$, $-SR_6$, $-SOR_6$, $-SO_2R_6$, $-CO_2R_6$, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent;

R_7 is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with a D residue;

R_8 is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with an E residue;

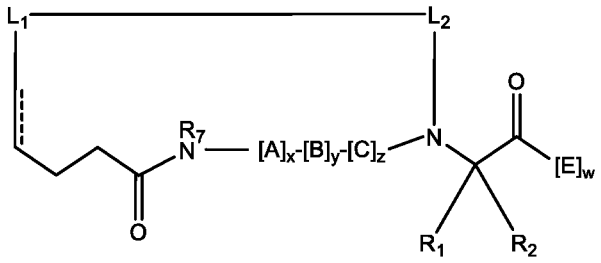
v and w are independently integers from 1-1000;

u, x, y and z are independently integers from 0-10; and

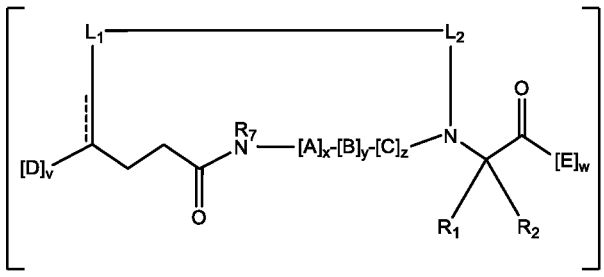
n is an integer from 1-5.

Item 11. The peptidomimetic macrocycle of item 1, wherein the peptidomimetic macrocycle comprises a crosslinker linking a backbone amino group of a first amino acid to a second amino acid within the peptidomimetic macrocycle.

Item 12. The peptidomimetic macrocycle of item 11, wherein the peptidomimetic macrocycle has the formula (II) or (IIa):



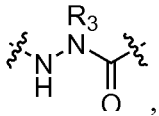
Formula (II)



Formula (IIa)

wherein:

each A, C, D, and E is independently a natural or non-natural amino acid;

B is a natural or non-natural amino acid, amino acid analog,  , [-NH-L_3-CO-], [-NH-L_3-SO_2-], or [-NH-L_3-];

R_1 and R_2 are independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–, or part of a cyclic structure with an E residue;

R_3 is hydrogen, alkyl, alkenyl, alkynyl, arylalkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, cycloalkylalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

L_1 and L_2 are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4-K-R_4-]_n$, each being optionally substituted with R_5;

each R_4 is alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

each R_5 is independently halogen, alkyl, $-OR_6$, $-N(R_6)_2$, $-SR_6$, $-SOR_6$, $-SO_2R_6$, $-CO_2R_6$, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent;

R_7 is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

v and w are independently integers from 1-1000;

u, x, y and z are independently integers from 0-10; and

n is an integer from 1-5.

Item 13. A method of increasing the circulating level of growth hormone (GH) in a subject comprising administering to the subject a peptidomimetic macrocycle of item 1.

Item 14. A method of increasing lean muscle mass in a subject comprising administering to the subject a peptidomimetic macrocycle of item 1.

Item 15. A method of reducing adipose tissue in a subject comprising administering to the subject a peptidomimetic macrocycle of item 1.

Item 16. A method of treating muscle wasting diseases, including anorexias, cachexias (such as cancer cachexia, chronic heart failure cachexia, chronic obstructive pulmonary disease cachexia, rheumatoid arthritis cachexia) or sarcopenias in a subject comprising administering to the subject a peptidomimetic macrocycle of item 1.

Item 17. A method of treating lipodystrophies, including HIV lipodystrophy, in a subject comprising administering to the subject a peptidomimetic macrocycle of item 1.

Item 18. A method of treating growth hormone disorders, including adult growth hormone deficiency and pediatric growth hormone deficiency, in a subject comprising administering to the subject a peptidomimetic macrocycle of item 1.

Item 19. A method of treating gastroparesis or short bowel syndrome in a subject comprising administering to the subject a peptidomimetic macrocycle of item 1.

Item 20. A method of treating muscle wasting diseases, lipodystrophies, growth hormone disorders or gastroparesis/short bowel syndrome in a subject by administering an agonist of the GHRH receptor, wherein the agonist is administered no more frequently than once daily, no more frequently than every other day, no more frequently than twice weekly, no more frequently than weekly, or no more frequently than every other week.

Item 21. A method of treating muscle wasting diseases, lipodystrophies, growth hormone disorders or gastroparesis/short bowel syndrome in a subject by administering a GHRH analog, wherein the GHRH analog is administered no more frequently than once daily, no more frequently than every other day, no more frequently than twice weekly, no more frequently than weekly, or no more frequently than every other week.

Item 22. A method of increasing the circulating level of growth hormone (GH) in a subject by administering an agonist of the GHRH receptor, wherein the agonist is administered no more frequently than once daily, no more frequently than every other day, no more frequently than twice weekly, no more frequently than weekly, or no more frequently than every other week.

Item 23. A method of increasing the circulating level of growth hormone (GH) in a subject by administering a GHRH analog, wherein the GHRH analog is administered no more frequently than once daily, no more frequently than every other day, no more frequently than twice weekly, no more frequently than weekly, or no more frequently than every other week.

Item 24. The peptidomimetic macrocycle of item 10, wherein L_1 and L_2 are independently alkylene, alkenylene or alkynylene.

Item 25. The peptidomimetic macrocycle of item 24, wherein L_1 and L_2 are independently C_3-C_{10} alkylene or alkenylene

Item 26. The peptidomimetic macrocycle of item 24, wherein L_1 and L_2 are independently C_3-C_6 alkylene or alkenylene.

Item 27. The peptidomimetic macrocycle of item 10, wherein R_1 and R_2 are H.

Item 28. The peptidomimetic macrocycle of item 10, wherein R_1 and R_2 are independently alkyl.

Item 29. The peptidomimetic macrocycle of item 10, wherein R_1 and R_2 are methyl.

[00192] While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is

intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

Examples

Example 1: Peptidomimetic macrocycles of the invention

[00193] Peptidomimetic macrocycles were synthesized, purified and analyzed as previously described and as described below (Schafmeister et al., J. Am. Chem. Soc. 122:5891-5892 (2000); Schafmeister & Verdine, J. Am. Chem. Soc. 122:5891 (2005); Walensky et al., Science 305:1466-1470 (2004); and US Patent No. 7,192,713). Peptidomimetic macrocycles were designed by replacing two or more naturally occurring amino acids with the corresponding synthetic amino acids. Substitutions were made at i and i+4, and i and i+7 positions. Peptide synthesis was performed either manually or on an automated peptide synthesizer (Applied Biosystems, model 433A), using solid phase conditions, rink amide AM resin (Novabiochem), and Fmoc main-chain protecting group chemistry. For the coupling of natural Fmoc-protected amino acids (Novabiochem), 10 equivalents of amino acid and a 1:1:2 molar ratio of coupling reagents HBTU/HOBt (Novabiochem)/DIEA were employed. Non-natural amino acids (4 equiv) were coupled with a 1:1:2 molar ratio of HATU (Applied Biosystems)/HOBt/DIEA. The N-termini of the synthetic peptides were acetylated, while the C-termini were amidated.

[00194] Purification of cross-linked compounds was achieved by high performance liquid chromatography (HPLC) (Varian ProStar) on a reverse phase C18 column (Varian) to yield the pure compounds. Chemical composition of the pure products was confirmed by LC/MS mass spectrometry (Micromass LCT interfaced with Agilent 1100 HPLC system) and amino acid analysis (Applied Biosystems, model 420A).

[00195] Table 4 shows a list of peptidomimetic macrocycles of the invention prepared.

Table 4 (SEQ ID NOS 89-180, respectively, in order of appearance)

SP#	Sequence	Olefin Isomer	Exact mass	Calc'd (M + 3)/3	Obsv'd (M+3)/3
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29				
SP-1	H- Y a D $ I F T $ S Y R K V L G Q L S A R $ L L Q $ I Nle S R -NH2		3410	1137.67	1137.42
SP-2	H- Y a D $ I F T $ S Y R K V L G Q L S A R K L L Q $ I Nle S $ -NH2		3381.99	1128.34	1127.8
SP-3	H- Y A D $ I F T $ S Y R K V L G Q L S A R $ L L Q $ I Nle S R -NH2		3410	1137.67	1137.05
SP-4	H- Y A D $ I F T $ S Y R K V L G Q L S A R K L L Q $ I Nle S $ -NH2		3381.99	1128.34	1127.8
SP-5	H- Y a D $ I F T $ S Y R K V L A Q L S A R K L L Q $ I Nle S $ -NH2		3396.01	1133.01	1132.86
SP-6	H- Y a D $ I F T $ S Y R K V L $r8 Q L S A R K $ L Q D I Nle S R -NH2		3525.06	1176.03	1175.76
SP-7	H- Y a D $ I F T $ S Y R K V L G Q L $r8 A R K L L Q $ I Nle S R -NH2		3493.11	1165.38	1165.02
SP-8	H- Y a D $ I F T $ S Y R K V L G Q L S A R $r8 L L Q D I Nle $ R -NH2		3480.04	1161.02	1160.66
SP-9	H- Y a D $ I F T $ S Y R K V L G Q L S A R K $r8 L Q D I Nle S $ -NH2		3425.98	1143	1142.53
SP-10	H- Y a D $ I F T $ S Y R K V L G Q L S A R K $r8 L Q D I Nle S $ -NH2	iso2	3425.98	1143	1142.6
SP-11	H- Y a D A I F T $ S Y R $ V L G Q L S A R $ L L Q $ I Nle S R -NH2		3352.94	1118.65	1118.25
SP-12	H- Y a D A I F T $ S Y R $ V L G Q L S A R K L L Q $ I Nle S $ -NH2		3324.93	1109.32	1108.93
SP-13	H- Y a D A I F T $ S Y R $ V L G Q L $r8 A R K L L Q $ I Nle S R -NH2		3436.05	1146.36	1146.15
SP-14	H- Y a D A I F T $ S Y R $ V L G Q L $r8 A R K L L Q $ I Nle S R -NH2	iso2	3436.05	1146.36	1146.08
SP-15	H- Y a D A I F T $ S Y R $ V L G Q L S A R $r8 L L Q D I Nle $ R -NH2		3422.98	1142	1141.94
SP-16	H- Y a D A I F T $ S Y R $ V L G Q L S A R $r8 L L Q D I Nle $ R -NH2	iso2	3422.98	1142	1141.79
SP-17	H- Y a D A I F T $ S Y R $ V L G Q L S A R K $r8 L Q D I Nle S $ -NH2		3368.92	1123.98	1123.66
SP-18	H- Y a D A I F T $ S Y R $ V L G Q L S A R K $r8 L Q D I Nle S $ -NH2	iso2	3368.92	1123.98	1123.73
SP-19	H- Y a D A I F T N S Y R $ V L G $ L S A R $ L L Q $ I Nle S R -NH2		3338.92	1113.98	1113.37
SP-20	H- Y a D A I F T N S Y R $ V L G $ L S A R K L L Q $ I Nle S $ -NH2		3310.92	1104.65	1104.34
SP-21	H- Y a D A $r8 F T N S Y R $ V L G Q L S A R $ L L Q $ I Nle S R -NH2		3395.95	1132.99	1133.64
SP-22	H- Y a D A $r8 F T N S Y R $ V L G Q L S A R K L L Q $ I Nle S $ -NH2		3367.94	1123.65	1123.36
SP-23	H- Y a D A I F T $r8 S Y R K V L $ Q L S A R $ L L Q $ I Nle S R -NH2		3466.06	1156.36	1156.14
SP-24	H- Y a D A I F T $r8 S Y R K V L $ Q L S A R K L L Q $ I Nle S $ -NH2		3438.05	1147.02	1146.75
SP-25	H- Y a D A I F T N $r8 Y R K V L G $ L S A R K L L Q $ I Nle S $ -NH2		3394.03	1132.35	1132.02
SP-26	H- Y a D A I F T N $r8 Y R K V L G $ L S A R K L L Q $ I Nle S $ -NH2	iso2	3394.03	1132.35	1132.09
SP-27	H- Y a D A I F T N $r8 Y R K V L G $ L S A R $ L L Q $ I Nle S R -NH2		3422.03	1141.68	1141.42
SP-28	H- Y a D A I F T N $r8 Y R K V L G $ L S A R $ L L Q $ I Nle S R -NH2	iso2	3422.03	1141.68	1141.42
SP-29	H- Y a D A I F T N $r8 Y R K V L G $ L S A R K L L Q D I Nle S R -NH2		3414.99	1139.34	1139.05
SP-30	H- Y a D A I F T N $r8 Y R K V L G $ L S A R K L L Q D I Nle S R -NH2	iso2	3414.99	1139.34	1139.05
SP-31	H- Y a D A I F T N S Y R $r8 V L G Q L S $ R K L L Q D I Nle S R -NH2		3430.95	1144.66	1144.45
SP-32	H- Y a D A I F T N S Y R $r8 V L G Q L S $ R K L L Q D I Nle S R -NH2	iso2	3430.95	1144.66	1145.3
SP-33	H- Y a D A I F T N S Y R $r8 V L G Q L S $ R K L L Q $ I Nle S $ -NH2		3409.99	1137.67	1137.42
SP-34	H- Y a D $ I F T $ S Y A K V L G Q L S A R $ L L Q $ I Nle S R -NH2		3324.93	1109.32	1110.29
SP-35	H- Y a D $ I F T $ S Y R A V L G Q L S A R $ L L Q $ I Nle S R -NH2		3352.94	1118.65	1119.73
SP-36	H- Y a D $ I F T $ S Y R K V L G Q L S A A $ L L Q $ I Nle S R -NH2		3324.93	1109.32	1110.2
SP-37	H- Y a D $ I F T $ S Y R A V L G Q L S A R $ L L Q $ I Nle S A -NH2		3267.88	1090.3	1091.14
SP-38	H- Y a D $ I F T $ S Y Q K V L G Q L S A R $ L L Q $ I Nle S R -NH2		3381.96	1128.33	1129.16
SP-39	H- Y a D $ I F T $ S Y R Q V L G Q L S A R $ L L Q $ I Nle S R -NH2		3409.96	1137.66	1138.5
SP-40	H- Y a D $ I F T $ S Y R K V L G Q L S A Q $ L L Q $ I Nle S R -NH2		3381.96	1128.33	1129.16
SP-41	H- Y a D $ I F T $ S Y R K V L G Q L S A R $ L L Q $ I Nle S Q -NH2		3381.96	1128.33	1129.16
SP-42	H- Y a D $ I F T $ S Y R K V L A Q L S A R $ A L Q $ I Nle S R -NH2		3381.97	1128.33	1129.16
SP-43	H- Y a D $ I F T $ S Y R K V L G Q L S A R $ L L Q $ I Nle S -NH2		3253.9	1085.64	1086.52
SP-44	H- Y a D % I F T % S Y R K V L G Q L S A R % L L Q % I Nle S R -NH2				
SP-45	H- Y a D $5a5 I F T $5n3 S Y R K V L G Q L S A R $5a5 L L Q $5n3 I Nle S R -NH2				
SP-46	H- Y a D $5n3 I F T $5a5 S Y R K V L G Q L S A R $5n3 L L Q $5a5 I Nle S R -NH2				
SP-47	H- Y a D $5a5 I F T $5n3 S Y R K V L G Q L S A R $5n3 L L Q $5a5 I Nle S R -NH2				
SP-48	H- Y a D $5n3 I F T $5a5 S Y R K V L G Q L S A R $5a5 L L Q $5n3 I Nle S R -NH2				
SP-49	H- Y a D A I F T N S Y R $4m6 V L G Q L S $4a5 R K L L Q D I Nle S R -NH2				

