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(54) Titre : PEPTIDES DE PENETRATION CELLULAIRE A LIAISONS DISULFURE, LEURS PROCEDES DE PREPARATION ET D'UTILISATION
(54) Title: DI-SULFIDE CONTAINING CELL PENETRATING PEPTIDES AND METHODS OF MAKING AND USING THEREOF

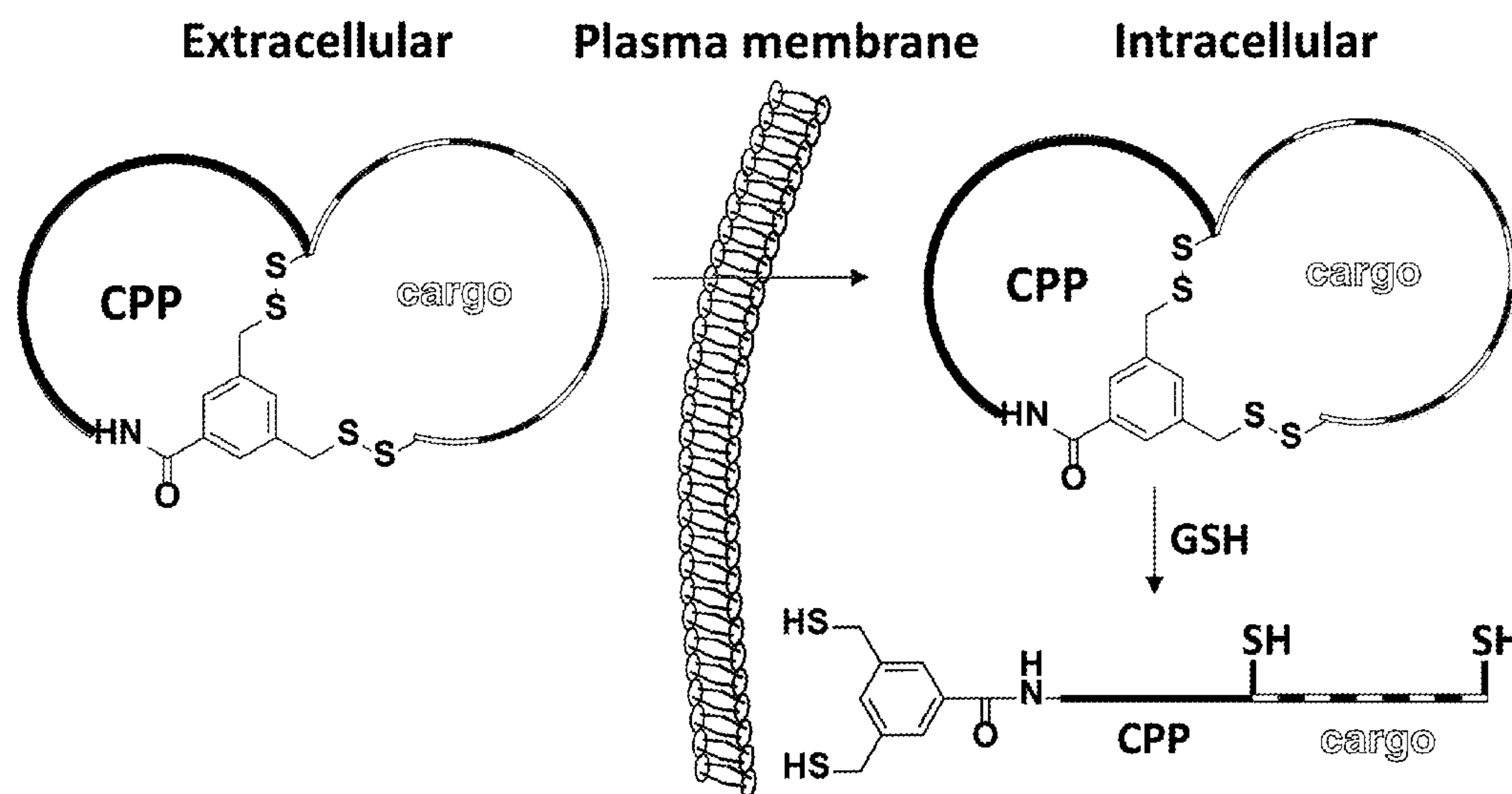


FIG. 2

(57) **Abrégé/Abstract:**

Disclosed is a general, reversible bicyclization strategy to increase both the proteolytic stability and cell permeability of peptidyl drugs. A peptide drug is fused with a short cell-penetrating motif and converted into a conformationally constrained bicyclic structure through the formation of a pair of disulfide bonds. The resulting bicyclic peptide has greatly enhanced proteolytic stability as well as cell-permeability. Once inside the cell, the disulfide bonds are reduced to produce a linear, biologically active peptide. This strategy was applied to generate a cell-permeable bicyclic peptidyl inhibitor against the NEMO-IKK interaction.

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(54) Title: DI-SULFIDE CONTAINING CELL PENETRATING PEPTIDES AND METHODS OF MAKING AND USING THERE-OF

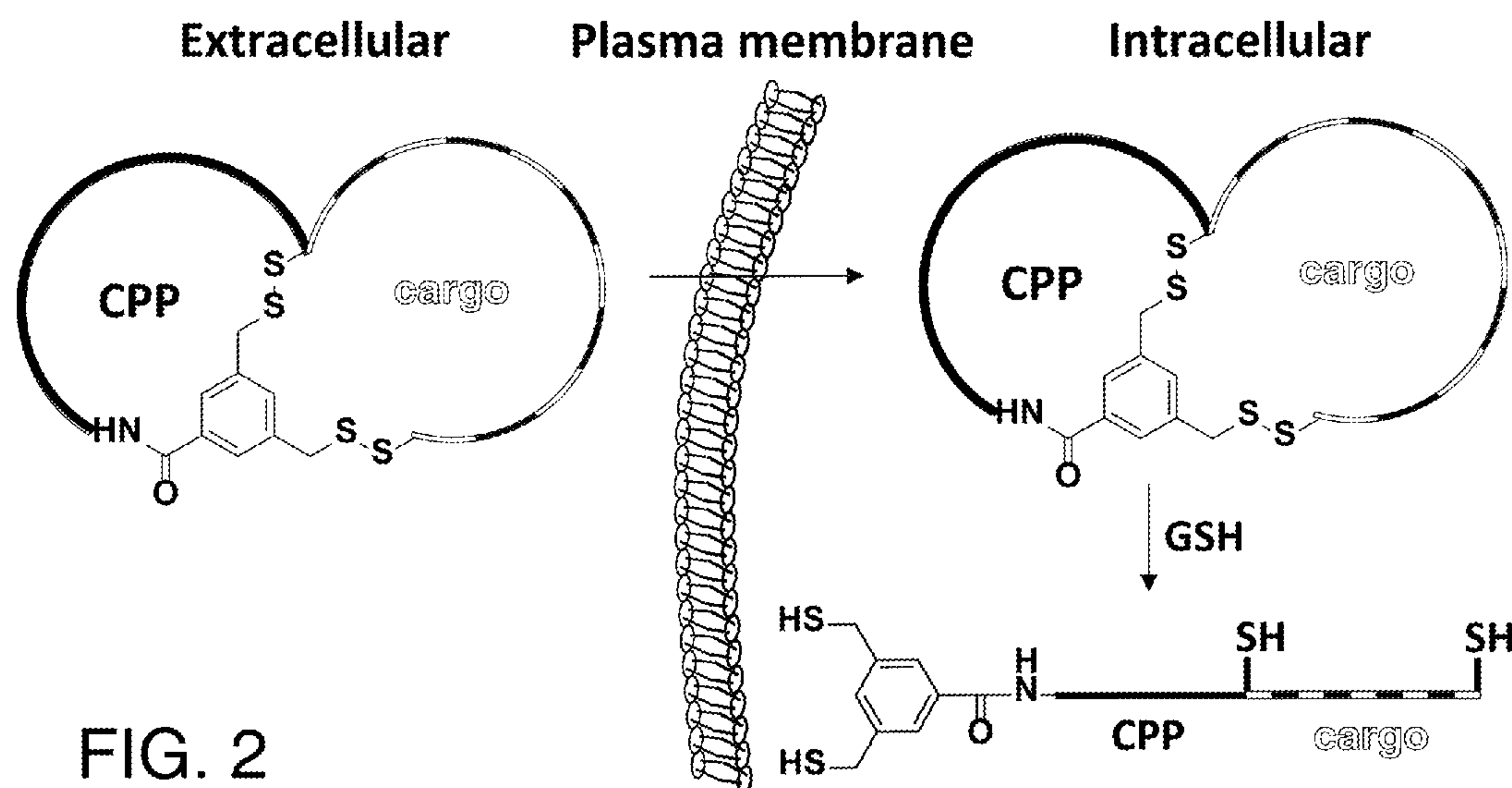


FIG. 2

(57) Abstract: Disclosed is a general, reversible bicyclization strategy to increase both the proteolytic stability and cell permeability of peptidyl drugs. A peptide drug is fused with a short cell-penetrating motif and converted into a conformationally constrained bicyclic structure through the formation of a pair of disulfide bonds. The resulting bicyclic peptide has greatly enhanced proteolytic stability as well as cell-permeability. Once inside the cell, the disulfide bonds are reduced to produce a linear, biologically active peptide. This strategy was applied to generate a cell-permeable bicyclic peptidyl inhibitor against the NEMO-IKK interaction.

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DI-SULFIDE CONTAINING CELL PENETRATING PEPTIDES AND METHODS OF MAKING AND USING THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This application claims priority to U.S. App. No. 62/419,781, filed on November 9, 2016, U.S. App. No. 62/425,550, filed November 22, 2016, and U.S. App. No. 62/438,141, filed December 22, 2016, each of which are herein incorporated by reference in its entirety.

STATEMENT REGARDING FEDERALLY FUNDED RESEARCH

10 This invention was made with government support under grant numbers GM062820, GM110208, and GM122459 awarded by the National Institutes of Health. The government has certain rights in this invention.

BACKGROUND

15 Compared to small-molecule drugs, peptides are highly selective and efficacious and, at the same time, relatively safe and well tolerated. A particularly exciting application of peptides is the inhibition of protein-protein interactions (PPIs), which remain challenging targets for small molecules. Consequently, there is an increased interest in peptides in pharmaceutical research and development, and ~140 peptide therapeutics are currently being evaluated in clinical trials. However, peptides are inherently susceptible to proteolytic degradation.

20 Additionally, peptides are generally impermeable to the cell membrane, largely limiting their applications to extracellular targets. Although N-methylation of the peptide backbone and formation of intramolecular hydrogen bonds have been shown to improve the proteolytic stability and membrane permeability of certain cyclic peptides (T. Rezai, et al., *J. Am. Chem. Soc.* 2006, 128, 14073), alternative strategies to increase both the metabolic stability and cell

25 permeability of peptide drugs are clearly needed.

NF- κ B is a transcription factor that controls the expression of numerous gene products involved in immune, stress, inflammatory responses, cell proliferation, and apoptosis (A. Oeckinghaus, S. Ghosh, *Cold Spring Harb. Perspect. Biol.* 2009, 1, a000034). Aberrant activation of NF- κ B signaling has been implicated in a number of autoimmune diseases (e.g.,

30 rheumatoid arthritis) and cancer (e.g., diffuse large B-cell lymphoma), among others (V. Baud, M. Karin, *Nat. Rev. Drug Discov.* 2009, 8, 33; S.-C. Sun, et al., *Trends Immunol.* 2013, 34, 282; F. D. Herrington, et al., *J. Biomol. Screen.* 2016, 21, 223; G. Cildir, et al., *Trends Mol. Med.* 2016, 22, 414). Canonical NF- κ B signaling is mediated by the interaction between the inhibitor of κ B (I κ B)-kinase (IKK) complex and regulatory protein NF- κ B essential modifier

(NEMO) (S. Yamaoka, et al., *Cell* 1998, 26, 1231; D. M. Rothwarf, et al., *Nature* 1998, 395, 297). Binding to NEMO activates IKK, which in turn phosphorylates I κ B, promoting the proteasomal degradation of I κ B and release of active NF- κ B. Modulators targeting various steps of the NF- κ B signaling pathway have been reported, and some of them have progressed into the clinic (V. Baud, M. Karin, *Nat. Rev. Drug Discov.* 2009, 8, 33; S.-C. Sun, et al., *Trends Immunol.* 2013, 34, 282; F. D. Herrington, et al., *J. Biomol. Screen.* 2016, 21, 223; G. Cildir, et al., *Trends Mol. Med.* 2016, 22, 414; S. C. Gupta, et al., *Biochim. Biophys. Acta.* 2011, 1799, 775; T. M. Herndon, et al., *Clin. Cancer Res.* 2013, 19, 4559). One attractive strategy for ameliorating the NF- κ B activity is to selectively disrupt the IKK-NEMO interaction. Previous studies generated a weak NEMO inhibitor ($K_D \sim 37 \mu\text{M}$), Antp-NBD (Table 6, peptide 1), which contains the 11-residue NEMO-binding domain (NBD) of IKK β covalently linked to a cell-penetrating peptide (CPP), Antp (M. J. May, et al., *Science* 2000, 289, 1550). Interestingly, Antp-NBD blocks the IKK activity stimulated by different pro-inflammatory stimuli, but does not affect the basal NF- κ B activity, thus providing a potentially safe and effective mechanism for reducing aberrant NF- κ B activity (J. May, et al., *Science* 2000, 289, 1550). In several pre-clinical studies, Antp-NBD demonstrated *in vivo* efficacy for treating Duchenne muscular dystrophy and large B-cell lymphoma in mouse and canine models (E. Jimi, et al., *Nat. Med.* 2004, 10, 617; S. Dai, et al., *J. Biol. Chem.* 2004, 279, 37219; W. Shibata, et al., *J. Immunol.* 2007, 179, 2681; S. H. Dave, et al., *J. Immunol.* 2007, 179, 7852; A. Gurnier-Hausser, et al., *Clin. Cancer Res.* 2011, 17, 4661; J. M. Peterson, et al., *Mol. Med.* 2011, 17, 508; D. A. Delfin, et al., *J. Transl. Med.* 2011, 9, 68; D. P. Reay, et al., *Neurobiol. Dis.* 2011, 43, 598; J. N. Kornegay, et al., *Skelet. Muscle* 2014, 4, 18; G. Habineza Ndikuyeze, et al., *PLoS One*, 2014, 9, e95404). However, to achieve clinical utility, Antp-NBD would benefit significantly from improvements in its NEMO-binding affinity, metabolic stability, and cell-permeability. What are thus needed are new compositions and methods for modulating NF- κ B signaling. The compositions and methods disclosed herein address these and other needs.

SUMMARY

Disclosed herein are compounds, compositions, methods for making and using such compounds and compositions. In various embodiments disclosed herein are bicyclic peptides, compositions comprising such bicyclic peptides, and methods of making and using them.

In some embodiments, the bicyclic peptides disclosed herein comprise: (a) a first cyclic peptide comprising a cell-penetrating peptide sequence (X_m); (b) a second cyclic peptide comprising a peptidyl ligand (X_n); and (c) at least one disulfide bond which forms at least one of the first cyclic peptide or the second cyclic peptide, wherein the first cyclic peptide is
 5 conjugated to the second cyclic peptide.

In various embodiments, X_m comprises the following peptide sequence:



wherein:

AA^1 , AA^2 , AA^3 , AA^4 , AA^5 , AA^6 , AA^7 , AA^8 , and AA^9 , are each independently an
 10 amino acid, which is optionally substituted, and where at least three amino acids are arginine and at least two amino acids independently comprise a hydrophobic side chain; and
 m , n , p , and q are independently selected from 0 and 1.

In some embodiments, the bicyclic peptides comprise a linking moiety which is
 15 conjugated, directly or indirectly, to X_m and X_n . In some embodiments, X_m is cyclized through the linking moiety, the C- or N-terminus of X_n is conjugated to the linking moiety, and X_n is cyclized through the disulfide bond, thereby forming the bicyclic peptide. In other
 embodiments, the linking moiety is conjugated to the side chain of an amino acid in the first
 cyclic peptide, the C- or N-terminus of X_n is conjugated to the linking moiety, and wherein X_n
 20 is cyclized through the disulfide bond, thereby forming the bicyclic peptide.

In some embodiments, the bicyclic peptides disclosed herein comprise a first disulfide bond and a second disulfide bond. In other embodiments, linking moiety comprises a first
 substituent which forms the first disulfide bond and a second substituent which forms the
 second disulfide bond. In some embodiments, X_m is cyclized through the first disulfide bond,
 25 and X_n is cyclized through the second disulfide bond, thereby forming the bicyclic peptide. In
 still other embodiments, the linking moiety is conjugated to the side chain of the first cyclic
 peptide, and X_n is cyclized through the first disulfide bond and the second disulfide bond,
 thereby forming the bicyclic peptide. In yet still other embodiments, the C- or N- terminus of
 X_m is conjugated to the linking moiety and X_m is cyclized through the first disulfide bond, and
 30 wherein the C- or N- terminus of X_n is conjugated to the linking moiety and X_n is cyclized
 through the second disulfide bond, thereby forming the bicyclic peptide. In still even more

embodiments, the C- or N- terminus of X_n is conjugated to the linking moiety, and wherein X_m is cyclized through the first disulfide bond and X_n is cyclized through the second disulfide bond, thereby forming the bicyclic peptide.

In some embodiments, the bicyclic peptides disclosed herein comprise a third disulfide bond. In other embodiments, the linker moiety comprises a first substituent which forms the first disulfide bond, a second substituent which forms the second disulfide bond, and third substituent which forms the third disulfide bond. In still other embodiments, X_m is fused to X_n , thereby forming a fused X_m - X_n peptide, and the linking moiety is conjugated to the fused X_m - X_n peptide through the third disulfide bond, and wherein X_m is cyclized through the first disulfide bond and X_n is cyclized through the second disulfide bond, thereby forming the bicyclic peptide.

In some embodiments, the bicyclic peptides disclosed herein comprise a fourth disulfide bond. In some embodiments, the linker moiety comprises a first substituent which forms the first disulfide bond, a second substituent which forms the second disulfide bond, third substituent which forms the third disulfide bond comprises, and a fourth substituent which forms a fourth disulfide bond. In other embodiments, X_m is cyclized through the first disulfide bond and the second disulfide bond, and X_n is cyclized through the third disulfide bond and the fourth disulfide bond, thereby forming the bicyclic peptide.

In various embodiments, the bicyclic peptides disclosed herein have a structure according to any of Formulae 1-12

Number	Formula
1	
2	
3	

4	Diagram 4 shows a graph structure with nodes X_m, AAS, X_n, L, J, and SS. The connections are: X_m — AAS — X_n — L; AAS — SS; SS — J (diagonal line); SS — J (horizontal line).
5	Diagram 5 shows a graph structure with nodes L, X_n, AAS, X_m, J, and SS. The connections are: L — X_n — AAS — X_m; AAS — SS; J — SS (diagonal line); J — SS (horizontal line).
6	Diagram 6 shows a graph structure with nodes X_n, L, X_m, AAS, J, and SS. The connections are: X_n — L — X_m — AAS; AAS — SS; J — SS (diagonal line); J — SS (horizontal line).
7	Diagram 7 shows a graph structure with nodes X_n, AAS, X_m, L, J, and SS. The connections are: X_n — AAS — X_m — L; AAS — SS; J — SS (diagonal line); J — SS (horizontal line).
8	Diagram 8 shows a graph structure with nodes X_n, AAS, X_m, J, and SS. The connections are: X_n — AAS — X_m; AAS — SS; J — SS (diagonal line); J — SS (horizontal line).
9	Diagram 9 shows a graph structure with nodes X_m, AAS, X_n, J, and SS. The connections are: X_m — AAS — X_n; AAS — SS; J — SS (diagonal line); J — SS (horizontal line).
10	Diagram 10 shows a graph structure with nodes X_n, AAS, SS, J, and X_m. The connections are: X_n — AAS — SS — J; AAS — SS; J — SS (diagonal line); J — SS (horizontal line).

11	
12	

wherein:

AA^S at each occurrence is independently a moiety which forms a disulfide bond with J;

5 L-J is the linking moiety, wherein:

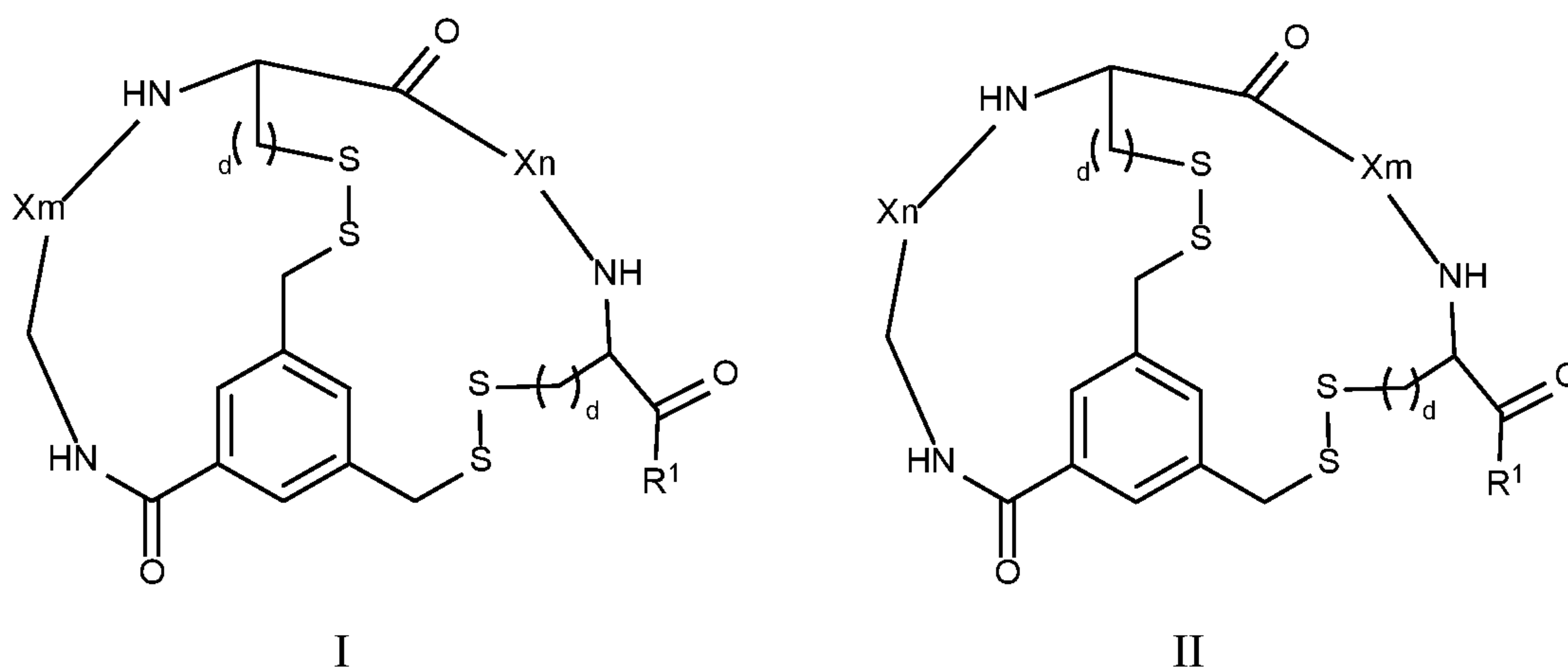
J is absent, or an alkyl, *N*-alkyl, alkenyl, alkynyl, carbocyclyl, or heterocyclyl, each of which are independently substituted with at least two substituents which independently form a disulfide bond with AA^S at each occurrence; and

10 L is absent or a moiety which links AA^S to an amino acid in X_m , X_n , or a combination thereof; and

SS at each instance represents a disulfide bond.

15 In some embodiments, the bicyclic peptides described above have a structure according to any of Formula I, II, V, VI, VII, VIII, IX, X, and XII, each of which are described in more detail below.

In embodiments, disclosed herein are bicyclic peptides comprising Formula I or II

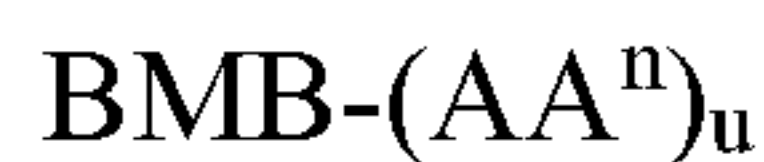


wherein X_m and X_n independently comprise a sequence of 1-20 amino acids and R^1 is OH, OR^2 , or NHR^2 , wherein R^2 is a C_{1-20} alkyl, C_{6-10} aryl or heteroaryl, amino acid, peptide sequence of 2 to 20 amino acids, detectable moiety, or solid support.

As used herein, X_m refers to a cell penetrating peptide sequence. In some
 5 embodiments, X_m is from 5 to 10 amino acids in length. In further embodiments, at least one, at least two, or at least three amino acids in X_m have a hydrophobic side chain. In certain
 embodiments, X_m comprises one or more phenylalanine, naphthylalanine, tryptophan, or an
 analog or derivative thereof. In some embodiments, X_m comprises at least one arginine or an
 analog or derivative thereof. In other embodiments, X_m comprises a sequence listed in Table 2
 10 (SEQ ID NO:62 through SEQ ID NO:146). In certain embodiments, X_m is or comprises
 RRRRΦF or FΦRRRR.

As used herein, X_n refers to a cargo sequence. In some embodiments, X_n comprises a
 sequence listed in Table 5 (SEQ ID NO:147 through SEQ ID NO:159). In some embodiments,
 the bicyclic peptide has a sequence listed in Table 6 (SEQ ID NO:160 through SEQ ID
 15 NO:167).

In additional examples disclosed herein are peptides of Formula III

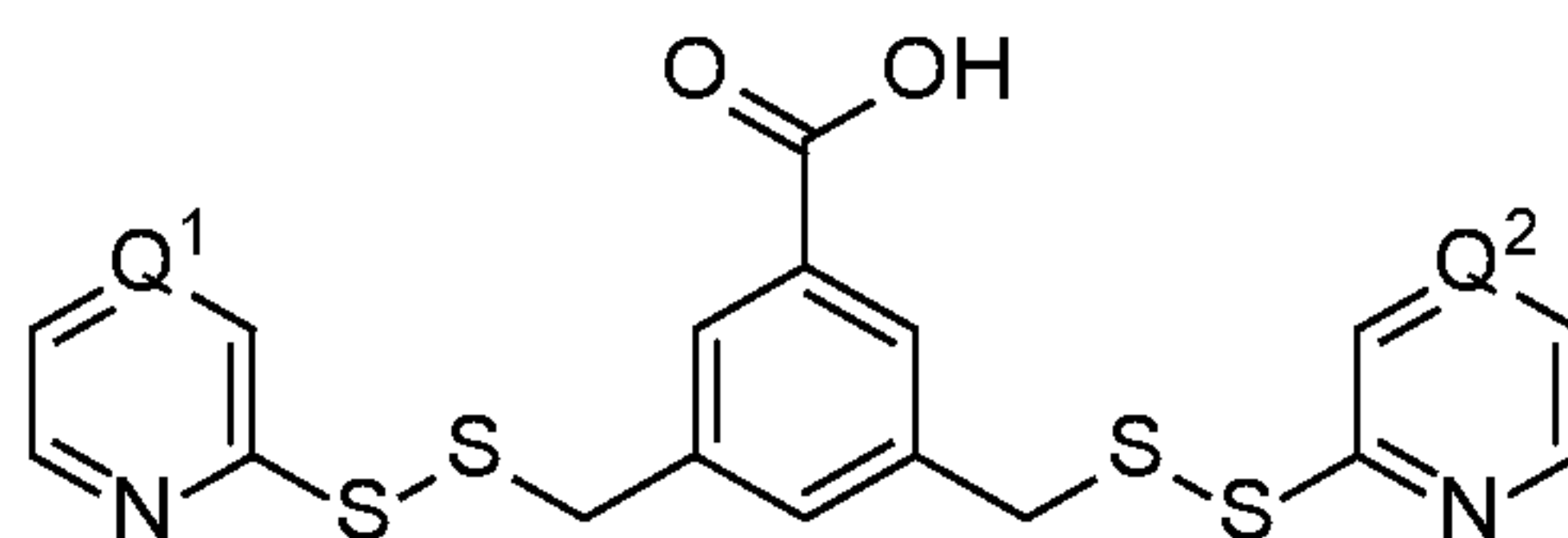


III

wherein n is an integer of from 5 to 20, and each AA^n is, independently, a natural or non-natural
 20 amino acid residue, with at least two AA^n residues being cysteine, and BMB is a 3,5-
 bis(mercaptomethyl)benzoic acid residue. In some specific examples u is 4 to 20, 5 to 9, 6 to
 9, 7 to 8, or 8 to 9.

Also disclosed herein, in various embodiments, are methods of making a bicyclic peptide,
 comprising:

25 (a) contacting a solid supported peptide having from 8 to 40 amino acid, wherein at least two
 amino acids are independently selected from the group consisting of a cysteine, homocysteine,
 an amino acid analog having a thiol group, with a compound of Formula IV:

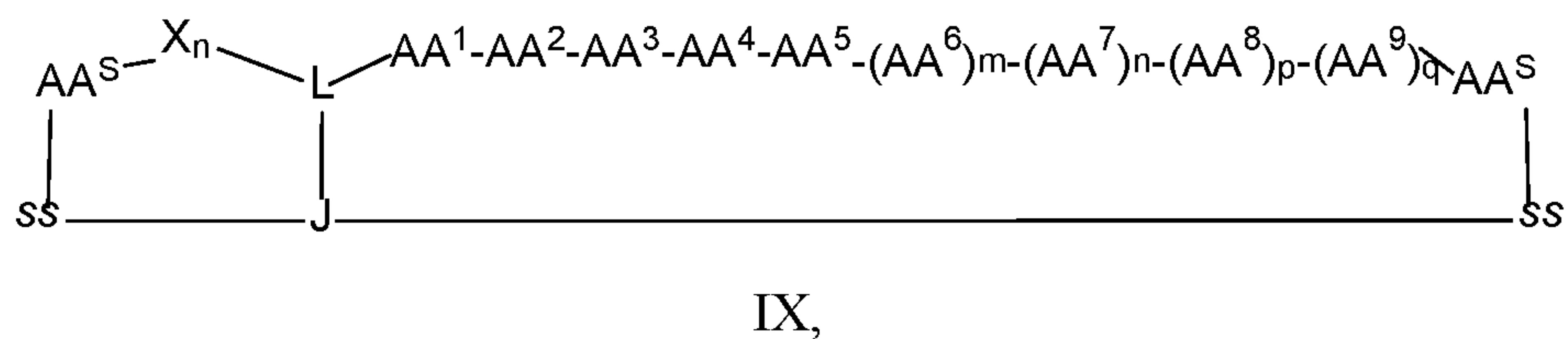
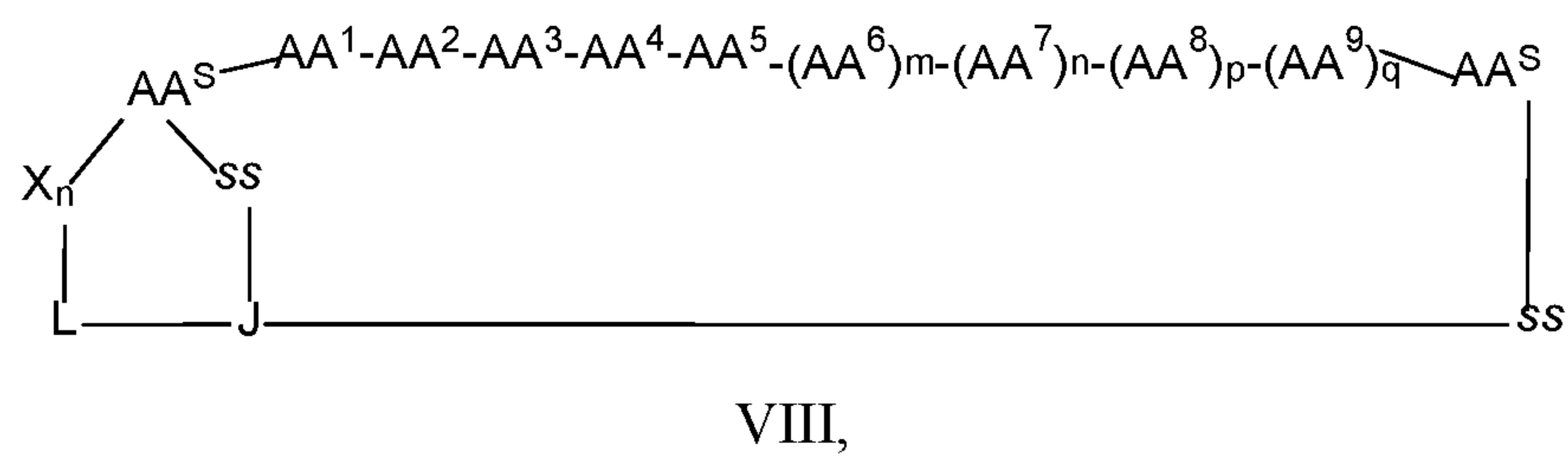
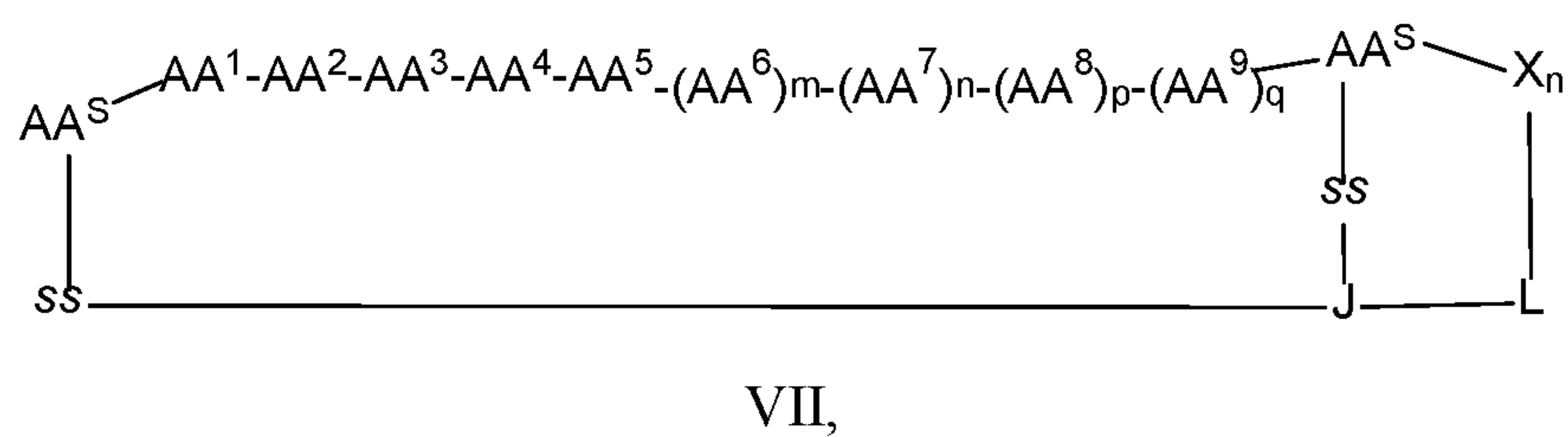
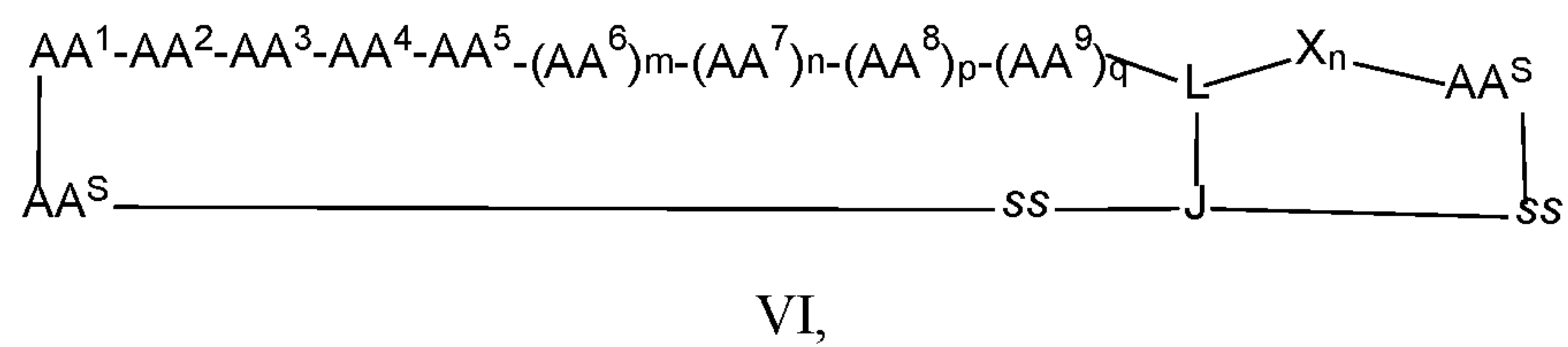
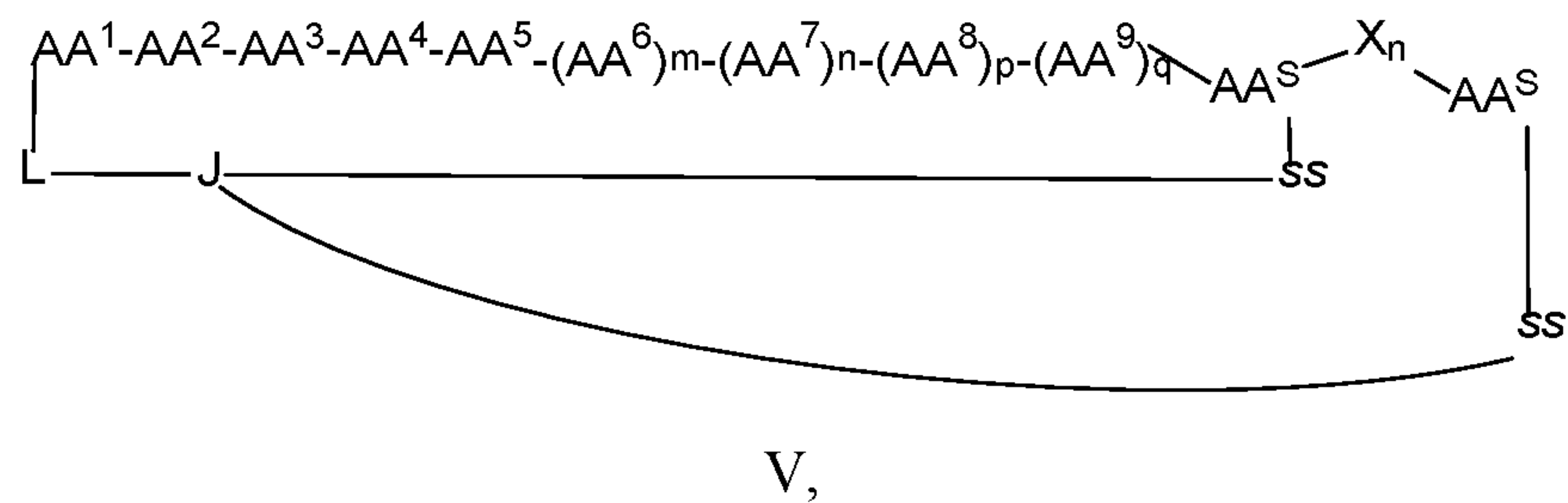


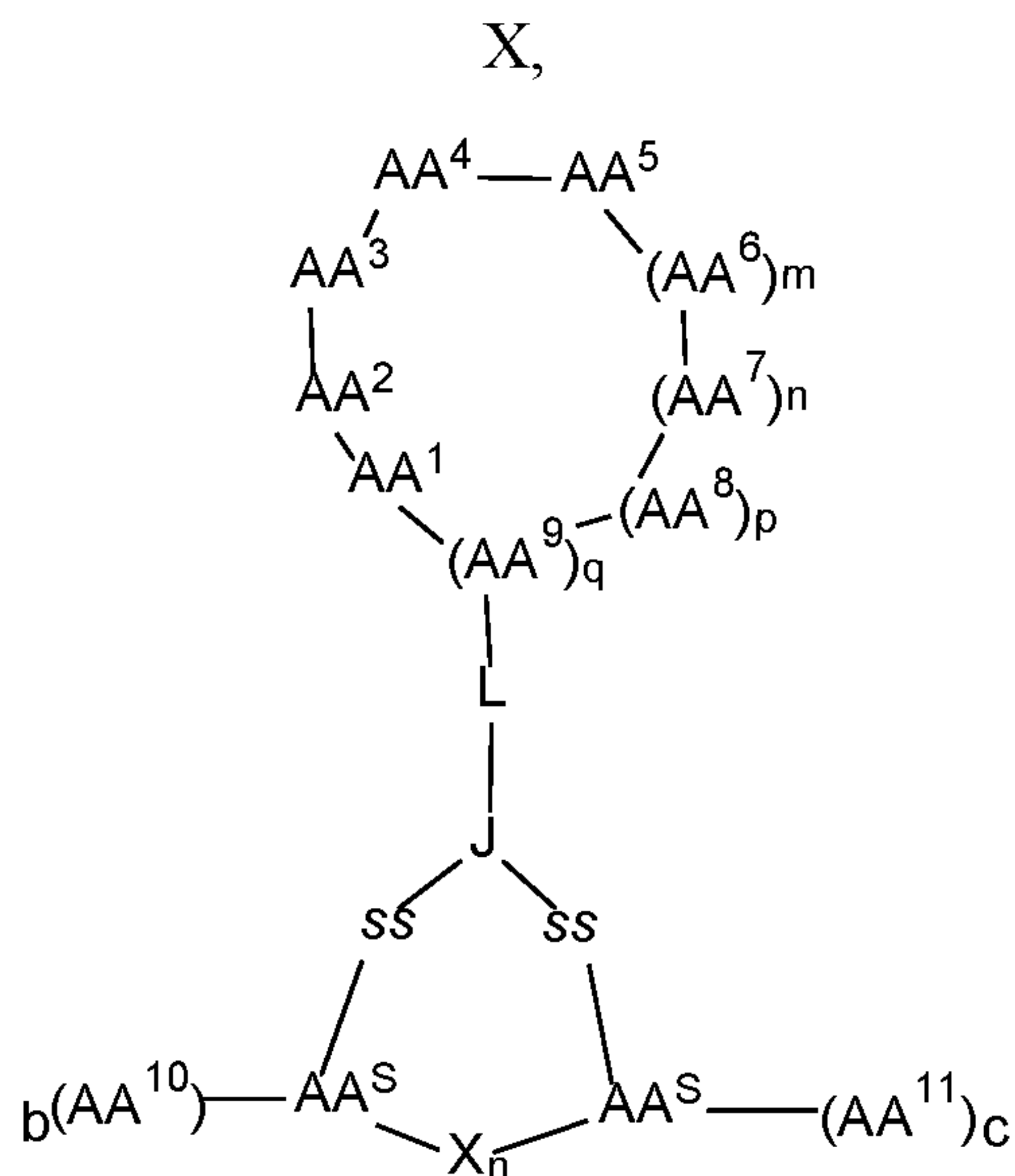
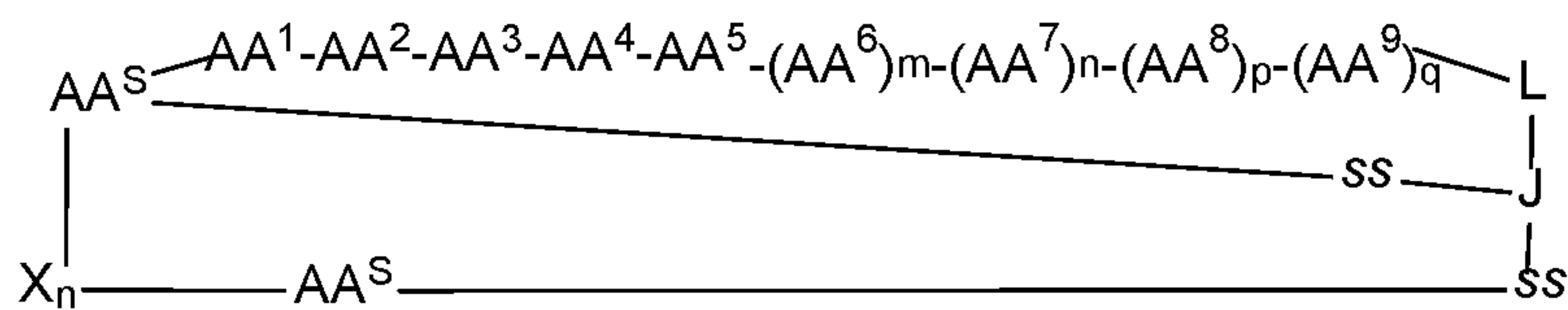
IV

wherein Q^1 and Q^2 are, independent of one another, chosen from CH or N; and
 (b) cleaving the peptide from the solid support.

Other embodiments of the present disclosure provide a bicyclic peptide comprising

5 Formula V, VI, VII, VIII, IX, X, or XII:





XII

5 or a pharmaceutically acceptable salt thereof,

wherein:

10 AA^1 , AA^2 , AA^3 , AA^4 , AA^5 , AA^6 , AA^7 , AA^8 , and AA^9 are each independently an amino acid, which is optionally substituted, where at least three amino acids are arginine and at least two amino acids independently comprise a hydrophobic side chain;

m , n , p , and q are independently selected from 0 and 1;

AA^{10} and AA^{11} , are each independently an amino acid, which is optionally substituted;

b and c are independently an integer from 0 to 20;

15 AA^S at each occurrence is independently a moiety which forms a disulfide bond with J ;

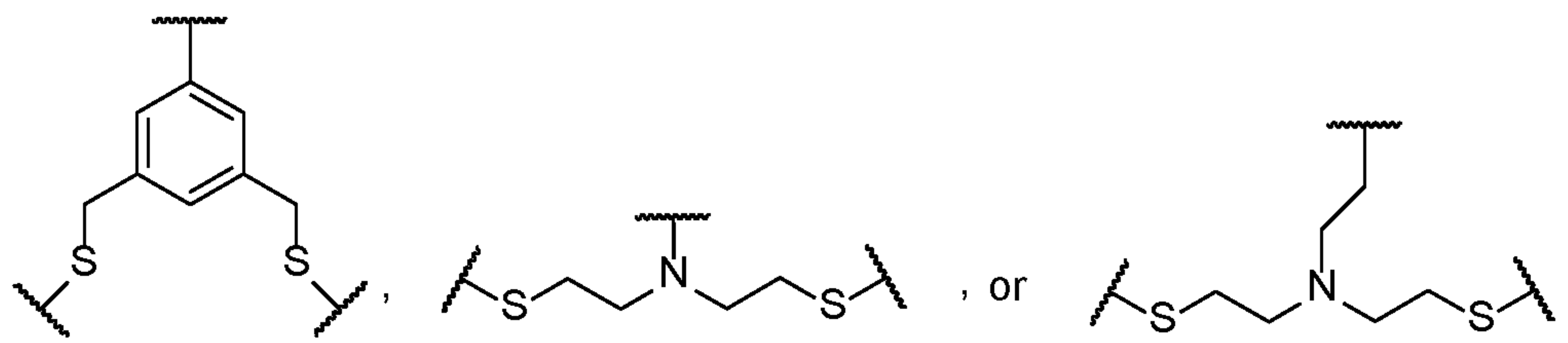
J is an alkyl, *N*-alkyl, alkenyl, alkynyl, carbocyclyl, or heterocyclyl, each of which are independently substituted with at least two substituents which independently form a disulfide bond with AA^S at each occurrence;

20 ss at each instance represents a disulfide bond; and

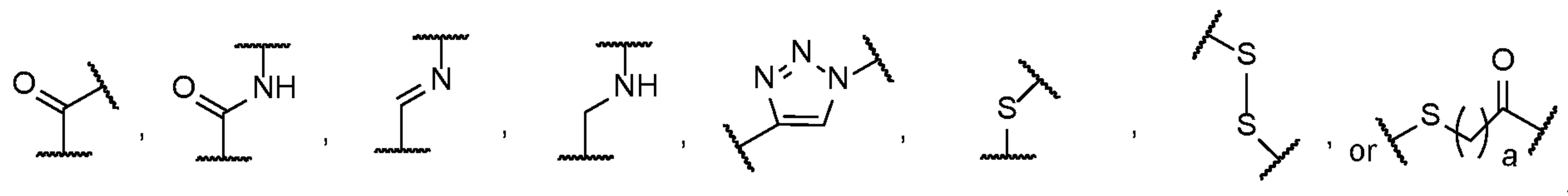
L is a moiety which links J to an amino acid, X_n , or a combination thereof; and

X_n is a cargo moiety comprising a peptide sequence having from 1 to 20 amino acids.

In some embodiments, J is *N*-alkyl, aryl, or heteroaryl, each of which are independently substituted with at least two substituents which independently form a disulfide bond with AA^S at each occurrence. In other embodiments, J is

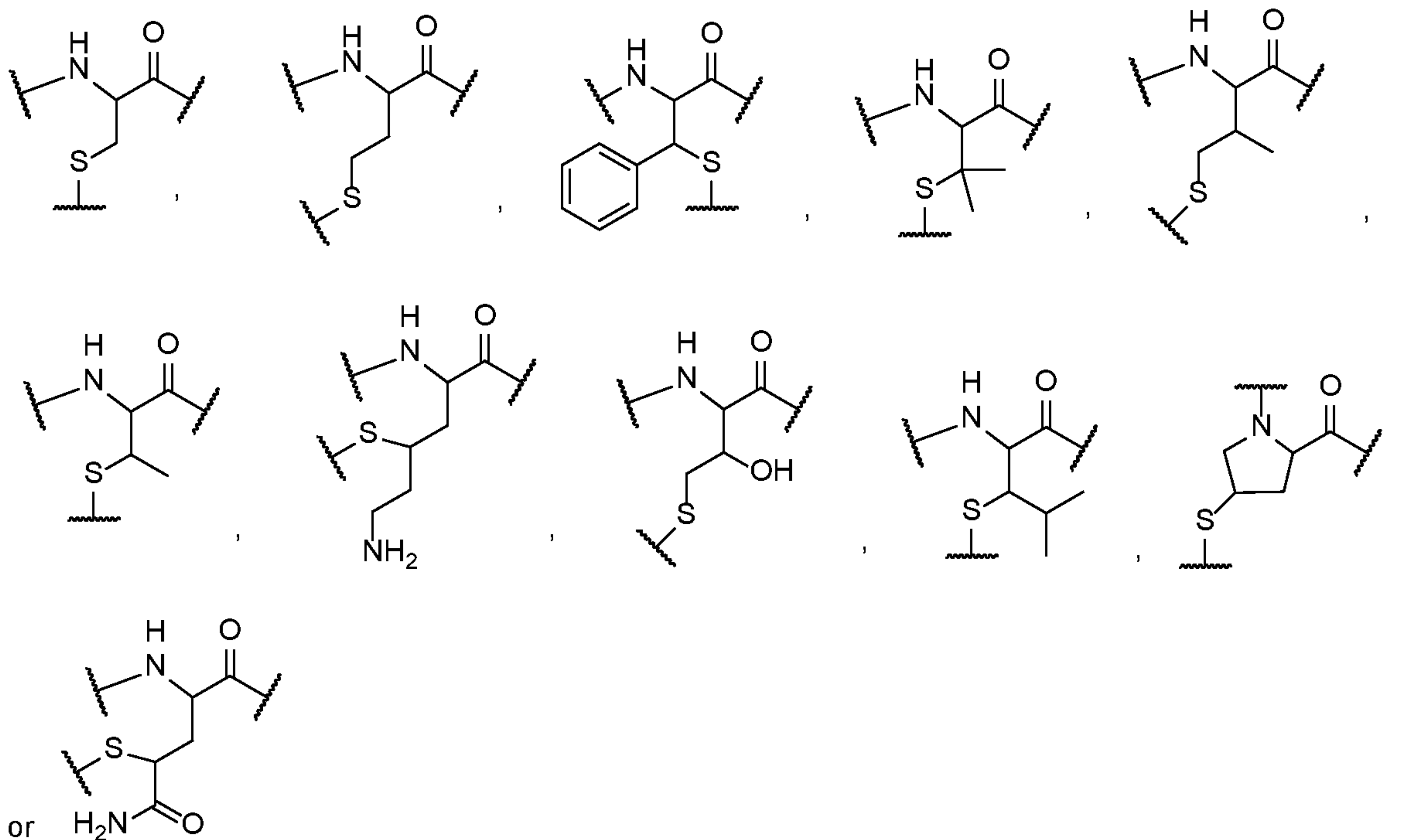


5 In some embodiments, L is a bond, an amino acid,



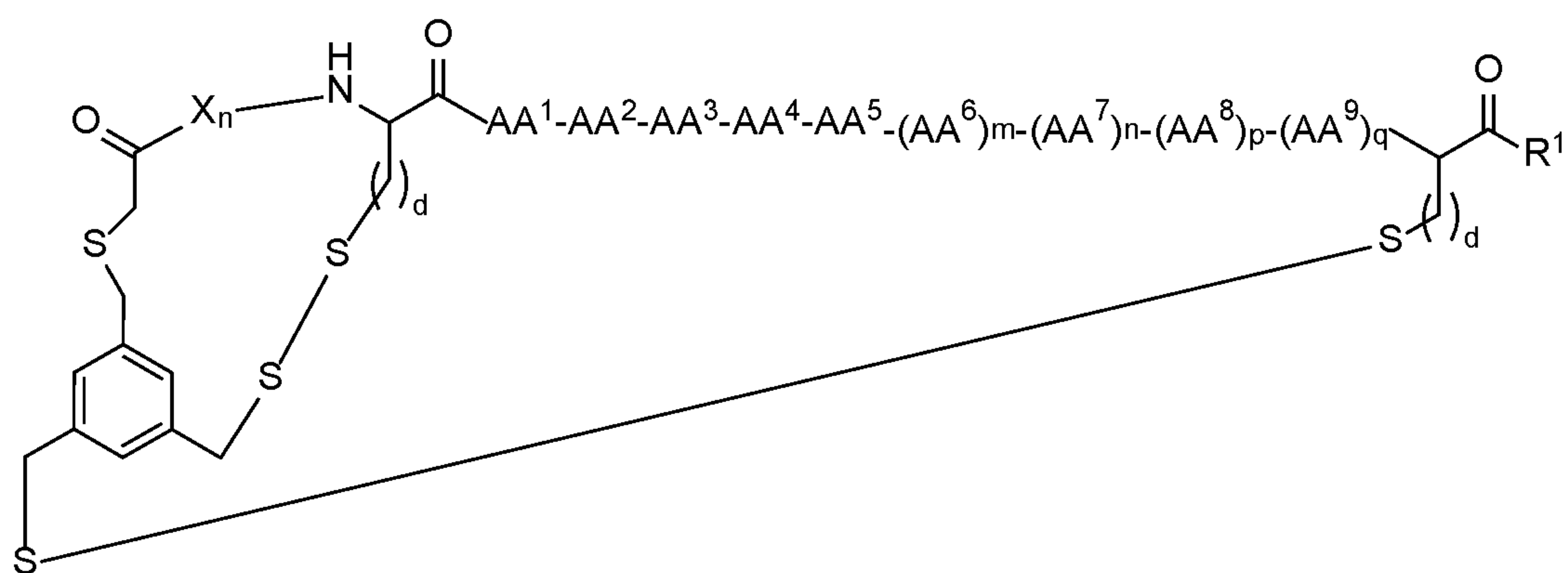
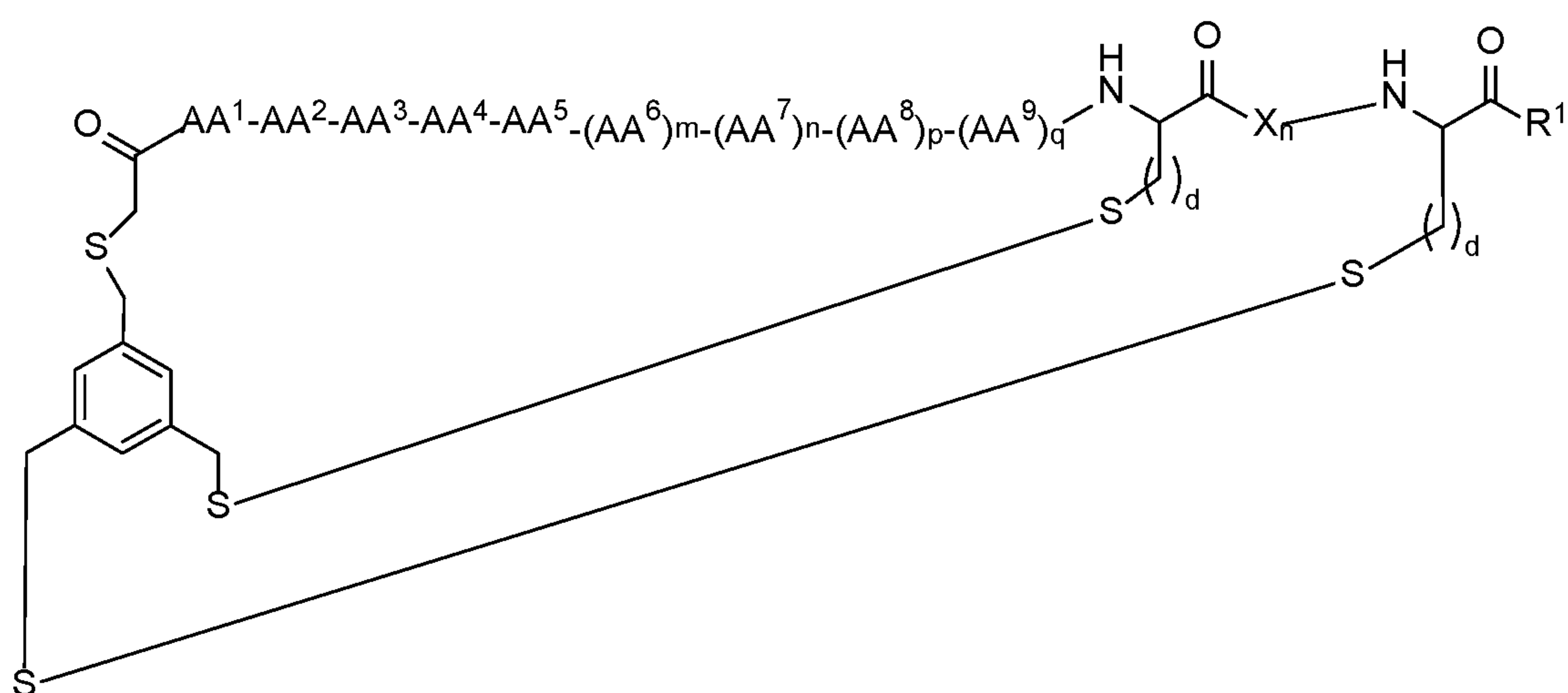
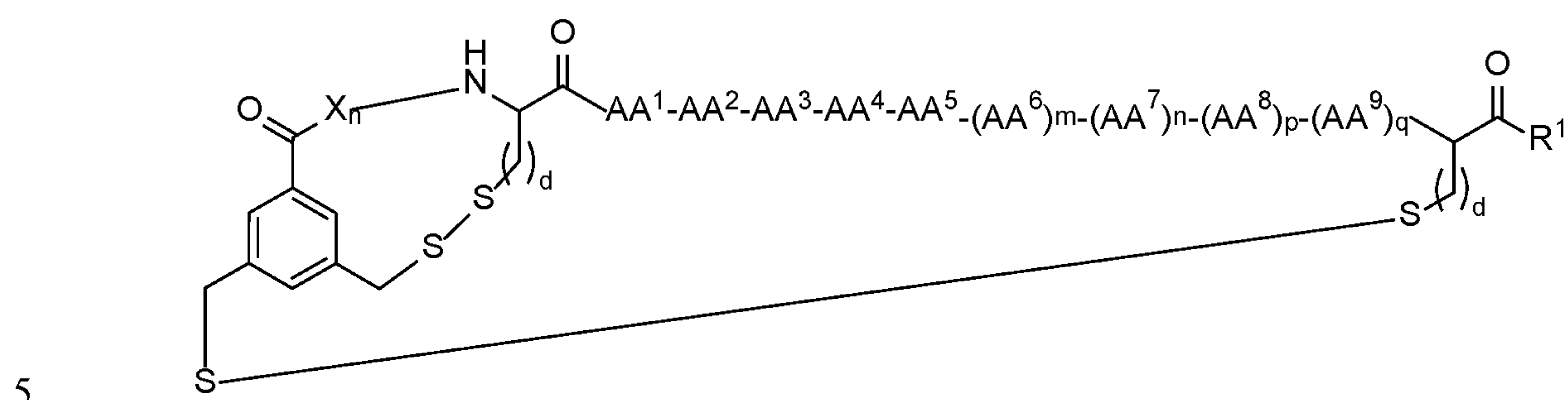
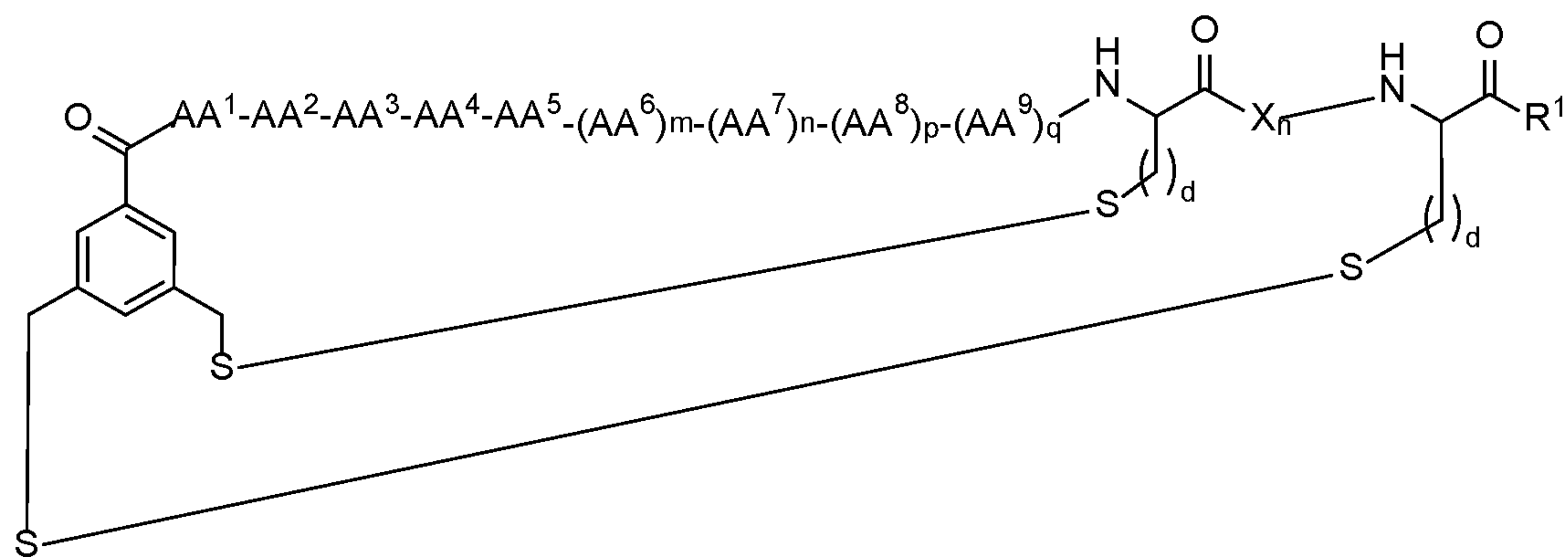
wherein a is an integer from 0 to 10.

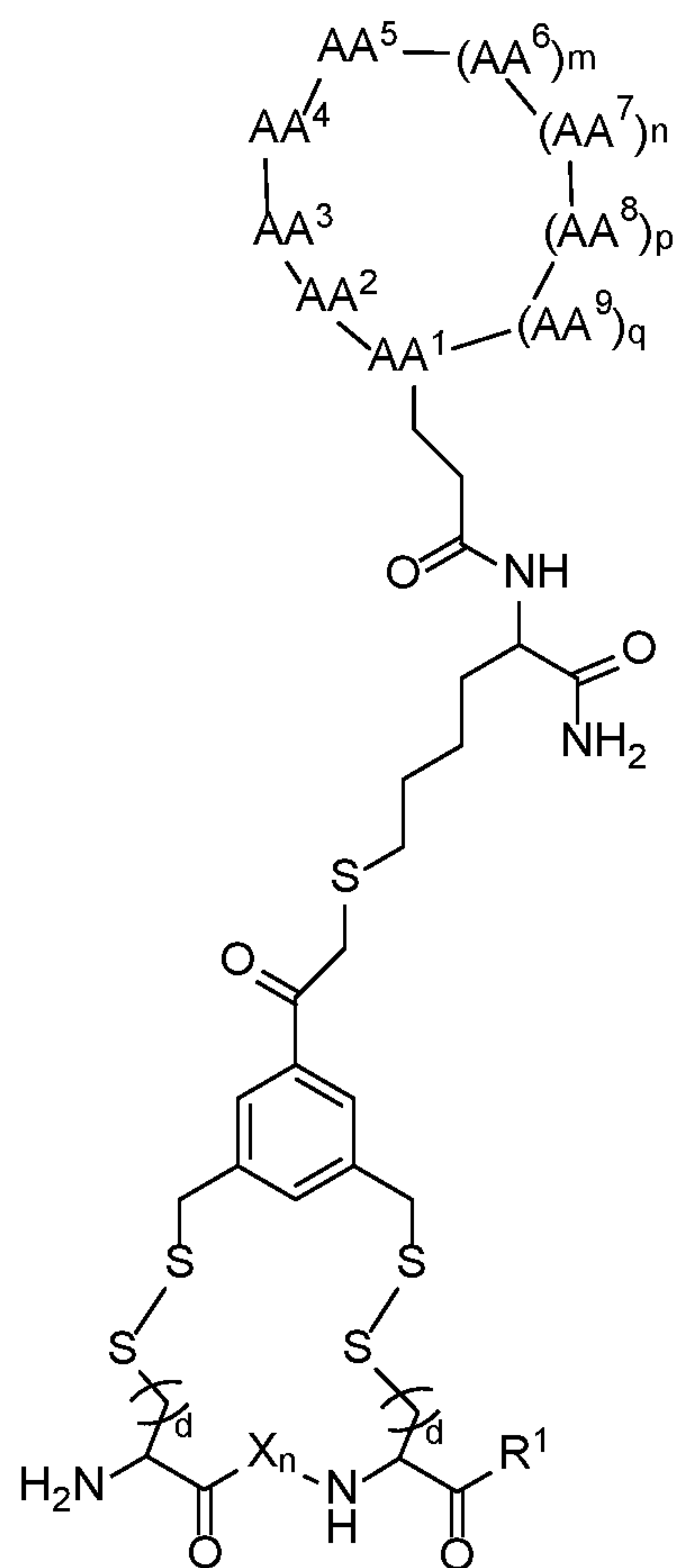
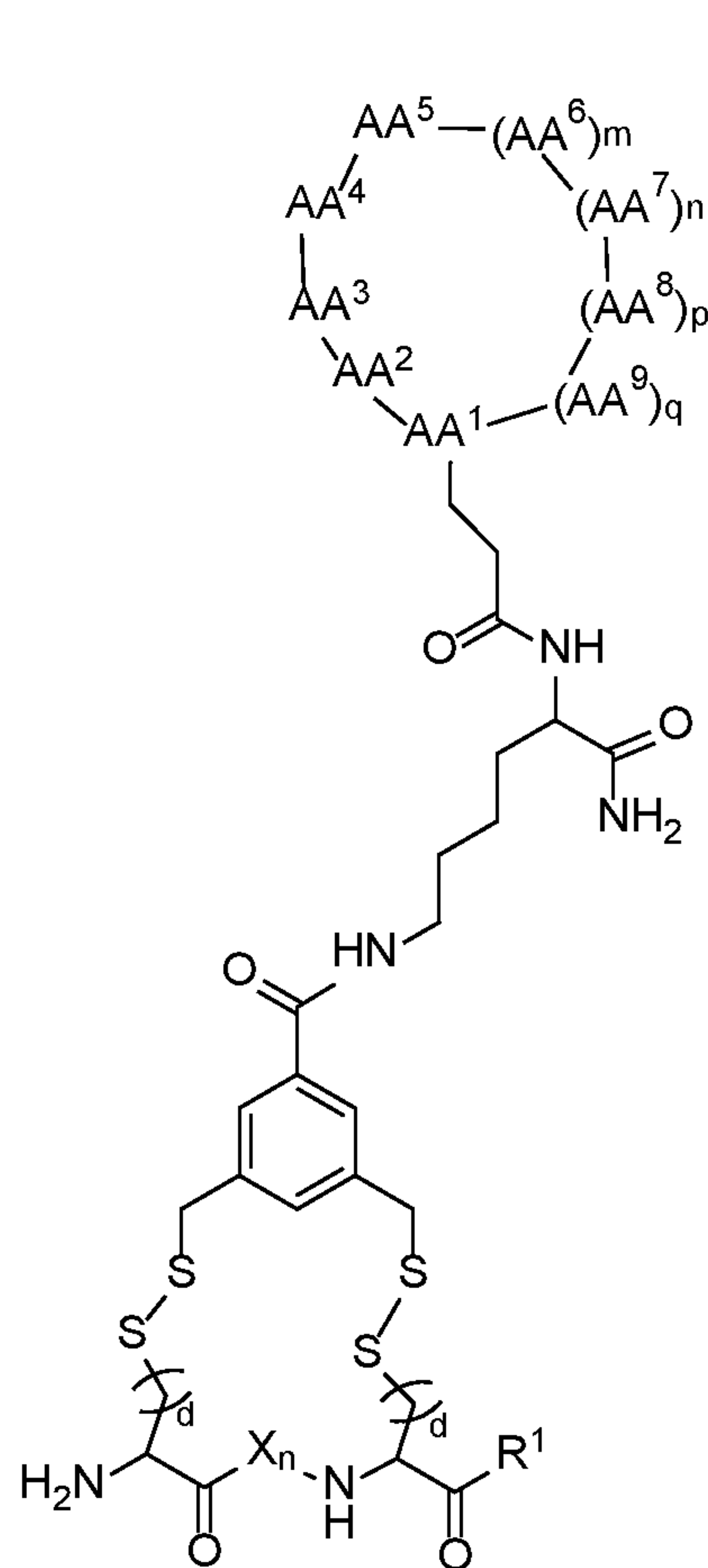
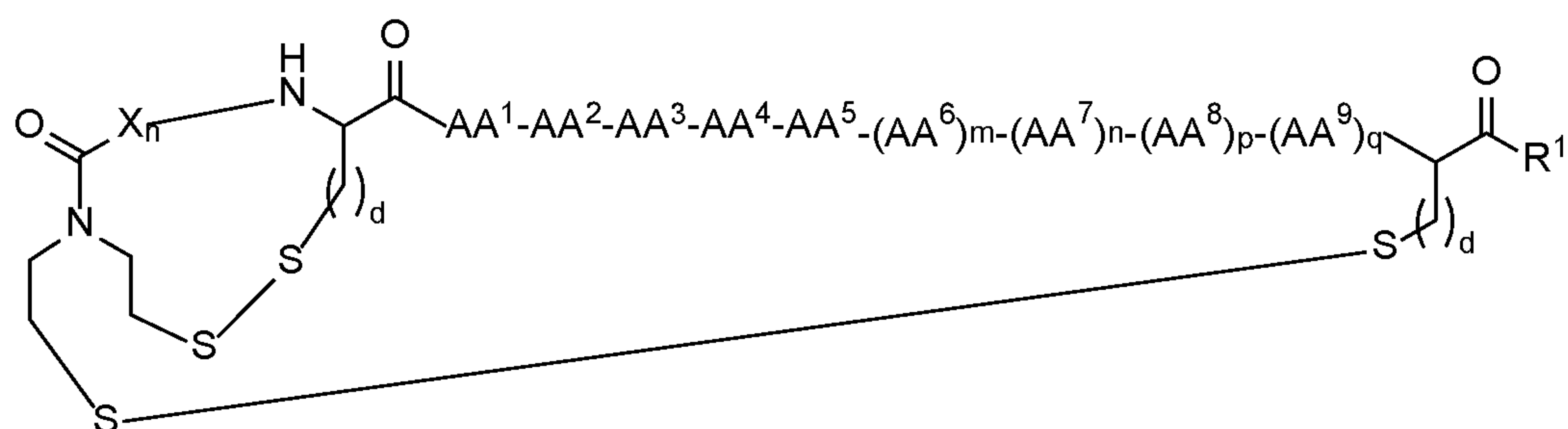
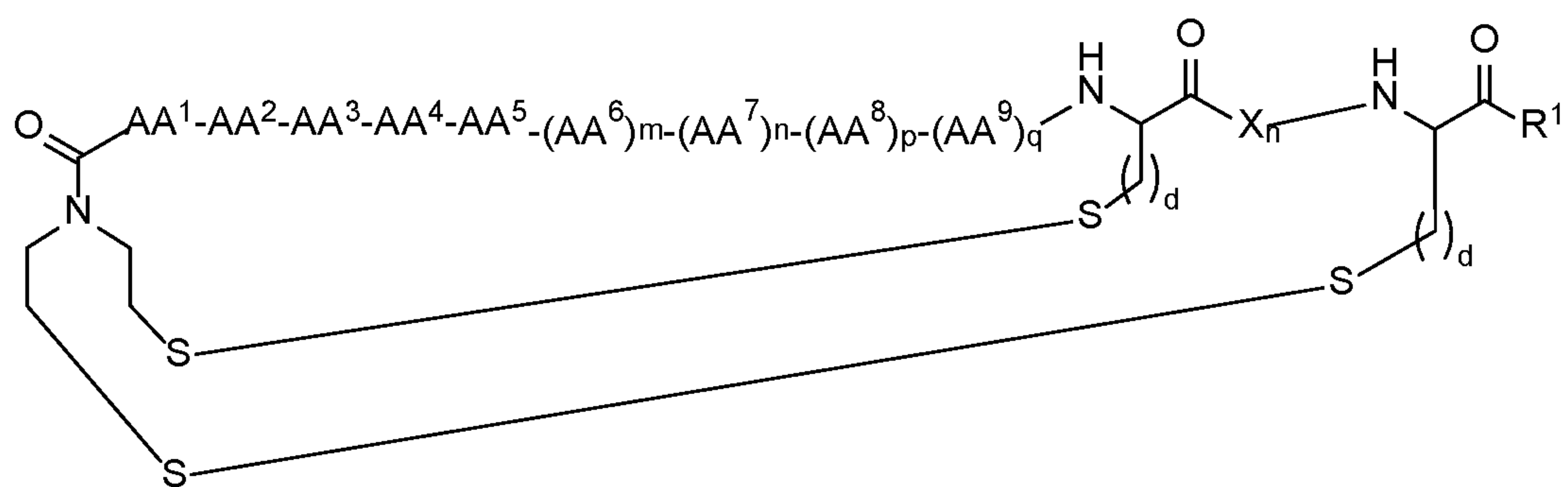
In some embodiments, each AA^S independently is



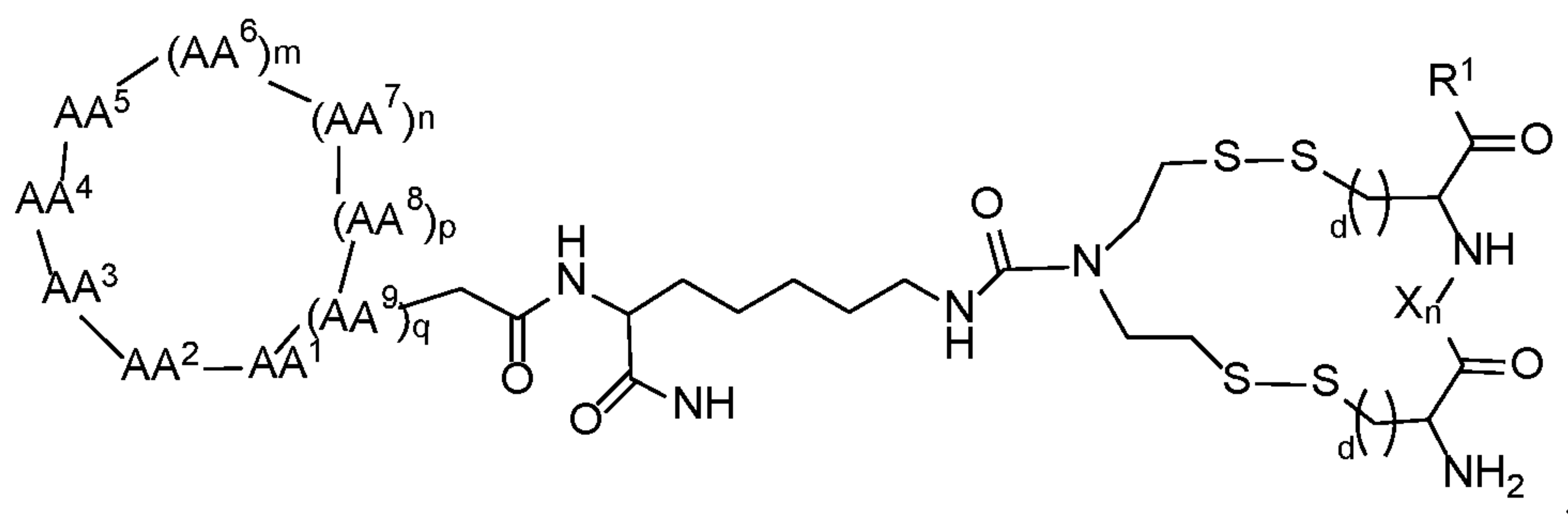
10 wherein the C-terminus of AA^S forms an amide bond or is R¹, wherein R¹ is OH, OR², NHR²; and wherein R² is an alkyl, aryl, heteroaryl, amino acid, peptide sequence of 2 to 20 amino acids, detectable moiety, or solid support.

In some embodiments, the bicyclic peptides disclosed herein are selected from the group consisting of:





, and



or a pharmaceutically acceptable salt thereof,

wherein each d is independently 1 or 2; and

5 wherein R¹ is OH, OR², NHR²; and R² is a alkyl, aryl, heteroaryl, amino acid residue, peptide sequence of 2 to 20 amino acid residues, detectable moiety, or solid support.

In some embodiments, the at least two amino acid which independently comprise a hydrophobic side chain are selected from the group consisting of glycine, phenylglycine, alanine, valine, leucine, isoleucine, norleucine, phenylalanine, tryptophan, naphthylalanine, proline, and combinations thereof, wherein the aromatic side chains on phenylglycine, phenylalanine, tryptophan, or naphthylalanine are each optionally substituted with a halogen. In other embodiments, the at least two amino acid which independently comprise a hydrophobic side chain are independently selected from the group consisting of phenylalanine, naphthylalanine, and combinations thereof. In still other embodiments, the at least two amino acids which independently comprise a hydrophobic residue are consecutive amino acids.