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Exact mass	Calc'd (M + 3) / 3	Obsv'd (M+3)/3
SP-50	H-	Y	a	D	A	I	F	T	N	S	Y	Q	$r8	V	L	G	Q	L	S	$	R	K	L	L	Q	N	I	Nle	S	R	-NH2	3401.92	1134.98	1135.64
SP-51	H-	Y	a	D	A	I	F	T	N	S	Y	R	$r8	V	L	G	Q	L	S	$	Q	K	L	L	Q	N	I	Nle	S	R	-NH2	3401.92	1134.98	1135.73
SP-52	H-	Y	a	D	A	I	F	T	N	S	Y	R	$r8	V	L	G	Q	L	S	$	R	Q	L	L	Q	N	I	Nle	S	R	-NH2	3429.93	1144.32	1145.07
SP-53	H-	Y	a	D	A	I	F	T	N	S	Y	R	$r8	V	L	G	Q	L	S	$	R	K	L	L	Q	N	I	Nle	S	Q	-NH2	3401.92	1134.98	1136.19
SP-54	H-	Y	a	D	A	I	F	T	N	S	Y	R	$r8	V	L	G	Q	L	S	$	R	K	L	L	Q	N	I	Nle	S		-NH2	3273.86	1092.29	1093.18
SP-55	H-	Y	a	D	A	I	F	T	A	S	Y	Q	$r8	V	L	G	Q	L	S	$	R	K	L	L	Q	N	I	Nle	S	R	-NH2	3358.91	1120.64	1121.76
SP-56	H-	Y	a	D	A	I	F	T	A	S	Y	R	$r8	V	L	G	Q	L	S	$	Q	K	L	L	Q	N	I	Nle	S	R	-NH2	3358.91	1120.64	1121.76
SP-57	H-	Y	a	D	A	I	F	T	A	S	Y	R	$r8	V	L	G	Q	L	S	$	R	Q	L	L	Q	N	I	Nle	S	R	-NH2	3386.92	1129.98	1131.1
SP-58	H-	Y	a	D	A	I	F	T	A	S	Y	R	$r8	V	L	G	Q	L	S	$	R	K	L	L	Q	N	I	Nle	S	Q	-NH2	3358.91	1120.64	1121.76
SP-59	H-	Y	a	D	A	I	F	T	A	S	Y	R	$r8	V	L	G	Q	L	S	$	R	K	L	L	Q	N	I	Nle	S		-NH2	3230.86	1077.96	1079.12
SP-60	H-	Y	a	D	A	I	F	T	A	S	Y	R	$r8	V	L	G	Q	L	S	$	R	Q	L	L	Q	N	I	Nle	S		-NH2	3230.82	1077.95	1079.02
SP-61	H-	Y	a	D	A	I	F	T	A	S	Y	R	$r8	V	L	G	Q	L	S	$	R	K	L	L	Q	N	I	Nle	S	R	-NH2	3386.96	1129.99	1130.83
SP-62	H-	Y	a	D	A	I	F	T	A	S	Y	R	$r8	V	L	A	Q	L	S	$	R	K	A	L	Q	N	I	Nle	S	R	-NH2	3358.93	1120.65	1121.48
SP-63	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	G	Q	L	S	A	R	$	L	L	Q	$	I	Nle	S	R	-OH	3410.98	1138	1138.08
SP-64	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	G	E	L	S	A	R	$	L	L	E	$	I	Nle	S	R	-OH	3412.95	1138.66	1138.73
SP-65	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	G	E	L	S	A	R	$	L	L	Q	$	I	Nle	S	R	-OH	3411.97	1138.33	1138.45
SP-66	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	G	Q	L	S	A	R	$	L	L	E	$	I	Nle	S	R	-OH	3411.97	1138.33	1138.36

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
SP-67	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	A	Q	L	S	A	R	$	L	L	Q	$	I	Nle	S	R	-NH2
SP-68	H-	Y	a	D	$	I	F	T	$	S	Y	R	A	V	L	A	Q	L	S	A	R	$	L	L	Q	$	I	Nle	S	R	-NH2
SP-69	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	A	Q	L	S	A	A	$	L	L	Q	$	I	Nle	S	R	-NH2
SP-70	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	A	Q	L	S	A	R	$	L	L	Q	$	I	Nle	S	A	-NH2
SP-71	H-	Y	a	D	A	I	F	T	D	S	Y	R	$r8	V	L	G	E	L	S	$	R	K	L	L	E	D	I	Nle	S	R	-NH2
SP-72	H-	Y	a	D	A	I	F	T	D	S	Y	R	$r8	V	L	G	Q	L	S	$	R	K	L	L	Q	D	I	Nle	S	R	-NH2
SP-73	H-	Y	a	D	A	I	F	T	N	S	Y	R	$r8	V	L	G	E	L	S	$	R	K	L	L	Q	D	I	Nle	S	R	-NH2
SP-74	H-	Y	a	D	A	I	F	T	N	S	Y	R	$r8	V	L	G	Q	L	S	$	R	K	L	L	E	D	I	Nle	S	R	-NH2
SP-75	H-	Y	a	D	A	I	F	T	D	S	Y	R	$r8	V	L	G	E	L	S	$	R	K	L	L	Q	D	I	Nle	S	R	-NH2
SP-76	H-	Y	a	D	A	I	F	T	N	S	Y	R	$r8	V	L	G	E	L	S	$	R	K	L	L	E	D	I	Nle	S	R	-NH2
SP-77	H-	Y	a	D	A	I	F	T	D	S	Y	R	$r8	V	L	G	Q	L	S	$	R	K	L	L	E	D	I	Nle	S	R	-NH2
SP-78	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	G	E	L	S	A	R	$	L	L	E	$	I	Nle	S	R	-NH2
SP-79	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	G	E	L	S	A	R	$	L	L	Q	$	I	Nle	S	R	-NH2
SP-80	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	G	Q	L	S	A	R	$	L	L	E	$	I	Nle	S	R	-NH2
SP-81	H-	Y	a	D	A	I	F	T	N	S	Y	Q	$r8	V	L	G	Q	L	S	$	R	K	L	L	Q	N	I	Nle	S	R	-NH2
SP-82	H-	Y	a	D	A	I	F	T	N	S	Y	R	$r8	V	L	G	Q	L	S	$	Q	K	L	L	Q	N	I	Nle	S	R	-NH2
SP-83	H-	Y	a	D	A	I	F	T	N	S	Y	R	%r8	V	L	G	Q	L	S	%	R	K	L	L	Q	D	I	Nle	S	R	-NH2
SP-84	H-	Y	a	D	$	I	F	T	$	S	Y	R	K	V	L	G	Q	L	S	A	R	$	L	L	Q	$	I	Nle	S	R	-NH2
SP-85	HBS-	Y	A	Aar	A	I	F	T	N	S	Y	R	K	V	L	G	Q	L	S	A	R	$	L	L	Q	$	I	Nle	S	R	-NH2
SP-86	HBS-	Y	A	Dar	A	I	F	T	N	S	Y	R	K	V	L	G	Q	L	S	A	R	$	L	L	Q	$	I	Nle	S	R	-NH2
SP-87	HBS-	Y	A	Gar	A	I	F	T	N	S	Y	R	K	V	L	G	Q	L	S	A	R	K	L	L	Q	D	I	Nle	S	R	-NH2
SP-88	HBS-	Y	A	Gar	A	I	F	T	N	S	Y	R	K	V	L	G	Q	L	S	A	R	$	L	L	Q	$	I	Nle	S	R	-NH2
SP-89	H-	Y	a	D	$5a5	I	F	T	$5n3	S	Y	R	K	V	L	G	Q	L	S	A	R	$5n3	L	L	Q	$5a5	I	Nle	S	R	-NH2
SP-90	H-	Y	a	D	$5n3	I	F	T	$5a5	S	Y	R	K	V	L	G	Q	L	S	A	R	$5a5	L	L	Q	$5n3	I	Nle	S	R	-NH2
SP-91	HBS-	Y	A	Dar	A	I	F	T	N	S	Y	R	K	V	L	G	Q	L	S	A	R	K	L	L	Q	D	I	Nle	S	R	-NH2
SP-92	tetHBS-	Y	A	teGar	A	I	F	T	N	S	Y	R	K	V	L	G	Q	L	S	A	R	K	L	L	Q	D	I	Nle	S	R	-NH2

[00196] In the sequences shown above and elsewhere, the following abbreviations are used: amino acids represented as "$" are alpha-Me S5-pentenyl-alanine olefin amino acids connected by an all-carbon i to i+4 crosslinker comprising one double bond. "%" are alpha-Me S5-pentenyl-alanine olefin amino acids connected by an all-carbon i to i+4 crosslinker comprising no double bonds (fully saturated alkylene crosslinker). Amino acids represented as "$r8" are alpha-Me R8-octenyl-alanine olefin amino acids connected by an all-carbon i to i+7 crosslinker comprising one double bond. Amino acids represented as "%r8" are alpha-Me R8-octenyl-alanine olefin amino acids connected by an all-carbon i to i+7 crosslinker comprising no double bonds (fully saturated alkylene crosslinker).The designation "iso1" or "iso2" indicates that the peptidomimetic macrocycle is a single isomer. Amino acids designated as lower case "a" represent D-Alanine.