In some embodiments:

AA¹ is L arginine;

AA² is L-arginine;

AA³ is L-arginine;

20 AA⁴ is L-phenylalanine;

AA⁵ is L phenylalanine; and

m, n, p, and q, are each 0.

or

AA¹ is L-phenylalanine;

25 AA² is L-naphthylalanine;

AA³ is L-arginine;

AA⁴ is L-arginine;

AA⁵ is L-arginine;
 m is 1 and AA⁶ is L-arginine; and
 n, p, and q are each 0.

or

5 AA¹ is L-arginine;
 AA² is L-arginine;
 AA³ is L-arginine;
 AA⁴ is L-arginine;
 AA⁵ is L- naphthylalanine;
 10 m is 1 and AA⁶ is L- phenylalanine; and
 n, p, and q are each 0.

In some embodiments, at least three consecutive amino acids have alternating chirality.
 In other embodiments, the at least three consecutive amino acids having alternating chirality
 are arginines.

15 In some embodiments:
 AA¹ is D-phenylalanine;
 AA² is L-naphthylalanine;
 AA³ is L-arginine;
 AA⁴ is D-arginine;
 20 AA⁵ is L-arginine;
 m is 1 and AA⁶ is D-arginine; and
 n, p, and q are each 0.

or

25 AA¹ is D-phenylalanine;
 AA² is L-naphthylalanine;
 AA³ is L-arginine;
 AA⁴ is D-arginine;
 AA⁵ is L-arginine;
 m and n are each 1, and AA⁶ is D-arginine and AA⁷ is L-arginine; and
 30 p and q are each 0.

or

AA¹ is D-phenylalanine;

AA² is L-naphthylalanine;

AA³ is L-arginine;

AA⁴ is D-arginine;

5 AA⁵ is L-arginine;

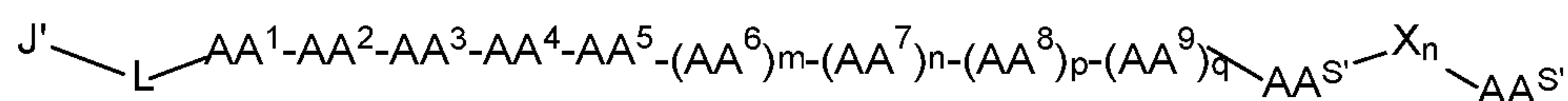
m and n are each 1, and AA⁶ is D-arginine and AA⁷ is L-phenylalanine; and

p and q are each 0.

In other embodiments, AA¹, AA², AA³, AA⁴, AA⁵, AA⁶, AA⁷, AA⁸, and AA⁹ is selected from SEQ ID NO:62 through SEQ ID NO:146.

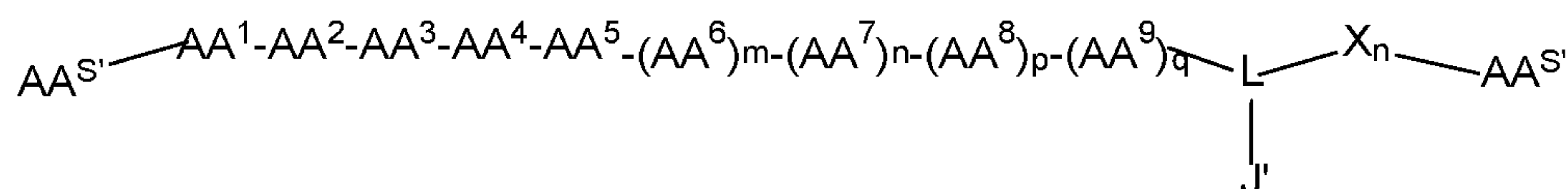
10 In some embodiments, the peptide sequence in X_n inhibits at least one protein-protein interaction. In other embodiments, the protein-protein interaction is an interaction between a κB-kinase (IKK) complex and a regulatory protein NF-κB essential modifier (NEMO). In still other embodiments, the peptide sequence in X_n is an inhibitor against Ras, PTP1 B, Pin 1, Grb2 SH2, MDM2, or combinations thereof. In yet still other embodiments, the peptide
15 sequence in X_n is a wild-type peptidyl ligand or a peptide mimetic.

In some embodiments, the provided herein are compounds according to Formula V-A, VI-A, VII-A, VIII-A, IX-A, X-A, or XII-A and XII-B:

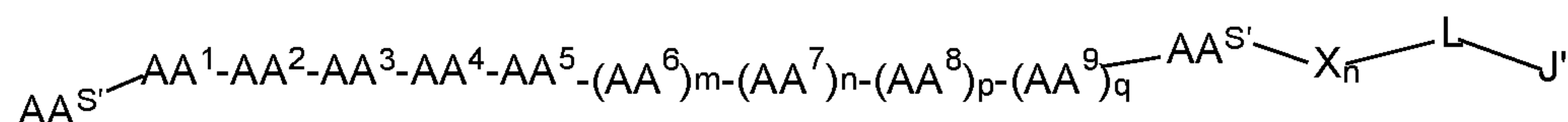


V-A,

20

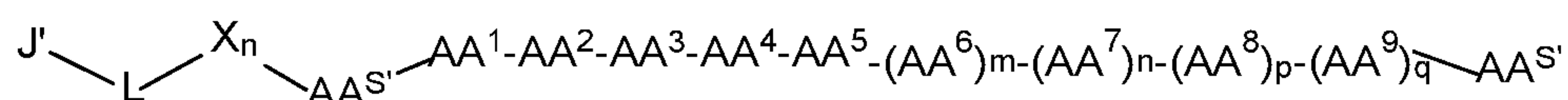


VI-A,

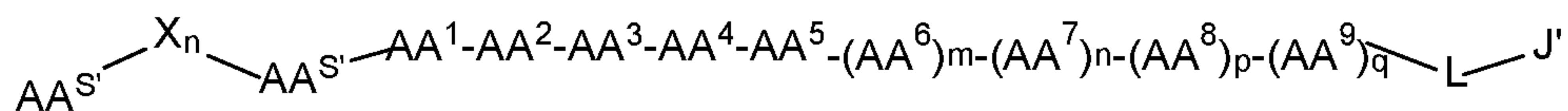
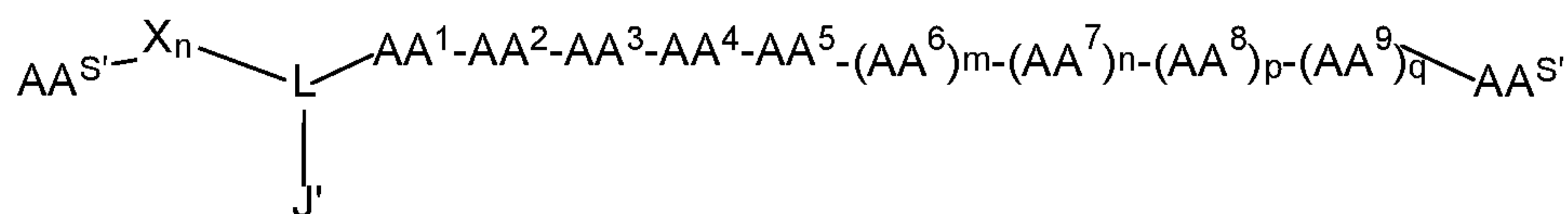


25

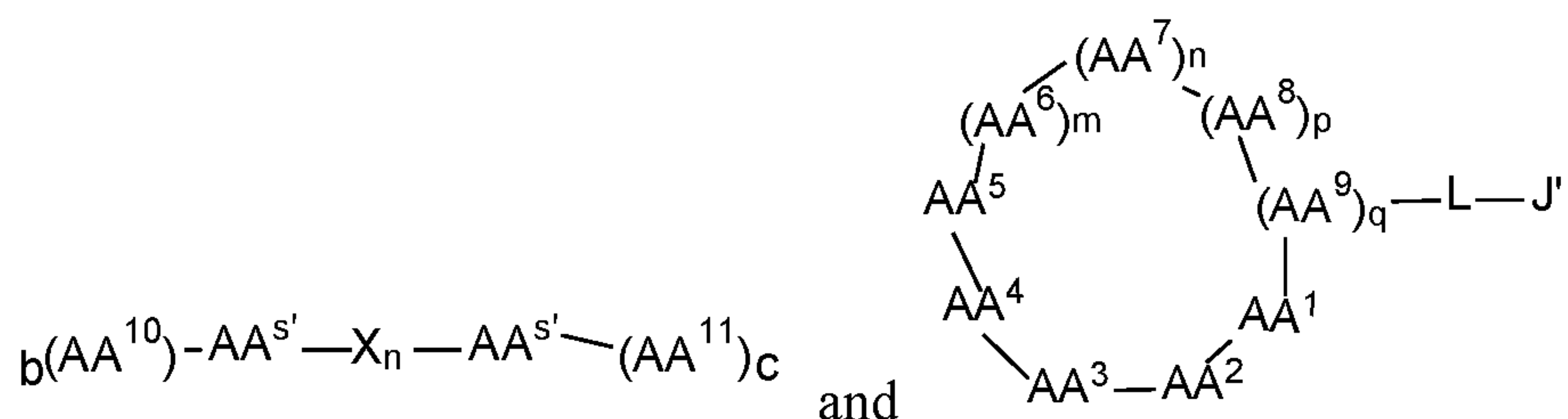
VII-A,



VIII-A,



and



or a pharmaceutically acceptable salt thereof,

wherein:

AA^1 , AA^2 , AA^3 , AA^4 , AA^5 , AA^6 , AA^7 , AA^8 , AA^9 , AA^{10} , and AA^{11} are

independently selected from an amino acid, which is optionally substituted,

where at least three amino acids are arginine, and at least two amino acids

independently comprise a hydrophobic side chain;

m , n , p , or q are independently selected from 0 and 1;

b and c are independently an integer from 0 to 20;

$\text{AA}^{\text{S}'}$ at each occurrence is independently a moiety which comprises a thiol;

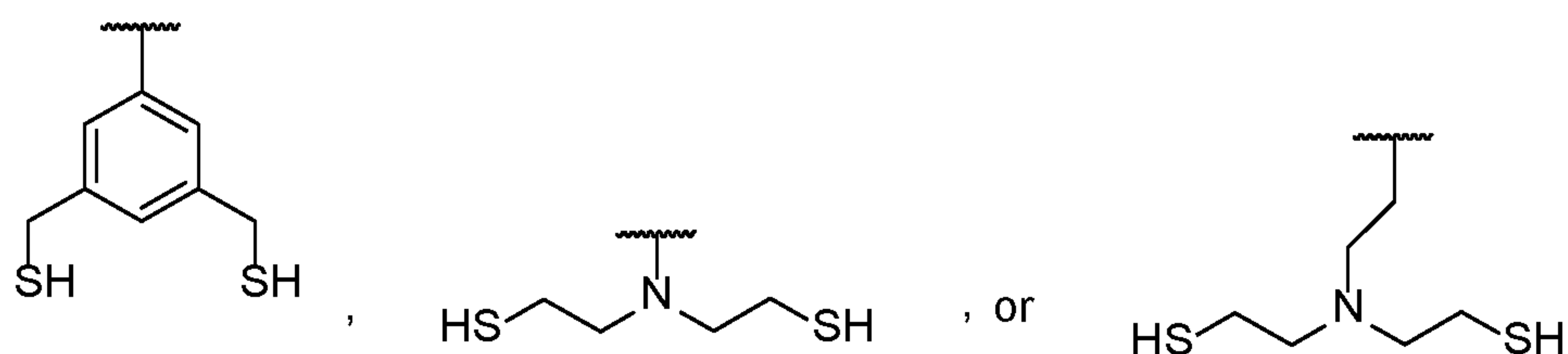
J' is an alkyl, *N*-alkyl, alkenyl, alkynyl, carbocyclyl, or heterocyclyl, each of which

are independently substituted with at least two thiol substituents; and

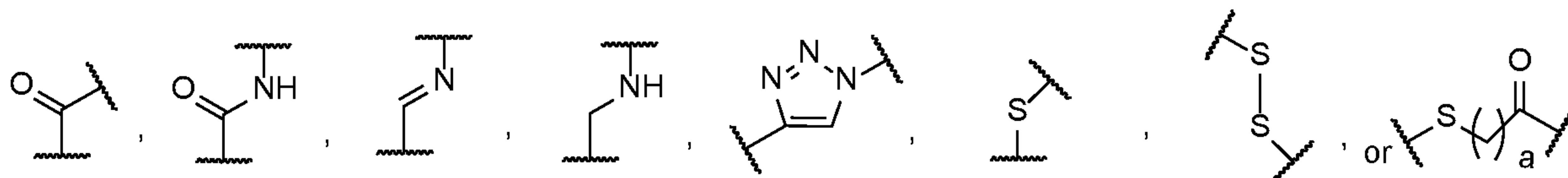
L is an optional moiety which links $\text{AA}^{\text{S}'}$ to an amino acid, X_n , or a combination thereof; and

X_n is a cargo moiety comprising a peptide sequence having from 4 to 20 amino acids.

In some embodiments, J' is *N*-alkyl, aryl, or heteroaryl. In further embodiments, J' is

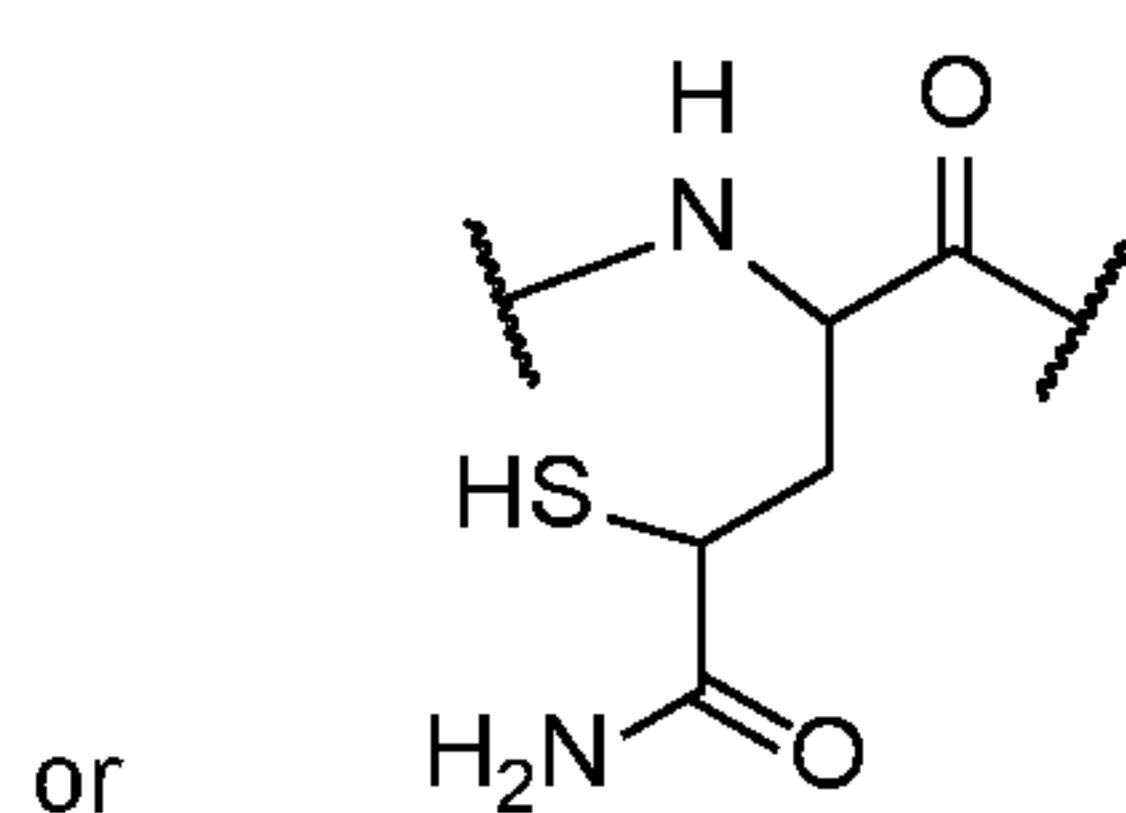
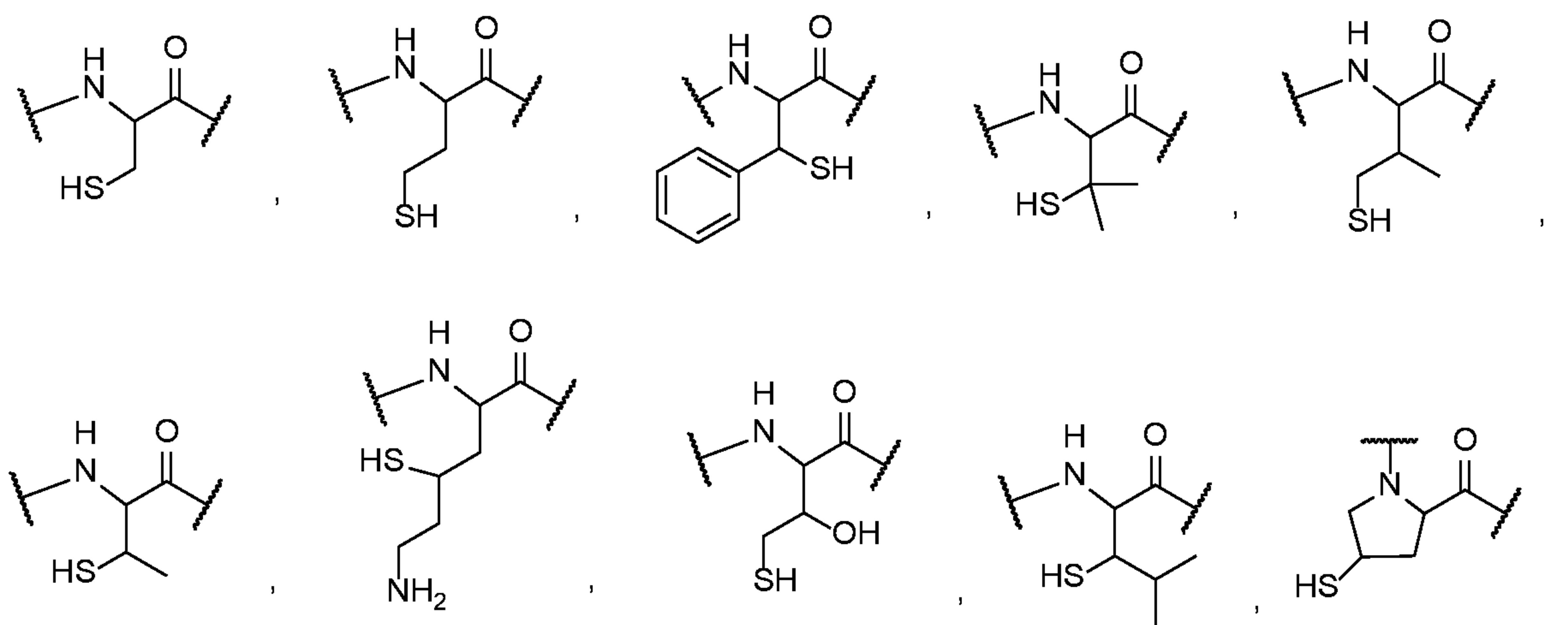


In some embodiments, L is absent, an amino acid,



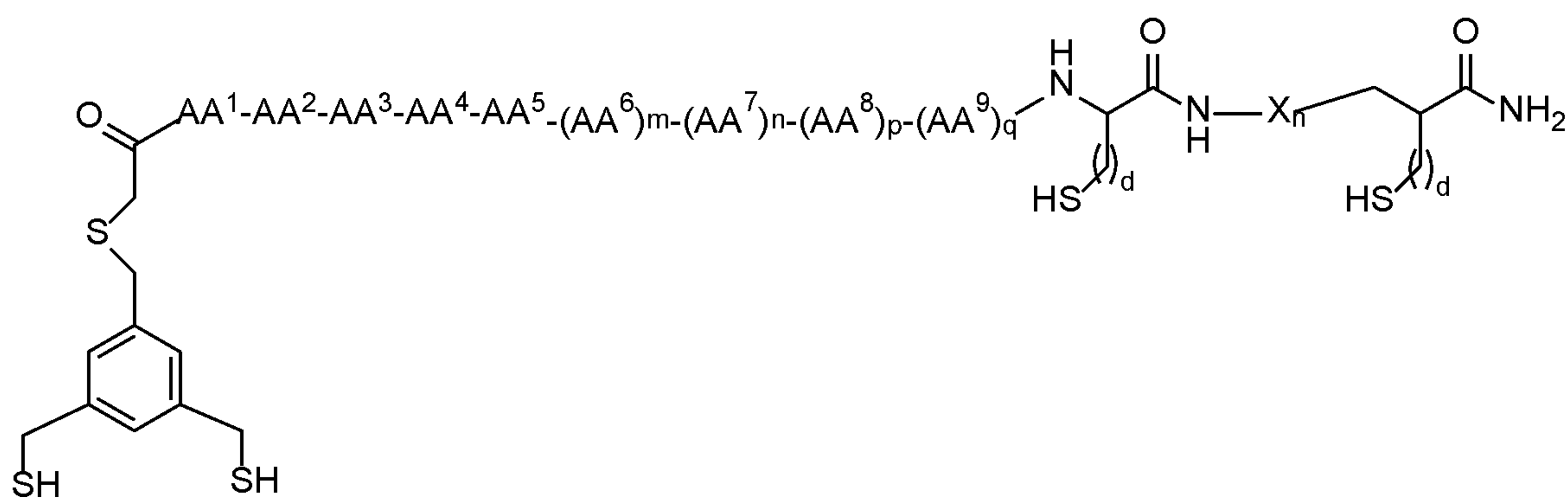
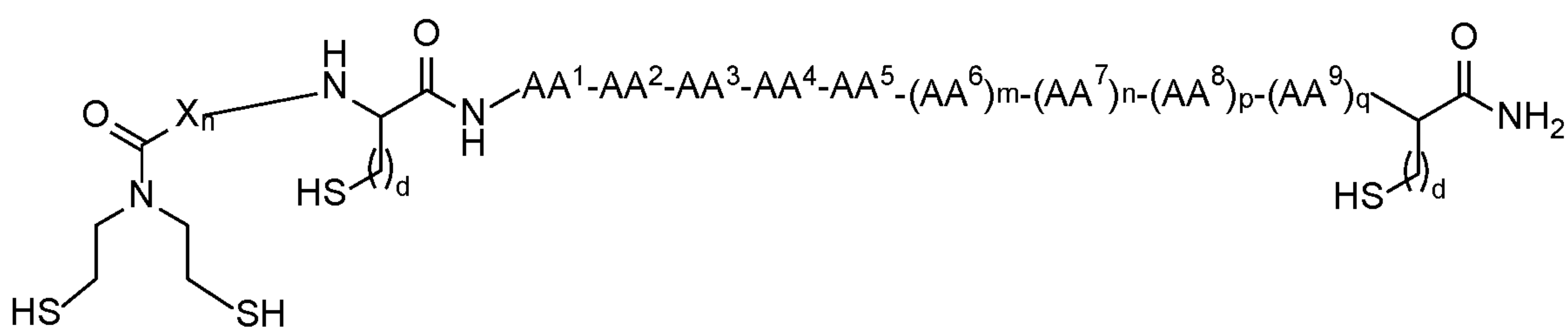
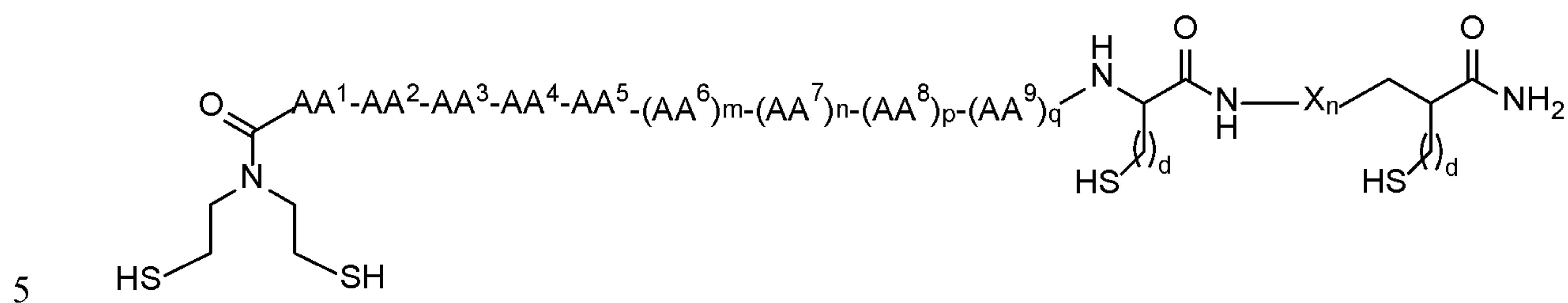
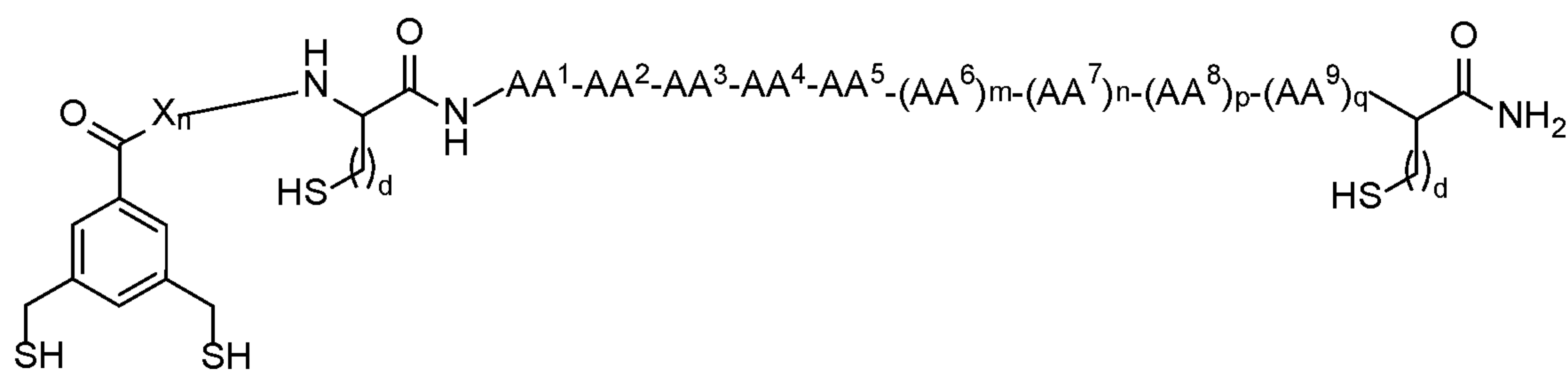
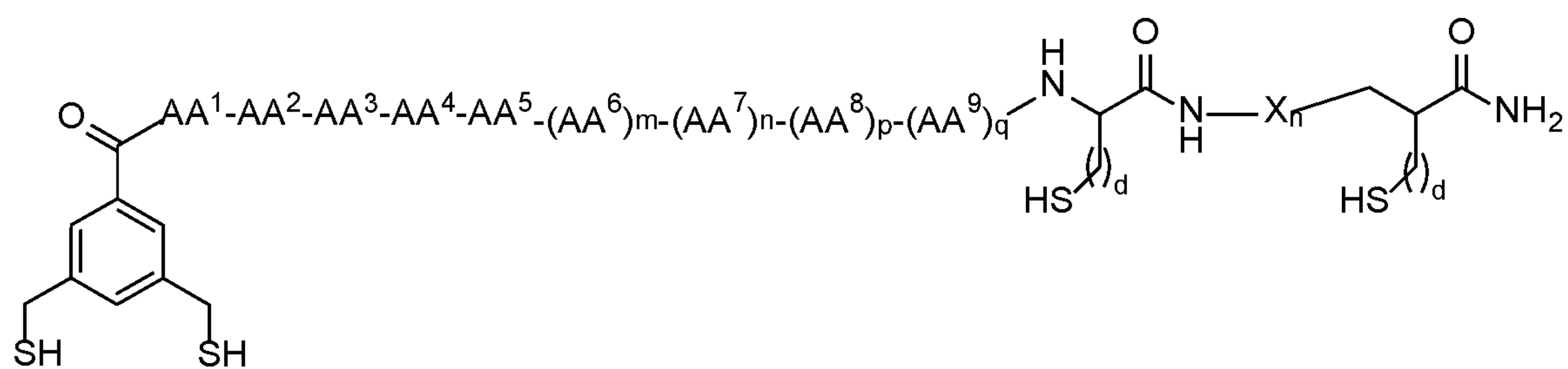
wherein a is an integer from 0 to 20.

5 In some embodiments, each AA^{S'} is independently:

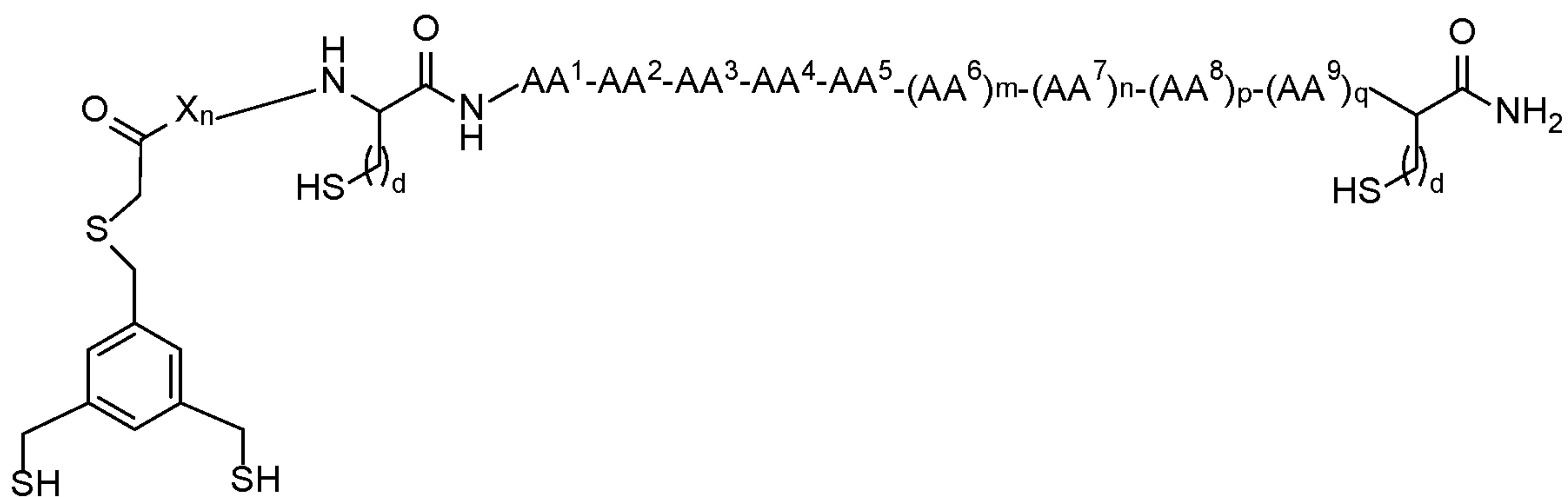


wherein the C-terminus of AA^{S'} forms an amide bond or is R¹, wherein R¹ is OH, OR², NHR²; and wherein R² is a alkyl, aryl, heteroaryl, amino acid residue, peptide sequence of 2 to 20 amino acid residues, detectable moiety, or solid support.

10 In some embodiments, the compounds have a structure selected from the group consisting of



10 and



or a pharmaceutically acceptable salt thereof, wherein each d is independently 1 or 0.

In embodiments of the above compounds, the at least two amino acids which
 5 independently comprise a hydrophobic side chain are selected from the group consisting of
 glycine, phenylglycine, alanine, valine, leucine, isoleucine, norleucine, phenylalanine,
 tryptophan, naphthylalanine, proline, and combinations thereof, wherein the aromatic residues
 on phenylglycine, phenylalanine, tryptophan, naphthylalanine are optionally substituted. In
 other embodiments, the at least two amino acids which independently comprise a hydrophobic
 10 side chain are selected from the group consisting of phenylalanine, naphthylalanine, and
 combinations thereof. In still other embodiments, the at least two amino acids which
 independently comprise a hydrophobic side chain are consecutive amino acids.

In some embodiments:

15 AA¹ is L arginine;
 AA² is L-arginine;
 AA³ is L-arginine;
 AA⁴ is L-phenylalanine;
 AA⁵ is L phenylalanine; and
 m, n, p, and q, are each 0.

20 or

AA¹ is L-phenylalanine;
 AA² is L-naphthylalanine;
 AA³ is L-arginine;
 AA⁴ is L-arginine;
 25 AA⁵ is L-arginine;
 m is 1 and AA⁶ is L-arginine; and
 n, p, and q are each 0.

or

AA¹ is L-arginine;
 AA² is L-arginine;
 AA³ is L-arginine;
 5 AA⁴ is L-arginine;
 AA⁵ is L-naphthylalanine;
 m is 1 and AA⁶ is L-phenylalanine; and
 n, p, and q are each 0.

In some embodiments, at least three consecutive amino acids have alternating chirality.

10 In other embodiments, the at least three consecutive amino acids having alternating chirality are arginines.

In some embodiments:

AA¹ is D-phenylalanine;
 AA² is L-naphthylalanine;
 15 AA³ is L-arginine;
 AA⁴ is D-arginine;
 AA⁵ is L-arginine;
 m is 1 and AA⁶ is D-arginine; and
 n, p, and q are each 0.

20 or

AA¹ is D-phenylalanine;
 AA² is L-naphthylalanine;
 AA³ is L-arginine;
 AA⁴ is D-arginine;
 25 AA⁵ is L-arginine;
 m and n are each 1, and AA⁶ is D-arginine and AA⁷ is L-arginine; and
 p and q are each 0.

or

AA¹ is D-phenylalanine;
 30 AA² is L-naphthylalanine;
 AA³ is L-arginine;
 AA⁴ is D-arginine;

AA⁵ is L-arginine;

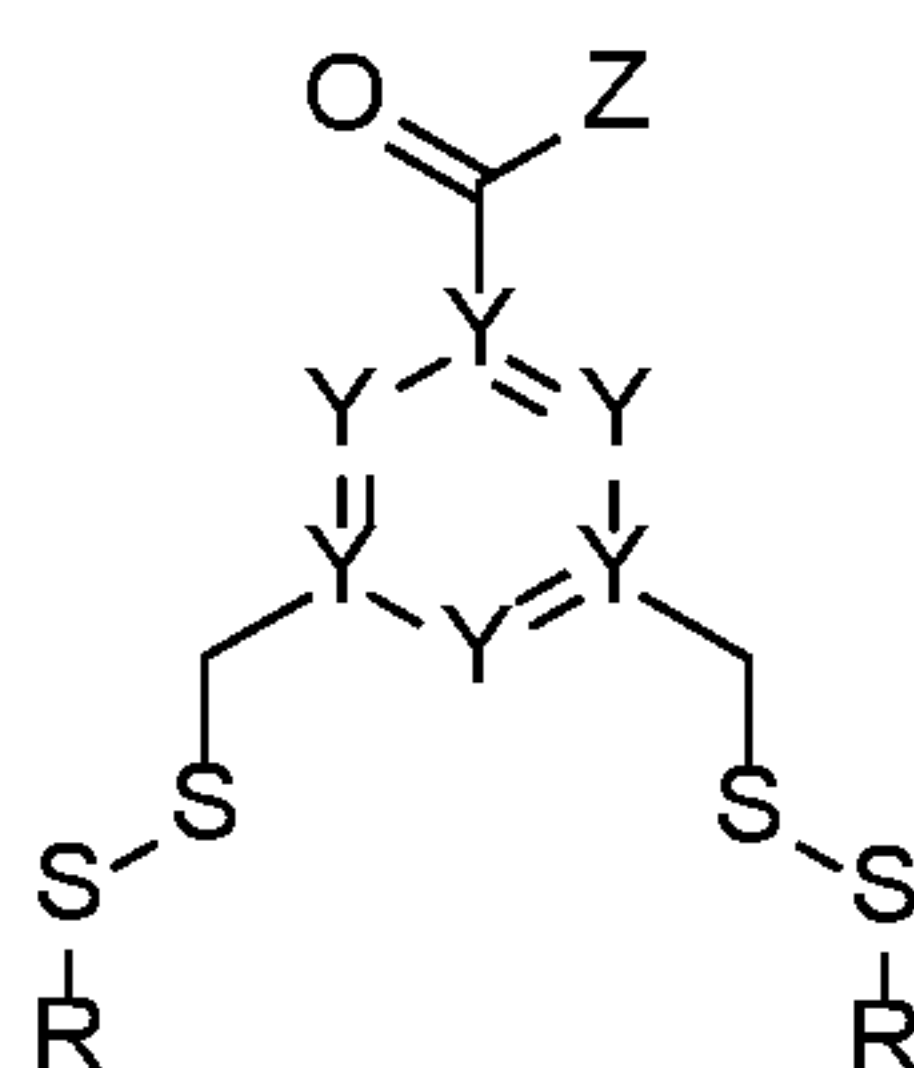
m and n are each 1, and AA⁶ is D-arginine and AA⁷ is L-phenylalanine; and

p and q are each 0.

In other embodiments, AA¹, AA², AA³, AA⁴, AA⁵, AA⁶, AA⁷, AA⁸, and AA⁹ is
5 selected from SEQ ID NO:62 through SEQ ID NO:146.

In some embodiments, the peptide sequence in X_n inhibits at least one protein-protein interaction. In further embodiments, the protein-protein interaction is an interaction between a
κB-kinase (IKK) complex and a regulatory protein NF-κB essential modifier (NEMO). In
other embodiments, the peptide sequence in X_n is an inhibitor against Ras, PTP1 B, Pin 1, Grb2
10 SH2, MDM2, or combinations thereof. In still other embodiments, the peptide sequence in X_n is
a peptidyl is a wild-type peptide ligand or a peptide mimetic.

In various embodiments, a compound according to Formula XI is disclosed:



XI

15 wherein:

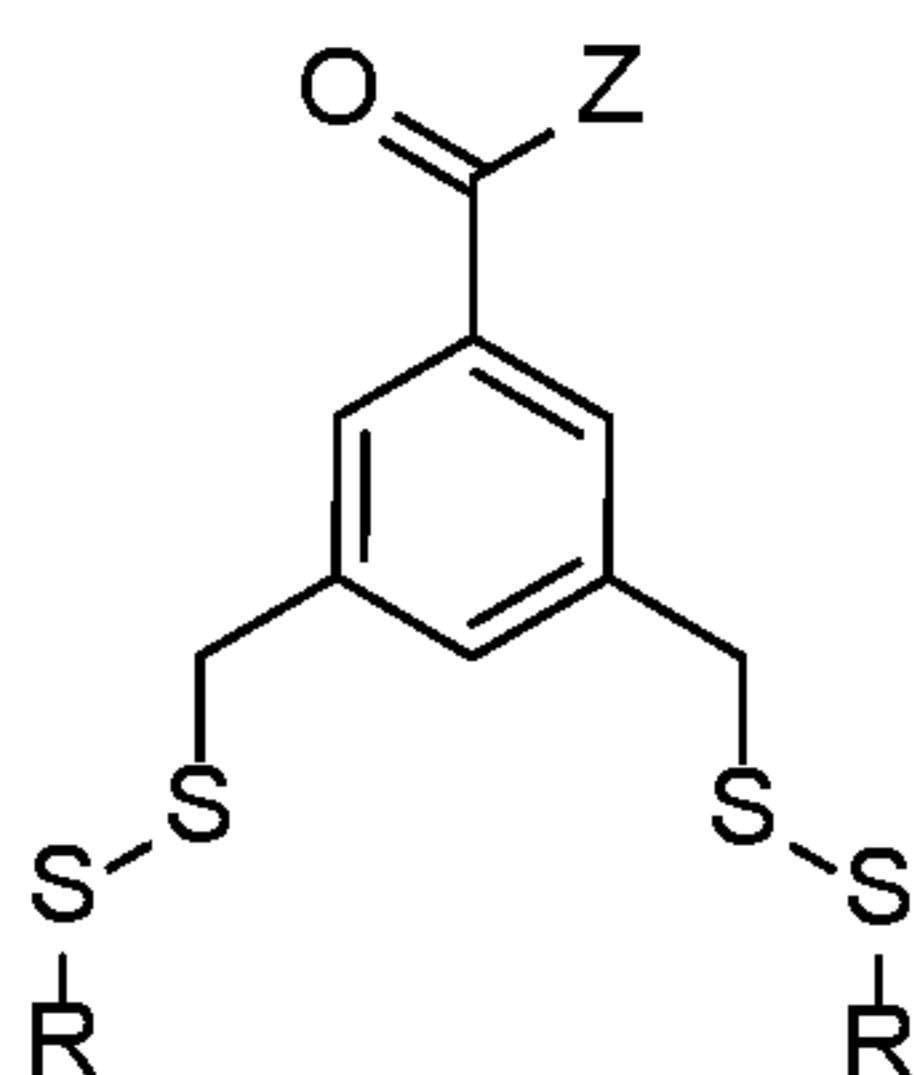
Y at each instance is independently CH, N, O or S, provided no more than four Y are
N, O, S, or combinations thereof;

Z is OR_a, hydrogen, halogen, carbocyclyl, heterocyclyl, or an amino acid;

R at each instance is independently an alkyl, alkenyl, alkynyl, carbocyclyl,
20 heterocyclyl, or an amino acid; and

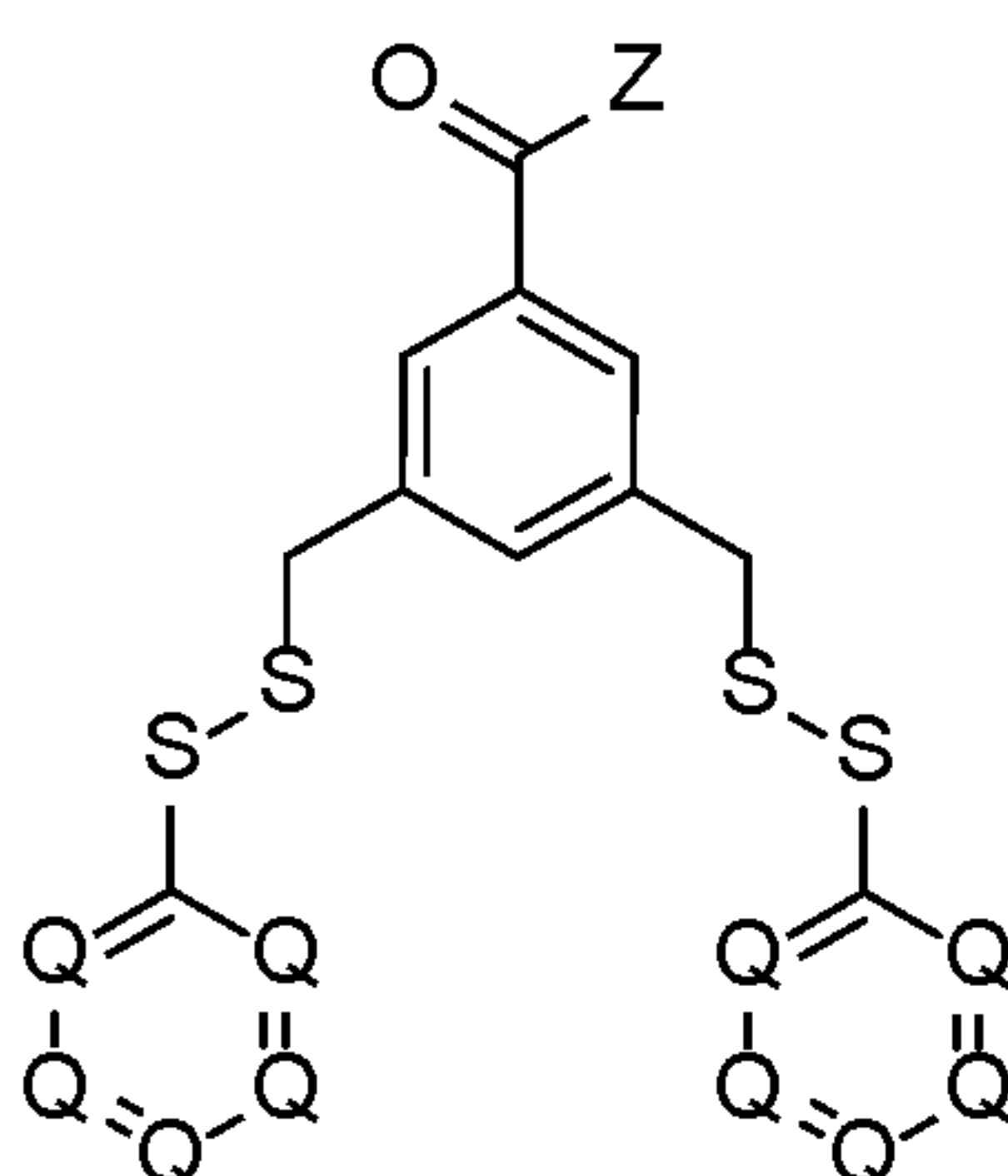
R_a is independently H, C(O)alkyl, alkyl, alkenyl, alkynyl, carbocyclic, or heterocyclyl.

In some embodiments, Y is independently CH. In other embodiments, the compound
has a structure according to Formula XI-A:



XI-A.

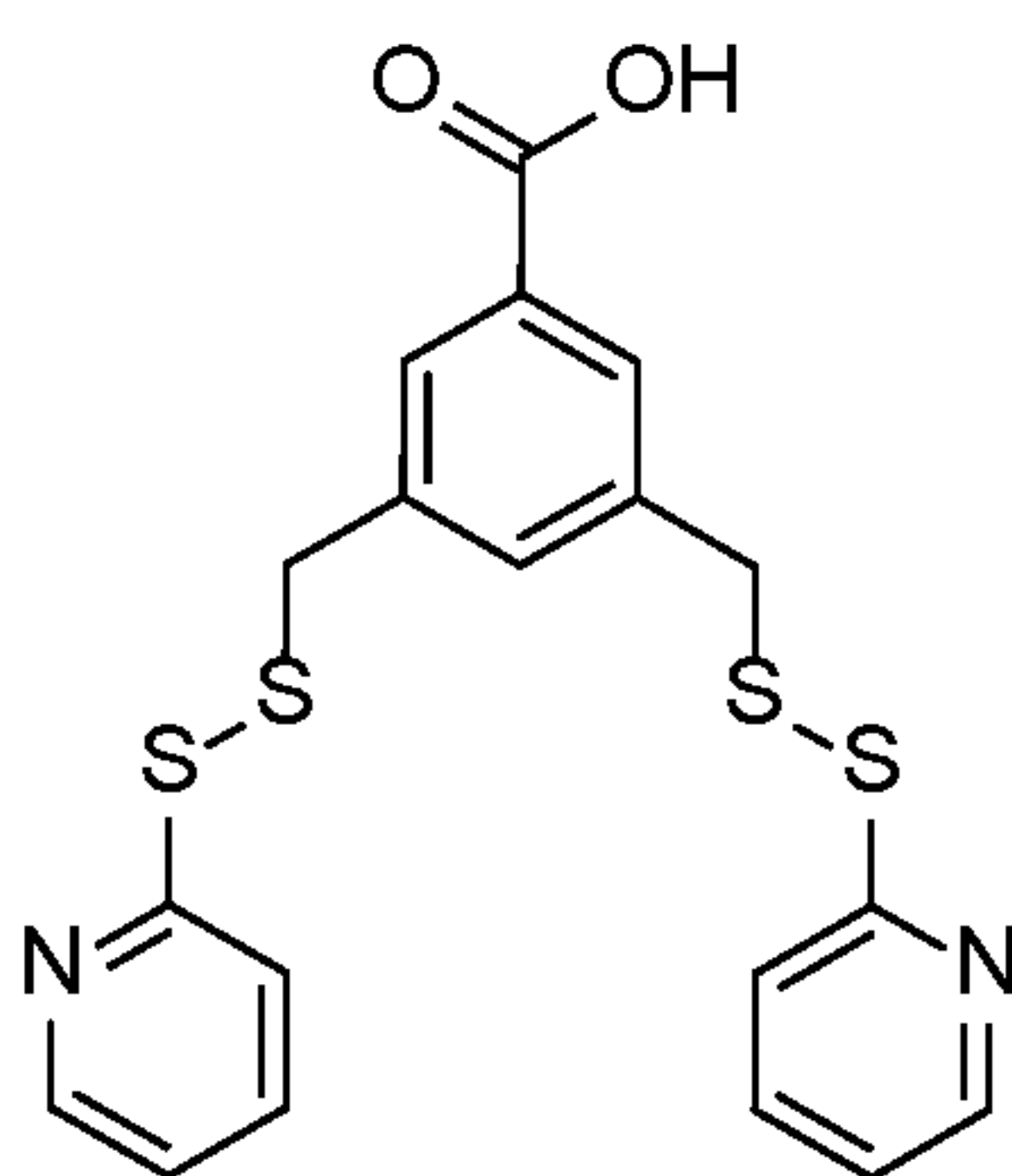
In some embodiments, each R is independently aryl or hetereoaryl. In further embodiments, the compound has a structure according to Formula XI-B:



XI-B

wherein Q at each instance is independently CH or N.

In some embodiments, Z is OH. In other embodiments, the compound has the following structure:



Also disclosed herein are methods delivering a therapeutic agent to cytoplasm of a cell, comprising administering a compound of any one of claims 18-38.

Also disclosed are pharmaceutical compositions comprising a bicyclic peptide disclosed herein and a pharmaceutical carrier

Also disclosed herein are methods of treating or preventing a disorder in a subject, such as a human, comprising administering to the subject an effective amount of a compound disclosed herein or a pharmaceutically acceptable salt thereof. In some examples, the subject

is an animal, such as a human. In some examples, the subject is identified as having a need for treatment of the disorder. In some examples, the method treats a disorder. In some examples, the disorder is associated with aberrant NF- κ B signaling. In some examples the disorder is associated with uncontrolled cellular proliferation, such as cancer. In some examples, the disorder is cancer. In some examples the disorder is an inflammatory disorder, such as irritable bowel syndrome. In some examples, the disorder is an autoimmune disorder, such as a disorder selected from rheumatoid arthritis, ankylosing spondylitis, Crohn's disease, psoriasis, hidradenitis suppurativa, and refractory asthma. In some further examples, disclosed herein is a method of treating Duchenne muscular dystrophy or large B-cell lymphoma.

Also disclosed herein is a method for identifying a drug candidate for treatment of a disorder, the method comprising the steps of: exposing a compound disclosed herein, a compound prepared by the methods disclosed herein, a library disclosed herein, or a library prepared by the methods disclosed to a receptor associated with the disorder; b) detecting reaction between the receptor and the compound or the library; and c) determining the identity of compound reacting with the receptor.

While aspects of the present invention can be described and claimed in a particular statutory class, such as the system statutory class, this is for convenience only and one of skill in the art will understand that each aspect of the present invention can be described and claimed in any statutory class. Unless otherwise expressly stated, it is in no way intended that any method or aspect set forth herein be construed as requiring that its steps be performed in a specific order. Accordingly, where a method claim does not specifically state in the claims or descriptions that the steps are to be limited to a specific order, it is no way intended that an order be inferred, in any respect. This holds for any possible non-express basis for interpretation, including matters of logic with respect to arrangement of steps or operational flow, plain meaning derived from grammatical organization or punctuation, or the number or type of aspects described in the specification.

DESCRIPTION OF FIGURES

The accompanying figures, which are incorporated in and constitute a part of this specification, illustrate several aspects and together with the description serve to explain the principles of the invention.

Figure 1A shows MFI of HeLa cells after 2-h treatment with 5 μ M FITC-labeled peptide cF Φ R4 (SEQ ID NO.:68) or 1-5, as determined by flow cytometry analysis. Blank, no peptide. **Figure 1B** shows inhibition of the NEMO-IKK γ interaction by peptides 1, 4, and 5 as

monitored by the HTRF assay. **Figure 1C** shows dose-dependent inhibition of TNF α induced activation of NF- κ B signaling in HEK293 cells by peptides 1, 4, and 5. **Figure 1D** shows a comparison of the serum stability of peptides 1, 4, and 6. Data reported are the mean $\pm$ SD of three independent experiments.

5 **Figure 2** is a reversible peptide bicyclization strategy. GSH, glutathione.

Figure 3 shows the structures of FITC-labeled peptides 2 and 3.

Figure 4 shows the structures of peptides 4, 5, and 6.

Figure 5A is a preparative reversed-phase HPLC chromatogram showing the purification of crude peptide 4 following solid-phase synthesis and trituration with diethyl
10 ether. **Figure 5B** is an analytical reversed-phase HPLC and MALDI-TOF MS analysis of purified peptide 4 before and after incubation with 5 mM glutathione in phosphate buffer (pH 7.4) at RT for 2 h.

Figure 6 shows the inhibition of the NEMO-IKK γ interaction by peptides
RRRR Φ FCALDWSWLQC (IC₅₀ = 1.4 μ M) (SEQ ID NO.:215) and
15 RRRR Φ FTALDWSWLQT (IC₅₀ = 1.6 μ M) (SEQ ID NO.:216) as monitored by the HTRF assay.

Figure 7 is an analytical reversed-phase HPLC showing the purity of other peptides used in this work. The authenticity of the peptides was confirmed by MALDI-TOF MS analysis.

20 **Figure 8** is a schematic illustration of a tris-(disulfide) containing bicyclic peptide.

Figure 9 is a schematic illustration of a bis-(disulfide) containing bicyclic peptide which releases the cargo from the cyclic cell-penetrating peptide upon entry into the cytosol of a cell.

Figure 10A shows the structure of a bicyclic peptide comprising cyclic comprising
25 CPP12 (Ff Φ RrRr) conjugated to a peptidyl inhibitor against Keap1-Nrf2, having a fluorescent label (NFL). **Figure 10B** shows a structure of the linear peptidyl inhibitor against Keap1-Nrf2, having a fluorescent label (NFL) in the absence of a cyclic CPP.

Figure 11 shows the structure of a bicyclic peptide comprising cyclic comprising a
30 cyclic CPP12 (Ff Φ RrRr) conjugated to a peptidyl inhibitor against Pin1, having a fluorescent label (NFL).

Figure 12A shows the structure of a bicyclic peptide comprising cyclic comprising a cyclic CPP12 (Ff Φ RrRr) conjugated to a peptidyl inhibitor against the CAL PDZ-CFTR interaction, having a fluorescent label (NFL). **Figure 12B** shows a structure of the linear

peptidyl inhibitor against the CAL PDZ-CFTR interaction, having a fluorescent label (NFL) in the absence of a cyclic CPP.

Figure 13A shows the structure of a bicyclic peptide comprising cyclic comprising a cyclic CPP12 (FfΦRrRr) conjugated to a peptidyl inhibitor against the MDM2-p53 interaction (PMI), having a fluorescent label (NFL). **Figure 13B** shows a structure of the linear peptidyl inhibitor against the PMI, having a fluorescent label (NFL) in the absence of a cyclic CPP.

Figure 14 graphically illustrates the cytosolic uptake efficiency of unconjugated peptidyl inhibitors compared to the cyclic CPP-peptide conjugates (i.e., the bicyclic peptides of the present disclosure).

Figure 15A shows the structure of a bicyclic peptide comprising cyclic comprising a cyclic CPP12 (FfΦRrRr) conjugated to a peptidyl inhibitor against Keap1-Nrf2. **Figure 15B** shows a structure of the linear peptidyl inhibitor against Keap1-Nrf2 in the absence of a cyclic CPP.

Figure 16 shows the structure of a bicyclic peptide comprising cyclic comprising a cyclic CPP12 (FfΦRrRr) conjugated to a peptidyl inhibitor against Pin1.

Figure 17 graphically illustrates the serum stability of bicyclic peptide comprising a cyclic CPP12 (FfΦRrRr) conjugated to a peptidyl inhibitor against the MDM2-p53 interaction (PMI), compared to that of the linear peptidyl inhibitor against the PMI.

Figure 18 graphically illustrates the serum stability of a bicyclic peptide comprising cyclic CPP12 (FfΦRrRr) conjugated to a peptidyl inhibitor against the Keap1-Nrf2 interaction, compared to that of the linear peptidyl inhibitor against the Keap1-Nrf2.

Figure 19 graphically illustrates the serum stability of a bicyclic peptide comprising CPP12 (FfΦRrRr) conjugated to a peptidyl inhibitor against Pin-1 (P1), compared to that of linear peptidyl inhibitor against P1.

DETAILED DESCRIPTION

The present invention can be understood more readily by reference to the following detailed description of the invention and the Examples and Figures included therein.

Before the present compounds, compositions, articles, systems, devices, and/or methods are disclosed and described, it is to be understood that they are not limited to specific synthetic methods unless otherwise specified, or to particular reagents unless otherwise specified, as such may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular aspects only and is not intended to be limiting. Although any

methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, example methods and materials are now described.

All publications mentioned herein are incorporated herein by reference to disclose and describe the methods and/or materials in connection with which the publications are cited. The publications discussed herein are provided solely for their disclosure prior to the filing date of the present application. Nothing herein is to be construed as an admission that the present invention is not entitled to antedate such publication by virtue of prior invention. Further, the dates of publication provided herein can be different from the actual publication dates, which can require independent confirmation.

General Definitions

As used herein, nomenclature for compounds, including organic compounds, can be given using common names, IUPAC, IUBMB, or CAS recommendations for nomenclature. When one or more stereochemical features are present, Cahn-Ingold-Prelog rules for stereochemistry can be employed to designate stereochemical priority, *E/Z* specification, and the like. One of skill in the art can readily ascertain the structure of a compound if given a name, either by systemic reduction of the compound structure using naming conventions, or by commercially available software, such as CHEMDRAW™ (Cambridgesoft Corporation, U.S.A.).

As used in the specification and the appended claims, the singular forms "a," "an" and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a functional group," "an alkyl," or "a residue" includes mixtures of two or more such functional groups, alkyls, or residues, and the like.

Ranges can be expressed herein as from "about" one particular value, and/or to "about" another particular value. When such a range is expressed, a further aspect includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent "about," it will be understood that the particular value forms a further aspect. It will be further understood that the endpoints of each of the ranges are significant both in relation to the other endpoint, and independently of the other endpoint. It is also understood that there are a number of values disclosed herein, and that each value is also herein disclosed as "about" that particular value in addition to the value itself. For example, if the value "10" is disclosed, then "about 10" is also disclosed. It is also understood that each unit between two particular units are also disclosed. For example, if 10 and 15 are disclosed, then 11, 12, 13, and 14 are also disclosed.

References in the specification and concluding claims to parts by weight of a particular element or component in a composition denotes the weight relationship between the element or component and any other elements or components in the composition or article for which a part by weight is expressed. Thus, in a compound containing 2 parts by weight of component X and 5 parts by weight component Y, X and Y are present at a weight ratio of 2:5, and are present in such ratio regardless of whether additional components are contained in the compound.

A weight percent (wt. %) of a component, unless specifically stated to the contrary, is based on the total weight of the formulation or composition in which the component is included.

As used herein, the terms "optional" or "optionally" means that the subsequently described event or circumstance can or cannot occur, and that the description includes instances where said event or circumstance occurs and instances where it does not.

As used herein, the term "subject" refers to the target of administration, e.g. a subject. Thus the subject of the herein disclosed methods can be a vertebrate, such as a mammal, a fish, a bird, a reptile, or an amphibian. Alternatively, the subject of the herein disclosed methods can be a human, non-human primate, horse, pig, rabbit, dog, sheep, goat, cow, cat, guinea pig, fish, bird, or rodent. The term does not denote a particular age or sex. Thus, adult and newborn subjects, as well as fetuses, whether male or female, are intended to be covered. In some examples, the subject is a mammal. A patient refers to a subject afflicted with a disease or disorder. The term "patient" includes human and veterinary subjects. In some examples of the disclosed methods, the subject has been diagnosed with a need for treatment of cancer prior to the administering step. In some examples of the disclosed method, the subject has been diagnosed with cancer prior to the administering step. The term subject also includes a cell, such as an animal, for example human, cell.

As used herein, the term "treatment" refers to the medical management of a patient with the intent to cure, ameliorate, stabilize, or prevent a disease, pathological condition, or disorder. This term includes active treatment, that is, treatment directed specifically toward the improvement of a disease, pathological condition, or disorder, and also includes causal treatment, that is, treatment directed toward removal of the cause of the associated disease, pathological condition, or disorder. In addition, this term includes palliative treatment, that is, treatment designed for the relief of symptoms rather than the curing of the disease, pathological condition, or disorder; preventative treatment, that is, treatment directed to minimizing or partially or completely inhibiting the development of the associated disease,

pathological condition, or disorder; and supportive treatment, that is, treatment employed to supplement another specific therapy directed toward the improvement of the associated disease, pathological condition, or disorder. In some examples, the term covers any treatment of a subject, including a mammal (e.g., a human), and includes: (i) preventing the disease
5 from occurring in a subject that can be predisposed to the disease but has not yet been diagnosed as having it; (ii) inhibiting the disease, i.e., arresting its development; or (iii) relieving the disease, i.e., causing regression of the disease. In some examples, the subject is a mammal such as a primate, and, in some examples, the subject is a human. The term "subject" also includes domesticated animals (e.g., cats, dogs, etc.), livestock (e.g., cattle, horses, pigs,
10 sheep, goats, fish, bird, etc.), and laboratory animals (e.g., mouse, rabbit, rat, guinea pig, fruit fly, etc.).

As used herein, the term "prevent" or "preventing" refers to precluding, averting, obviating, forestalling, stopping, or hindering something from happening, especially by advance action. It is understood that where reduce, inhibit or prevent are used herein, unless
15 specifically indicated otherwise, the use of the other two words is also expressly disclosed.

As used herein, the term "diagnosed" means having been subjected to a physical examination by a person of skill, for example, a physician, and found to have a condition that can be diagnosed or treated by the compounds, compositions, or methods disclosed herein. For example, "diagnosed with cancer" means having been subjected to a physical
20 examination by a person of skill, for example, a physician, and found to have a condition that can be diagnosed or treated by a compound or composition that can treat or prevent cancer. As a further example, "diagnosed with a need for treating or preventing cancer" refers to having been subjected to a physical examination by a person of skill, for example, a physician, and found to have a condition characterized by cancer or other disease wherein
25 treating or preventing cancer would be beneficial to the subject.

As used herein, the phrase "identified to be in need of treatment for a disorder," or the like, refers to selection of a subject based upon need for treatment of the disorder. For example, a subject can be identified as having a need for treatment of a disorder (e.g., a disorder related to cancer) based upon an earlier diagnosis by a person of skill and thereafter subjected to
30 treatment for the disorder. It is contemplated that the identification can, In some examples, be performed by a person different from the person making the diagnosis. It is also contemplated, in some examples, that the administration can be performed by one who subsequently performed the administration.

As used herein, the terms "administering" and "administration" refer to any method of providing a pharmaceutical preparation to a subject. Such methods are well known to those skilled in the art and include, but are not limited to, oral administration, transdermal administration, administration by inhalation, nasal administration, topical administration, intravaginal administration, ophthalmic administration, intraaural administration, intracerebral administration, rectal administration, sublingual administration, buccal administration, and parenteral administration, including injectable such as intravenous administration, intra-arterial administration, intramuscular administration, and subcutaneous administration. Administration can be continuous or intermittent. In some examples, a preparation can be administered therapeutically; that is, administered to treat an existing disease or condition. In some examples, a preparation can be administered prophylactically; that is, administered for prevention of a disease or condition.

The term "contacting" as used herein refers to bringing a disclosed compound and a cell, target receptor, or other biological entity together in such a manner that the compound can affect the activity of the target (e.g., receptor, transcription factor, cell, etc.), either directly; i.e., by interacting with the target itself, or indirectly; i.e., by interacting with another molecule, co-factor, factor, or protein on which the activity of the target is dependent.

As used herein, the terms "effective amount" and "amount effective" refer to an amount that is sufficient to achieve the desired result or to have an effect on an undesired condition. For example, a "therapeutically effective amount" refers to an amount that is sufficient to achieve the desired therapeutic result or to have an effect on undesired symptoms, but is generally insufficient to cause adverse side effects. The specific therapeutically effective dose level for any particular patient will depend upon a variety of factors including the disorder being treated and the severity of the disorder; the specific composition employed; the age, body weight, general health, sex and diet of the patient; the time of administration; the route of administration; the rate of excretion of the specific compound employed; the duration of the treatment; drugs used in combination or coincidental with the specific compound employed and like factors well known in the medical arts. For example, it is well within the skill of the art to start doses of a compound at levels lower than those required to achieve the desired therapeutic effect and to gradually increase the dosage until the desired effect is achieved. If desired, the effective daily dose can be divided into multiple doses for purposes of administration. Consequently, single dose compositions can contain such amounts or submultiples thereof to make up the daily dose.

The dosage can be adjusted by the individual physician in the event of any contraindications. Dosage can vary, and can be administered in one or more dose administrations daily, for one or several days. Guidance can be found in the literature for appropriate dosages for given classes of pharmaceutical products. In some examples, a
5 preparation can be administered in a "prophylactically effective amount"; that is, an amount effective for prevention of a disease or condition.

As used herein, "EC₅₀," is intended to refer to the concentration or dose of a substance (e.g., a compound or a drug) that is required for 50% enhancement or activation of a biological process, or component of a process, including a protein, subunit, organelle, ribonucleoprotein,
10 etc. EC₅₀ also refers to the concentration or dose of a substance that is required for 50% enhancement or activation *in vivo*, as further defined elsewhere herein. Alternatively, EC₅₀ can refer to the concentration or dose of compound that provokes a response halfway between the baseline and maximum response. The response can be measured in an *in vitro* or *in vivo* system as is convenient and appropriate for the biological response of interest. For example,
15 the response can be measured *in vitro* using cultured muscle cells or in an *ex vivo* organ culture system with isolated muscle fibers. Alternatively, the response can be measured *in vivo* using an appropriate research model such as rodent, including mice and rats. The mouse or rat can be an inbred strain with phenotypic characteristics of interest such as obesity or diabetes. As appropriate, the response can be measured in a transgenic or
20 knockout mouse or rat wherein the gene or genes has been introduced or knocked-out, as appropriate, to replicate a disease process.

As used herein, "IC₅₀," is intended to refer to the concentration or dose of a substance (e.g., a compound or a drug) that is required for 50% inhibition or diminuation of a biological process, or component of a process, including a protein, subunit, organelle,
25 ribonucleoprotein, etc. IC₅₀ also refers to the concentration or dose of a substance that is required for 50% inhibition or diminuation *in vivo*, as further defined elsewhere herein. Alternatively, IC₅₀ also refers to the half maximal (50%) inhibitory concentration (IC) or inhibitory dose of a substance. The response can be measured in an *in vitro* or *in vivo* system as is convenient and appropriate for the biological response of interest. For example, the
30 response can be measured *in vitro* using cultured muscle cells or in an *ex vivo* organ culture system with isolated muscle fibers. Alternatively, the response can be measured *in vivo* using an appropriate research model such as rodent, including mice and rats. The mouse or rat can be an inbred strain with phenotypic characteristics of interest such as obesity or diabetes. As

appropriate, the response can be measured in a transgenic or knockout mouse or rat wherein a gene or genes has been introduced or knocked-out, as appropriate, to replicate a disease process.

5 The term "pharmaceutically acceptable" describes a material that is not biologically or otherwise undesirable, i.e., without causing an unacceptable level of undesirable biological effects or interacting in a deleterious manner.

As used herein, the term "derivative" refers to a compound having a structure derived from the structure of a parent compound (e.g., a compound disclosed herein) and whose structure is sufficiently similar to those disclosed herein and based upon that similarity,
10 would be expected by one skilled in the art to exhibit the same or similar activities and utilities as the claimed compounds, or to induce, as a precursor, the same or similar activities and utilities as the claimed compounds. Exemplary derivatives include salts, esters, amides, salts of esters or amides, and N-oxides of a parent compound.

As used herein, the term "pharmaceutically acceptable carrier" refers to sterile aqueous
15 or nonaqueous solutions, dispersions, suspensions or emulsions, as well as sterile powders for reconstitution into sterile injectable solutions or dispersions just prior to use. Examples of suitable aqueous and nonaqueous carriers, diluents, solvents or vehicles include water, ethanol, polyols (such as glycerol, propylene glycol, polyethylene glycol and the like), carboxymethylcellulose and suitable mixtures thereof, vegetable oils (such as olive oil) and
20 injectable organic esters such as ethyl oleate. Proper fluidity can be maintained, for example, by the use of coating materials such as lecithin, by the maintenance of the required particle size in the case of dispersions and by the use of surfactants. These compositions can also contain adjuvants such as preservatives, wetting agents, emulsifying agents and dispersing agents.

Prevention of the action of microorganisms can be ensured by the inclusion of various
25 antibacterial and antifungal agents such as paraben, chlorobutanol, phenol, sorbic acid and the like. It can also be desirable to include isotonic agents such as sugars, sodium chloride and the like. Prolonged absorption of the injectable pharmaceutical form can be brought about by the inclusion of agents, such as aluminum monostearate and gelatin, which delay absorption.

Injectable depot forms are made by forming microencapsule matrices of the drug in
30 biodegradable polymers such as polylactide-polyglycolide, poly(orthoesters) and poly(anhydrides). Depending upon the ratio of drug to polymer and the nature of the particular polymer employed, the rate of drug release can be controlled. Depot injectable formulations are also prepared by entrapping the drug in liposomes or microemulsions which are compatible

with body tissues. The injectable formulations can be sterilized, for example, by filtration through a bacterial-retaining filter or by incorporating sterilizing agents in the form of sterile solid compositions which can be dissolved or dispersed in sterile water or other sterile injectable media just prior to use. Suitable inert carriers can include sugars such as lactose.

- 5 Desirably, at least 95% by weight of the particles of the active ingredient have an effective particle size in the range of 0.01 to 10 micrometers.

A residue of a chemical species, as used in the specification and concluding claims, refers to the moiety that is the resulting product of the chemical species in a particular reaction scheme or subsequent formulation or chemical product, regardless of whether the moiety is
10 actually obtained from the chemical species. Thus, an ethylene glycol residue in a polyester refers to one or more $\text{-OCH}_2\text{CH}_2\text{O-}$ units in the polyester, regardless of whether ethylene glycol was used to prepare the polyester. Similarly, a sebacic acid residue in a polyester refers to one or more $\text{-CO(CH}_2)_8\text{CO-}$ moieties in the polyester, regardless of whether the residue is obtained by reacting sebacic acid or an ester thereof to obtain the polyester. As another
15 example, an amino acid residue, e.g., in a peptide, refers to one or more -AA- moieties, and such residues may be referred to herein interchangeably as an amino acid or an amino acid residue.

Chemical Definitions

As used herein, the term "substituted" is contemplated to include all permissible
20 substituents of organic compounds. In some examples, the permissible substituents include acyclic and cyclic, branched and unbranched, carbocyclic and heterocyclic, and aromatic and nonaromatic substituents of organic compounds. Illustrative substituents include, for example, those described below. The permissible substituents can be one or more and the same or different for appropriate organic compounds. For purposes of this disclosure, the
25 heteroatoms, such as nitrogen, can have hydrogen substituents and/or any permissible substituents of organic compounds described herein which satisfy the valences of the heteroatoms. This disclosure is not intended to be limited in any manner by the permissible substituents of organic compounds. Also, the terms "substitution" or "substituted with" include the implicit proviso that such substitution is in accordance with permitted valence of
30 the substituted atom and the substituent, and that the substitution results in a stable compound, e.g., a compound that does not spontaneously undergo transformation such as by rearrangement, cyclization, elimination, etc. It is also contemplated that, in certain

examples, unless expressly indicated to the contrary, individual substituents can be further optionally substituted (i.e., further substituted or unsubstituted).

In defining various terms, "A¹," "A²," "A³," and "A⁴" are used herein as generic symbols to represent various specific substituents. These symbols can be any substituent, not limited to those disclosed herein, and when they are defined to be certain substituents in one instance, they can, in another instance, be defined as some other substituents.

The term "alkyl" as used herein is a branched or unbranched saturated hydrocarbon group of 1 to 24 carbon atoms, such as methyl, ethyl, *n*-propyl, isopropyl, *n*-butyl, isobutyl, *s*-butyl, *t*-butyl, *n*-pentyl, isopentyl, *s*-pentyl, neopentyl, hexyl, heptyl, octyl, nonyl, decyl, dodecyl, tetradecyl, hexadecyl, eicosyl, tetracosyl, and the like. The alkyl group can be cyclic or acyclic. The alkyl group can be branched or unbranched. The alkyl group can also be substituted or unsubstituted. For example, the alkyl group can be substituted with one or more groups including, but not limited to, alkyl, cycloalkyl, alkoxy, amino, ether, halide, hydroxy, nitro, silyl, sulfo-oxo, or thiol, as described herein. A "lower alkyl" group is an alkyl group containing from one to six (e.g., from one to four) carbon atoms.

Throughout the specification "alkyl" is generally used to refer to both unsubstituted alkyl groups and substituted alkyl groups; however, substituted alkyl groups are also specifically referred to herein by identifying the specific substituent(s) on the alkyl group. For example, the term "halogenated alkyl" or "haloalkyl" specifically refers to an alkyl group that is substituted with one or more halide, *e.g.*, fluorine, chlorine, bromine, or iodine. The term "alkoxyalkyl" specifically refers to an alkyl group that is substituted with one or more alkoxy groups, as described below. The term "alkylamino" specifically refers to an alkyl group that is substituted with one or more amino groups, as described below, and the like. When "alkyl" is used in one instance and a specific term such as "alkylalcohol" is used in another, it is not meant to imply that the term "alkyl" does not also refer to specific terms such as "alkylalcohol" and the like.

This practice is also used for other groups described herein. That is, while a term such as "cycloalkyl" refers to both unsubstituted and substituted cycloalkyl moieties, the substituted moieties can, in addition, be specifically identified herein; for example, a particular substituted cycloalkyl can be referred to as, *e.g.*, an "alkylcycloalkyl." Similarly, a substituted alkoxy can be specifically referred to as, *e.g.*, a "halogenated alkoxy," a particular substituted alkenyl can be, *e.g.*, an "alkenylalcohol," and the like. Again, the practice of using a general

term, such as "cycloalkyl," and a specific term, such as "alkylcycloalkyl," is not meant to imply that the general term does not also include the specific term.

The term "cycloalkyl" as used herein is a non-aromatic carbon-based ring composed of at least three carbon atoms. Examples of cycloalkyl groups include, but are not limited to, cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, norbornyl, and the like. The term "heterocycloalkyl" is a type of cycloalkyl group as defined above, and is included within the meaning of the term "cycloalkyl," where at least one of the carbon atoms of the ring is replaced with a heteroatom such as, but not limited to, nitrogen, oxygen, sulfur, or phosphorus. The cycloalkyl group and heterocycloalkyl group can be substituted or unsubstituted. The cycloalkyl group and heterocycloalkyl group can be substituted with one or more groups including, but not limited to, alkyl, cycloalkyl, alkoxy, amino, ether, halide, hydroxy, nitro, silyl, sulfo-oxo, or thiol as described herein.

The term "polyalkylene group" as used herein is a group having two or more CH₂ groups linked to one another. The polyalkylene group can be represented by the formula —(CH₂)_a—, where "a" is an integer of from 2 to 500.

The terms "alkoxy" and "alkoxyl" as used herein to refer to an alkyl or cycloalkyl group bonded through an ether linkage; that is, an "alkoxy" group can be defined as —OA¹ where A¹ is alkyl or cycloalkyl as defined above. "Alkoxy" also includes polymers of alkoxy groups as just described; that is, an alkoxy can be a polyether such as —OA¹—OA² or —OA¹—(OA²)_a—OA³, where "a" is an integer of from 1 to 200 and A¹, A², and A³ are alkyl and/or cycloalkyl groups.

The term "alkenyl" as used herein is a hydrocarbon group of from 2 to 24 carbon atoms with a structural formula containing at least one carbon-carbon double bond. Asymmetric structures such as (A¹A²)C=C(A³A⁴) are intended to include both the *E* and *Z* isomers. This can be presumed in structural formulae herein wherein an asymmetric alkene is present, or it can be explicitly indicated by the bond symbol C=C. The alkenyl group can be substituted with one or more groups including, but not limited to, alkyl, cycloalkyl, alkoxy, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, heteroaryl, aldehyde, amino, carboxylic acid, ester, ether, halide, hydroxy, ketone, azide, nitro, silyl, sulfo-oxo, or thiol, as described herein.

"Carbocyclyl," "carbocyclic ring" or "carbocycle" refers to a ring structure, wherein the atoms which form the ring are each carbon. Carbocyclic rings can comprise from 3 to 20 carbon atoms in the ring. Carbocyclic rings include aryls and cycloalkyl, cycloalkenyl and

cycloalkynyl as defined herein. The carbocyclic group can be substituted or unsubstituted. The carbocyclic group can be substituted with one or more groups including, but not limited to, alkyl, cycloalkyl, alkoxy, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, heteroaryl, aldehyde, amino, carboxylic acid, ester, ether, halide, hydroxy, ketone, azide, nitro, silyl, sulfo-oxo, or thiol as described herein.

The term "cycloalkenyl" as used herein is a non-aromatic carbon-based ring composed of at least three carbon atoms and containing at least one carbon-carbon double bond, *i.e.*, C=C. Examples of cycloalkenyl groups include, but are not limited to, cyclopropenyl, cyclobutenyl, cyclopentenyl, cyclopentadienyl, cyclohexenyl, cyclohexadienyl, norbornenyl, and the like. The term "heterocycloalkenyl" is a type of cycloalkenyl group as defined above, and is included within the meaning of the term "cycloalkenyl," where at least one of the carbon atoms of the ring is replaced with a heteroatom such as, but not limited to, nitrogen, oxygen, sulfur, or phosphorus. The cycloalkenyl group and heterocycloalkenyl group can be substituted or unsubstituted. The cycloalkenyl group and heterocycloalkenyl group can be substituted with one or more groups including, but not limited to, alkyl, cycloalkyl, alkoxy, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, heteroaryl, aldehyde, amino, carboxylic acid, ester, ether, halide, hydroxy, ketone, azide, nitro, silyl, sulfo-oxo, or thiol as described herein.

The term "alkynyl" as used herein is a hydrocarbon group of 2 to 24 carbon atoms with a structural formula containing at least one carbon-carbon triple bond. The alkynyl group can be unsubstituted or substituted with one or more groups including, but not limited to, alkyl, cycloalkyl, alkoxy, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, heteroaryl, aldehyde, amino, carboxylic acid, ester, ether, halide, hydroxy, ketone, azide, nitro, silyl, sulfo-oxo, or thiol, as described herein.

The term "cycloalkynyl" as used herein is a non-aromatic carbon-based ring composed of at least seven carbon atoms and containing at least one carbon-carbon triple bond. Examples of cycloalkynyl groups include, but are not limited to, cycloheptynyl, cyclooctynyl, cyclononyl, and the like. The term "heterocycloalkynyl" is a type of cycloalkenyl group as defined above, and is included within the meaning of the term "cycloalkynyl," where at least one of the carbon atoms of the ring is replaced with a heteroatom such as, but not limited to, nitrogen, oxygen, sulfur, or phosphorus. The cycloalkynyl group and heterocycloalkynyl group can be substituted or unsubstituted. The cycloalkynyl group and heterocycloalkynyl group can be substituted with one or more groups including, but not limited to, alkyl,

cycloalkyl, alkoxy, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, heteroaryl, aldehyde, amino, carboxylic acid, ester, ether, halide, hydroxy, ketone, azide, nitro, silyl, sulfo-oxo, or thiol as described herein.