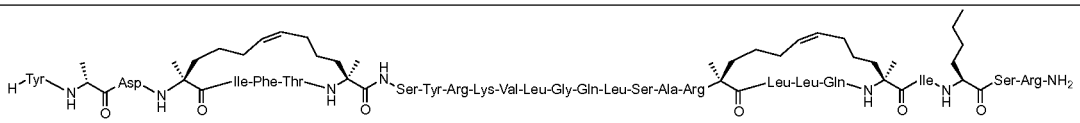
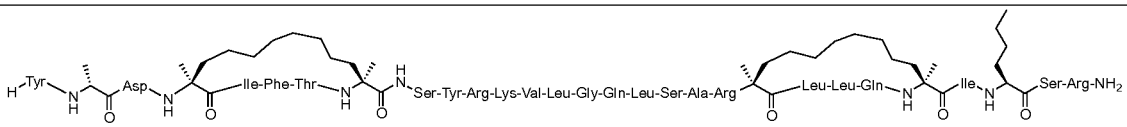
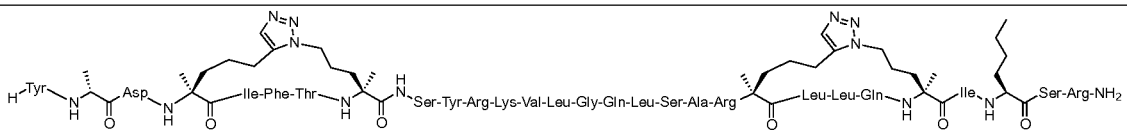
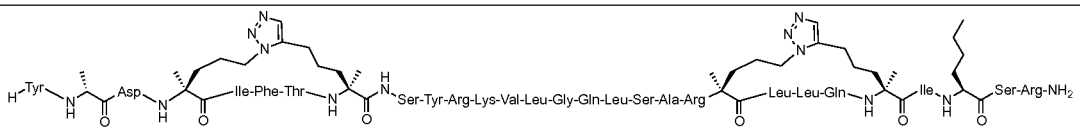
[00197] Amino acids which are used in the formation of triazole crosslinkers are represented according to the legend indicated below. Stereochemistry at the alpha position of each amino acid is S unless otherwise indicated. For azide amino acids, the number of carbon atoms indicated refers to the number of methylene units between the alpha carbon and the terminal azide. For alkyne amino acids, the number of carbon atoms indicated is the number of methylene units between the alpha position and the triazole moiety plus the two carbon atoms within the triazole group derived from the alkyne.

$5a5	Alpha-Me alkyne 1,5 triazole (5 carbon)
$5n3	Alpha-Me azide 1,5 triazole (3 carbon)
$4rn6	Alpha-Me R-azide 1,4 triazole (6 carbon)
$4a5	Alpha-Me alkyne 1,4 triazole (5 carbon)

[00198] Exemplary structures of several peptidomimetic macrocycles are shown in Table 5.

Table 5 (SEQ ID NOS 89 and 133-135, respectively, in order of appearance)

SP#	Structure

SP-1	 Chemical Formula: $C_{161}H_{264}N_{42}O_{39}$ Exact Mass: 3410.00 Molecular Weight: 3412.08
SP-45	 Chemical Formula: $C_{161}H_{268}N_{42}O_{39}$ Exact Mass: 3414.03 Molecular Weight: 3416.11
SP-46	 Chemical Formula: $C_{161}H_{262}N_{48}O_{39}$ Exact Mass: 3492.00 Molecular Weight: 3494.10
SP-47	 Chemical Formula: $C_{161}H_{262}N_{48}O_{39}$ Exact Mass: 3492.00 Molecular Weight: 3494.10

Example 2: Metabolism by Purified Protease

[00199] Linear peptides and cross-linked peptidomimetic macrocycles were tested for stability to proteolysis by Trypsin (MP Biomedicals, Solon OH) by solubilizing each peptide at 10 µM concentration in 200 µL 100 mM NH4OAc (pH 7.5). The reaction was initiated by adding 3.5 µl of Trypsin (12.5 µg protease per 500 µL reaction) and shaking continually in sealed vials while incubating in a Room Temperature (22±2 ℃). The enzyme/substrate ratio was 1:102 (w/w). After incubation times of 0, 5, 30, 60 and 135 min the reaction was stopped by addition of equal volume of 0.2% trifluoroacetic acid. Then, the solution was immediately analyzed by LC-MS in positive detection mode. The reaction half-life for each peptide was calculated in GraphPad Prism by a non-linear fit of uncalibrated MS response versus enzyme incubation time. Results are shown in Figures 1A and 1B.

Example 3: GHRHR Agonism measured by cAMP

[00200] GHRH (1-29) and cross-linked peptidomimetic macrocycles were tested for agonism at the human GHRH receptor (hGHRHR) at various concentrations. Human 293 cells transiently or stably expressing hGHRHR were detached from cell culture flasks with versene (Lifetechnologies), suspended in serum-free medium (50k cells/assay point), and stimulated for 30 min at RT with GHRH (1-29) (Bachem) or cross-linked peptidomimetic macrocycles. cAMP was quantified using an HTRF®-based assay (CisBio) and used according to the manufacturers instructions. An EC50% for each agonist was calculated from a non-linear fit of response vs dose

(GraphPad Prism). The maximum response was determined by stimulating with 10 μM GHRH (1-29). Results are shown in Figure 3.

Example 4: Plasma PK/PD study in rats.

[00201] Five peptidomimetic macrocycles of the invention (SP-1, SP-6, SP-8, SP-21, SP-32), as well as sermorelin, were studied to determine pharmacokinetic and pharmacodynamic parameters in rats. Male Sprague-Dawley rats (300 g, non-fasted, cannulated) were used. The study had three arms: IV administration, SC administration, and SC administration (vehicle control). For experiments using sermorelin, a dose level of 3 mg/kg IV/SC bolus was used (dose volume of 3 mL/kg dose and dose concentration of 1 mg/mL). The vehicle used was: 10 wt% N, N-Dimethylacetamide, 10 wt% DMSO, 2 wt% Solutol HS 15 in water for injection containing 45 mg/mL (4.5 wt%) Mannitol and 25 mM (0.38 wt%) Histidine (pH 7.5; 320 mOsm/kg). The peptide was first dissolved at high concentration in DMA and DMSO before a second dilution in Solutol vehicle.

[00202] For experiments using peptidomimetic macrocycles, 0.1 mL of DMA and 0.1 mL of DMSO were used to combine with each mg of macrocycle (~4.3-4.5 mg of macrocycle used in each experiment). Sonication was used to ensure complete solubilization. 0.8 mL of Solutol vehicle was used for each mg of macrocycle in DMA/DMSO. The solutions were mixed gently with pipet or light vortexing. Fresh vials were used for each day of dosing, and macrocycles were stored solid at -20°C prior to formulation.

[00203] For each study arm, 2 rats were bled (350 μL) at specific timepoints (5 min, 15 min, 30 min, 1h, 2h, 4h, 8h, 24h, and 48h) and a 150 μL bleed was performed just before dosing. Plasma was prepared into K2EDTA tubes by centrifuging for 20 minutes at 4°C at 2000G maximum 30 minutes after collection. From each 350 μL bleed, 120 μL were transferred to one tube for PK studies and 50 μL to another tube for PD studies and frozen immediately. From the 150 μL bleed, 70 μL were transferred to one tube for PD studies and frozen immediately.

[00204] Results are shown in Figures 4-11.

WHAT IS CLAIMED IS:

1. A peptidomimetic macrocycle comprising an amino acid sequence which is at least about 60% identical to GHRH 1-29, comprising at least two macrocycle-forming linkers, wherein the first of said two macrocycle-forming linkers connects a first amino acid to a second amino acid, and the second of said two macrocycle-forming linkers connects a third amino acid to a fourth amino acid, wherein the peptidomimetic macrocycle comprises an α,α-disubstituted amino acid.

2. The peptidomimetic macrocycle of claim 1, comprising two macrocycle-forming linkers.

3. The peptidomimetic macrocycle of any preceding claim, wherein each of said macrocycle-forming linkers connects a pair of amino acids corresponding to one of the following locations of amino acids: 4 and 8; 5 and 12; 8 and 12; 8 and 15; 9 and 16; 12 and 16; 12 and 19; 15 and 22; 18 and 25; 21 and 25; 21 and 28; 22 and 29; and 25 and 29 of GHRH 1-29.

4. The peptidomimetic macrocycle of claim 3, wherein each of said macrocycle-forming linkers connects a pair of amino acids corresponding to one of the following locations of amino acids: 4 and 8; 5 and 12; 12 and 19; 15 and 22; 18 and 25; 21 and 25; and 21 and 28 of GHRH 1-29.

5. The peptidomimetic macrocycle of claim 3, wherein the first macrocycle-forming linker connects a pair of amino acids corresponding to one of the following locations of amino acids: 4 and 8; 5 and 12; 8 and 12; 8 and 15; 9 and 16; 12 and 16; and 12 and 19; and the second macrocycle-forming linker connects a pair of amino acids corresponding to one of the following locations of amino acids: 15 and 22; 18 and 25; 21 and 25; 21 and 28; 22 and 29; and 25 and 29 of GHRH 1-29.

6. The peptidomimetic macrocycle of claim 3, wherein the first macrocycle-forming linker connects a pair of amino acids corresponding to one of the following locations of amino acids: 4 and 8; 5 and 12; and 12 and 19; and the second macrocycle-forming linker connects a pair of amino acids corresponding to one of the following locations of amino acids: 15 and 22; 18 and 25; 21 and 25; and 21 and 28 of GHRH 1-29.

7. The peptidomimetic macrocycle of claim 3, wherein the first macrocycle-forming linker connects a pair of amino acids corresponding to amino acid locations 4 and 8 of GHRH 1-29, and the second macrocycle-forming linker connects a pair of amino acids corresponding to amino acid locations 21 and 25 of GHRH 1-29.

8. A peptidomimetic macrocycle comprising:

i) an amino acid sequence which is at least about 60% identical to GHRH 1-29; and

ii) a macrocycle-forming linker connecting a first amino acid to a second amino acid,

wherein the peptidomimetic macrocycle comprises an α,α-disubstituted amino acid, and wherein the first and second amino acids are selected from amino acids corresponding to the following locations of amino acids: 4 and 8; 5 and 12; 8 and 12; 8 and 15; 9 and 16; 12 and 16; 12 and 19; 15 and 22; 18 and 25; 21 and 25; 21 and 28; and 22 and 29 of GHRH 1-29.

9. The peptidomimetic macrocycle of claim 8, wherein the macrocycle-forming linker connects amino acids corresponding to amino acid locations 12 and 19 of GHRH 1-29.

10. A peptidomimetic macrocycle of any preceding claim, comprising an amino acid sequence which is at least about 60% identical to an amino acid sequence chosen from the group consisting of the amino acid sequences in Tables 1, 2, and 4.

11. The peptidomimetic macrocycle of any preceding claim, wherein the amino acid sequence of said peptidomimetic macrocycle is at least about 80% identical to an amino acid sequence chosen from the group consisting of the amino acid sequences in Tables 1, 2, and 4.

12. The peptidomimetic macrocycle of any preceding claim, wherein the amino acid sequence of said peptidomimetic macrocycle is at least about 90% identical to an amino acid sequence chosen from the group consisting of the amino acid sequences in Tables 1, 2, and 4.

13. The peptidomimetic macrocycle of claim 1, wherein the amino acid sequence of said peptidomimetic macrocycle is chosen from the group consisting of the amino acid sequences in Tables 1, 2, and 4.