The term "aryl" as used herein is a group that contains any carbon-based aromatic group including, but not limited to, benzene, naphthalene, phenyl, biphenyl, phenoxybenzene, and the like. The term "aryl" also includes "heteroaryl," which is defined as a group that contains an aromatic group that has at least one heteroatom incorporated within the ring of the aromatic group. Examples of heteroatoms include, but are not limited to, nitrogen, oxygen, sulfur, and phosphorus. Likewise, the term "non-heteroaryl," which is also included in the term "aryl," defines a group that contains an aromatic group that does not contain a heteroatom. The aryl group can be substituted or unsubstituted. The aryl group can be substituted with one or more groups including, but not limited to, alkyl, cycloalkyl, alkoxy, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, heteroaryl, aldehyde, amino, carboxylic acid, ester, ether, halide, hydroxy, ketone, azide, nitro, silyl, sulfo-oxo, or thiol as described herein. The term "biaryl" is a specific type of aryl group and is included in the definition of "aryl." Biaryl refers to two aryl groups that are bound together *via* a fused ring structure, as in naphthalene, or are attached *via* one or more carbon-carbon bonds, as in biphenyl.

The term "aldehyde" as used herein is represented by the formula —C(O)H . Throughout this specification "C(O)" is a short hand notation for a carbonyl group, *i.e.*, C=O .

The terms "amine" or "amino" as used herein are represented by the formula $\text{—NA}^1\text{A}^2$, where A^1 and A^2 can be, independently, hydrogen or alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group as described herein.

The term "alkylamino" as used herein is represented by the formula —NH(—alkyl) where alkyl is as described herein. Representative examples include, but are not limited to, methylamino group, ethylamino group, propylamino group, isopropylamino group, butylamino group, isobutylamino group, (sec-butyl)amino group, (tert-butyl)amino group, pentylamino group, isopentylamino group, (tert-pentyl)amino group, hexylamino group, and the like.

The term "dialkylamino" as used herein is represented by the formula —N(—alkyl)_2 where alkyl is as described herein. Representative examples include, but are not limited to, dimethylamino group, diethylamino group, dipropylamino group, diisopropylamino group, dibutylamino group, diisobutylamino group, di(sec-butyl)amino group, di(tert-butyl)amino group, dipentylamino group, diisopentylamino group, di(tert-pentyl)amino group,

dihexylamino group, N-ethyl-N-methylamino group, N-methyl-N-propylamino group, N-ethyl-N-propylamino group and the like.

The term "carboxylic acid" as used herein is represented by the formula —C(O)OH .

The term "ester" as used herein is represented by the formula —OC(O)A^1 or —C(O)OA^1 , where A^1 can be alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group as described herein. The term "polyester" as used herein is represented by the formula $\text{—(A}^1\text{O(O)C-A}^2\text{-C(O)O)}_a\text{—}$ or $\text{—(A}^1\text{O(O)C-A}^2\text{-OC(O))}_a\text{—}$, where A^1 and A^2 can be, independently, an alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group described herein and "a" is an integer from 1 to 500.

"Polyester" is as the term used to describe a group that is produced by the reaction between a compound having at least two carboxylic acid groups with a compound having at least two hydroxyl groups.

The term "ether" as used herein is represented by the formula A^1OA^2 , where A^1 and A^2 can be, independently, an alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group described herein. The term "polyether" as used herein is represented by the formula $\text{—(A}^1\text{O-A}^2\text{O)}_n\text{—}$, where A^1 and A^2 can be, independently, an alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group described herein and "a" is an integer of from 1 to 500. Examples of polyether groups include polyethylene oxide, polypropylene oxide, and polybutylene oxide.

The term "halide" as used herein refers to the halogens fluorine, chlorine, bromine, and iodine.

The term "heterocycle," as used herein refers to single and multi-cyclic aromatic or non-aromatic ring systems in which at least one of the ring members is other than carbon. Heterocycle includes azetidine, dioxane, furan, imidazole, isothiazole, isoxazole, morpholine, oxazole, oxazole, including, 1,2,3-oxadiazole, 1,2,5-oxadiazole and 1,3,4-oxadiazole, piperazine, piperidine, pyrazine, pyrazole, pyridazine, pyridine, pyrimidine, pyrrole, pyrrolidine, tetrahydrofuran, tetrahydropyran, tetrazine, including 1,2,4,5-tetrazine, tetrazole, including 1,2,3,4-tetrazole and 1,2,4,5-tetrazole, thiadiazole, including, 1,2,3-thiadiazole, 1,2,5-thiadiazole, and 1,3,4-thiadiazole, thiazole, thiophene, triazine, including 1,3,5-triazine and 1,2,4-triazine, triazole, including, 1,2,3-triazole, 1,3,4-triazole, and the like.

"N-alkyl" refers to a alkyl radical as defined above containing at least one nitrogen and where a point of attachment of the alkyl radical to the rest of the molecule is through a nitrogen

atom in the *N*-alkyl radical. Unless stated otherwise specifically in the specification, a *N*-alkyl group can be optionally substituted.

The term "hydroxyl" as used herein is represented by the formula —OH.

The term "ketone" as used herein is represented by the formula $A^1C(O)A^2$, where A^1 and A^2 can be, independently, an alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group as described herein.

The term "azide" as used herein is represented by the formula —N₃.

The term "nitro" as used herein is represented by the formula —NO₂.

The term "nitrile" as used herein is represented by the formula —CN.

The term "silyl" as used herein is represented by the formula —SiA¹A²A³, where A^1 , A^2 , and A^3 can be, independently, hydrogen or an alkyl, cycloalkyl, alkoxy, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group as described herein.

The term "sulfo-oxo" as used herein is represented by the formulas —S(O)A¹, —S(O)₂A¹, —OS(O)₂A¹, or —OS(O)₂OA¹, where A^1 can be hydrogen or an alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group as described herein. Throughout this specification "S(O)" is a short hand notation for S=O. The term "sulfonyl" is used herein to refer to the sulfo-oxo group represented by the formula —S(O)₂A¹, where A^1 can be hydrogen or an alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group as described herein. The term "sulfone" as used herein is represented by the formula $A^1S(O)_2A^2$, where A^1 and A^2 can be, independently, an alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group as described herein. The term "sulfoxide" as used herein is represented by the formula $A^1S(O)A^2$, where A^1 and A^2 can be, independently, an alkyl, cycloalkyl, alkenyl, cycloalkenyl, alkynyl, cycloalkynyl, aryl, or heteroaryl group as described herein.

The term "thiol" as used herein is represented by the formula —SH.

"R¹," "R²," "R³," "Rⁿ," where n is an integer, as used herein can, independently, possess one or more of the groups listed above. For example, if R¹ is a straight chain alkyl group, one of the hydrogen atoms of the alkyl group can optionally be substituted with a hydroxyl group, an alkoxy group, an alkyl group, a halide, and the like. Depending upon the groups that are selected, a first group can be incorporated within second group or, alternatively, the first group can be pendant (*i.e.*, attached) to the second group. For example, with the phrase "an alkyl group comprising an amino group," the amino group can be incorporated within the backbone of the alkyl group. Alternatively, the amino group can be attached to the backbone

of the alkyl group. The nature of the group(s) that is (are) selected will determine if the first group is embedded or attached to the second group.

As described herein, compounds can contain "optionally substituted" moieties. In general, the term "substituted," whether preceded by the term "optionally" or not, means that one or more hydrogens of the designated moiety are replaced with a suitable substituent. Unless otherwise indicated, an "optionally substituted" group can have a suitable substituent at each substitutable position of the group, and when more than one position in any given structure can be substituted with more than one substituent selected from a specified group, the substituent can be either the same or different at every position. Combinations of substituents envisioned herein are preferably those that result in the formation of stable or chemically feasible compounds. It is also contemplated that, in some examples, unless expressly indicated to the contrary, individual substituents can be further optionally substituted (i.e., further substituted or unsubstituted).

The term "stable," as used herein, refers to compounds that are not substantially altered when subjected to conditions to allow for their production, detection, and, in some examples, their recovery, purification, and use for one or more of the purposes disclosed herein.

Suitable monovalent substituents on a substitutable carbon atom of an "optionally substituted" group are independently halogen; $-(CH_2)_{0-4}R^\circ$; $-O(CH_2)_{0-4}R^\circ$; $-O-(CH_2)_{0-4}C(O)OR^\circ$; $-(CH_2)_{0-4}CH(OR^\circ)_2$; $-(CH_2)_{0-4}SR^\circ$; $-(CH_2)_{0-4}Ph$, which may be substituted with R° ; $-(CH_2)_{0-4}O(CH_2)_{0-1}Ph$ which may be substituted with R° ; $-CH=CHPh$, which may be substituted with R° ; $-(CH_2)_{0-4}O(CH_2)_{0-1}pyridyl$ which may be substituted with R° ; $-NO_2$; $-CN$; $-N_3$; $-(CH_2)_{0-4}N(R^\circ)_2$; $-(CH_2)_{0-4}N(R^\circ)C(O)R^\circ$; $-N(R^\circ)C(S)R^\circ$; $-(CH_2)_{0-4}N(R^\circ)C(O)NR^\circ_2$; $-N(R^\circ)C(S)NR^\circ_2$; $-(CH_2)_{0-4}N(R^\circ)C(O)OR^\circ$; $-N(R^\circ)N(R^\circ)C(O)R^\circ$; $-N(R^\circ)N(R^\circ)C(O)NR^\circ_2$; $-N(R^\circ)N(R^\circ)C(O)OR^\circ$; $-(CH_2)_{0-4}C(O)R^\circ$; $-C(S)R^\circ$; $-(CH_2)_{0-4}C(O)OR^\circ$; $-(CH_2)_{0-4}C(O)SR^\circ$; $-(CH_2)_{0-4}C(O)OSiR^\circ_3$; $-(CH_2)_{0-4}OC(O)R^\circ$; $-OC(O)(CH_2)_{0-4}SR-$, $SC(S)SR^\circ$; $-(CH_2)_{0-4}SC(O)R^\circ$; $-(CH_2)_{0-4}C(O)NR^\circ_2$; $-C(S)NR^\circ_2$; $-C(S)SR^\circ$; $-SC(S)SR^\circ$; $-(CH_2)_{0-4}OC(O)NR^\circ_2$; $-C(O)N(OR^\circ)R^\circ$; $-C(O)C(O)R^\circ$; $-C(O)CH_2C(O)R^\circ$; $-C(NOR^\circ)R^\circ$; $-(CH_2)_{0-4}SSR^\circ$; $-(CH_2)_{0-4}S(O)_2R^\circ$; $-(CH_2)_{0-4}S(O)_2OR^\circ$; $-(CH_2)_{0-4}OS(O)_2R^\circ$; $-S(O)_2NR^\circ_2$; $-(CH_2)_{0-4}S(O)R^\circ$; $-N(R^\circ)S(O)_2NR^\circ_2$; $-N(R^\circ)S(O)_2R^\circ$; $-N(OR^\circ)R^\circ$; $-C(NH)NR^\circ_2$; $-P(O)_2R^\circ$; $-P(O)R^\circ_2$; $-OP(O)R^\circ_2$; $-OP(O)(OR^\circ)_2$; SiR°_3 ; $-(C_{1-4}$ straight or branched alkylene) $O-N(R^\circ)_2$; or $-(C_{1-4}$ straight or branched alkylene) $C(O)O-N(R^\circ)_2$, wherein each R° may be substituted as defined below and is independently hydrogen, C_{1-6} aliphatic, $-CH_2Ph$, $-O(CH_2)_{0-1}Ph$, $-CH_2$ -(5-6 membered heteroaryl ring), or a 5-6-membered saturated,

partially unsaturated, or aryl ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur, or, notwithstanding the definition above, two independent occurrences of R° , taken together with their intervening atom(s), form a 3-12-membered saturated, partially unsaturated, or aryl mono— or bicyclic ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur, which may be substituted as defined below.

Suitable monovalent substituents on R° (or the ring formed by taking two independent occurrences of R° together with their intervening atoms), are independently halogen, $-(CH_2)_{0-2}R^\bullet$, $-(haloR^\bullet)$, $-(CH_2)_{0-2}OH$, $-(CH_2)_{0-2}O_2OR^\bullet$, $-(CH_2)_{0-2}CH(OR^\bullet)_2$; $-O(haloR^\bullet)$, $-CN$, $-N_3$, $-(CH_2)_{0-2}C(O)R^\bullet$, $-(CH_2)_{0-2}C(O)OH$, $-(CH_2)_{0-2}C(O)OR^\bullet$, $-(CH_2)_{0-2}SR^\bullet$, $-(CH_2)_{0-2}SH$, $-(CH_2)_{0-2}NH_2$, $-(CH_2)_{0-2}NHR^\bullet$, $-(CH_2)_{0-2}NR^\bullet_2$, $-NO_2$, $-SiR^\bullet_3$, $-OSiR^\bullet_3$, $-C(O)SR$, $-(C_{1-4} \text{ straight or branched alkylene})C(O)OR$; or $-SSR^\bullet$ wherein each $R^\bullet$ is unsubstituted or where preceded by "halo" is substituted only with one or more halogens, and is independently selected from C_{1-4} aliphatic, $-CH_2Ph$, $-O(CH_2)_{0-1}Ph$, or a 5-6-membered saturated, partially unsaturated, or aryl ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur. Suitable divalent substituents on a saturated carbon atom of R° include $=O$ and $=S$.

Suitable divalent substituents on a saturated carbon atom of an "optionally substituted" group include the following: $=O$, $=S$, $=NNR^*_2$, $=NNHC(O)R^*$, $=NNHC(O)OR^*$, $=NNHS(O)_2R^*$, $=NR^*$, $=NOR^*$, $-O(C(R^*_2))_{2-3}O-$, or $-S(C(R^*_2))_{2-3}S-$, wherein each independent occurrence of R^* is selected from hydrogen, C_{1-6} aliphatic which may be substituted as defined below, or an unsubstituted 5-6—membered saturated, partially unsaturated, or aryl ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur. Suitable divalent substituents that are bound to vicinal substitutable carbons of an "optionally substituted" group include: $-O(CR^*_2)_{2-3}O-$, wherein each independent occurrence of R^* is selected from hydrogen, C_{1-6} aliphatic which may be substituted as defined below, or an unsubstituted 5-6—membered saturated, partially unsaturated, or aryl ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur.

Suitable substituents on the aliphatic group of R^* include halogen, $-R^\bullet$, $-(haloR^\bullet)$, $-OH$, $-OR^\bullet$, $-O(haloR^\bullet)$, $-CN$, $-C(O)OH$, $-C(O)OR^\bullet$, $-NH_2$, $-NHR^\bullet$, $-NR^\bullet_2$, or $-NO_2$, wherein each $R^\bullet$ is unsubstituted or where preceded by "halo" is substituted only with one or more halogens, and is independently C_{1-4} aliphatic, $-CH_2Ph$, $-O(CH_2)_{0-1}Ph$, or a 5-6—membered saturated, partially unsaturated, or aryl ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur.

Suitable substituents on a substitutable nitrogen of an "optionally substituted" group include $\text{—R}^\dagger$, $\text{—NR}^\dagger_2$, $\text{—C(O)R}^\dagger$, $\text{—C(O)OR}^\dagger$, $\text{—C(O)C(O)R}^\dagger$, $\text{—C(O)CH}_2\text{C(O)R}^\dagger$, $\text{—S(O)}_2\text{R}^\dagger$, $\text{—S(O)}_2\text{NR}^\dagger_2$, $\text{—C(S)NR}^\dagger_2$, $\text{—C(NH)NR}^\dagger_2$, or $\text{—N(R}^\dagger\text{)S(O)}_2\text{R}^\dagger$; wherein each $\text{R}^\dagger$ is independently hydrogen, C_{1-6} aliphatic which may be substituted as defined below, unsubstituted —OPh , or an unsubstituted 5-6—membered saturated, partially unsaturated, or aryl ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur, or, notwithstanding the definition above, two independent occurrences of $\text{R}^\dagger$, taken together with their intervening atom(s) form an unsubstituted 3-12—membered saturated, partially unsaturated, or aryl mono— or bicyclic ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur.

Suitable substituents on the aliphatic group of $\text{R}^\dagger$ are independently halogen, $\text{—R}^\bullet$, $\text{—(haloR}^\bullet\text{)}$, —OH , $\text{—OR}^\bullet$, $\text{—O(haloR}^\bullet\text{)}$, —CN , —C(O)OH , $\text{—C(O)OR}^\bullet$, —NH_2 , $\text{—NHR}^\bullet$, $\text{—NR}^\bullet_2$, or —NO_2 , wherein each $\text{R}^\bullet$ is unsubstituted or where preceded by "halo" is substituted only with one or more halogens, and is independently C_{1-4} aliphatic, $\text{—CH}_2\text{Ph}$, $\text{—O(CH}_2\text{)}_{0-1}\text{Ph}$, or a 5-6—membered saturated, partially unsaturated, or aryl ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur.

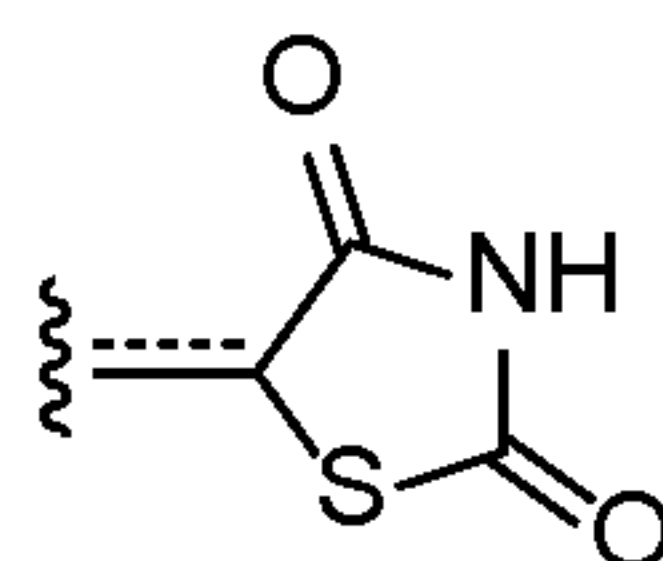
The term "leaving group" refers to an atom (or a group of atoms) with electron withdrawing ability that can be displaced as a stable species, taking with it the bonding electrons. Examples of suitable leaving groups include halides and sulfonate esters, including, but not limited to, triflate, mesylate, tosylate, and brosylate.

The terms "hydrolysable group" and "hydrolysable moiety" refer to a functional group capable of undergoing hydrolysis, e.g., under basic or acidic conditions. Examples of hydrolysable residues include, without limitation, acid halides, activated carboxylic acids, and various protecting groups known in the art (see, for example, "Protective Groups in Organic Synthesis," T. W. Greene, P. G. M. Wuts, Wiley-Interscience, 1999).

The term "organic residue" defines a carbon containing residue, i.e., a residue comprising at least one carbon atom, and includes but is not limited to the carbon-containing groups, residues, or radicals defined hereinabove. Organic residues can contain various heteroatoms, or be bonded to another molecule through a heteroatom, including oxygen, nitrogen, sulfur, phosphorus, or the like. Examples of organic residues include but are not limited alkyl or substituted alkyls, alkoxy or substituted alkoxy, mono or di-substituted amino, amide groups, etc. Organic residues can preferably comprise 1 to 18 carbon atoms, 1 to 15, carbon atoms, 1 to 12 carbon atoms, 1 to 8 carbon atoms, 1 to 6 carbon atoms, or 1 to 4 carbon atoms. In some examples, an organic residue can comprise 2 to 18 carbon atoms, 2 to 15,

carbon atoms, 2 to 12 carbon atoms, 2 to 8 carbon atoms, 2 to 4 carbon atoms, or 2 to 4 carbon atoms.

A very close synonym of the term "residue" is the term "radical," which as used in the specification and concluding claims, refers to a fragment, group, or substructure of a molecule described herein, regardless of how the molecule is prepared. For example, a 2,4-thiazolidinedione radical in a particular compound has the structure

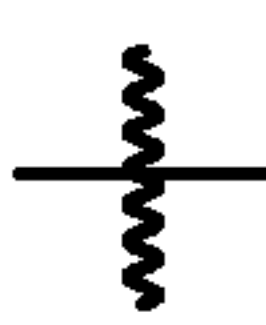


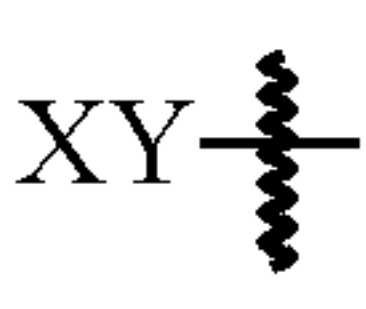
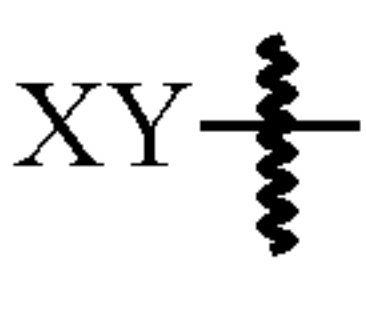
regardless of whether thiazolidinedione is used to prepare the compound. In some embodiments the radical (for example an alkyl) can be further modified (i.e., substituted alkyl) by having bonded thereto one or more "substituent radicals." The number of atoms in a given radical is not critical to the compounds and compositions disclosed herein unless it is indicated to the contrary elsewhere herein.

"Organic radicals," as the term is defined and used herein, contain one or more carbon atoms. An organic radical can have, for example, 1-26 carbon atoms, 1-18 carbon atoms, 1-12 carbon atoms, 1-8 carbon atoms, 1-6 carbon atoms, or 1-4 carbon atoms. In some examples, an organic radical can have 2-26 carbon atoms, 2-18 carbon atoms, 2-12 carbon atoms, 2-8 carbon atoms, 2-6 carbon atoms, or 2-4 carbon atoms. Organic radicals often have hydrogen bound to at least some of the carbon atoms of the organic radical. One example, of an organic radical that comprises no inorganic atoms is a 5, 6, 7, 8-tetrahydro-2-naphthyl radical. In some embodiments, an organic radical can contain 1-10 inorganic heteroatoms bound thereto or therein, including halogens, oxygen, sulfur, nitrogen, phosphorus, and the like. Examples of organic radicals include but are not limited to an alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, mono-substituted amino, di-substituted amino, acyloxy, cyano, carboxy, carboalkoxy, alkylcarboxamide, substituted alkylcarboxamide, dialkylcarboxamide, substituted dialkylcarboxamide, alkylsulfonyl, alkylsulfinyl, thioalkyl, thiohaloalkyl, alkoxy, substituted alkoxy, haloalkyl, haloalkoxy, aryl, substituted aryl, heteroaryl, heterocyclic, or substituted heterocyclic radicals, wherein the terms are defined elsewhere herein. A few non-limiting examples of organic radicals that include heteroatoms include alkoxy radicals, trifluoromethoxy radicals, acetoxy radicals, dimethylamino radicals and the like.

"Inorganic radicals," as the term is defined and used herein, contain no carbon atoms and therefore comprise only atoms other than carbon. Inorganic radicals comprise bonded combinations of atoms selected from hydrogen, nitrogen, oxygen, silicon, phosphorus, sulfur,

selenium, and halogens such as fluorine, chlorine, bromine, and iodine, which can be present individually or bonded together in their chemically stable combinations. Inorganic radicals have 10 or fewer, or preferably one to six or one to four inorganic atoms as listed above bonded together. Examples of inorganic radicals include, but not limited to, amino, hydroxy, halogens, nitro, thiol, sulfate, phosphate, and like commonly known inorganic radicals. The inorganic radicals do not have bonded therein the metallic elements of the periodic table (such as the alkali metals, alkaline earth metals, transition metals, lanthanide metals, or actinide metals), although such metal ions can sometimes serve as a pharmaceutically acceptable cation for anionic inorganic radicals such as a sulfate, phosphate, or like anionic inorganic radical. Inorganic radicals do not comprise metalloids elements such as boron, aluminum, gallium, germanium, arsenic, tin, lead, or tellurium, or the noble gas elements, unless otherwise specifically indicated elsewhere herein.

As used herein, the symbol “” (hereinafter can be referred to as “a point of attachment bond”) denotes a bond that is a point of attachment between two chemical entities, one of which is depicted as being attached to the point of attachment bond and the other of which is not depicted as being attached to the point of attachment bond. For example,

“” indicates that the chemical entity “XY” is bonded to another chemical entity via the point of attachment bond. Furthermore, the specific point of attachment to the non-depicted chemical entity can be specified by inference. For example, the compound $\text{CH}_3\text{-R}^3$, wherein R^3 is H or “” infers that when R^3 is “XY”, the point of attachment bond is the same bond as the bond by which R^3 is depicted as being bonded to CH_3 .

Compounds described herein can contain one or more double bonds and, thus, potentially give rise to cis/trans (E/Z) isomers, as well as other conformational isomers. Unless stated to the contrary, the compounds and compositions disclosed herein include all such possible isomers, as well as mixtures of such isomers.

Unless stated to the contrary, a formula with chemical bonds shown only as solid lines and not as wedges or dashed lines contemplates each possible isomer, *e.g.*, each enantiomer and diastereomer, and a mixture of isomers, such as a racemic or scalemic mixture. Compounds described herein can contain one or more asymmetric centers and, thus, potentially give rise to diastereomers and optical isomers. Unless stated to the contrary, the

compounds and compositions disclosed herein include all such possible diastereomers as well as their racemic mixtures, their substantially pure resolved enantiomers, all possible geometric isomers, and pharmaceutically acceptable salts thereof. Mixtures of stereoisomers, as well as isolated specific stereoisomers, are also included. During the course of the synthetic procedures used to prepare such compounds, or in using racemization or epimerization procedures known to those skilled in the art, the products of such procedures can be a mixture of stereoisomers.

Many organic compounds exist in optically active forms having the ability to rotate the plane of plane-polarized light. In describing an optically active compound, the prefixes D and L or R and S are used to denote the absolute configuration of the molecule about its chiral center(s). The prefixes d and l or (+) and (-) are employed to designate the sign of rotation of plane-polarized light by the compound, with (-) or meaning that the compound is levorotatory. A compound prefixed with (+) or d is dextrorotatory. For a given chemical structure, these compounds, called stereoisomers, are identical except that they are non-superimposable mirror images of one another. A specific stereoisomer can also be referred to as an enantiomer, and a mixture of such isomers is often called an enantiomeric mixture. A 50:50 mixture of enantiomers is referred to as a racemic mixture. Many of the compounds described herein can have one or more chiral centers and therefore can exist in different enantiomeric forms. If desired, a chiral carbon can be designated with an asterisk (*). When bonds to the chiral carbon are depicted as straight lines in the disclosed formulas, it is understood that both the (R) and (S) configurations of the chiral carbon, and hence both enantiomers and mixtures thereof, are embraced within the formula. As is used in the art, when it is desired to specify the absolute configuration about a chiral carbon, one of the bonds to the chiral carbon can be depicted as a wedge (bonds to atoms above the plane) and the other can be depicted as a series or wedge of short parallel lines is (bonds to atoms below the plane). The Cahn-Ingold-Prelog system can be used to assign the (R) or (S) configuration to a chiral carbon.

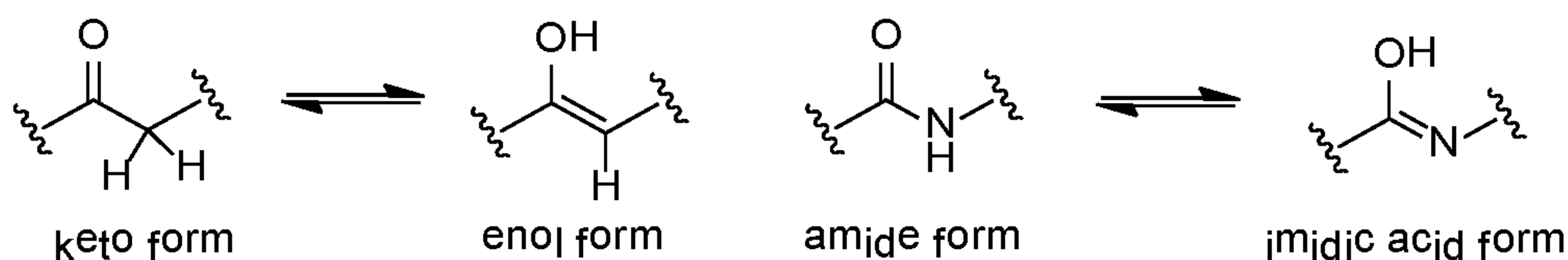
Compounds described herein comprise atoms in both their natural isotopic abundance and in non-natural abundance. The disclosed compounds can be isotopically-labelled or isotopically-substituted compounds identical to those described, but for the fact that one or more atoms are replaced by an atom having an atomic mass or mass number different from the atomic mass or mass number typically found in nature. Examples of isotopes that can be incorporated into compounds disclosed herein include isotopes of hydrogen, carbon, nitrogen,

oxygen, phosphorous, fluorine and chlorine, such as ^2H , ^3H , ^{13}C , ^{14}C , ^{15}N , ^{18}O , ^{17}O , ^{35}S , ^{18}F and ^{36}Cl respectively. Compounds further comprise prodrugs thereof, and pharmaceutically acceptable salts of said compounds or of said prodrugs which contain the aforementioned isotopes and/or other isotopes of other atoms are within the scope of this invention. Certain isotopically-labeled compounds, for example those into which radioactive isotopes such as ^3H and ^{14}C are incorporated, are useful in drug and/or substrate tissue distribution assays. Tritiated, i.e., ^3H , and carbon-14, i.e., ^{14}C , isotopes are particularly preferred for their ease of preparation and detectability. Further, substitution with heavier isotopes such as deuterium, i.e., ^2H , can afford certain therapeutic advantages resulting from greater metabolic stability, for example increased in vivo half-life or reduced dosage requirements and, hence, may be preferred in some circumstances. Isotopically labeled compounds and prodrugs thereof can generally be prepared by carrying out the procedures below, by substituting a readily available isotopically labeled reagent for a non- isotopically labeled reagent.

The compounds described herein can be present as a solvate. In some cases, the solvent used to prepare the solvate is an aqueous solution, and the solvate is then often referred to as a hydrate. The compounds can be present as a hydrate, which can be obtained, for example, by crystallization from a solvent or from aqueous solution. In this connection, one, two, three or any arbitrary number of solvate or water molecules can combine with the compounds disclosed herein to form solvates and hydrates. Unless stated to the contrary, all such possible solvates are included in the discussion herein.

The term "co-crystal" means a physical association of two or more molecules which owe their stability through non-covalent interaction. One or more components of this molecular complex provide a stable framework in the crystalline lattice. In certain instances, the guest molecules are incorporated in the crystalline lattice as anhydrides or solvates, see e.g. "Crystal Engineering of the Composition of Pharmaceutical Phases. Do Pharmaceutical Co-crystals Represent a New Path to Improved Medicines?" Almarasson, O., et. al., The Royal Society of Chemistry, 1889-1896, 2004. Examples of co-crystals include p-toluenesulfonic acid and benzenesulfonic acid.

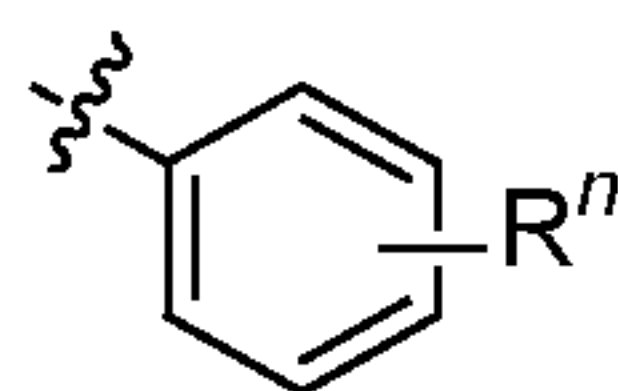
It is also appreciated that certain compounds described herein can be present as an equilibrium of tautomers. For example, ketones with an α -hydrogen can exist in an equilibrium of the keto form and the enol form.



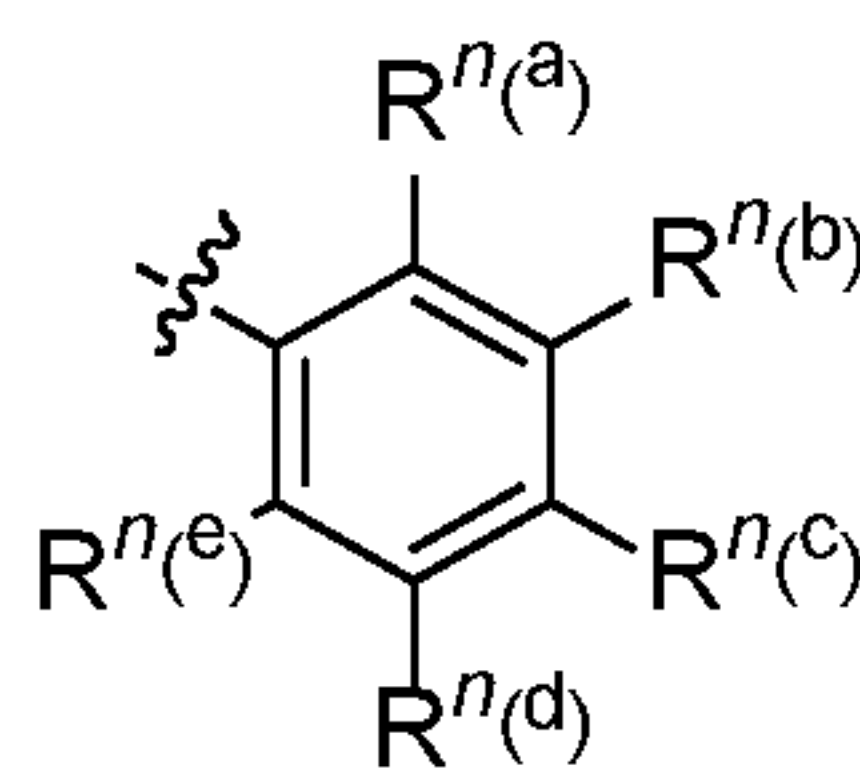
Likewise, amides with an N-hydrogen can exist in an equilibrium of the amide form and the imidic acid form. Unless stated to the contrary, all such possible tautomers are included herein.

- 5 It is known that chemical substances form solids which are present in different states of order which are termed polymorphic forms or modifications. The different modifications of a polymorphic substance can differ greatly in their physical properties. The compounds can be present in different polymorphic forms, with it being possible for particular modifications to be metastable. Unless stated to the contrary, all such possible polymorphic
- 10 forms are included.

In some examples, a structure of a compound can be represented by a formula:



which is understood to be equivalent to a formula:



- 15 wherein n is typically an integer. That is, R^n is understood to represent five independent substituents, $R^{(a)}$, $R^{(b)}$, $R^{(c)}$, $R^{(d)}$, $R^{(e)}$. By "independent substituents," it is meant that each R substituent can be independently defined. For example, if in one instance $R^{(a)}$ is halogen, then $R^{(b)}$ is not necessarily halogen in that instance.

- 20 Certain materials, compounds, compositions, and components disclosed herein can be obtained commercially or readily synthesized using techniques generally known to those of skill in the art. For example, the starting materials and reagents used in preparing the disclosed compounds and compositions are either available from commercial suppliers such as Aldrich Chemical Co., (Milwaukee, Wis.), Acros Organics (Morris Plains, N.J.), Fisher Scientific (Pittsburgh, Pa.), or Sigma (St. Louis, Mo.) or are prepared by methods known to
- 25 those skilled in the art following procedures set forth in references such as Fieser and Fieser's Reagents for Organic Synthesis, Volumes 1-17 (John Wiley and Sons, 1991); Rodd's Chemistry of Carbon Compounds, Volumes 1-5 and Supplementals (Elsevier Science

Publishers, 1989); Organic Reactions, Volumes 1-40 (John Wiley and Sons, 1991); March's Advanced Organic Chemistry, (John Wiley and Sons, 4th Edition); and Larock's Comprehensive Organic Transformations (VCH Publishers Inc., 1989).

Unless otherwise expressly stated, it is in no way intended that any method set forth
5 herein be construed as requiring that its steps be performed in a specific order. Accordingly, where a method claim does not actually recite an order to be followed by its steps or it is not otherwise specifically stated in the claims or descriptions that the steps are to be limited to a specific order, it is no way intended that an order be inferred, in any respect. This holds for
10 any possible non-express basis for interpretation, including: matters of logic with respect to arrangement of steps or operational flow; plain meaning derived from grammatical organization or punctuation; and the number or type of embodiments described in the specification.

Disclosed are the components to be used to prepare the compositions disclosed herein as well as the compositions themselves to be used within the methods disclosed herein. These
15 and other materials are disclosed herein, and it is understood that when combinations, subsets, interactions, groups, etc. of these materials are disclosed that while specific reference of each various individual and collective combinations and permutation of these compounds cannot be explicitly disclosed, each is specifically contemplated and described herein. For example, if a particular compound is disclosed and discussed and a number of modifications that can be
20 made to a number of molecules including the compounds are discussed, specifically contemplated is each and every combination and permutation of the compound and the modifications that are possible unless specifically indicated to the contrary. Thus, if a class of molecules A, B, and C are disclosed as well as a class of molecules D, E, and F and an example of a combination molecule, A-D is disclosed, then even if each is not individually recited each
25 is individually and collectively contemplated meaning combinations, A-E, A-F, B-D, B-E, B-F, C-D, C-E, and C-F are considered disclosed. Likewise, any subset or combination of these is also disclosed. Thus, for example, the sub-group of A-E, B-F, and C-E would be considered disclosed. This concept applies to all aspects of this application including, but not limited to, steps in methods of making and using the compositions disclosed herein. Thus, if there are a
30 variety of additional steps that can be performed it is understood that each of these additional steps can be performed with any specific embodiment or combination of embodiments of the methods disclosed herein.

It is understood that the compositions disclosed herein have certain functions. Disclosed herein are certain structural requirements for performing the disclosed functions, and it is understood that there are a variety of structures that can perform the same function that are related to the disclosed structures, and that these structures will typically achieve the same result.

Abbreviations used herein are as follows: Cpa, L-4-chlorophenylalanine; dap, D-2,3-diaminopropionic acid; Dap, L-2,3-diaminopropionic acid; FITC, fluorescein isothiocyanate; Fpa, L-4-fluorophenylalanine; F₂pa, L-3,4-difluorophenylalanine; fpa, D-2-fluorophenylalanine; f₂pa, D-3,4-difluorophenylalanine; Nal, L-2-naphthylalanine; Nle, norleucine; Phg, L- α -phenylglycine; Sar, sarcosine; TNF α , tumor necrosis factor-alpha; TNFR, TNF α receptor.

Compounds

Cyclo(F Φ RRRRQ) (cF Φ R₄, where Φ is L-2-naphthylalanine (SEQ ID NO.:72)) was previously reported as a member of a class of cyclic CPPs (Z. Qian, et al., *ACS Chem. Biol.* 2013, 8, 423; Z. Qian, et al., *Biochemistry* 2014, 53, 4034). These CPPs bind directly to the membrane phospholipids, enter cells by endocytosis, and efficiently escape from the early endosome into the cytosol by inducing budding of small, unstable vesicles (Id.; Z. Qian, et al., *Biochemistry* 2016, 55, 2601). With a cytosolic delivery efficiency (defined as the ratio of cytosolic over extracellular cargo concentration) of 20%, cF Φ R₄ (SEQ ID NO.:72) is an order of magnitude more active than Tat, one of the most widely used CPPs (Id.). Most importantly, cF Φ R₄ (SEQ ID NO.:72) and other cyclic CPPs are capable of efficiently delivering a variety of cargo molecules including small molecules, peptides, and proteins into the cytosol of mammalian cells. For example, short peptidyl cargos were directly incorporated into the cF Φ R₄ (SEQ ID NO.:72) ring (endocyclic delivery) and the resulting cyclic peptides were cell-permeable (Id.; P. Upadhyaya, et al., *Angew. Chem., Int. Ed.* 2015, 54, 7602; *Angew. Chem.* 2015, 127, 7712). cF Φ R₄ (SEQ ID NO.:72) was also fused with 5.7 million different cyclic peptides to generate a library of cell-permeable bicyclic peptides (bicyclic delivery) (T. B. Trinh, P et al., *ACS Comb. Sci.* 2016, 18, 75). However, many peptide ligands must be in their extended conformations to be biologically active and are not compatible with the above cyclization approaches. To this end, a reversible cyclization strategy for intracellular delivery of linear peptidyl ligands was developed by fusing them with F Φ R₄ (SEQ ID NO.:72) and cyclizing the fusion peptides through a disulfide bond (Z. Qian, et al., *Angew. Chem. Int. Ed.* 2015, 54, 5874; *Angew. Chem.* 2015, 127, 5972). Unfortunately, the previous approach is

limited to relatively short peptides, as cyclization of longer peptides results in large rings, whose conformational flexibility limits the gains in metabolic stability and cell-permeability (Z. Qian, et al., *ACS Chem. Biol.* 2013, 8, 423; Z. Qian, et al., *Biochemistry* 2014, 53, 4034). Cyclization via an internal thiol-containing moieties (e.g., the AA^S groups disclosed herein) results in smaller rings and better cellular uptake, but leaves a portion of the peptidyl cargo in the linear form, which remains susceptible to proteolytic degradation. To overcome this limitation, disclosed herein is a reversible bicyclization strategy, which allows the entire CPP-cargo fusion to be converted into a bicyclic structure by the formation of a pair of disulfide bonds (**Figure 2**). When outside the cell, the peptide exists as a highly constrained bicycle, which possesses enhanced cell permeability and proteolytic stability. Upon entering the cytosol, the disulfide bonds are reduced by the intracellular glutathione (GSH) to produce the linear, biologically active peptide. The bicyclic system permits the formation of a small CPP ring for optimal cellular uptake and a separate cargo ring to accommodate peptides of different lengths.

In various embodiments, the reversible bicyclic peptides described herein comprise a first cyclic peptide sequence and a second cyclic peptide sequence. In some embodiments, the first cyclic peptide sequence comprises a cell-penetrating sequence (X_m). In other embodiments, the second cyclic peptide sequence comprises a cargo peptide sequence (X_n).

In some embodiments, X_m and X_n are fused. In some embodiments, the fusion occurs between the C-terminus of X_m and the N-terminus of X_n. In other embodiments, the fusion occurs between the N-terminus X_m and the C-terminus of X_n. In further embodiments, an amino acid or a linking moiety may be used to fuse X_m and X_n. In still other embodiments, the amino acid or a linking moiety used to fuse X_m and X_n forms at least one intramolecular disulfide bond, thereby forming the bicyclic peptide sequence. In further embodiments, the amino acid which fuses X_m and X_n is represented by AA^S. In other embodiments, the linking moiety may be represented by “L-J” in the formulae provided herein.

In some embodiments, X_m may be conjugated, directed or indirectly, to X_n. For example, in some embodiments, X_m may comprise at least two AA^S moieties, and X_n may comprise at least two AA^S moieties, and the X_m may be directly conjugated to X_n via two disulfide bonds formed between opposing AA^S residues on X_m and X_n, respectively. In other embodiments, the linking moiety is covalently bound a side chain of an amino acid in X_m, and X_n comprises at least two AA^S moieties, each of which form disulfide bonds with a linking moiety. Amino acids having side chains which are suitable for conjugating the linking moiety

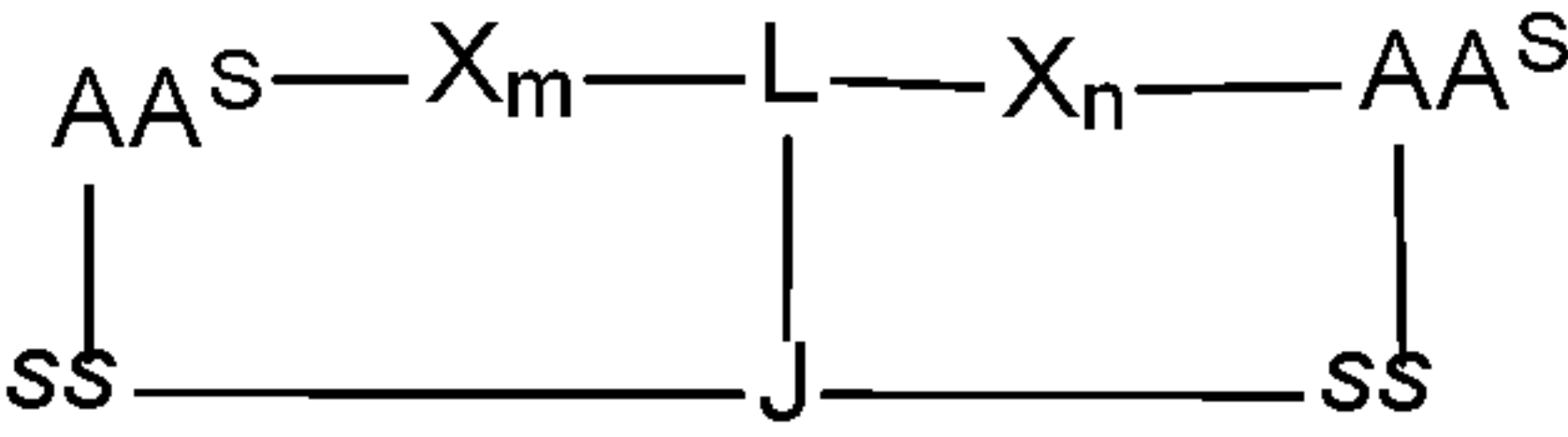
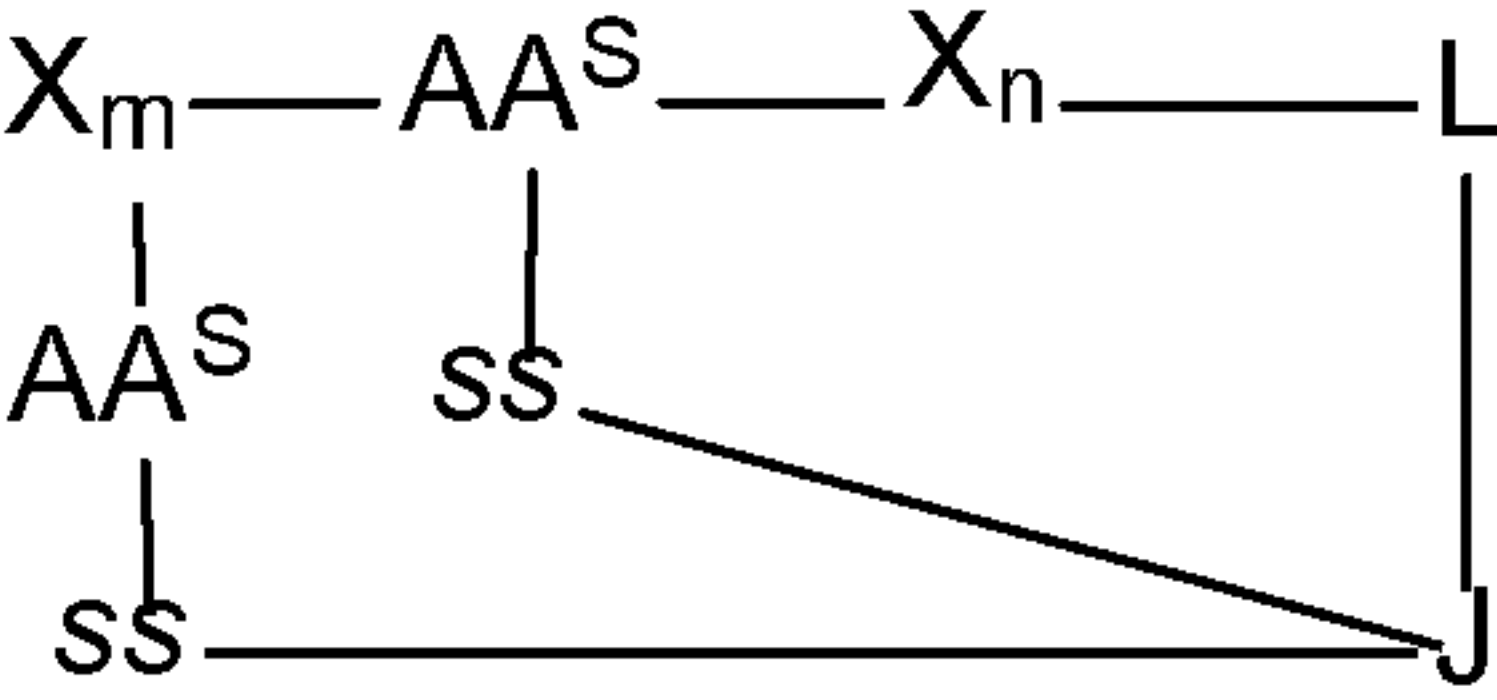
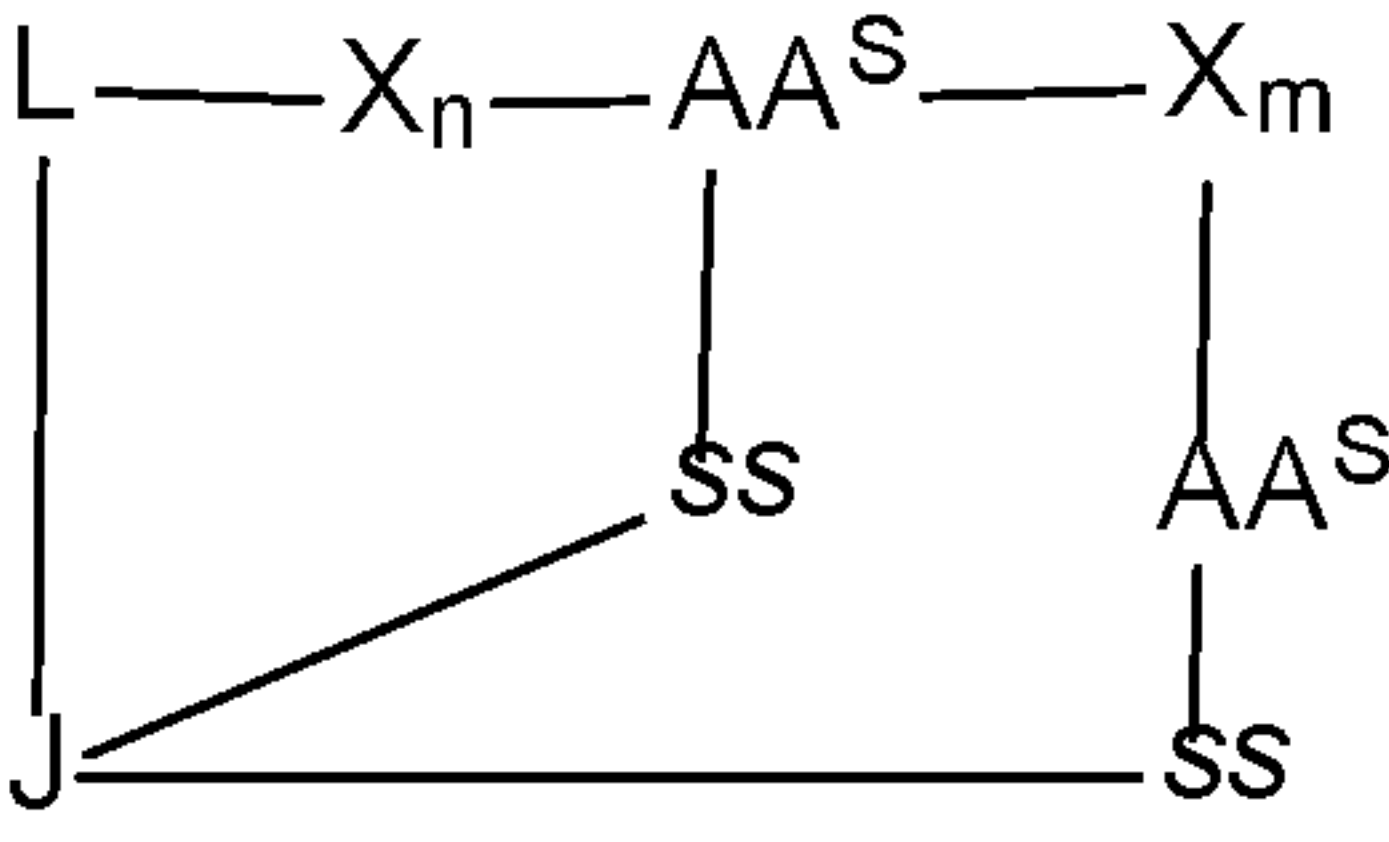
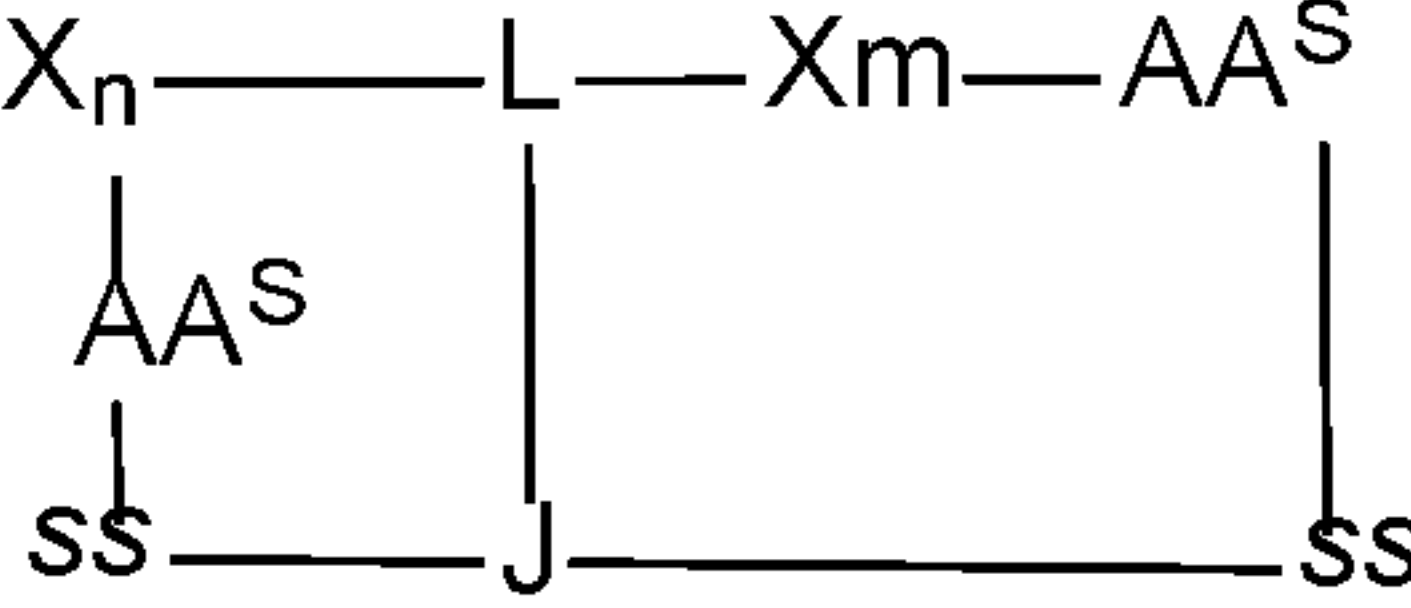
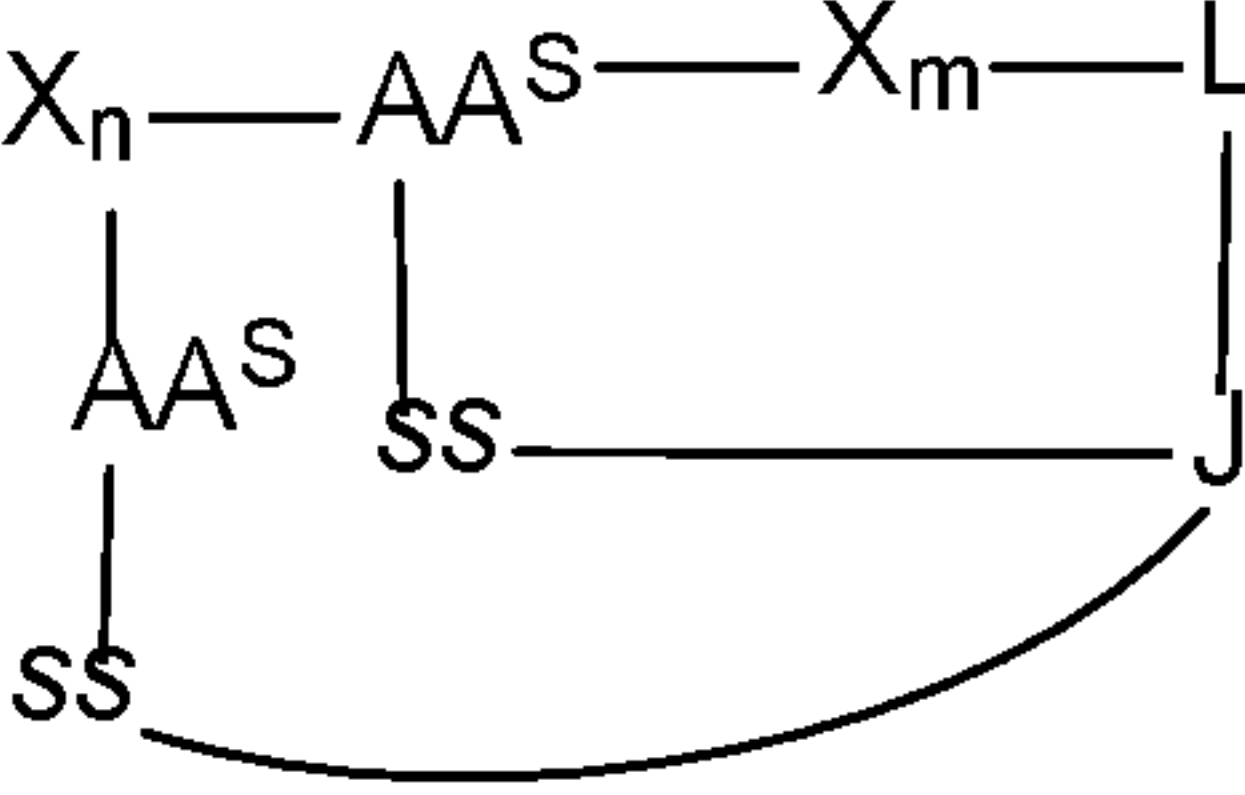
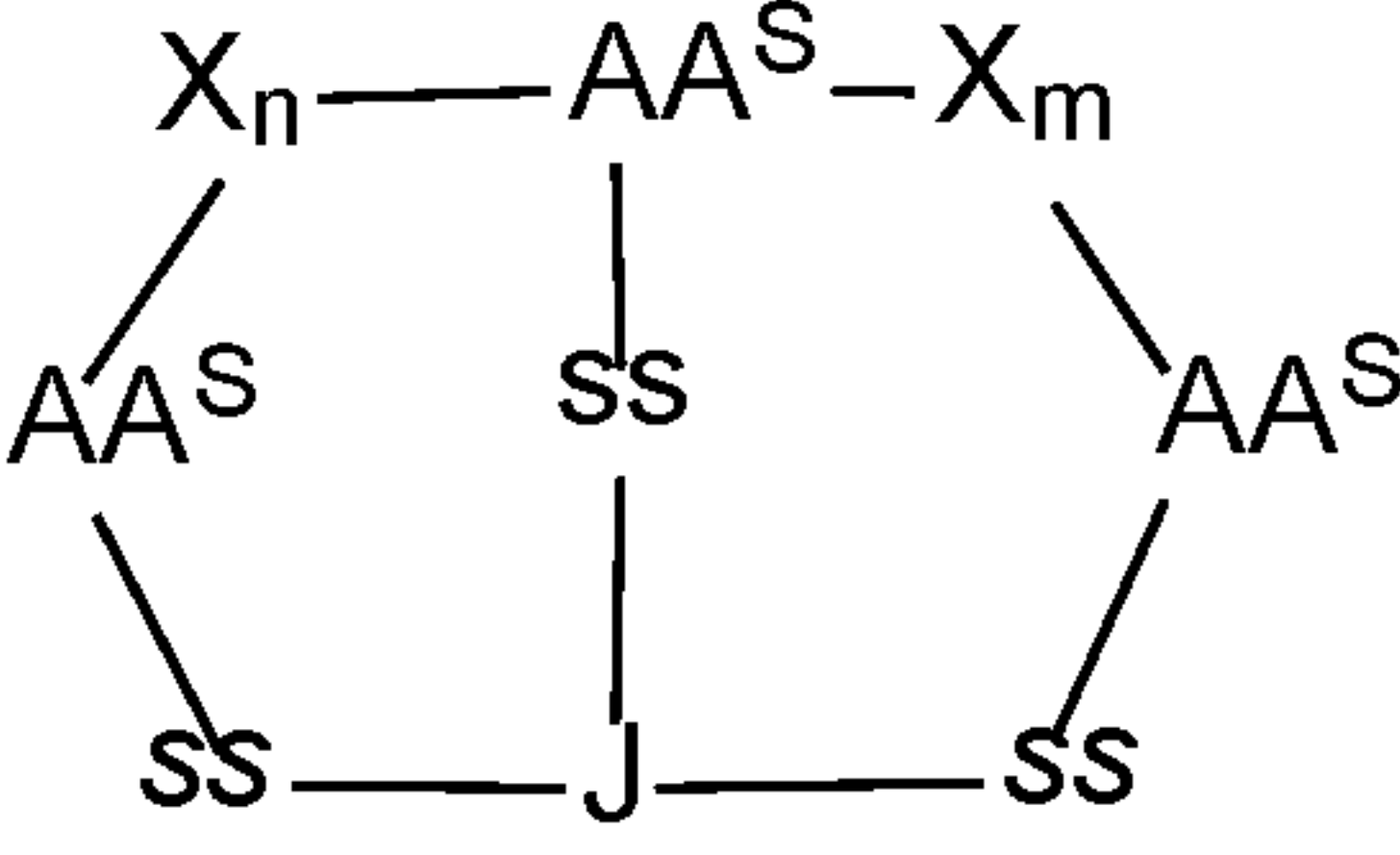
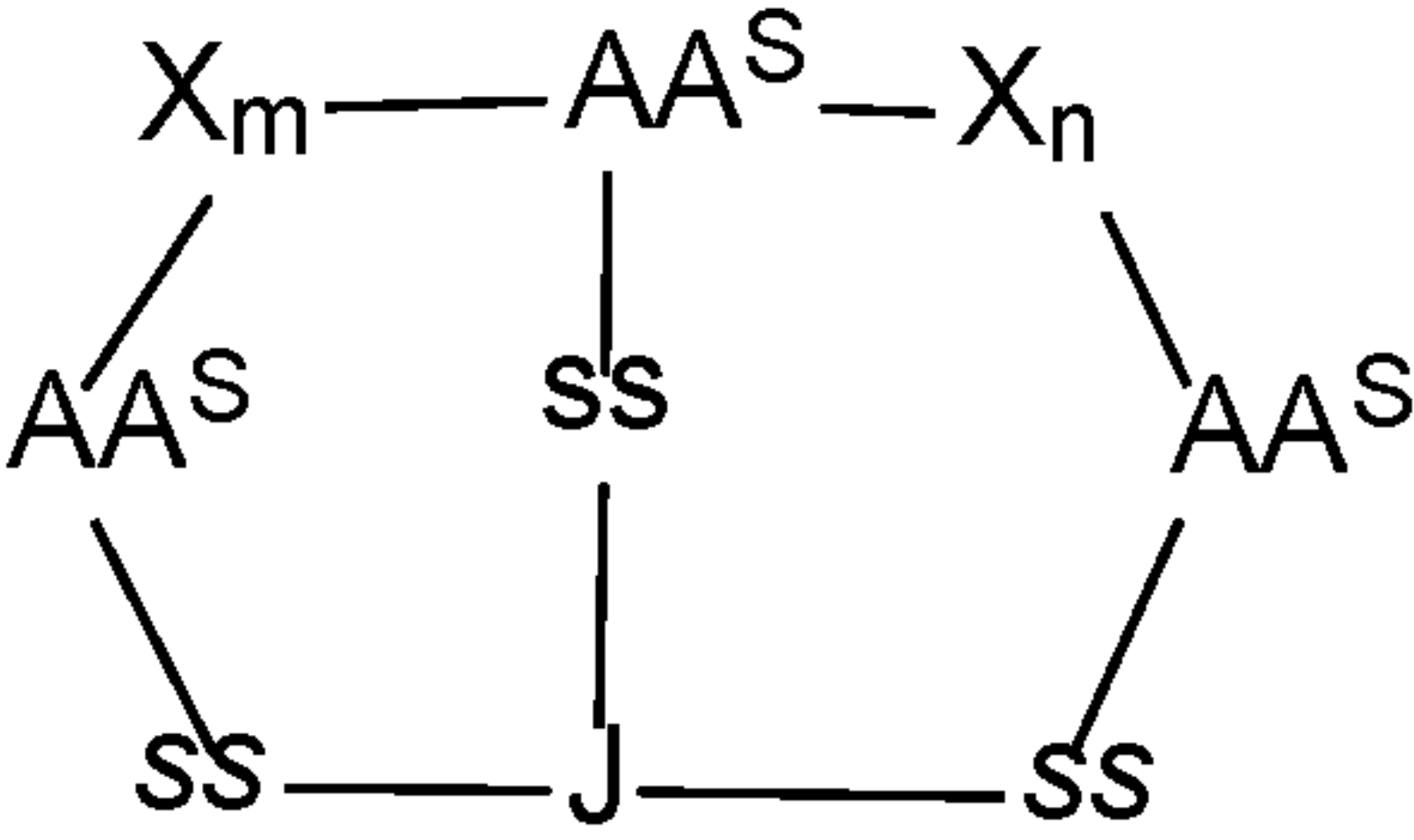
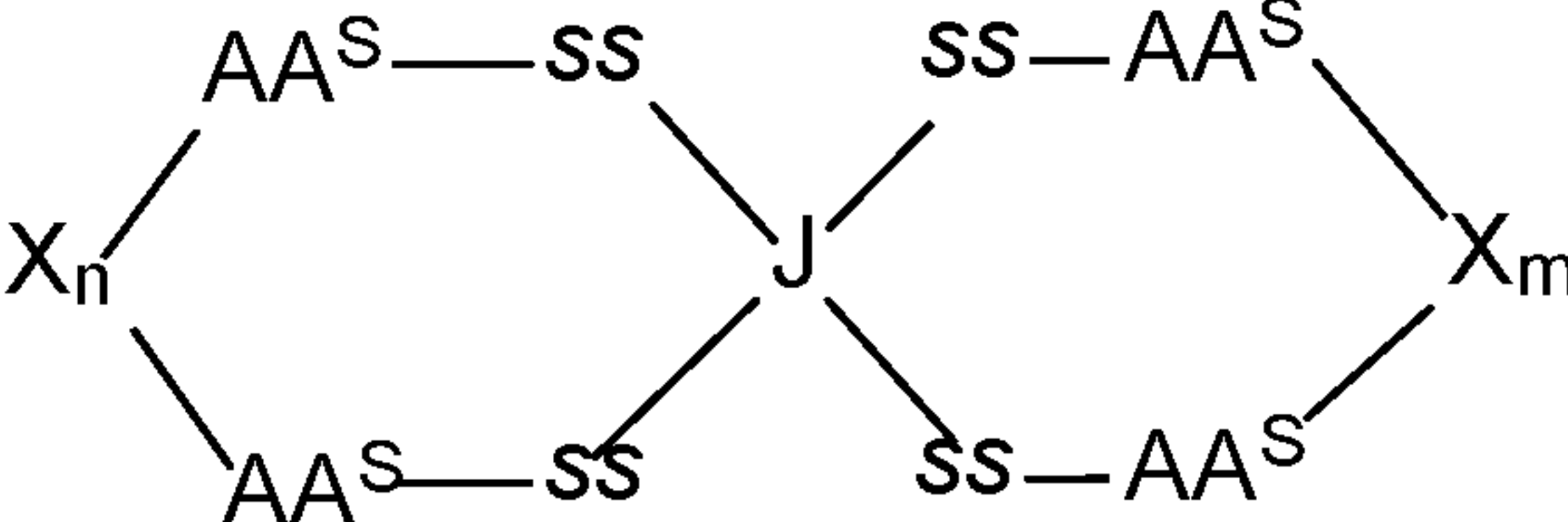
include asparagine, glutamine, aspartate, glutamate, and lysine. Further, amino acids may be appropriately modified for conjugation with the linking moiety.

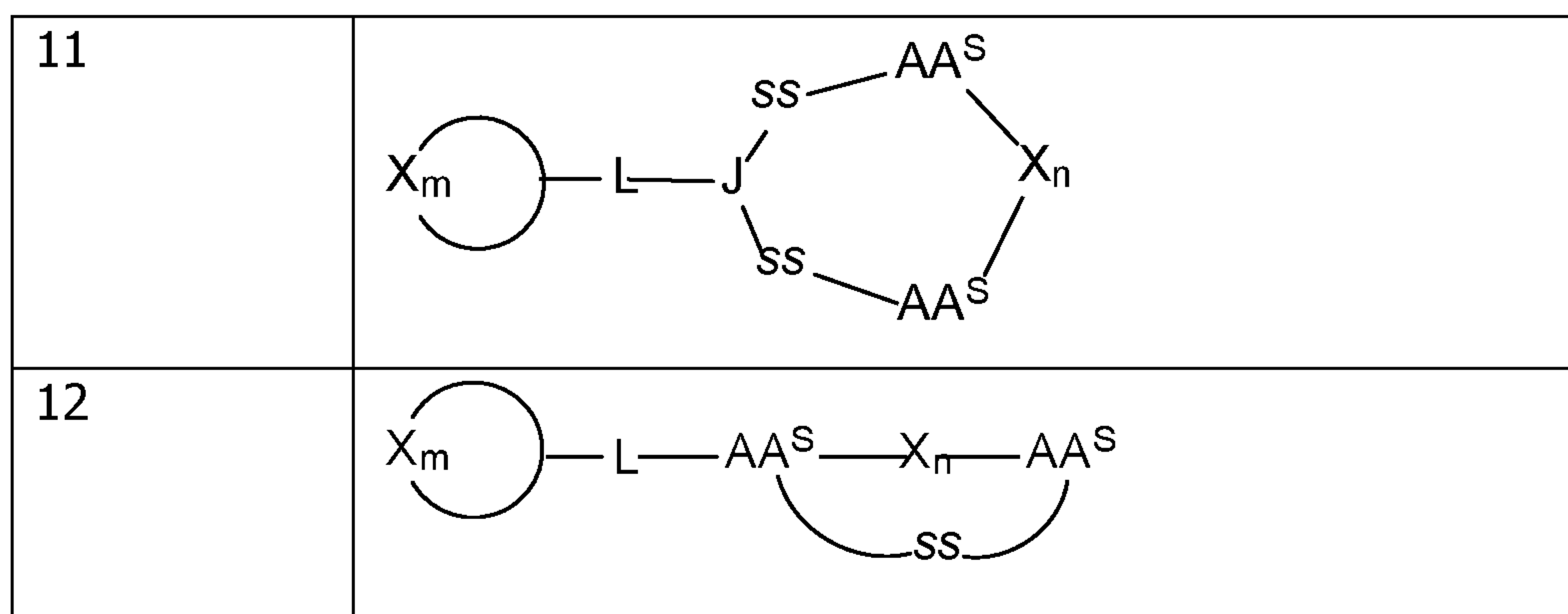
As discussed above, in some embodiments, the bicyclic peptides described herein comprise a linking moiety. In some embodiments, X_m is cyclized through a linking moiety. In other embodiments, X_n is cyclized through a linking moiety. In still other embodiments, each of X_m and X_n are independently cyclized through the linking moiety. In certain embodiments, only X_n is cyclized through a linking moiety, X_m is a cyclic peptide sequence, and the linking moiety conjugates X_n and X_m , thereby forming the bicyclic peptides disclosed herein.

In certain embodiments, the precursor to the linking moiety comprises at least two thiol groups which form at least two intramolecular disulfide bonds, thereby forming the bicyclic peptides disclosed herein. In these embodiments, the disulfide bonds can be reduced by intracellular GSH to form a linear peptide sequence comprising X_m and X_n , to release a linear sequence comprising X_m (in which case X_n remains cyclic), or a linear sequence comprising X_n (in which case X_m remains cyclic). In certain embodiments after entry into the cytosol of the cell the disulfide bonds are reduced by intracellular GSH to thereby release a linear sequence comprising X_n . In other embodiments, intracellular GSH reduces the two disulfide bonds to thereby release a linear sequence comprising X_m and X_n . In still other embodiments, a precursor to the linking moiety comprises three thiol groups, which form three intramolecular disulfide bonds in the bicyclic peptides disclosed herein. In still other embodiments, a precursor to the linking moiety comprises four thiol groups, which form four intramolecular disulfide bonds.

Accordingly, disclosed herein, in various embodiments, are bicyclic peptides according to Formulae 1-12.

Number	Formula
1	
2	

3	
4	
5	
6	
7	
8	
9	
10	



wherein:

X_m and X_n independently comprise a sequence of 1-50 (e.g., 4-10) natural or non-natural amino acids, wherein X_m corresponds to a cell-penetrating peptide (CPP) sequence as defined herein and X_n corresponds to a cargo peptide sequence as defined herein;

- 5 AA^S at each occurrence is independently a moiety which forms a disulfide bond with J;
 J is absent, or an alkyl, *N*-alkyl, alkenyl, alkynyl, carbocyclyl, or heterocyclyl, each of which are independently substituted with at least two substituents which independently form a disulfide bond with AA^S at each occurrence;

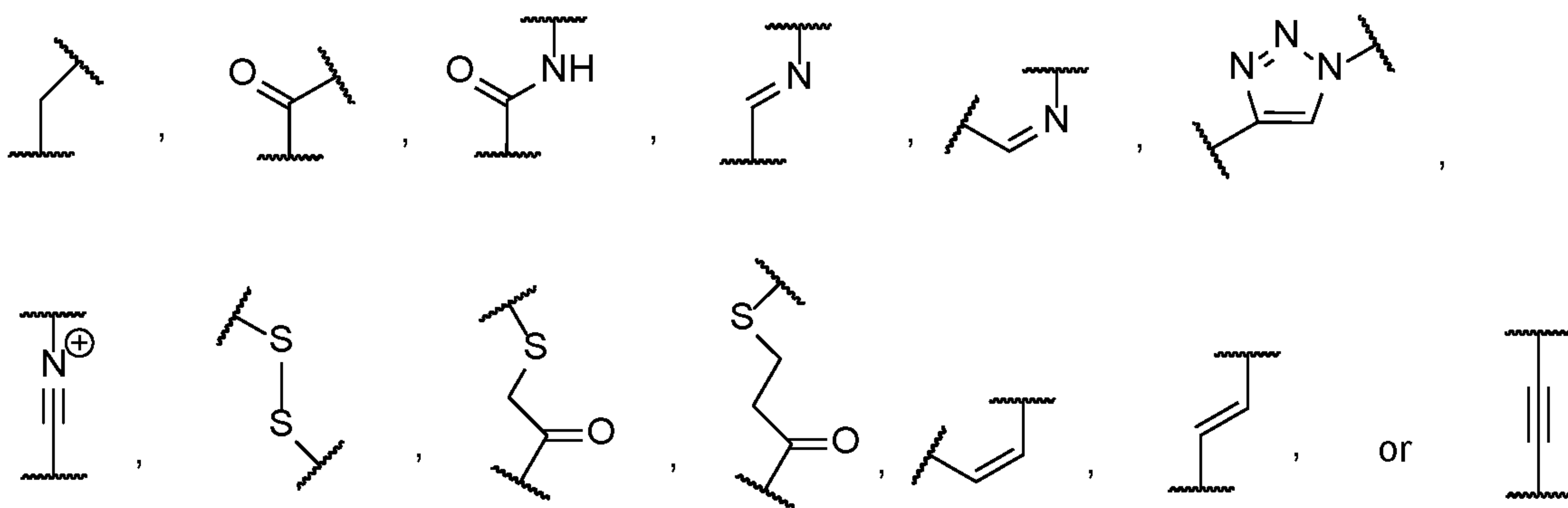
SS at each instance represents a disulfide bond; and

- 10 L is absent or a moiety which links AA^S to an amino acid in X_m , X_n , or a combination thereof.

As shown above in Formulae 1-12, X_n can be located on the N-terminus or C-terminus of X_m . In some embodiments, L is present and can be linked to the N-terminus or C-terminus of X_m , X_n , or AA^S . In other embodiments, L is present and can be located between and linked to each of X_m and X_n , X_m and AA^S , and/or X_n and AA^S . In some embodiments, one or more AA^S may be located in the X_n . In such embodiments, the AA^S may be a component of the wild type peptide sequence (i.e., X_n) or AA^S may be introduced into the peptide sequence (X_n). In some embodiments, the cargo peptide sequence (X_n) has two AA^S (e.g., Formula 11), which allows for the cargo peptide sequence to be cleaved from the CPP sequence after the compound enters the cytosol.