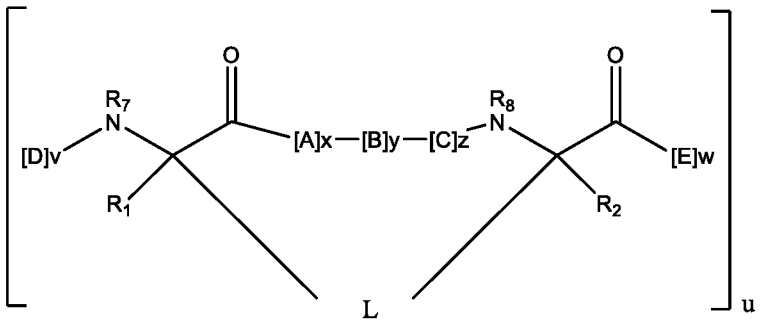
14. The peptidomimetic macrocycle of any preceding claim, wherein the peptidomimetic macrocycle comprises a helix.

15. The peptidomimetic macrocycle of any preceding claim, wherein the peptidomimetic macrocycle comprises an α-helix.

16. The peptidomimetic macrocycle of any of claims 1-7, wherein one of the first, second, third, and fourth amino acids is the α,α-disubstituted amino acid.

17. The peptidomimetic macrocycle of any of claims 1-16, wherein each amino acid connected by the macrocycle-forming linker is an α,α-disubstituted amino acid.

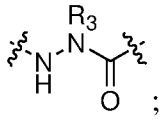
18. The peptidomimetic macrocycle of any preceding claim, having the formula:



Formula I Formula (I)

wherein:

each A, C, D, and E is independently an amino acid;

each B is independently an amino acid or  ;

each L is independently a macrocycle-forming linker of the formula $–L_1–L_2–$;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker L, form the amino acid sequence of the peptidomimetic macrocycle;

each R_1 and R_2 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–;

each R_3 is independently hydrogen, alkyl, alkenyl, alkynyl, arylalkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, cycloalkylalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

each L_1 and L_2 is independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4\text{-}K\text{-}R_4\text{-}]_n$, each being optionally substituted with R_5;

each R_4 is independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is independently O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

each R_5 is independently halogen, alkyl, $-OR_6$, $-N(R_6)_2$, $-SR_6$, $-SOR_6$, $-SO_2R_6$, $-CO_2R_6$, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_7 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with a D residue;

each R_8 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with an E residue;

each v and w is independently an integer from 1-100;

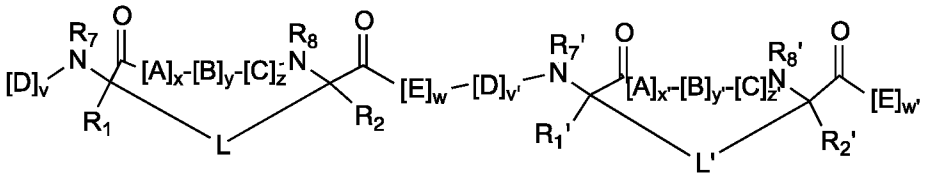
u is an integer from 1 to 3;

each x, y and z is independently an integer from 0-10; and

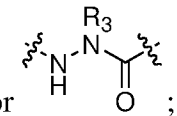
each n is independently an integer from 1-5.

19. The peptidomimetic macrocycle of claim 18, wherein u is 2.

20. The peptidomimetic macrocycle of claim 19, having the Formula:



wherein each A, C, D, and E is independently an amino acid;

each B is independently an amino acid or  ;

L' is a macrocycle-forming linker of the formula $-L_1'-L_2'-$;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linkers L and L', form the amino acid sequence of the peptidomimetic macrocycle;

R_1' and R_2' are independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–;

L_1' and L_2' are independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4-K-R_4-]_n$, each being optionally substituted with R_5;

each K is independently O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

R_7' is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with a D residue;

R_8' is –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with an E residue;

v' and w' are independently integers from 1-100;

x', y' and z' are independently integers from 0-10; and

each n is independently an integer from 1-5.

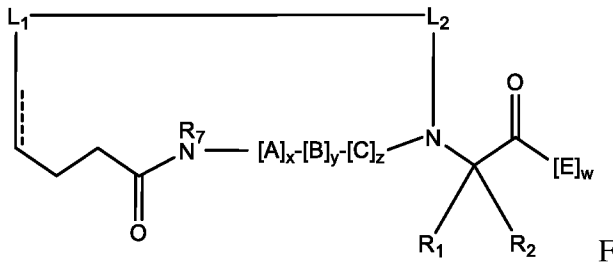
21. The peptidomimetic macrocycle of any of claims 18 to 20, wherein the sum of x+y+z is 2, 3 or 6.

22. The peptidomimetic macrocycle of claim 20, wherein the sum of x'+y'+z' is 2, 3 or 6.

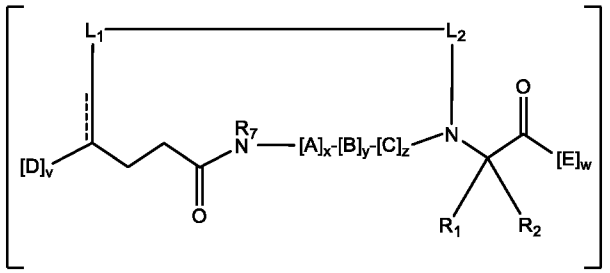
23. The peptidomimetic macrocycle of any one of claims 18 to 22, wherein each of v and w is independently an integer from 1 to 25.

24. The peptidomimetic macrocycle of any one of claims 1-15, wherein the peptidomimetic macrocycle comprises a crosslinker linking a backbone amino group of a first amino acid to a second amino acid within the peptidomimetic macrocycle.

25. The peptidomimetic macrocycle of claim 24, wherein the peptidomimetic macrocycle has the formula (II) or (IIa):



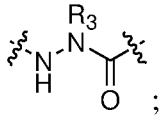
Formula (II)



Formula (IIa)

wherein:

each A, C, D, and E is independently an amino acid;

each B is independently an amino acid or  ;

each R_1 and R_2 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–, or part of a cyclic structure with an E residue;

each R_3 is independently hydrogen, alkyl, alkenyl, alkynyl, arylalkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, cycloalkylalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

each L_1 and L_2 is independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4\text{-}K\text{-}R_4\text{-}]_n$, each being optionally substituted with R_5;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker $-L_1\text{-}L_2-$, form the amino acid sequence of the peptidomimetic macrocycle which is at least about 60% identical to GHRH 1-44, GHRH 1-29 and/or to an amino acid sequence chosen from the group consisting of the amino acid sequences in Table 1, 2, and 4;

each R_4 is independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is independently O, S, SO, SO_2, CO, CO_2, or $CONR_3$;

each R_5 is independently halogen, alkyl, $-OR_6$, $-N(R_6)_2$, $-SR_6$, $-SOR_6$, $-SO_2R_6$, $-CO_2R_6$, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_7 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

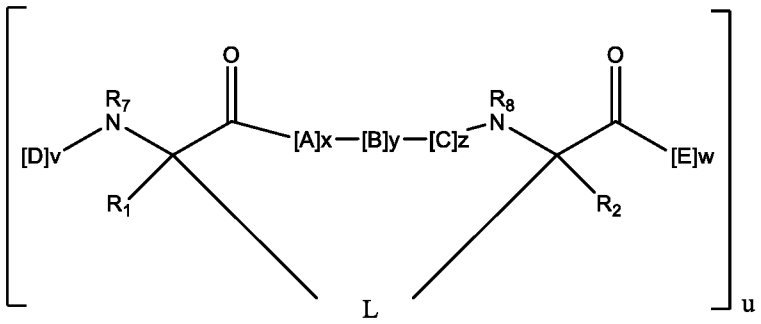
each v and w is independently an integer from 1-100;

u is an integer from 1 to 3;

each x, y and z is independently an integer from 0-10; and

each n is independently an integer from 1-5.

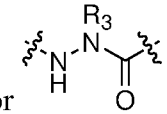
26. A peptidomimetic macrocycle of any one of claims 1-17, having the formula:



Formula I Formula (I)

wherein:

each A, C, D, and E is independently an amino acid;

each B is independently an amino acid or  ;

each L is independently a macrocycle-forming linker of the formula $–L_1–L_2–$;

and wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker L, form an amino acid sequence which is at least about 60% identical to GHRH 1-29;

each R_1 and R_2 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–;

each R_3 is independently hydrogen, alkyl, alkenyl, alkynyl, arylalkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, cycloalkylalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5;

each L_1 and L_2 is independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4\text{-}K\text{-}R_4-]_n$, each being optionally substituted with R_5;

each R_4 is independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is independently O, S, SO, SO_2, CO, or CO_2;

each R_5 is independently halogen, alkyl, $-OR_6$, $-N(R_6)_2$, $-SR_6$, $-SOR_6$, $-SO_2R_6$, $-CO_2R_6$, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_7 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with a D residue;

each R_8 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, heteroalkyl, cycloalkylalkyl, heterocycloalkyl, cycloaryl, or heterocycloaryl, optionally substituted with R_5, or part of a cyclic structure with an E residue;

each v and w is independently an integer from 1-100;

u is an integer from 1 to 3;

each x, y and z is independently an integer from 0-10; and

each n is independently an integer from 1-5.

27. The peptidomimetic macrocycle of claim 26, wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker L, form an amino acid sequence which is at least about 60% identical to an amino acid sequence of Table 1, 2, or 4.

28. The peptidomimetic macrocycle of claim 26, wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker L,

form an amino acid sequence which is at least about 70% identical to an amino acid sequence of Table 1, 2, or 4.

29. The peptidomimetic macrocycle of claim 26, wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker L, form an amino acid sequence which is at least about 80% identical to an amino acid sequence of Table 1, 2, or 4.

30. The peptidomimetic macrocycle of claim 26, wherein A, B, C, D, and E, taken together with the crosslinked amino acids connected by the macrocycle-forming linker L, form an amino acid sequence which is at least about 90% identical to an amino acid sequence of Table 1, 2, or 4.

31. A peptidomimetic macrocycle comprising an amino acid sequence of formula:

X1-X2-X3-X4-X5-X6-X7-X8-X9-X10-X11-X12-X13-X14-X15-X16-X17-X18-X19-X20-X21-X22-X23-X24-X25-X26-X27-X28-X29

wherein:
X1 is Tyr or His;
X2 is Ala, D-Ala, or Val;
X3 is Asp;
X4 is Ala or a crosslinked amino acid;
X5 is Ile;
X6 is Phe;
X7 is Thr;
X8 is Gln, Asn, or a crosslinked amino acid;
X9 is Ser or a crosslinked amino acid;
X10 is Tyr;
X11 is Arg, Ala or Gln;
X12 is Lys, Ala, Gln or a crosslinked amino acid;
X13 is Val or Ile;
X14 is Leu;
X15 is Gly, Ala or a crosslinked amino acid;

X16 is Gln, Glu or a crosslinked amino acid;

X17 is Leu;

X18 is Ser, Tyr or a crosslinked amino acid;

X19 is Ala or a crosslinked amino acid;

X20 is Arg or Gln;

X21 is Lys, Gln or a crosslinked amino acid;

X22 is Leu, Ala, or a crosslinked amino acid;

X23 is Leu;

X24 is Gln, Glu or His;

X25 is Asp, Glu or a crosslinked amino acid;

X26 is Ile;

X27 is Met, Ile, Leu or Nle;

X28 is Ser or a crosslinked amino acid;

X29 is Arg, Ala, Gln or a crosslinked amino acid;

wherein at least one of the crosslinked amino acids is an α,α-disubstituted amino acid;

wherein the peptidomimetic macrocycle comprises at least two macrocycle-forming linkers L, each independently connecting at least one pair of amino acids selected from X1-X29;

wherein each macrocycle-forming linker is independently of the formula $–L_1–L_2–$;

each L_1 and L_2 is independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, cycloarylene, heterocycloarylene, or $[-R_4-K-R_4-]_n$, each being optionally substituted with R_5;

each R_4 is independently alkylene, alkenylene, alkynylene, heteroalkylene, cycloalkylene, heterocycloalkylene, arylene, or heteroarylene;

each K is independently O, S, SO, SO_2, CO, or CO_2;

each R_5 is independently halogen, alkyl, $-OR_6$, $-N(R_6)_2$, $-SR_6$, $-SOR_6$, $-SO_2R_6$, $-CO_2R_6$, a fluorescent moiety, a radioisotope or a therapeutic agent;

each R_6 is independently –H, alkyl, alkenyl, alkynyl, arylalkyl, cycloalkylalkyl, heterocycloalkyl, a fluorescent moiety, a radioisotope or a therapeutic agent; and

each n is independently an integer from 1-5.

32. The peptidomimetic macrocycle of claim 31, wherein each macrocycle-forming linker connects one of the following pairs of amino acids: X4 and X8; X5 and X12; X8 and

X12; X8 and X15; X9 and X16; X12 and X16; X12 and X19; X15 and X22; X18 and X25; X21 and X25; X21 and X28; X22 and X29; and X25 and X29.

33. The peptidomimetic macrocycle of claim 32, wherein each macrocycle-forming linker connects one of the following pairs of amino acids: X4 and X8; X5 and X12; X12 and X19; X15 and X22; X18 and X25; X21 and X25; and X21 and X28.

34. The peptidomimetic macrocycle of any one of claims 18-33, wherein L_1 and L_2 are independently alkylene, alkenylene or alkynylene.

35. The peptidomimetic macrocycle of claim 34, wherein L_1 and L_2 are independently C_3-C_{10} alkylene or alkenylene.

36. The peptidomimetic macrocycle of claim 34, wherein L_1 and L_2 are independently C_3-C_6 alkylene or alkenylene.

37. The peptidomimetic macrocycle of any one of claims 18-30, wherein R_1 and R_2 are H.

38. The peptidomimetic macrocycle of any one of claims 18-30, wherein R_1 and R_2 are independently alkyl.

39. The peptidomimetic macrocycle of any one of claims 18-30, wherein R_1 and R_2 are methyl.

40. The peptidomimetic macrocycle of any one of claims 18-30, wherein R_1 and R_2 are independently alkyl, alkenyl, alkynyl, arylalkyl, cycloalkyl, cycloalkylalkyl, heteroalkyl, or heterocycloalkyl, unsubstituted or substituted with halo–.

41. The peptidomimetic macrocycle of any one of claims 18-30, wherein one of R_1 and R_2 is –H, and the other of R_1 and R_2 is alkyl.

42. A pharmaceutical composition comprising the peptidomimetic macrocycle of any one of claims 1-41.

43. The pharmaceutical composition of claim 42, further comprising a pharmaceutically-acceptable excipient.

44. A method of increasing the circulating level of growth hormone (GH) in a subject comprising administering to the subject a peptidomimetic macrocycle of any one of claims 1-41.

45. A method of increasing lean muscle mass in a subject comprising administering to the subject a peptidomimetic macrocycle of any one of claims 1-41.

46. A method of reducing adipose tissue in a subject comprising administering to the subject a peptidomimetic macrocycle of any one of claims 1-41.

47. The method of claim 46, wherein the adipose tissue is abdominal tissue.

48. The method of claim 46, wherein the subject suffers from obesity.

49. A method of treating a muscle wasting disease in a subject comprising administering to the subject a peptidomimetic macrocycle of any one of claims 1-41.

50. A method of treating a lipodystrophy in a subject comprising administering to the subject a peptidomimetic macrocycle of any one of claims 1-41.

51. A method of treating a growth hormone disorder in a subject comprising administering to the subject a peptidomimetic macrocycle of any one of claims 1-41.

52. The method of claim 51, wherein the disorder is adult growth hormone deficiency.

53. The method of claim 51, wherein the disorder is pediatric growth hormone deficiency.

54. The method of claim 53, wherein the pediatric growth hormone deficiency is associated with idiopathic short stature, SGA (infant small for gestational age), chronic kidney disease, Prader-Willi syndrome Turner syndrome, short stature homeobox (SHOX) gene deficiency, or primary IGF-1 deficiency.

55. A method of treating gastroparesis or short bowel syndrome in a subject comprising administering to the subject a peptidomimetic macrocycle of any one of claims 1-41.

56. Use of a peptidomimetic marcocycle of any one of claims 1-41 in preparation of a medicament for increasing the circulating level of growth hormone (GH) in a subject.

57. Use of a peptidomimetic marcocycle of any one of claims 1-41 in preparation of a medicament for increasing lean muscle mass in a subject.

58. Use of a peptidomimetic marcocycle of any one of claims 1-41 in preparation of a medicament for reducing adipose tissue in a subject.

59. The use of claim 58, wherein the adipose tissue is abdominal tissue.

60. The use of claim 58, wherein the subject suffers from obesity.

61. Use of a peptidomimetic marcocycle of any one of claims 1-41 in preparation of a medicament for treating a muscle wasting disease in a subject.

62. Use of a peptidomimetic marcocycle of any one of claims 1-41 in preparation of a medicament for treating a lipodystrophy in a subject.

63. Use of a peptidomimetic marcocycle of any one of claims 1-41 in preparation of a medicament for treating a growth hormone disorder in a subject.

64. The use of claim 63, wherein wherein the disorder is adult growth hormone deficiency.

65. The use of claim 63, wherein the disorder is pediatric growth hormone deficiency.

66. The use of claim 65, wherein the pediatric growth hormone deficiency is associated with idiopathic short stature, SGA (infant small for gestational age), chronic kidney disease, Prader-Willi syndrome Turner syndrome, short stature homeobox (SHOX) gene deficiency, or primary IGF-1 deficiency.

67. Use of a peptidomimetic marcocycle of any one of claims 1-41 in preparation of a medicament for treating gastroparesis or short bowel syndrome in a subject.

Figure 1a

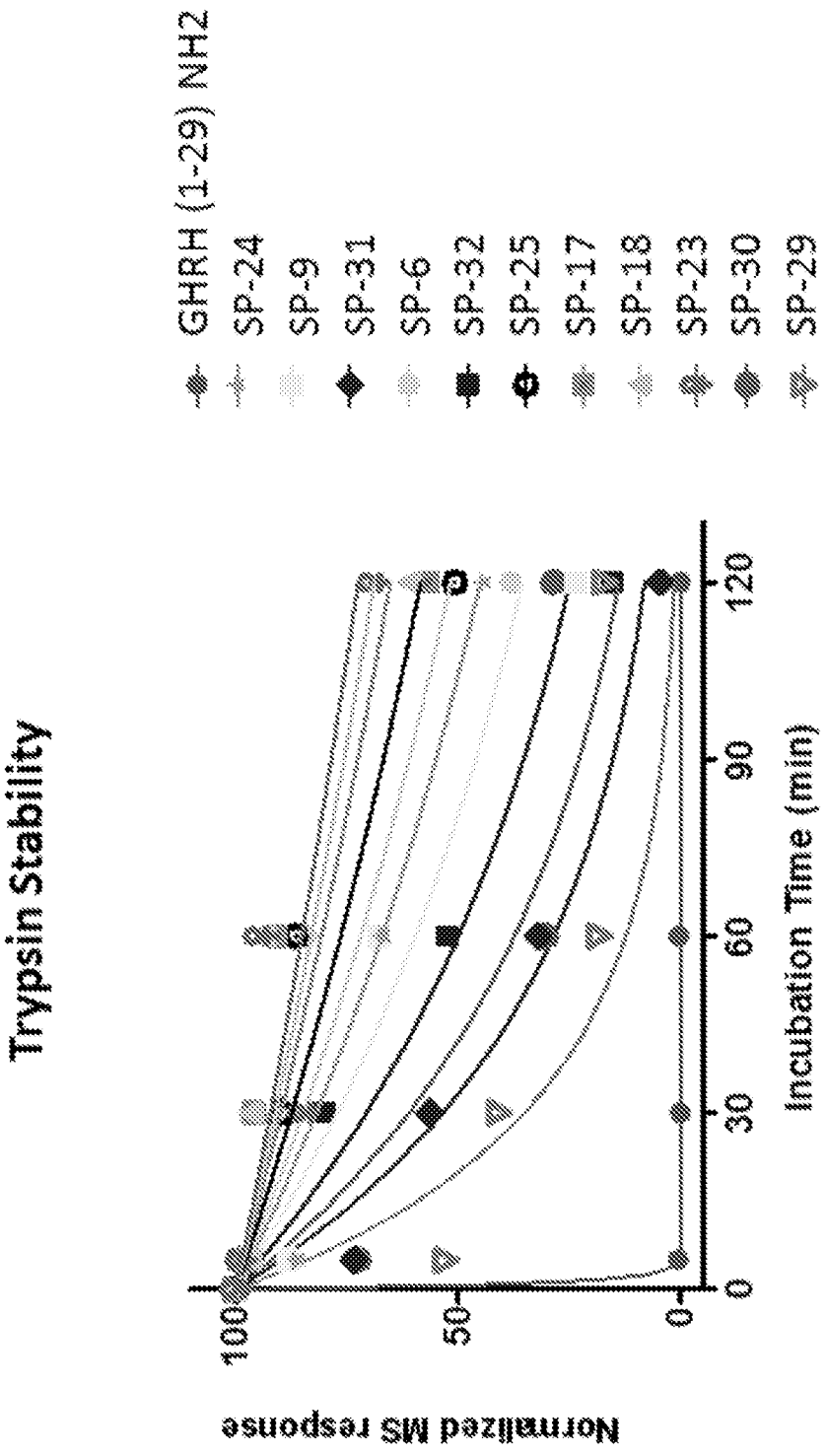

Trypsin Stability
GHRH (1-29) NH2
SP-24
SP-9
SP-31
SP-6
SP-32
SP-25
SP-17
SP-18
SP-23
SP-30
SP-29
Normalized MS response
100
50
0
0
30
60
90
120
Incubation Time (min)