- 20 As used herein, "L" refers to a connection between J and X_m , X_n , or combinations thereof. For example, in embodiments, L may comprise a moiety which is formed between a functional group on a precursor of J and amine group on an amino acid (e.g., on X_m or X_n). The amine group may be the N-terminus or it may be an amine group on a side chain of an amino acid, e.g., on X_m . In such embodiments, the precursor of J can include a carboxylic acid moiety or derivative thereof (e.g., a haloketone), which thereby forms an amide bond with the N-terminus on the amino acid or cargo. In other embodiments, L may comprise a moiety which

is formed between a functional group on a precursor of J and a carboxylic acid group on an amino acid (e.g., on X_m or X_n). The carboxylic group may be the C-terminus or it may be an carboxylic acid group on a side chain of an amino acid, e.g., on X_m . In such embodiments, the precursor of J includes an amine, which thereby forms an amide bond with the C-terminus of the amino acid or the cargo. Non-limiting examples of L include at least one amino acid, alkyl, alkenyl, alkynyl, carbonyl, amide, imine, enamine, alkene, alkyne, disulfide, thioketone, sulfonylketone, carbamoyl, carbonyloxy, disulfide, thioether, and triazole. In embodiments, L is absent, an amino acid,



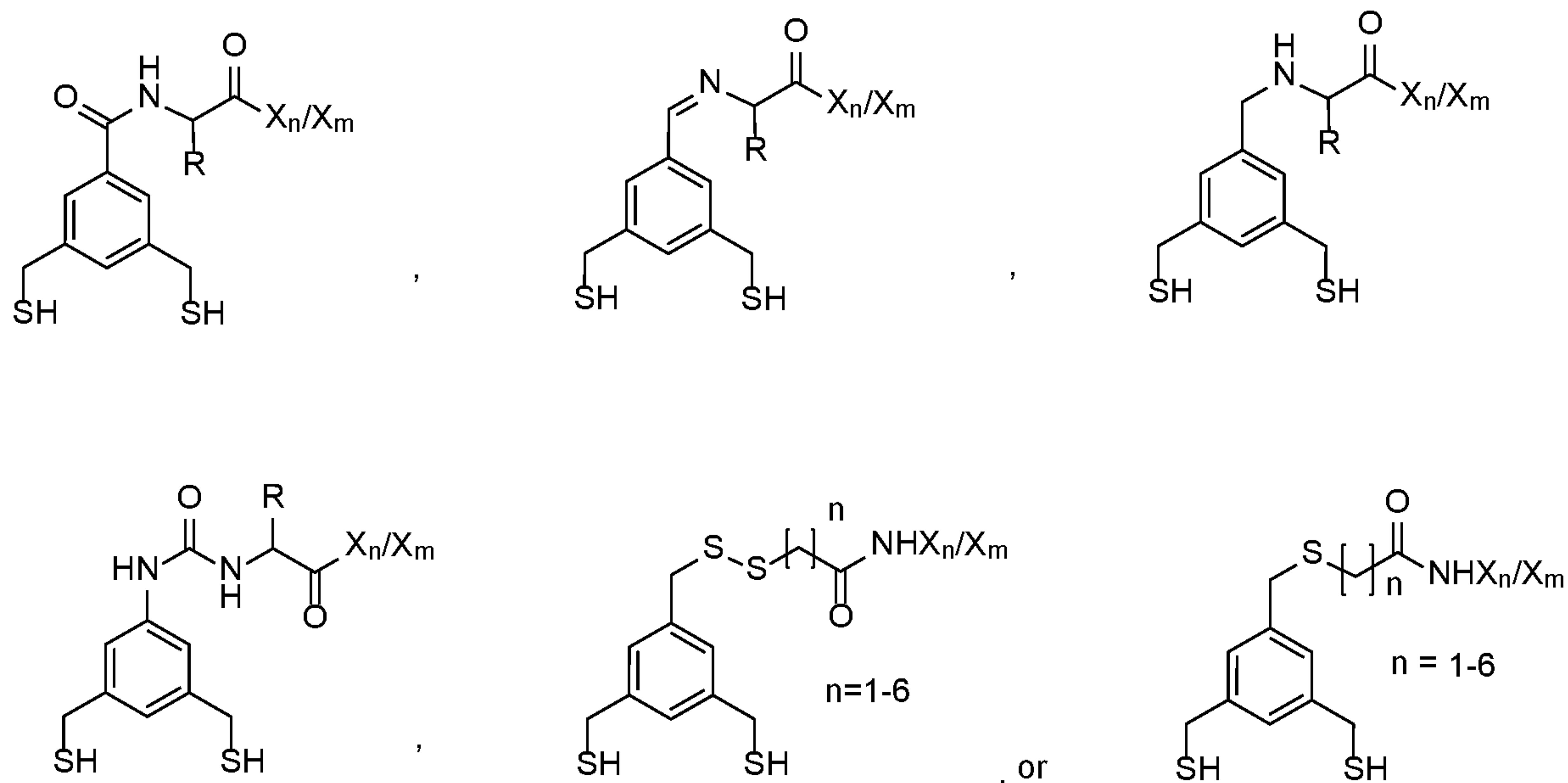
As defined above, in various embodiments, J may be an alkyl, *N*-alkyl, alkenyl, alkynyl, carbocyclyl, or heterocyclyl, each of which are independently substituted with at least two substituents which independently form a disulfide bond with AA^S at each occurrence. In some embodiments, J comprises at least two substituents which independently form a disulfide bond with AA^S at each occurrence. In other embodiments, J comprises at least three substituents which independently form a disulfide bond with AA^S at each occurrence. In still other embodiments, J comprises at least four substituents which independently form a disulfide bond with AA^S at each occurrence.

In some embodiments, L is absent, and J comprises three substituents which independently form a disulfide bond with AA^S at each occurrence. Examples of such a bicyclic peptide are provided in Formulae 8 and 9.

In other embodiments, L is absent, and J comprises at four substituents which independently form a disulfide bond with AA^S at each occurrence. An example of such a bicyclic peptide is provided in Formula 10.

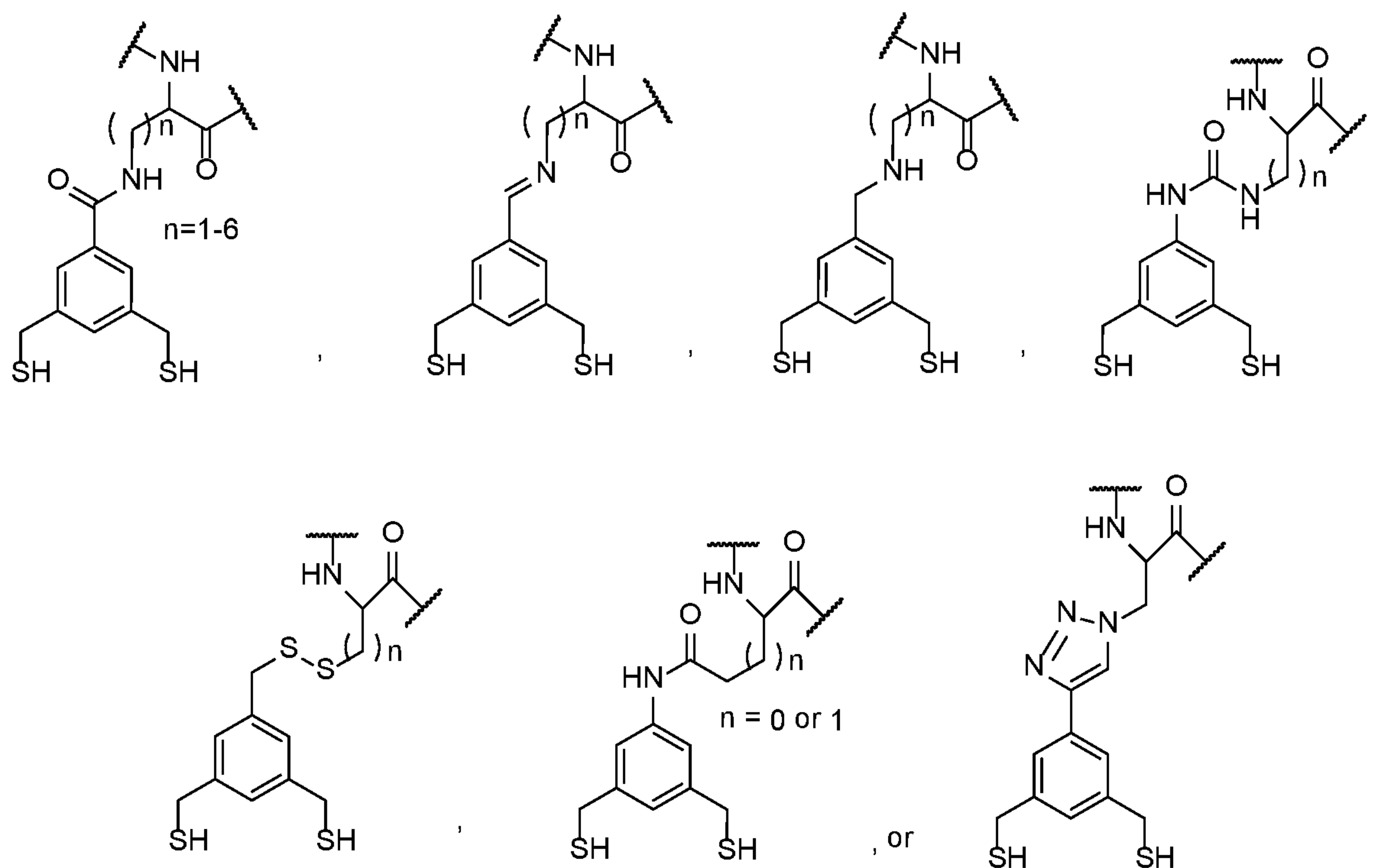
In some embodiments, J is absent, and L links X_m and AA^S .

In some embodiments, each of J and L are present. In some such embodiments, J and L can be located on the N-terminus of X_n or X_m and can be represented by at least one of the following (prior to forming disulfide bonds):



wherein R represents the side of an amino acid which can be part of the peptide sequence comprising X_m or X_n which can be part of L.

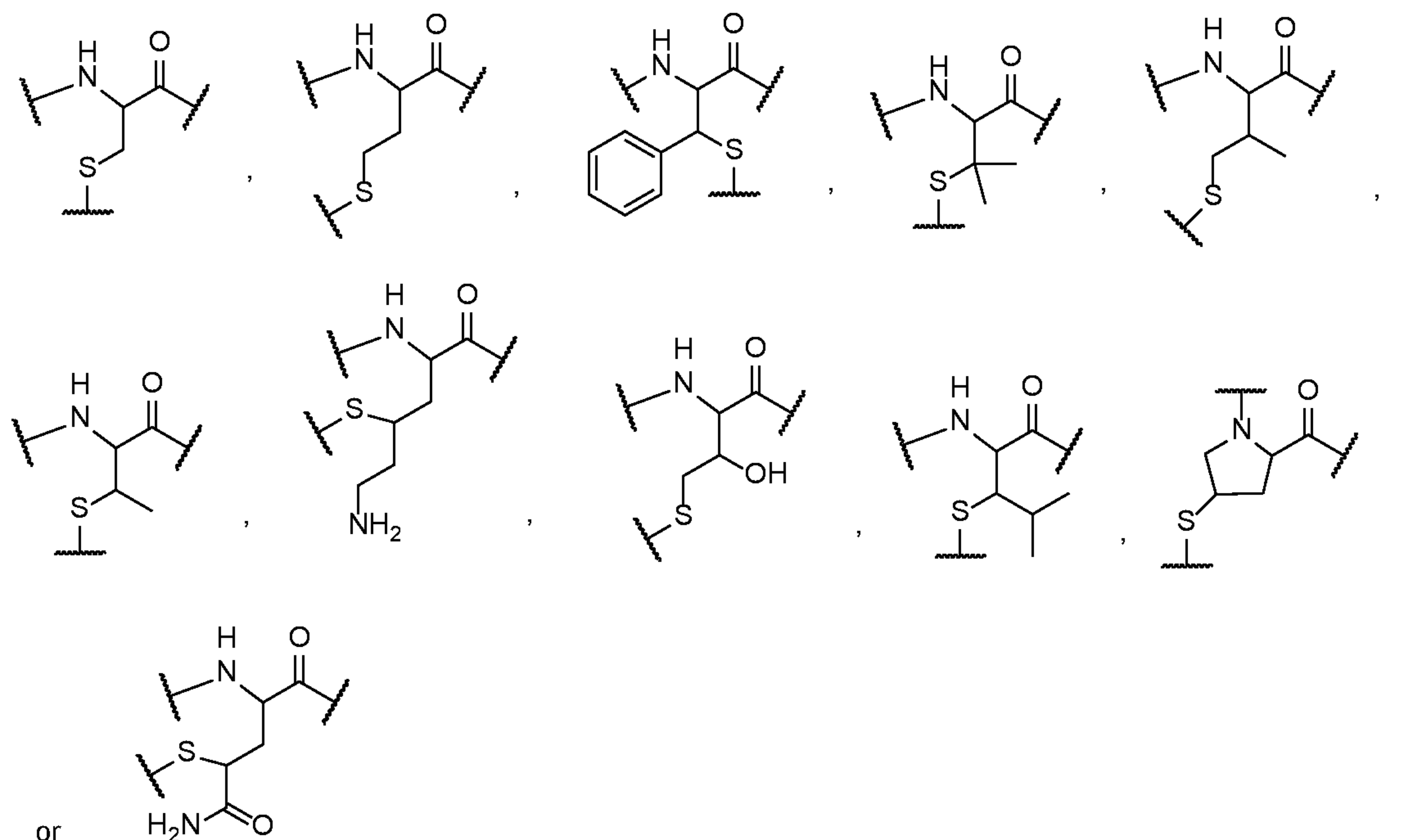
In other such embodiments, J and L can be located between X_n and X_m , between X_m and X_n , or at the C-terminus of either of X_n and X_m , and can be represented by one of the following (prior to forming disulfide bonds):



To form the bicyclic peptides of the present disclosure, the hydrogen on the thiol group of the above structures are independently replaced by a bond to a sulfor group.

In some embodiments, each AA^s is independently an amino acid, or analog or derivative thereof, which is capable of forming a disulfide bond (e.g., an amino acid which has

a thiol group prior to forming a disulfide bond). Non-limiting examples of such amino acids, or analogs or derivatives thereof, include:



wherein the C-terminus of AA^S forms an amide bond or R¹, wherein R¹ is OH, OR², NHR²; and wherein R² is a alkyl, aryl, heteroaryl, amino acid residue, peptide sequence of 2 to 20 amino acid residues, detectable moiety, or solid support.

In some embodiments, a compound of Formula 9 has the following formula:

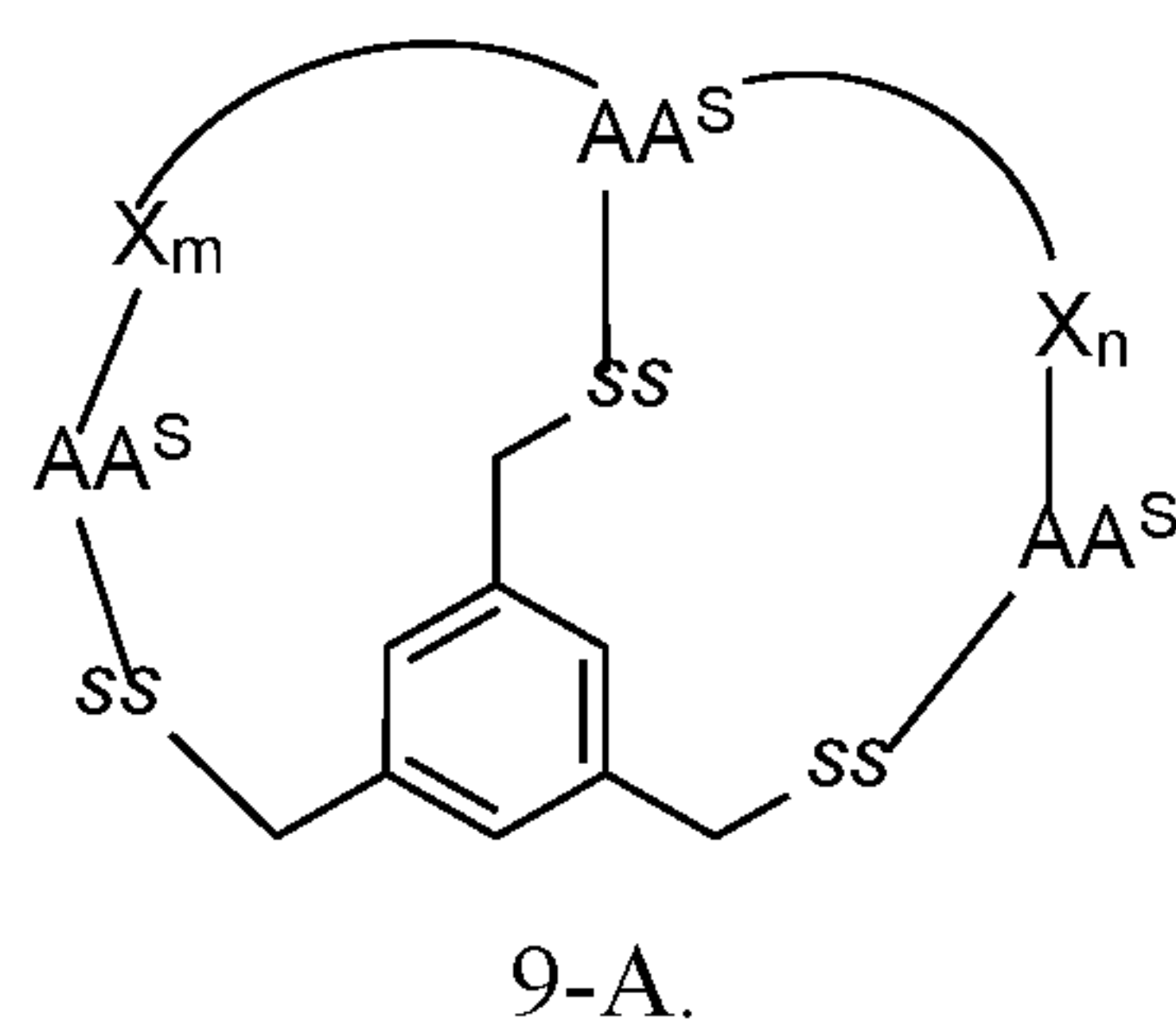
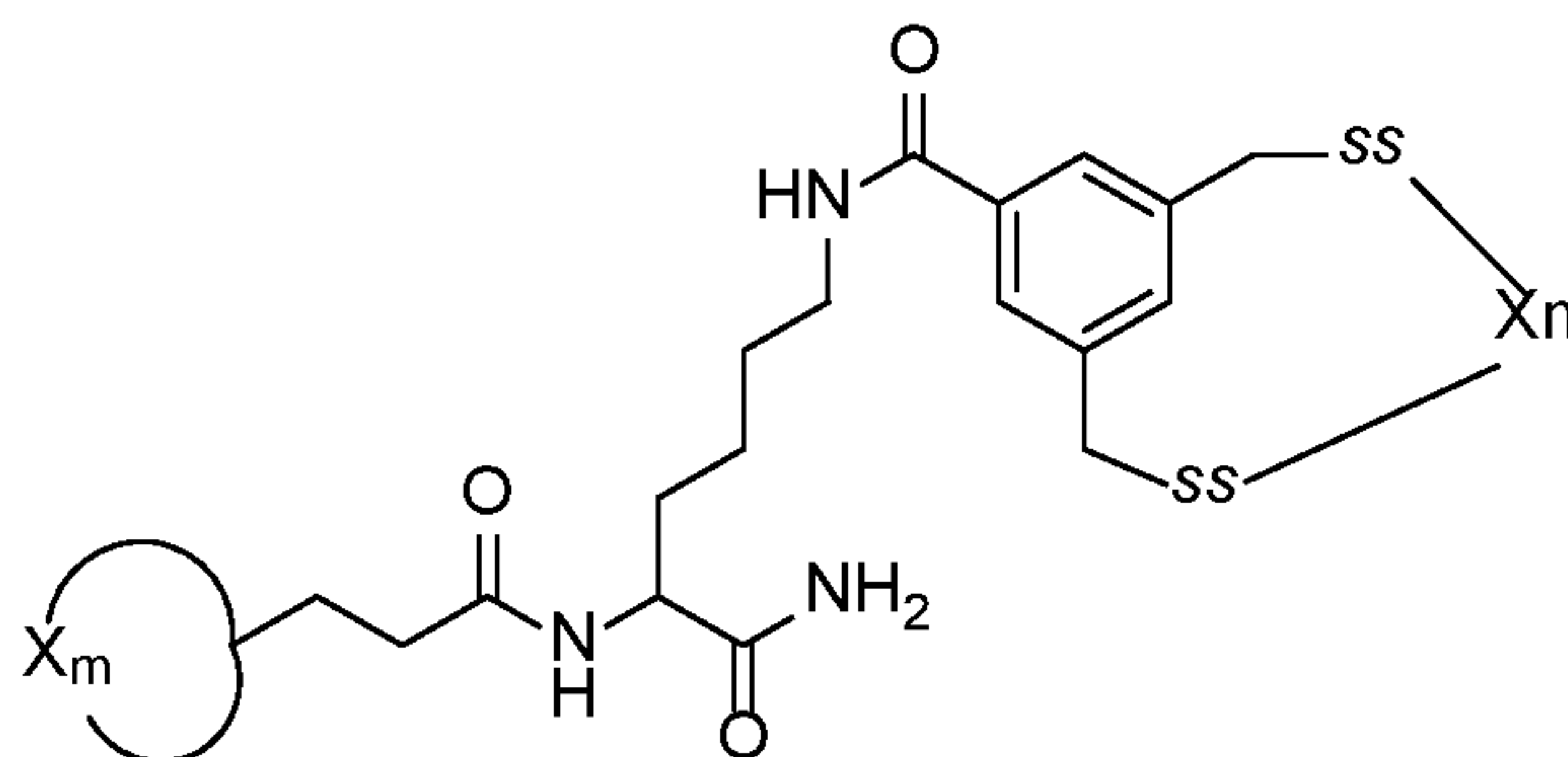


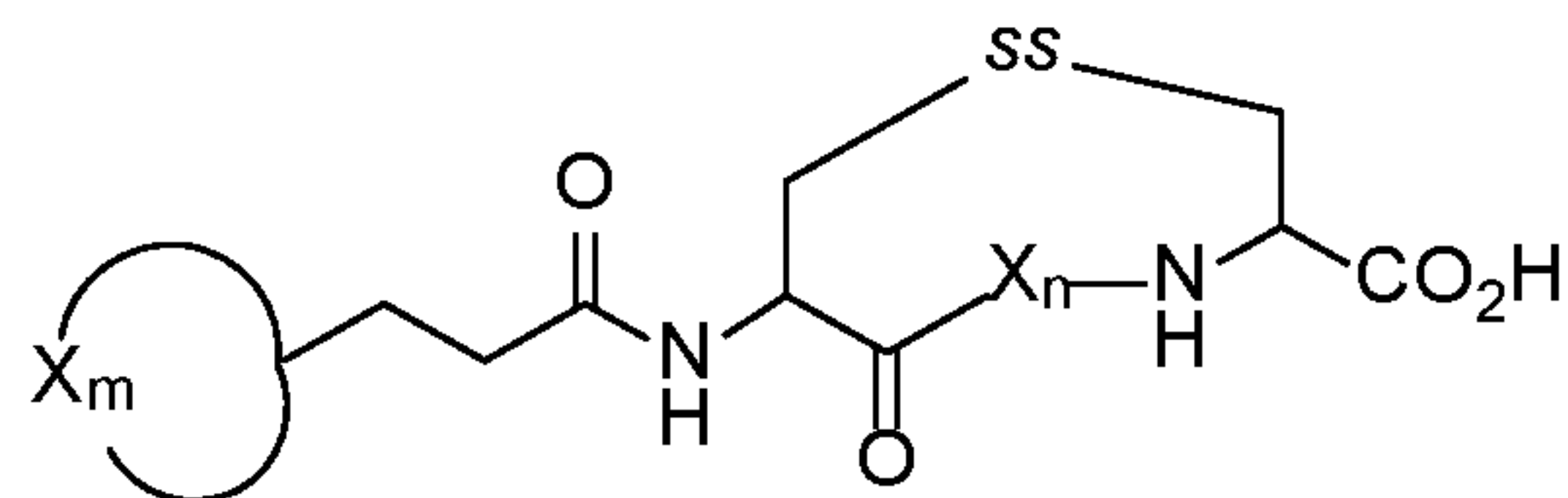
Figure 8 shows an embodiment of a tris-disulfide containing bicyclic peptide according to Formula 9-A.

In some embodiments, a compound of Formula 11 has the following formula:



11-A.

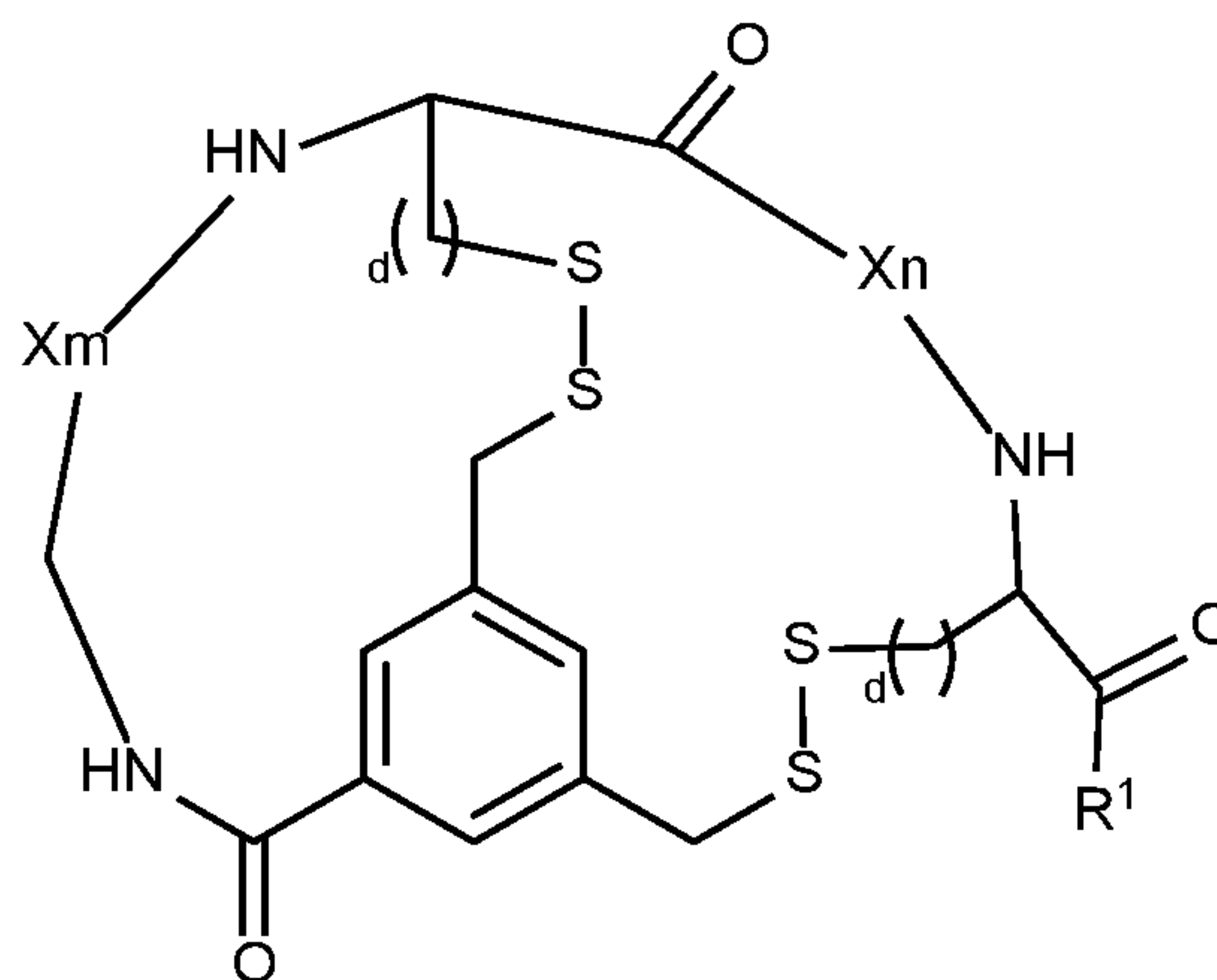
In some embodiments, a compound of Formula 12 has the following formula:



12-A.

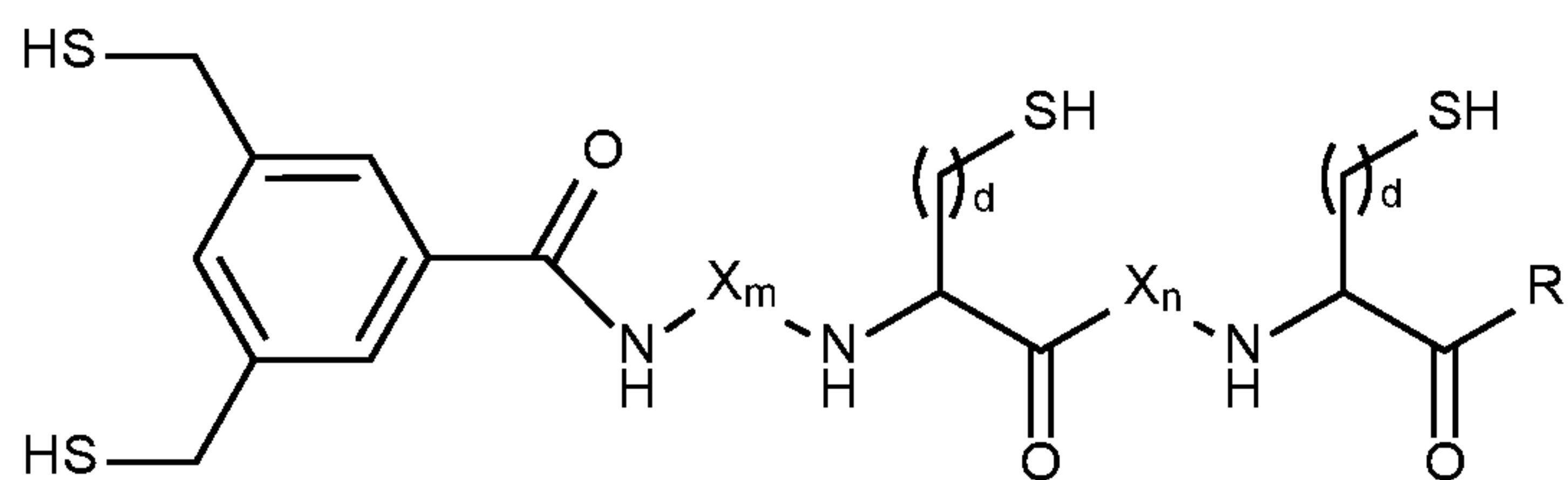
5 The Appendix attached herewith includes further illustrative formulae of the bicyclic peptides of the present disclosure.

In a particular aspect, disclosed herein are bicyclic peptides of Formula I.



I

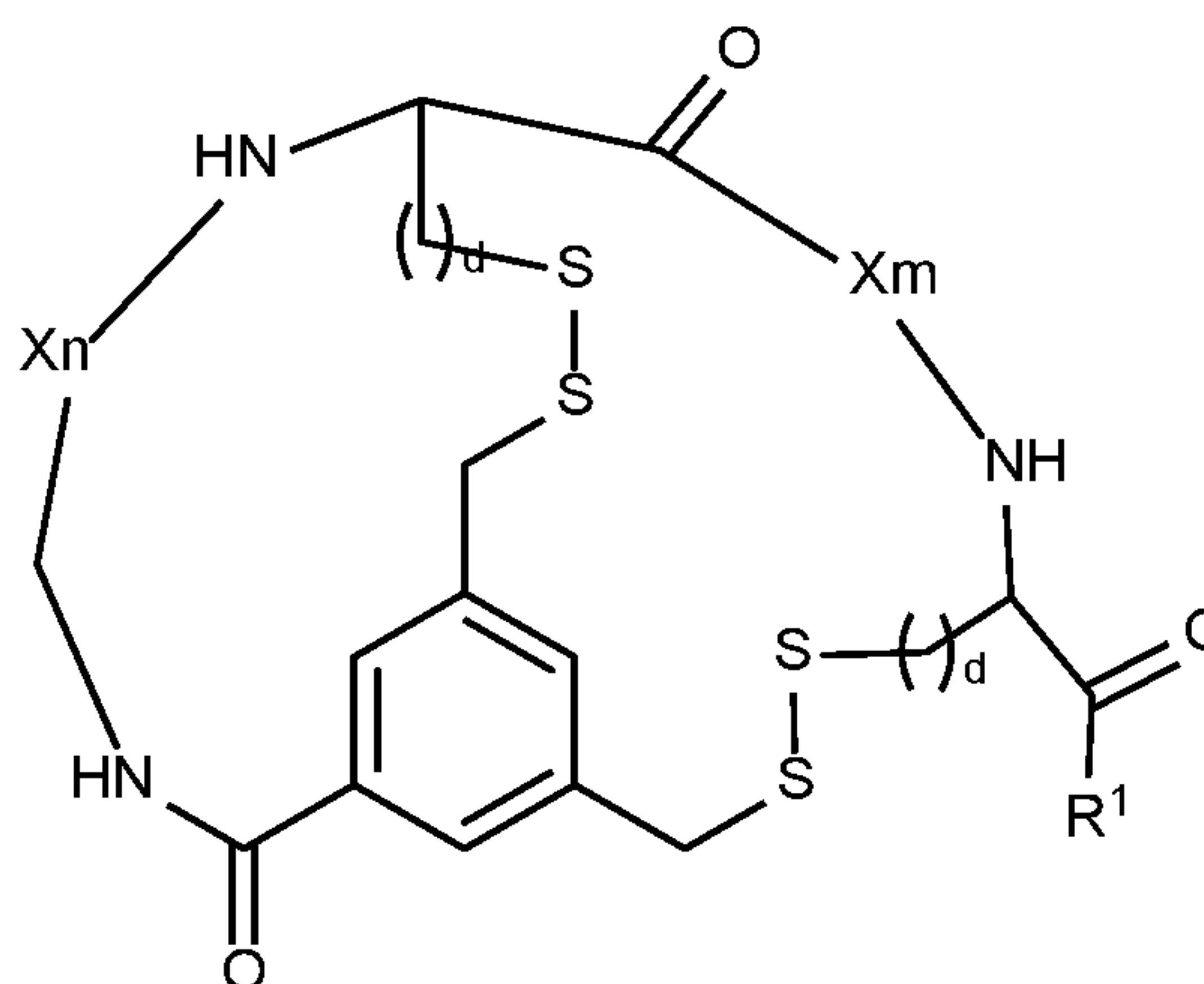
10 wherein R^1 is OH, OR^2 , NHR^2 , wherein R^2 is a C_{1-20} alkyl, C_{6-10} aryl or heteroaryl, amino acid residue, peptide sequence of 2 to 20 amino acid residues, detectable moiety, or solid support; and wherein each d is independently 1 or 2. The two peptide sequences X_m and X_n are coupled to a central 3,5-(bismercaptomethyl)benzoyl moiety, forming a bicyclic structure with a cell penetrating peptide loop of sequence X_m and a cargo loop of sequence X_n (see **Figure 2**). As
 15 discussed above, X_m and X_n are used to represent peptide sequences in the bicyclic peptides described herein, and the N-terminus and C-terminus of the X_m and X_n may be included in various formulae provided herein (e.g., in Formula I above) to illustrate the connectivity of X_m and X_n in the bicyclic peptide. It is to be understood that when the terminal residues of X_m and X_n (e.g., -NH-, or -NH-C(O)-) are provided in a formula, such residues do not represent
 20 additional atoms that are required by the bicyclic peptide, but rather these residues are components of the amino acids contained in X_m and/or X_n . When compounds of Formula I are in their uncyclized form, e.g., prior to forming the disulfide bridges or after entering the cell and being acted upon by GSH, they can be represented as Formula I-A.



I-A.

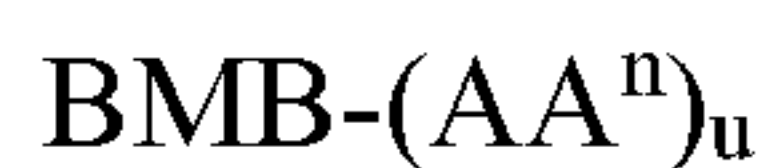
In an additional aspect, X_m and X_n can be coupled to the central 3,5-(bismercaptomethyl)benzoyl moiety in the opposite manner than that shown in Formula I.

5 These compounds are also disclosed herein and are represented by Formula II.



II.

Also disclosed herein are peptide sequences of Formula III.



III

wherein:

u is an integer of from 4 to 20;

each AA^n is, independently, a natural or non-natural amino acid residue, with at least two AA^n residues independently selected from the group consisting of cysteine, homocysteine, an amino acid analog having a thiol group; and

BMB is a 3,5-bis(mercaptomethyl)benzoic acid residue.

X_m and X_n

X_m and X_n can independently comprise any suitable number of amino acids which can be cyclized. In some embodiments, X_m and X_n can independently comprise a sequence of from 1-50 amino acid residues (e.g., 1-20 amino acids, including 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, and 20, including all ranges therebetween). In some embodiments, the combined number of amino acids in X_m and X_n is at least 8 residues. In some examples, X_m or X_n can independently comprise 4 or more amino acid (e.g., 5 or more, 6 or more, 7 or more, 8

or more, or 9 or more). In some examples, X_m or X_n can independently comprise 20 or less amino acids (*e.g.*, 19 or less, 18 or less, 17 or less, 16 or less, or 15 or less). In particular embodiments, X_m or X_n can independently comprise from 5 to 10 amino acids. Each amino acid can be a natural or non-natural amino acid, or an analog or derivative thereof. Thus, the term amino acid, when used herein, is inclusive of natural and non-natural amino acids, and analogs and derivatives thereof. The term “non-natural amino acid” refers to an organic compound that is a congener of a natural amino acid in that it has a structure similar to a natural amino acid so that it mimics the structure and reactivity of a natural amino acid. The non-natural amino acid can be a modified amino acid, and/or amino acid analog, that is not one of the 20 common naturally occurring amino acids or the rare natural amino acids selenocysteine or pyrrolysine. Examples of suitable amino acids include, but are not limited to, alanine, allosoleucine, arginine, asparagine, aspartic acid, cysteine, glutamine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, naphthylalanine, phenylalanine, proline, pyroglutamic acid, serine, threonine, tryptophan, tyrosine, valine, a derivative, or combinations thereof. These are listed in the Table 1 along with their abbreviations used herein.

Table 1. Amino Acid Abbreviations

Amino Acid	Abbreviations*	
	L-amino acid	D-amino acid
Alanine	Ala (A)	ala (a)
Allosoleucine	Alle	aile
Arginine	Arg (R)	arg (r)
Asparagine	Asn (N)	asn (n)
aspartic acid	Asp (D)	asp (d)
Cysteine	Cys (C)	cys (c)
Cyclohexylalanine	Cha	cha
2,3-diaminopropionic acid	Dap	dap
4-fluorophenylalanine	Fpa (Σ)	pfa
glutamic acid	Glu (E)	glu (e)
glutamine	Gln (Q)	gln (q)
glycine	Gly (G)	gly (g)
histidine	His (H)	his (h)

Amino Acid	Abbreviations*	
	L-amino acid	D-amino acid
Homoproline (aka pipecolic acid)	Pip (Θ)	pip (θ)
isoleucine	Ile (I)	ile (i)
leucine	Leu (L)	leu (l)
lysine	Lys (K)	lys (k)
methionine	Met (M)	met (m)
naphthylalanine	Nal (Φ)	nal (ϕ)
norleucine	Nle (Ω)	nle
phenylalanine	Phe (F)	phe (F)
phenylglycine	Phg (Ψ)	phg
4-(phosphonodifluoromethyl)phenylalanine	F ₂ Pmp (Λ)	f ₂ pmp
proline	Pro (P)	pro (p)
sarcosine	Sar (Ξ)	sar
selenocysteine	Sec (U)	sec (u)
serine	Ser (S)	ser (s)
threonine	Thr (T)	thr (y)
tyrosine	Tyr (Y)	tyr (y)
tryptophan	Trp (W)	trp (w)
Valine	Val (V)	val (v)
2,3-diaminopropionic acid	Dap	dap

* single letter abbreviations: when shown in capital letters herein it indicates the L-amino acid form, when shown in lower case herein it indicates the D-amino acid form

5

As discussed above, non-natural amino acids and D-amino acids can be used herein. The disclosed methods and compositions are particularly well suited for incorporating non-natural and D-amino acids. The amino acids can be coupled by a peptide bond. Each amino acid can be coupled to an adjacent amino acid at the amino group, the carboxylate group, or the side chain.

10

X_m

The amino acid sequence X_m can be a cell penetrating peptide sequence. In some embodiments, X_m is from 4 to 20 (e.g., 5 to 10) amino acid residues in length. In some embodiments, at least one, at least two, or at least three amino acids in X_m are arginine. In some examples, at least one, at least two, or at least three amino acids in X_m have a hydrophobic side chain. Non-limiting examples of amino acids having a hydrophobic side chain include glycine, alanine, valine, leucine, isoleucine, methionine, phenylalanine, tryptophan, proline, naphthylalanine, phenylglycine, homophenylalanine, tyrosine, cyclohexylalanine, or norleucine. In particular embodiments, the hydrophobic side chain is a hydrophobic aromatic side chain. In some embodiments, amino acids having an aromatic hydrophobic side chain include naphthylalanine, phenylglycine, homophenylalanine, phenylalanine, tryptophan, and tyrosine. In particular embodiments, the amino acid having a hydrophobic is phenylalanine, naphthylalanine, tryptophan, or an analog or derivative thereof. In some examples, at least one amino acid in X_m comprises phenylalanine, phenylglycine, or histidine, or analogs or derivatives thereof. In some examples, X_m comprises at least one arginine or an analog or derivative thereof.