Figure 1b

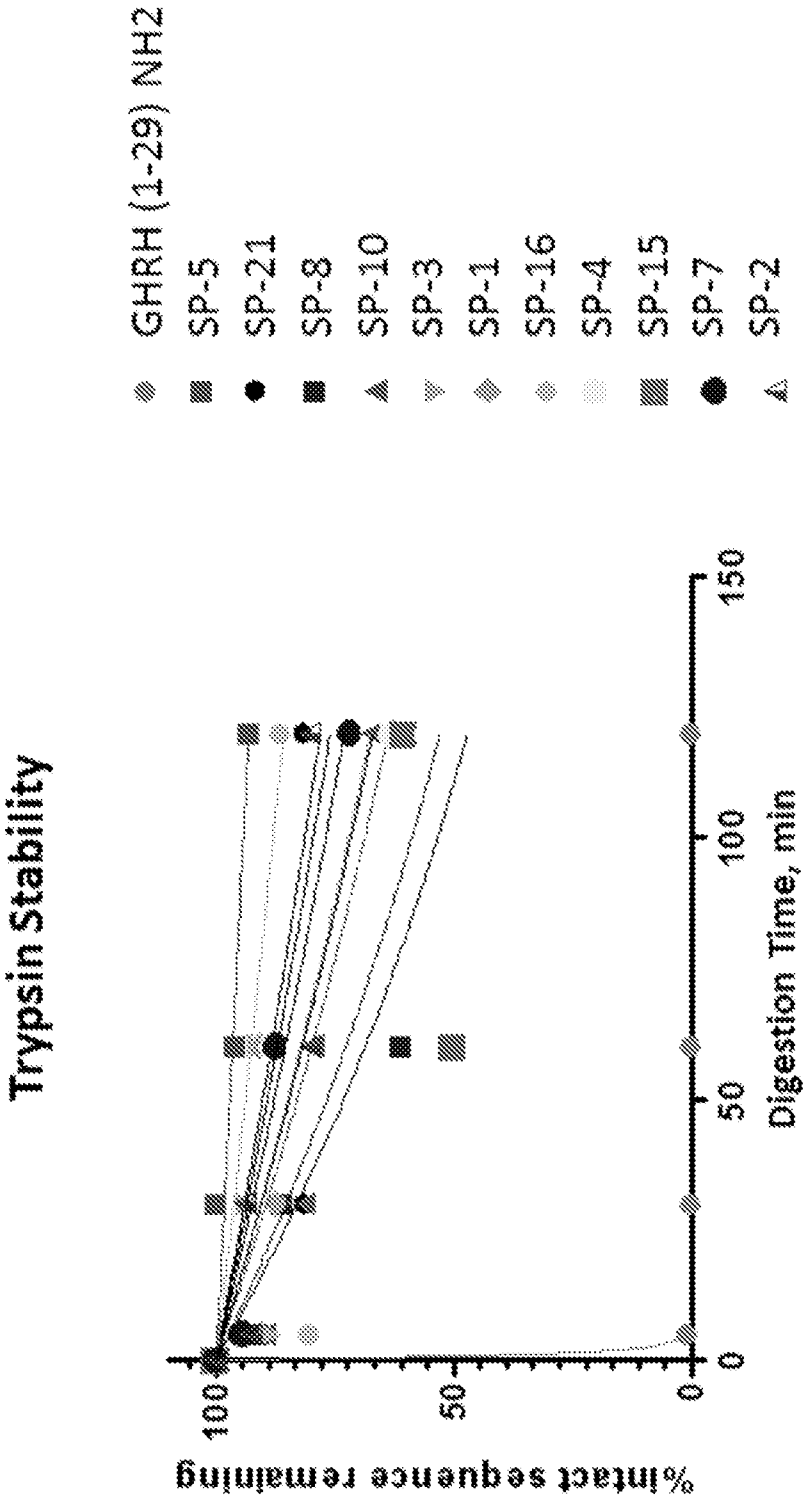

Trypsin Stability
GHRH (1-29) NH2
SP-5
SP-21
SP-8
SP-10
SP-3
SP-1
SP-16
SP-4
SP-15
SP-7
SP-2
% intact sequence remaining
100
50
0
0
50
100
150
Digestion Time, min

Figure 2

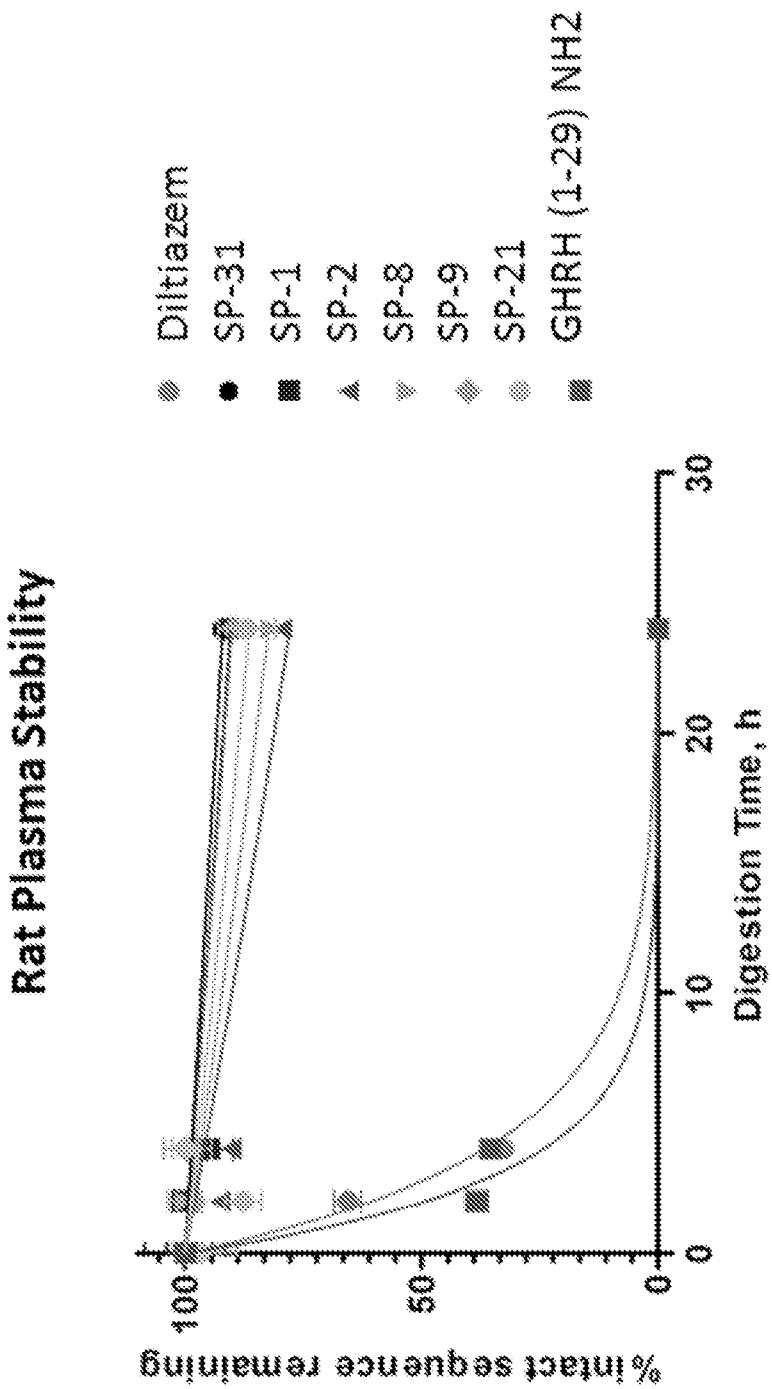

Rat Plasma Stability
Diltiazem
SP-31
SP-1
SP-2
SP-8
SP-9
SP-21
GHRH (1-29) NH2
% intact sequence remaining
100
50
0
0
10
20
30
Digestion Time, h

Figure 3

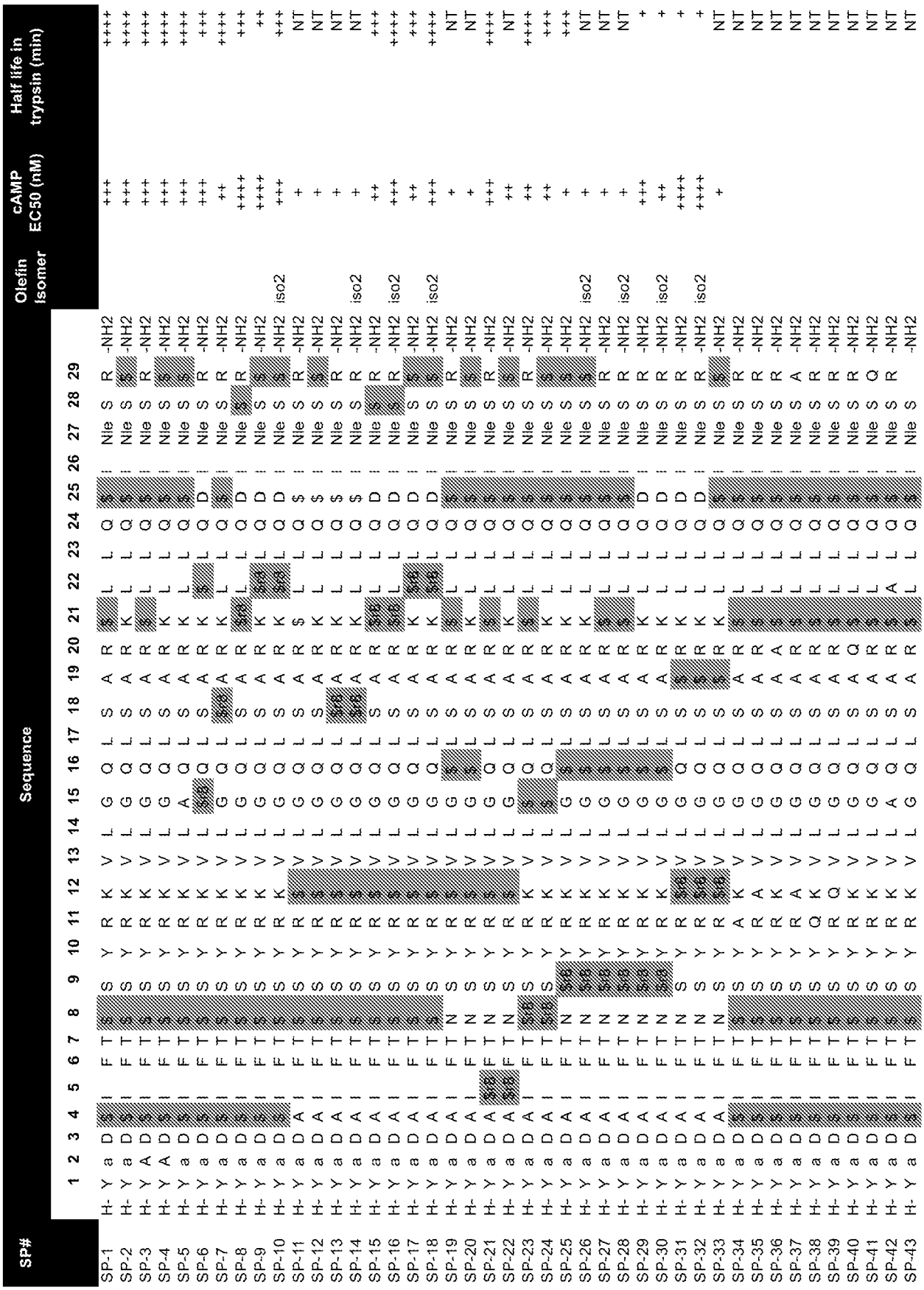

SP#
Sequence
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Olefin Isomer
cAMP EC50 (nM)
Half life in trypsin (min)
SP-1 H- Y a D $5 I F T $5 S Y R K V L G Q L S A R $5 L L Q $5 $5 Nle S R -NH2 +++ ++++
SP-2 H- Y a D $5 I F T $5 S Y R K V L G Q L S A R K L L Q $5 $5 Nle S $5 -NH2 +++ ++++
SP-3 H- Y A D $5 I F T $5 S Y R K V L G Q L S A R $5 L L Q $5 $5 Nle S R -NH2 +++ ++++
SP-4 H- Y A D $5 I F T $5 S Y R K V L G Q L S A R K L L Q $5 $5 Nle S $5 -NH2 +++ ++++
SP-5 H- Y a D $5 I F T $5 S Y R K V L A Q L $5$5 S A R K K L Q D Nle S R -NH2 +++ ++++
SP-6 H- Y a D $5 I F T $5 S Y R K V L G Q L $5$5 A R K K L Q $5 L Nle S R -NH2 ++ +++
SP-7 H- Y a D $5 I F T $5 S Y R K V L G Q L S A R K L L Q D L Nle $5 R -NH2 ++++ ++++
SP-8 H- Y a D $5 I F T $5 S Y R K V L G Q L S A R $5$5 L L Q D L Nle $5 R -NH2 +++ +++
SP-9 H- Y a D $5 I F T $5 S Y R K V L G Q L S A R K $5$5 L L Q D L Nle S $5 -NH2 ++++ ++
SP-10 H- Y a D $5 I F T $5 S Y R K V L G Q L S A R K $5$5 L L Q D L Nle S $5 -NH2 iso2 +++ +++
SP-11 H- Y a D A I F T $5 S Y R $5 V L G Q L S A R $ L L Q $ L Nle S R -NH2 + NT
SP-12 H- Y a D A I F T $5 S Y R $5 V L G Q L S A R K L L Q $ L Nle S $5 -NH2 + NT
SP-13 H- Y a D A I F T $5 S Y R $5 V L G Q L $5$6 A R K L L Q $ L Nle S R -NH2 + NT
SP-14 H- Y a D A I F T $5 S Y R $5 V L G Q L $5$6 A R K L L Q $ L Nle S R -NH2 iso2 + NT
SP-15 H- Y a D A I F T $5 S Y R $5 V L G Q L S A R $5$6 L L Q D L Nle $5 R -NH2 ++ +++
SP-16 H- Y a D A I F T $5 S Y R $5 V L G Q L S A R $5$6 L L Q D L Nle $5 R -NH2 iso2 +++ ++++
SP-17 H- Y a D A I F T $5 S Y R $5 V L G Q L S A R K $5$6 L Q D L Nle S $5 -NH2 ++ +++
SP-18 H- Y a D A I F T $5 S Y R $5 V L G Q L S A R K $5$6 L Q D L Nle S $5 -NH2 iso2 +++ ++++
SP-19 H- Y a D A I F T N S Y R $5 V L G $5 L S A R $5 L L Q $5 L L Nle S R -NH2 + NT
SP-20 H- Y a D A I F T N S Y R $5 V L G $5 L S A R K L L Q $5 L L Nle S $5 -NH2 + NT
SP-21 H- Y a D A $5$6 F T N S Y R $5 V L G Q L S A R $5 L L Q $5 L L Nle S R -NH2 +++ ++++
SP-22 H- Y a D A $5$6 F T N S Y R $5 V L G Q L S A R K L L Q $5 L L Nle S $5 -NH2 ++ NT
SP-23 H- Y a D A I F T $5$6 S Y R K V L $5 Q L S A R $5 L L Q $5 L L Nle S R -NH2 ++ ++++
SP-24 H- Y a D A I F T $5$6 S Y R K V L $5 Q L S A R K L L Q $5 L L Nle S $5 -NH2 ++ +++
SP-25 H- Y a D A I F T N $5$6 Y R K V L G $5 L S A R K L L Q $5 L L Nle S $5 -NH2 + +++
SP-26 H- Y a D A I F T N $5$6 Y R K V L G $5 L S A R K L L Q $5 L L Nle S $5 -NH2 iso2 + NT
SP-27 H- Y a D A I F T N $5$6 Y R K V L G $5 L S A R $5 L L Q $5 L L Nle S R -NH2 + NT
SP-28 H- Y a D A I F T N $5$6 Y R K V L G $5 L S A R $5 L L Q $5 L L Nle S R -NH2 iso2 + NT
SP-29 H- Y a D A I F T N $5$6 Y R K V L G $5 L S A R K L L Q D L Nle S R -NH2 + +++
SP-30 H- Y a D A I F T N $5$6 Y R K V L G $5 L S A R K L L Q D L Nle S R -NH2 iso2 + ++
SP-31 H- Y a D A I F T N S Y R $5$6 V L G Q L S A R K L L Q D L Nle S R -NH2 + ++++
SP-32 H- Y a D A I F T N S Y R $5$6 V L G Q L S A R K L L Q D L Nle S R -NH2 iso2 + ++++
SP-33 H- Y a D A I F T N S Y Y R $5$6 V L G Q L S A R K L L Q $5 L L Nle S $5 -NH2 + NT
SP-34 H- Y a D $5 I F T $5 S Y Y A K V L G Q L S A R $5 L L Q $5 L L Nle S R -NH2 NT
SP-35 H- Y a D $5 I F T $5 S Y Y R A V L G Q L S A R K L L Q $5 L L Nle S R -NH2 NT
SP-36 H- Y a D $5 I F T $5 S Y Y R K V L G Q L S A A R $5 L L Q $5 L L Nle S R -NH2 NT
SP-37 H- Y a D $5 I F T $5 S Y Y R A V L G Q L S A R $5 L L Q $5 L L Nle S A -NH2 NT
SP-38 H- Y a D $5 I F T $5 S Y Y Q K V L G Q L S A R $5 L L Q $5 L L Nle S R -NH2 NT
SP-39 H- Y a D $5 I F T $5 S Y Y R Q V L G Q L S A R $5 L L Q $5 L L Nle S R -NH2 NT
SP-40 H- Y a D $5 I F T $5 S Y Y R K V L G Q L S A Q $5 L L Q $5 L L Nle S R -NH2 NT
SP-41 H- Y a D $5 I F T $5 S Y Y R K V L G Q L S A R $5 L L Q $5 L L Nle S Q -NH2 NT
SP-42 H- Y a D $5 I F T $5 S Y Y R K V L A Q L S A R K L L Q $5 L L Nle S R -NH2 NT
SP-43 H- Y a D $5 I F T $5 S Y Y R K V L G Q L S A R $5 L L Q $5 L L Nle S -NH2 NT

Figure 3a

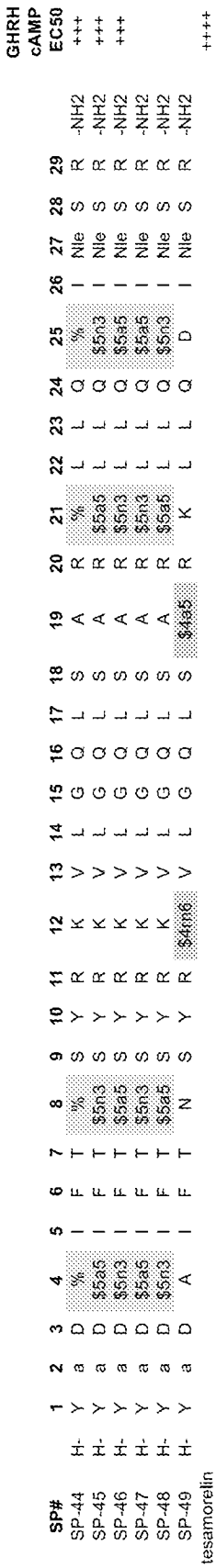

SP# 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 GHRH cAMP EC50
SP-44 H- Y a D % I F T % S Y R K V L G Q L S A R % L L Q % I Nle S R -NH2 +++
SP-45 H- Y a D $5a5 I F T $5n3 S Y R K V L G Q L S A R $5a5 L L Q $5n3 I Nle S R -NH2 +++
SP-46 H- Y a D $5n3 I F T $5a5 S Y R K V L G Q L S A R $5n3 L L Q $5a5 I Nle S R -NH2 +++
SP-47 H- Y a D $5a5 I F T $5n3 S Y R K V L G Q L S A R $5n3 L L Q $5a5 I Nle S R -NH2
SP-48 H- Y a D $5n3 I F T $5a5 S Y R $4m6 V L G Q L S $4a5 R $5a5 L L Q $5n3 I Nle S R -NH2
SP-49 H- Y a D A I F T N S Y R K V L G Q L S A R K L L Q D I Nle S R -NH2 ++++
tesamorelin

Figure 4

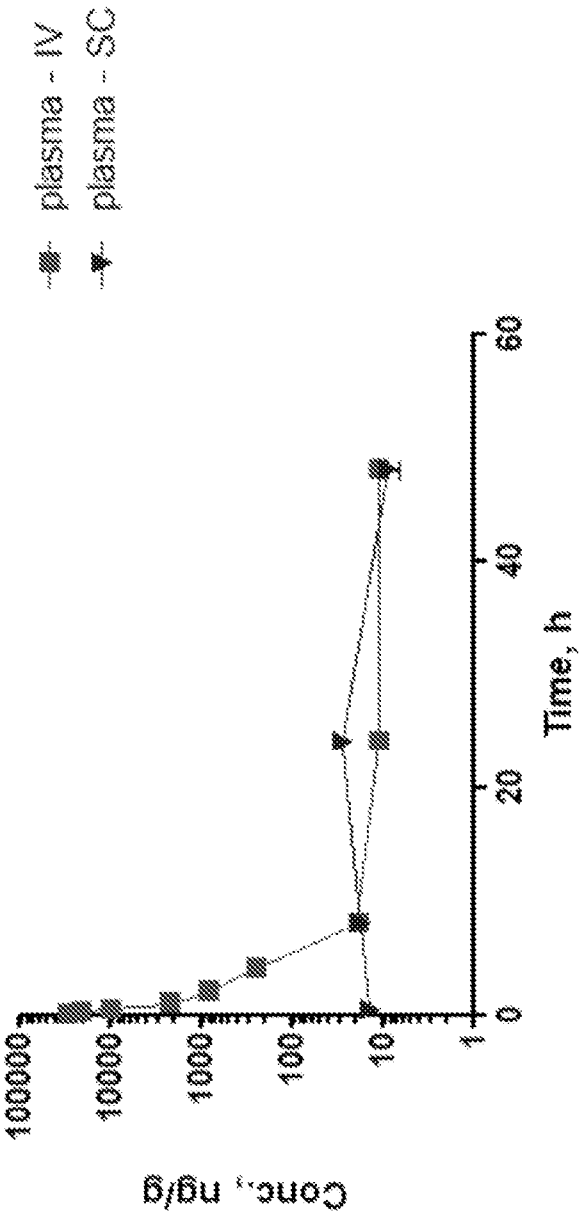

SP-1 Plasma PK in S-D Rat,
Single-dose at 3.0 mg/kg (5 mL/kg)
plasma - IV
plasma - SC
Conc., ng/g
100000
10000
1000
100
10
1
0
20
40
60
Time, h

Figure 5

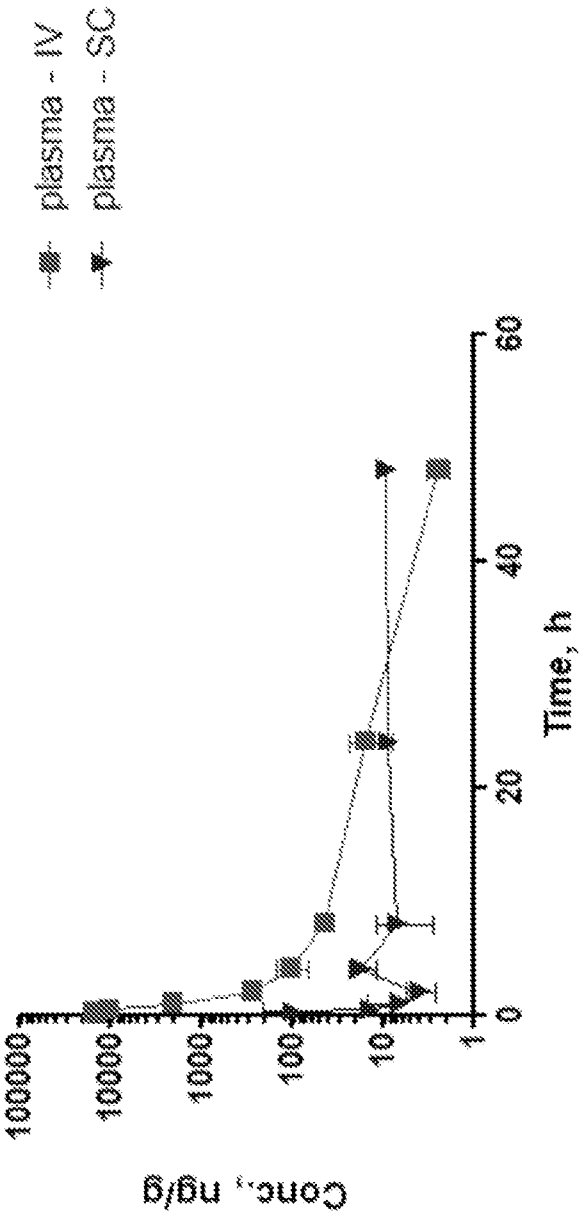

SP-8 Plasma PK in S-D Rat,
Single-dose at 3.0 mg/kg (5 mL/kg)
plasma - IV
plasma - SC
Conc., ng/g
100000
10000
1000
100
10
1
0
20
40
60
Time, h

Figure 6

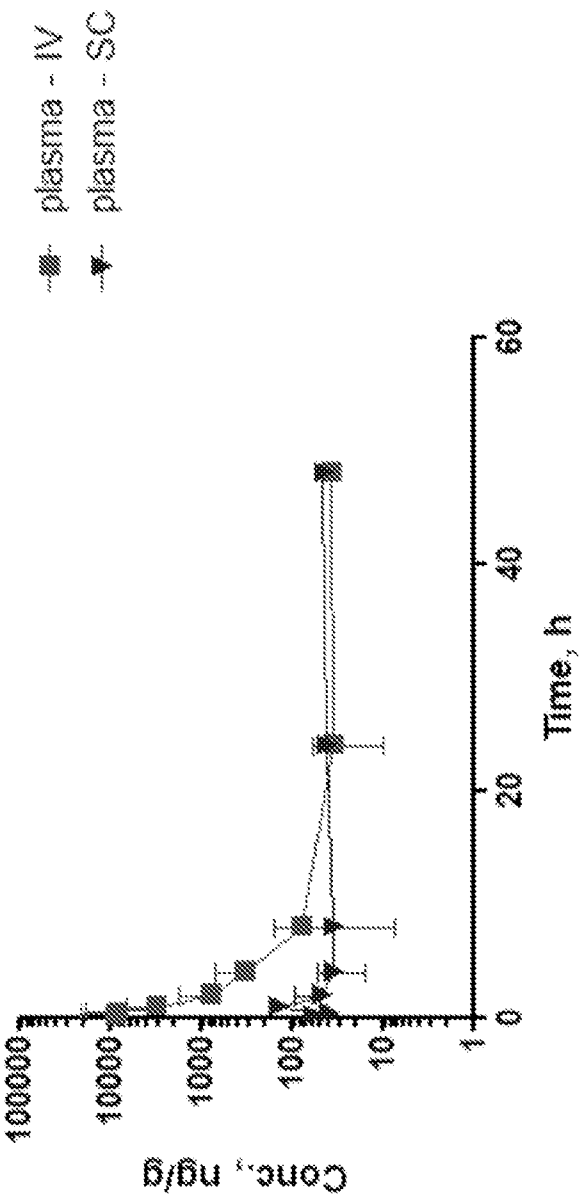

SP-6 Plasma PK in S-D Rat,
Single-dose at 3.0 mg/kg (5 mL/kg)
plasma - IV
plasma - SC
Conc., ng/g
100000
10000
1000
100
10
1
0
20
40
60
Time, h

Figure 7

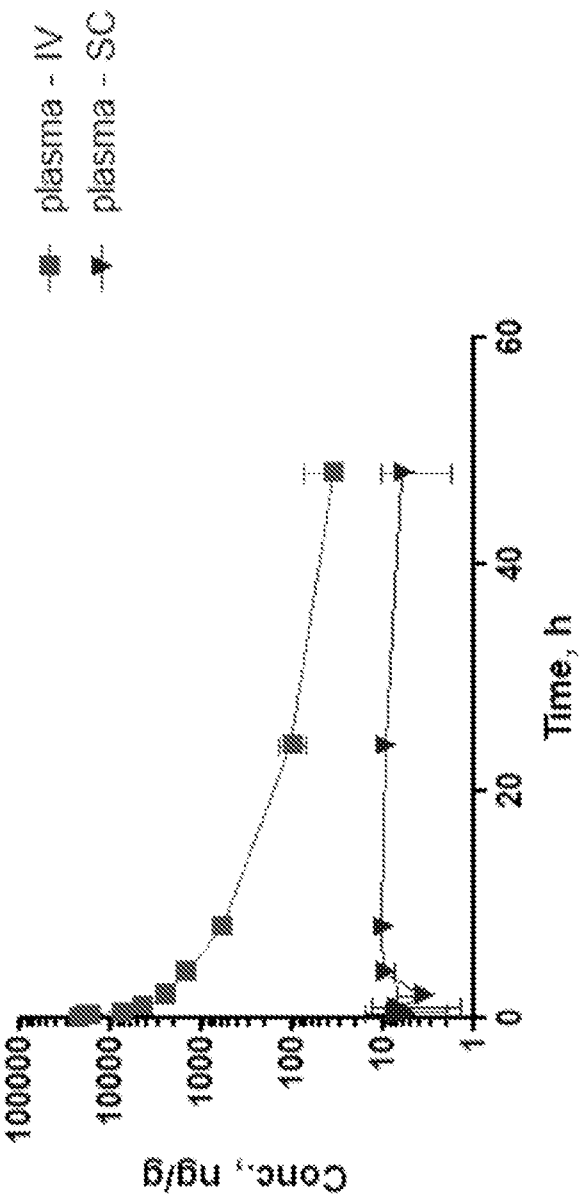

SP-21 Plasma PK in S-D Rat,
Single-dose at 3.0 mg/kg (5 mL/kg)
plasma - IV
plasma - SC
Conc., ng/g
100000
10000
1000
100
10
1
0
20
40
60
Time, h

Figure 8

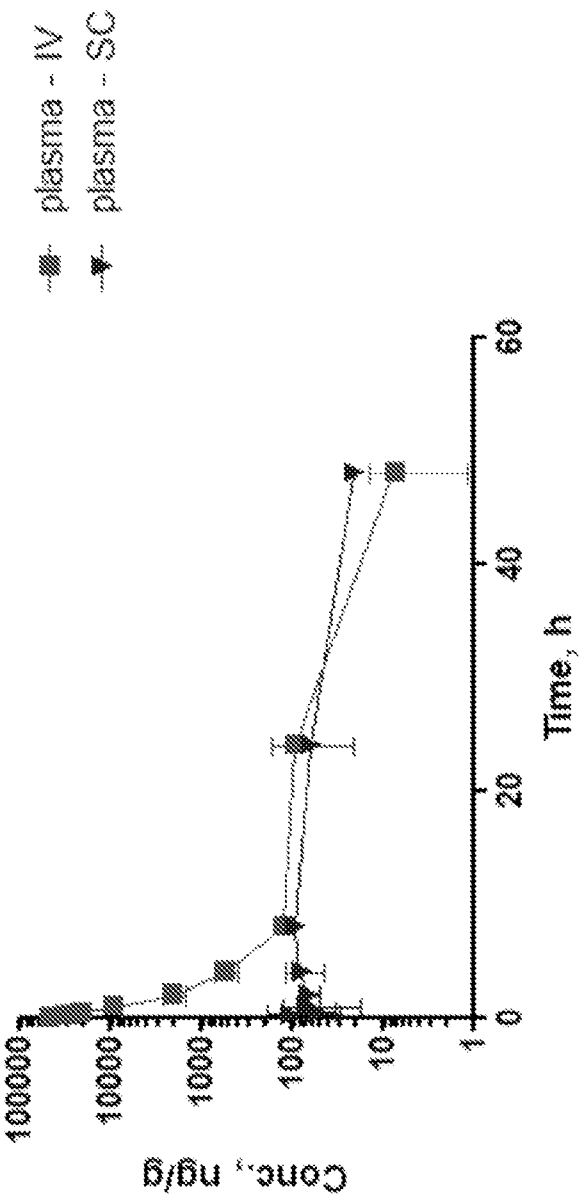

SP-32 Plasma PK in S-D Rat,
Single-dose at 3.0 mg/kg (5 mL/kg)
plasma - IV
plasma - SC
Conc., ng/g
100000
10000
1000
100
10
1
0
20
40
60
Time, h

Figure 9

Compound	AUCinf hr*ng/mL	AUC Ext (%) %	t 1/2 hr	MRT hr	Vdss mL/kg	Clp mL/hr/kg
SP-1	17529	13.8	55.1	1.6	267	171
SP-6	23477	16.3	20.6	3.7	474	128
SP-8	12575	4.8	10.2	1.6	390	239
SP-21	30455	9.4	10.1	5.3	524	99
SP-32	36963	3.0	9.7	2.3	190	81
Tesamorelin, dog 0.1 µg/kg IV**	5301		0.4			
Tesamorelin, human 0.5, 1, or 2 mg SC**			2-5h			
** literature values						

Figure 10

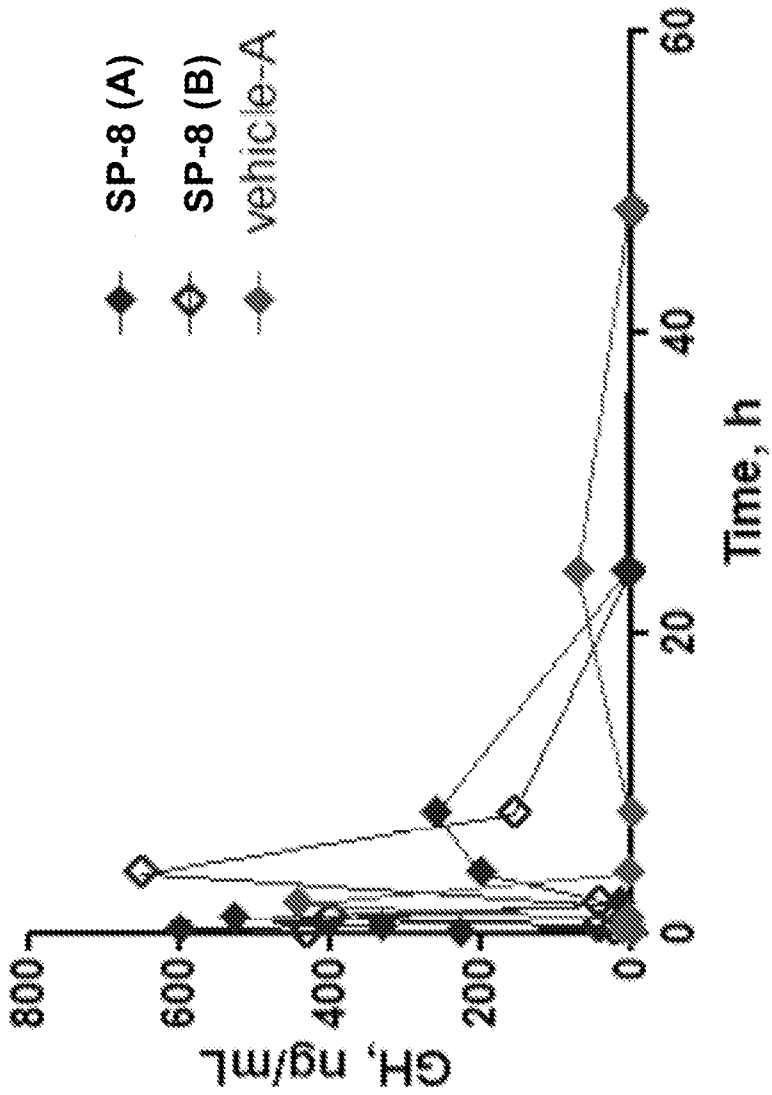
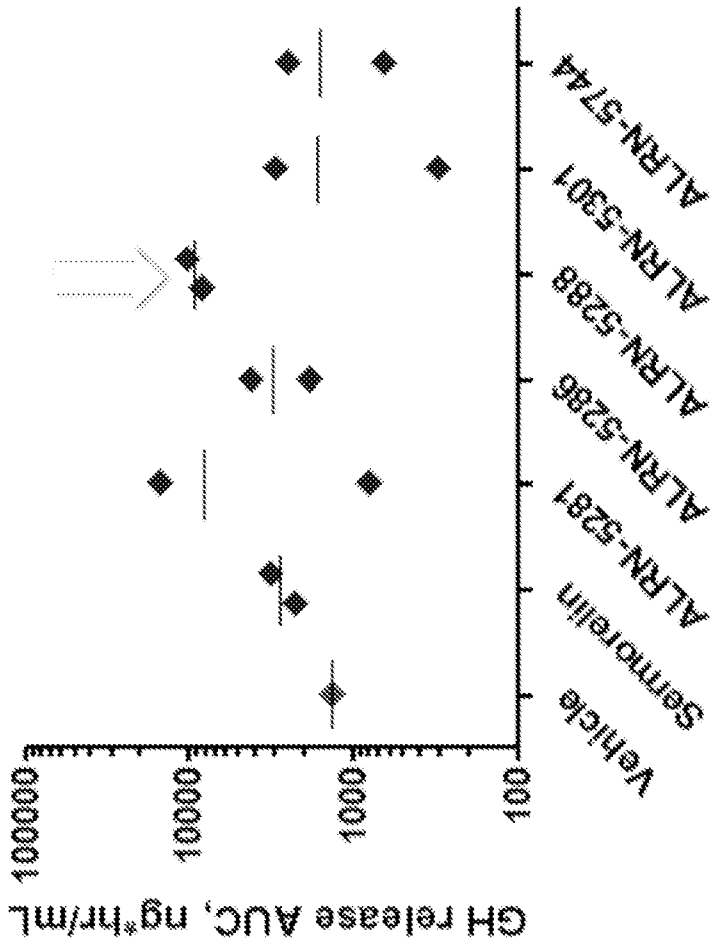


Figure 11


GH release AUC, ng*hr/mL
100000
10000
1000
100
Vehicle
Sermorelin
ALRN-5281
ALRN-5286
ALRN-5288
ALRN-5301
ALRN-5744