In some specific examples of Formula I or II, X_m can independently selected from any of the sequences listed in Table 2. In some examples, the cell penetrating peptide can be the reverse of any of the sequences listed in Table 2.

Table 2. Example sequences for X_m.

SEQ ID NO	CPP sequence
64	FΦRRR
65	FΦRRRC
66	FΦRRRU
67	RRRΦF
68	RRRRΦF
69	FΦRRRR
70	FφrRrR
71	FφrRrR
72	FΦRRRR
73	fΦRrRr
74	RRFRΦR
75	FRRRRΦ
76	rRFRΦR
77	RRΦFRR

78	CRRRRFW
79	FfΦRrRr
80	FFΦRRRR
81	RFRFRΦR
82	URRRRFW
83	CRRRRFW
84	FΦRRRRQK
85	FΦRRRRQC
86	fΦRrRrR
87	FΦRRRRR
88	RRRRΦFDΩC
89	FΦRRR
90	FWRRR
91	RRRΦF
92	RRRWF
93	FΦRRRR
94	FFRRR
95	FFrRr
96	FFRrR
97	FRFRR
98	FRRFR
99	FRRRF
100	GΦRRR
101	FFFRA
102	FFFRR
103	FFRRRR
104	FRRFRR
105	FRRRFR
106	RFFRRR
107	RFRRFR
108	FRFRRR
109	FFFRRR
110	FFRRRF
111	FRFFRR
112	RRFFFR
113	FFRFRR
114	FFRRFR
115	FRRFFR
116	FRRFRF
117	FRFRFR

118	RFFRFR
119	GΦRRRR
120	FFFRRRR
121	RFFRRRR
122	RRFFRRR
123	RFFFRRR
124	RRFFFRR
125	FFRRFRR
126	FFRRRRF
127	FRRFFRR
128	FFFRRRRR
129	FFFRRRRRR
130	FΦRrRr
131	XXRRRR
132	FfFRrR
133	fFfrRr
134	fFfRrR
135	FfFrRr
136	fFϕrRr
137	fΦfrRr
138	ϕFfrRr
139	FΦrRr
140	fΦrRr
141	Ac-Lys-fFRrRrD
142	Ac-Dap-fFRrRrD
143	WWWRRRR
144	WWWRRRRR
145	FWRRRR
146	WWWRRR

Φ = L-naphthylalanine; ϕ = D-naphthylalanine; Ω = L-norleucine; r = D-arginine; F = L-phenylalanine; f = D-phenylalanine; q = D-glutamine; X = L-4-fluorophenylalanine; Dap = L-2,3-diaminopropionic acid.

- 5 In some examples, X_m can be any of SEQ ID NO:64 to SEQ ID NO:146. In some examples, X_m can be a variant of any of SEQ ID NO:64 to SEQ ID NO:146. Also disclosed herein are cyclic sequences of the peptides in Table 2. Sequences 64-146 can also be modified by having one or more cysteine residues (or other amino acid having a thiol group) internally or at one or both ends (i.e., at the C- and/or N-terminus), which allows for cyclization of the

peptide by forming a disulfide bond with the cysteine (or other amino acid having a thiol group).

Peptide variants are well understood to those of skill in the art and can involve amino acid sequence modifications. For example, amino acid sequence modifications typically fall into one or more of three classes: substitutional, insertional, or deletional variants. Insertions include amino and/or carboxyl terminal fusions as well as intrasequence insertions of single or multiple amino acid residues. Insertions ordinarily will be smaller insertions than those of amino or carboxyl terminal fusions, for example, on the order of 1 to 3 residues. Deletions are characterized by the removal of one or more amino acid residues from the peptide sequence.

Typically, no more than from 1 to 3 residues are deleted at any one site within the peptide.

Amino acid substitutions are typically of single residues, but can occur at a number of different locations at once; insertions usually will be on the order of about from 1 to 3 amino acid residues; and deletions will range about from 1 to 3 residues. Deletions or insertions preferably are made in adjacent pairs, *i.e.* a deletion of 2 residues or insertion of 2 residues.

Substitutions, deletions, insertions or any combination thereof can be combined to arrive at a final construct. Substitutional variants are those in which at least one residue has been removed and a different residue inserted in its place. Such substitutions generally are made in accordance with the following Table 3 and are referred to as conservative substitutions.

Table 3. Amino Acid Substitutions

Exemplary Conservative Substitutions	
Ala replaced by Ser	Leu replaced by Ile or Val
Arg replaced by Lys or Gln	Lys replaced by Arg or Gln
Asn replaced by Gln or His	Met replaced by Leu or Ile
Asp replaced by Glu	Phe replaced by Met, Leu, Nal, Phg, or Tyr
Cys replaced by Ser	Ser replaced by Thr
Gln replaced by Asn or Lys	Thr replaced by Ser
Glu replaced by Asp	Trp replaced by Tyr
Gly replaced by Pro	Tyr replaced by Trp or Phe
His replaced by Asn or Gln	Val replaced by Ile or Leu
Ile replaced by Leu or Val	

Substantial changes in function are made by selecting substitutions that are less conservative than those in Table 3, *i.e.*, selecting residues that differ more significantly in their effect on maintaining (a) the structure of the peptide backbone in the area of the substitution, for example as a sheet or helical conformation, (b) the charge or hydrophobicity of the molecule at the target site or (c) the bulk of the side chain. The substitutions which in general are expected to produce the greatest changes in the protein properties will be those in which (a) a hydrophilic residue, e.g., seryl or threonyl, is substituted for (or by) a hydrophobic residue, e.g., leucyl, isoleucyl, phenylalanyl, valyl or alanyl; (b) a cysteine or proline is substituted for (or by) any other residue; (c) a residue having an electropositive side chain, e.g., lysyl, arginyl, or histidyl, is substituted for (or by) an electronegative residue, e.g., glutamyl or aspartyl; or (d) a residue having a bulky side chain, e.g., phenylalanine, is substituted for (or by) one not having a side chain, e.g., glycine, in this case, (e) by increasing the number of sites for sulfation and/or glycosylation.

For example, the replacement of one amino acid residue with another that is biologically and/or chemically similar is known to those skilled in the art as a conservative substitution. For example, a conservative substitution would be replacing one hydrophobic residue for another, or one polar residue for another. The substitutions include combinations such as, for example, Gly, Ala; Val, Ile, Leu; Asp, Glu; Asn, Gln; Ser, Thr; Lys, Arg; and Phe, Tyr. Such conservatively substituted variations of each explicitly disclosed sequence are included within the peptides provided herein.

It is understood that one way to define the variants of X_m is through defining the variants in terms of homology/identity to specific known sequences. For example, SEQ ID NO:64 to SEQ ID NO:146 each sets forth a particular sequence. Specifically disclosed are variants of these peptide that have at least, 85%, 90%, 95%, 97%, or 99% homology to SEQ ID NO:64 to SEQ ID NO:146. Those of skill in the art readily understand how to determine the homology of two proteins. For example, the homology can be calculated after aligning the two sequences so that the homology is at its highest level.

In addition to variants of SEQ ID NO:64 to SEQ ID NO:146 are derivatives of these peptides which also function in the disclosed methods and compositions. Derivatives are formed by replacing one or more residues with a modified residue, where the side chain of the residue has been modified.

In particular examples, X_m comprises at least one, at least two, or more specifically, at least three adjacent arginine (R or r) residues. Further, in these structures there are at least one,

at least two, or at least three hydrophobic residues, for example, phenylalanine, naphthylalanine, tryptophan, or an analog or derivative thereof. For example, there can be 1 arginine and 5 hydrophobic residues like phenylalanine, naphthylalanine, tryptophan, or an analog or derivative thereof, 2 arginine and 4 hydrophobic residues like phenylalanine, naphthylalanine, tryptophan, or an analog or derivative thereof, 3 arginine and 3 hydrophobic residues like phenylalanine, naphthylalanine, tryptophan, or an analog or derivative thereof, 4 arginine and 2 hydrophobic residues like phenylalanine, naphthylalanine, tryptophan, or an analog or derivative thereof, or 4 arginine and 1 hydrophobic residue like phenylalanine, naphthylalanine, tryptophan, or an analog or derivative thereof. In a specific example, the cyclic compounds disclosed herein have 3 arginines and 3 hydrophobic residues like phenylalanine, naphthylalanine, tryptophan, or an analog or derivative thereof. Further the arginine residues can be clustered, e.g., an arginine is within 2 amino acids of another arginine residue. Likewise, the hydrophobic residues can be clustered, e.g., one hydrophobic residue is with 2 amino acids of another hydrophobic residue.

In a preferred example, X_m is or comprises $RRRR\Phi F$, $F\Phi RRRR$, $Ff\Phi RrRr$, $f\Phi RrRr$, $f\Phi RrRr$, $F\phi rRrR$, or $F\phi rRrR$.

In some embodiments, the amino acid sequence X_m can be represented as or can comprise



wherein:

AA^1 , AA^2 , AA^3 , AA^4 , AA^5 , AA^6 , AA^7 , AA^8 , and AA^9 are each independently an amino acid;

at least three amino acids are arginine;

at least two amino acids comprise a hydrophobic side chain;

m , n , p , or q are independently selected from 0 and 1.

In some embodiments, AA^1 , AA^2 , AA^3 , AA^4 , AA^5 , AA^6 , AA^7 , AA^8 , and AA^9 corresponds to at least one amino acid sequence of SEQ ID NO:64 to SEQ ID NO:146.

Certain embodiments of the invention include amino acid sequences wherein at least four consecutive amino acids have alternating chirality. As used herein, chirality refers to the “D” and “L” isomers of amino acids. In particular embodiments of the invention, at least four consecutive amino acids have alternating chirality and the remaining amino acids are L-amino acids. In other embodiments, the peptides of the invention comprise a four amino acid

sequence having D-L-D-L chirality. In still other embodiments, the peptides of the invention comprise a four amino acid sequence having L-D-L-D chirality.

In embodiments, peptides of the invention comprise two consecutive L-amino acids. In further embodiments, peptides of the invention comprise two consecutive L-amino acids
 5 separating two D-amino acids. In yet further embodiments, peptides of the invention comprise two consecutive L-amino acids separating two D-amino acids and at least four consecutive amino acids having alternating chirality, such as, but not limited to peptide sequences with D-L-L-D-L-D or L-D-L-L-D-L-D chirality. In even further embodiments, peptides of the invention comprise two consecutive L-amino acids separating two D-amino acids and at least
 10 five consecutive amino acid having alternating chirality, such as, but not limited to peptide sequences with D-L-L-D-L-D-L or L-D-L-L-D-L-D-L chirality.

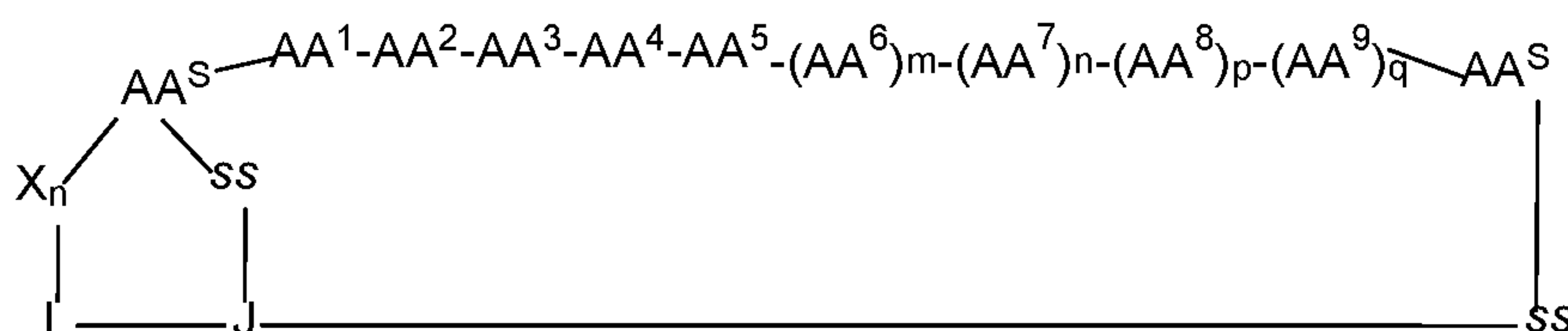
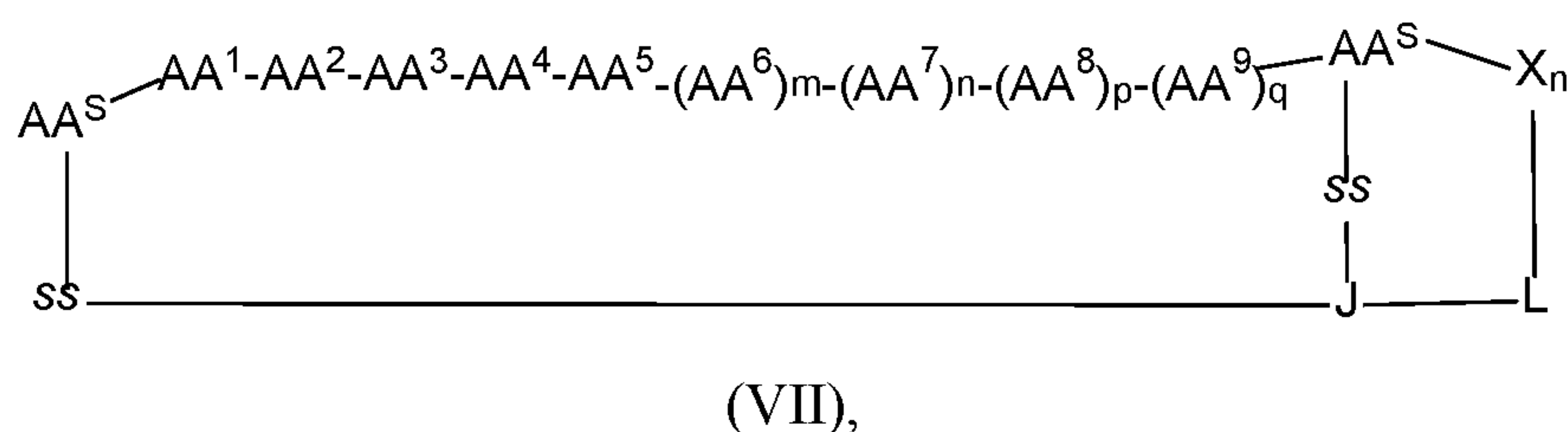
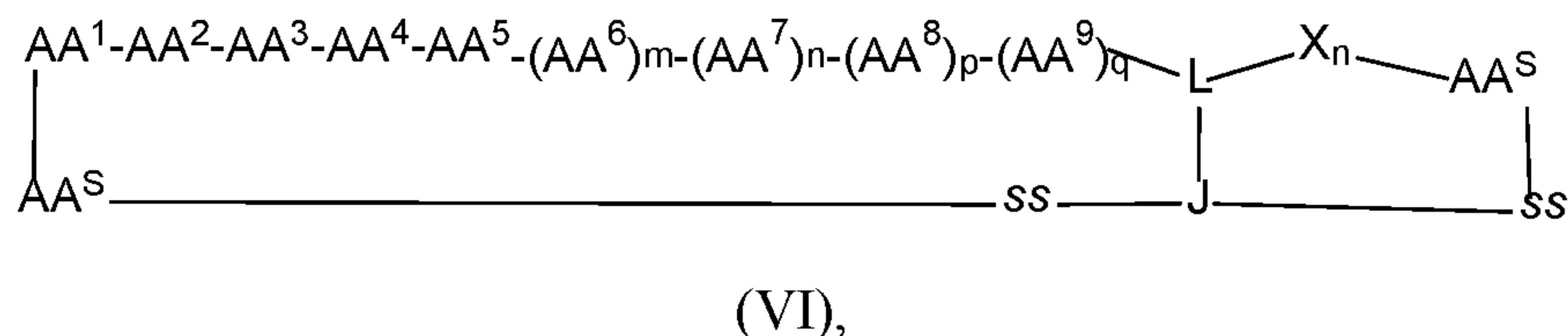
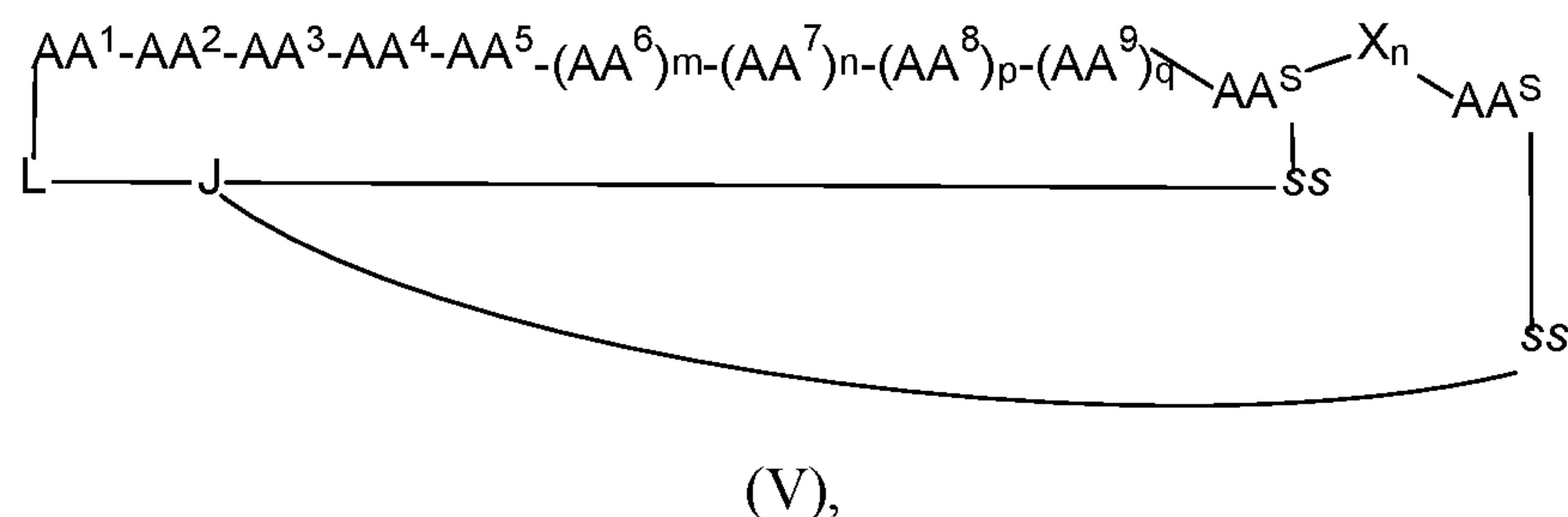
In embodiments, peptides of the invention comprise two consecutive D-amino acids. In further embodiments, peptides of the invention comprise two consecutive D-amino acids separating two L-amino acids. In still further embodiments of the invention, peptides of the
 15 invention comprise two consecutive D-amino acids separating two L-amino acids and at least four consecutive amino acids having alternating chirality, such as, but not limited to peptide sequences with L-D-D-L-D-L. In even further embodiments of the invention, peptides of the invention comprise two consecutive D-amino acids separating two L-amino acids and at least five consecutive amino acids having alternating chirality, such as, but not limited to peptide
 20 sequences with L-D-D-L-D-L-D.

In some embodiments, the amino acid sequence with alternating chirality comprises about at least about 4 amino acids, at least about 5 amino acids, at least about 6 amino acids, at least about 7 amino acids, at least about 8 amino acids or at least about 9 amino acids. In embodiments, the amino acid sequence with alternating chirality comprises of from about 4
 25 amino acids to about 9 amino acids, or about 5 amino acids to about 6 amino acids, or about 7 amino acids to about 9 amino acids, or about 8 amino acids to about 9 amino acids, or about 4 amino acids to about 8 amino acids, or about 4 amino acids to about 7 amino acids, or about 4 amino acids to about 6 amino acids, or about 4 amino acids to about 5 amino acids.

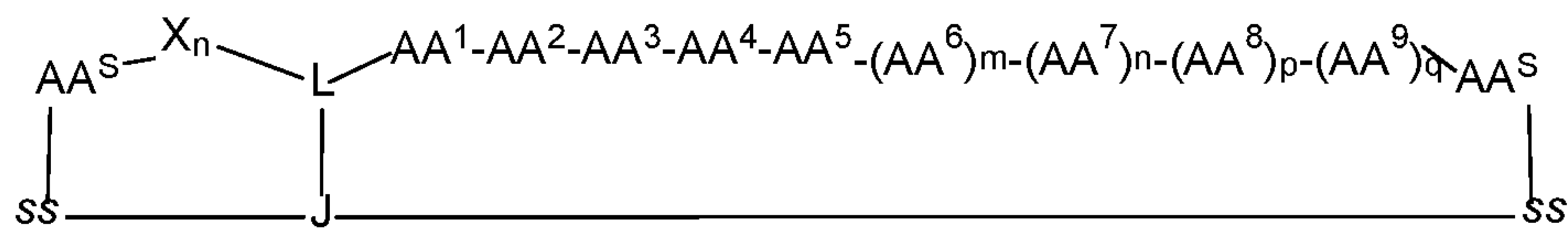
In certain embodiments, the peptides of the invention comprise at least one
 30 hydrophobic residue. In further embodiments, the peptides of the invention comprise two hydrophobic residues. In still further embodiments, the peptides of the invention comprise at least two hydrophobic residues. In certain embodiments, at least one hydrophobic residue is an aromatic hydrophobic residue. In particular embodiments, at least one hydrophobic residue is

selected from the group consisting of naphthylalanine, phenylalanine, tryptophan, and tyrosine. In further embodiments, at least one hydrophobic residue is selected from the group consisting of naphthylalanine and phenylalanine. In certain embodiments, peptides of the invention comprise at least one naphthylalanine. In yet other embodiments, peptides of the invention
 5 comprise at least one phenylalanine. In still other embodiments, peptides of the invention comprise at least one phenylalanine and at least one naphthylalanine. In certain embodiments of the invention, the peptide comprises at least one hydrophobic residue in the AA¹, AA², or AA³ position. In certain embodiments, the peptide comprises at least one aromatic hydrophobic residue in the AA¹, AA², or AA³ position. In further embodiments of the
 10 invention, the peptide comprises at least one hydrophobic residue selected from the group consisting of naphthylalanine and phenylalanine in the AA¹, AA², or AA³ position.

In certain aspects, disclosed herein are bicyclic peptides of Formula V, VI, VII, VIII, IX, X, and XII:

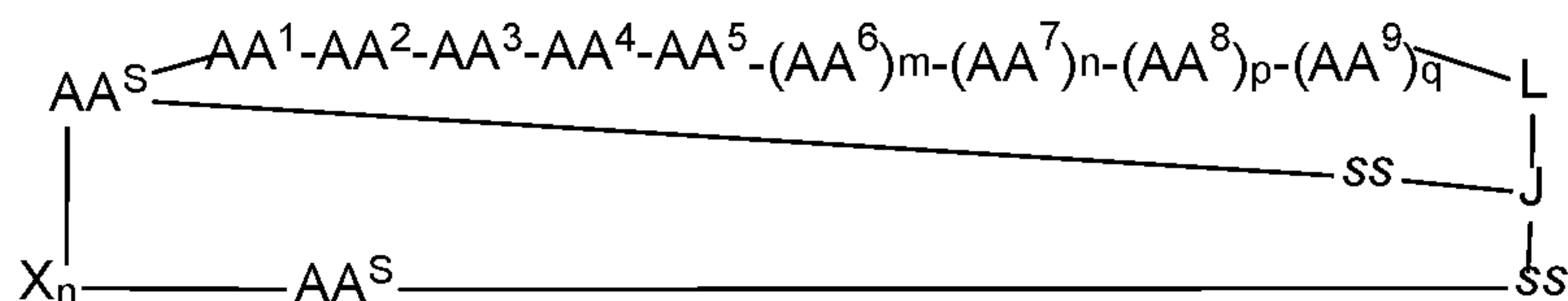


(VIII),

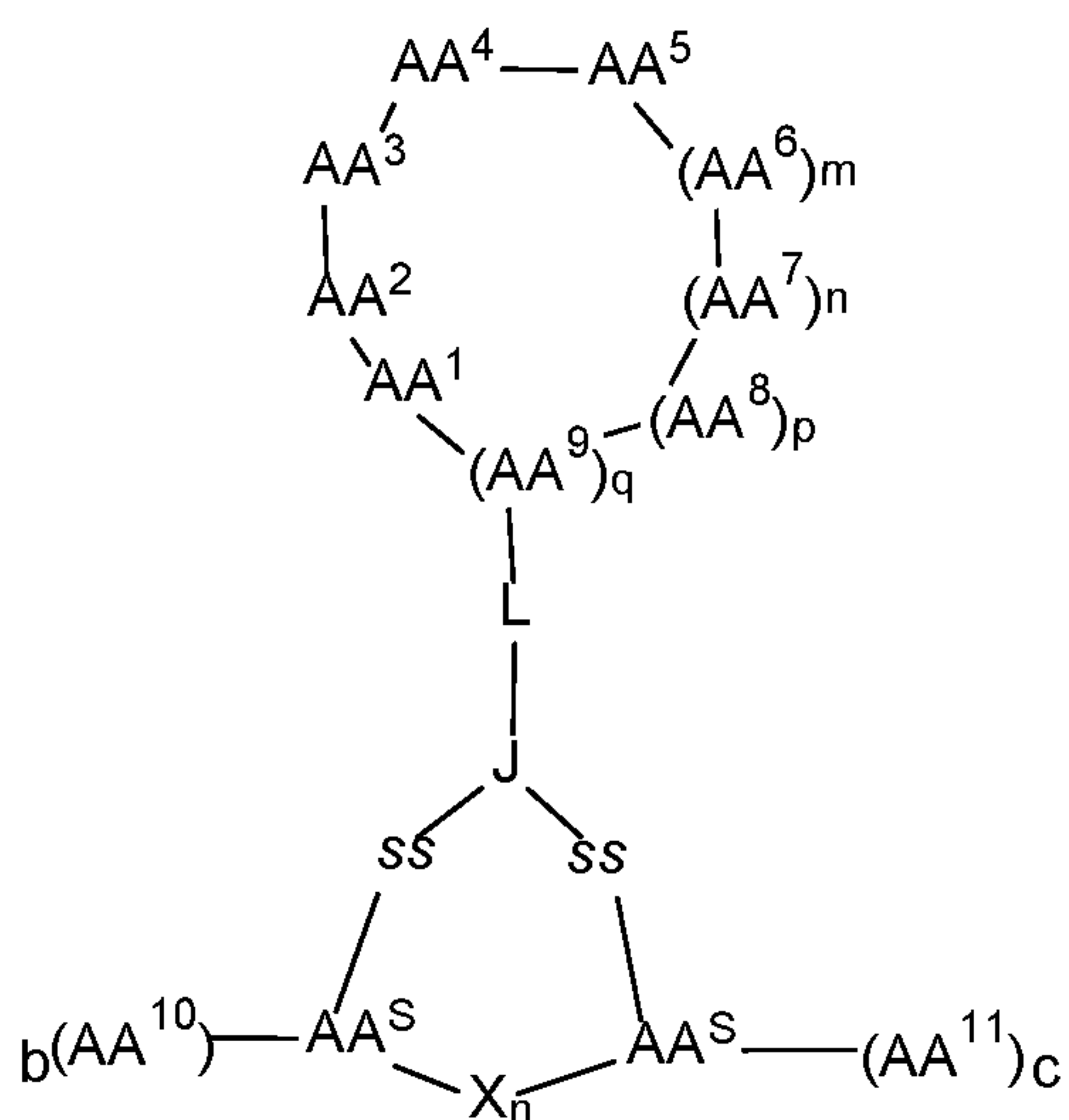


5

(IX),



(X),



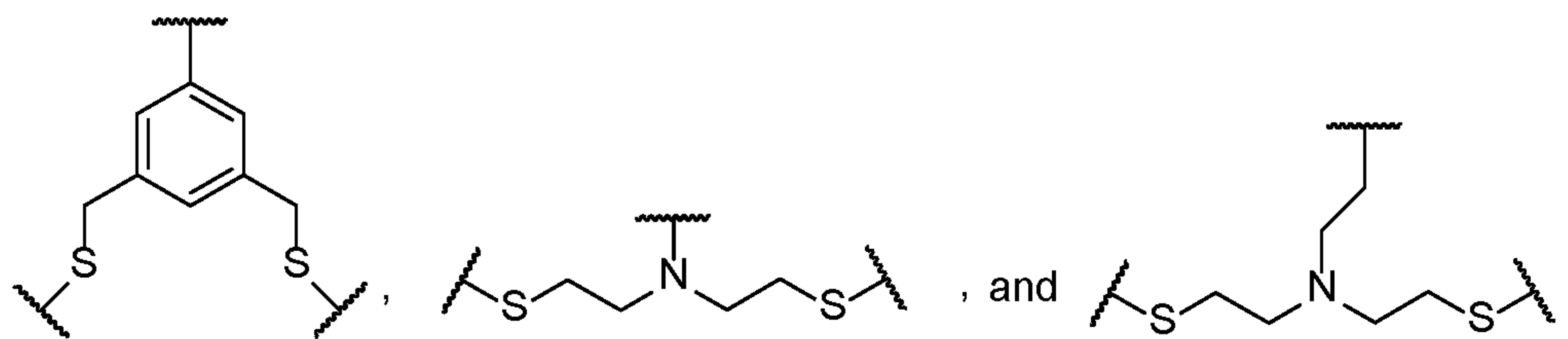
10

(XII)

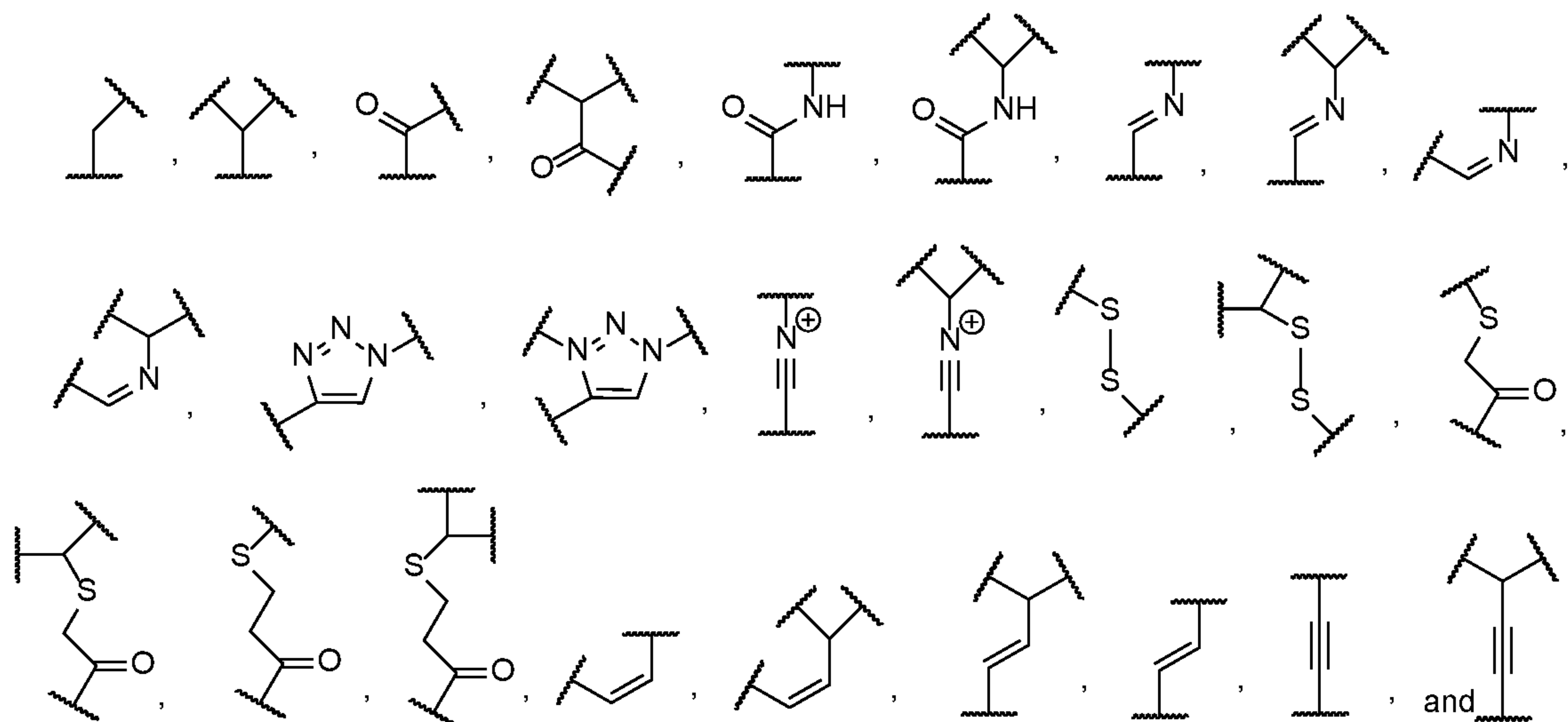
or a pharmaceutically acceptable salt thereof, wherein AA^1 , AA^2 , AA^3 , AA^4 , AA^5 , AA^6 , AA^7 , AA^8 , AA^9 , AA^{10} , and AA^{11} are each independently an amino acid.

15 In some embodiments, at least three amino acids are arginine. In further embodiments, at least two amino acids comprise a hydrophobic residue. In some embodiments, AA^S at each occurrence is independently a moiety which forms a disulfide bond with J.

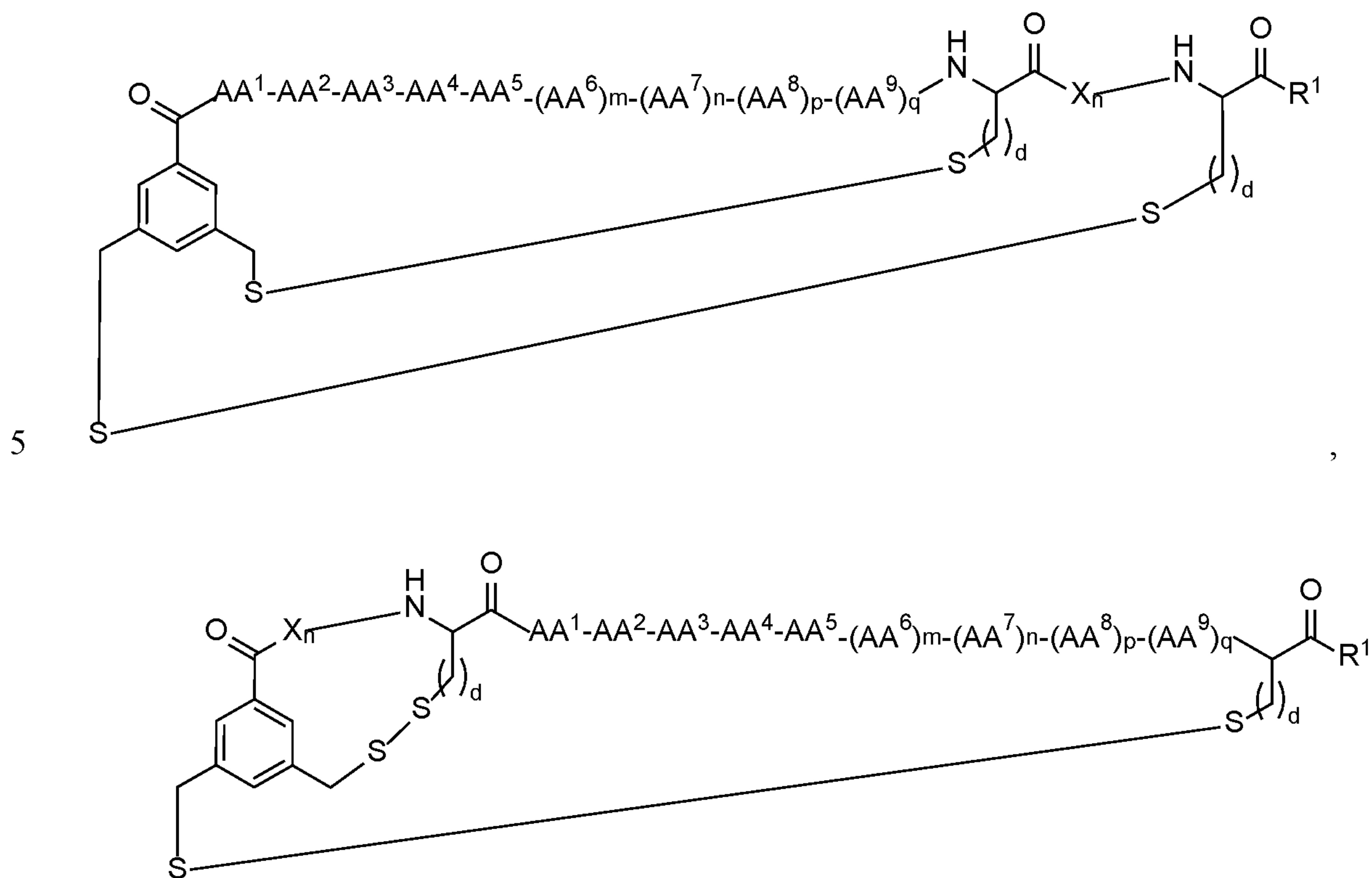
In some embodiments, J is *N*-alkyl, aryl, or heteroaryl, each of which are independently substituted with at least two substituents which independently form a disulfide bond with AA^S at each occurrence. In some embodiments J is selected from the group consisting of

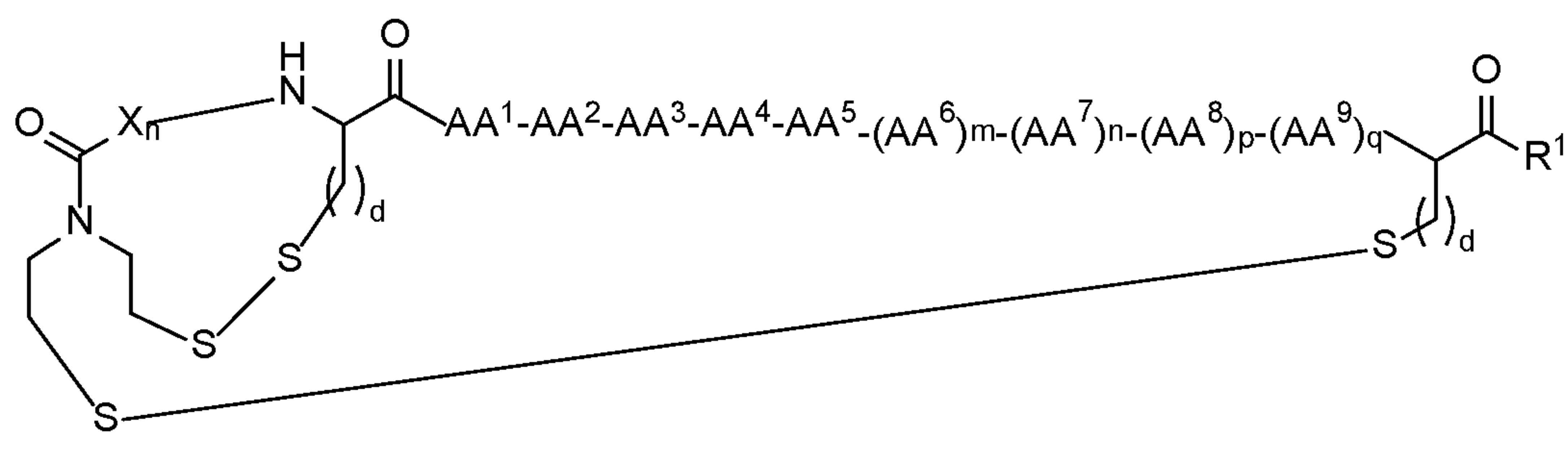
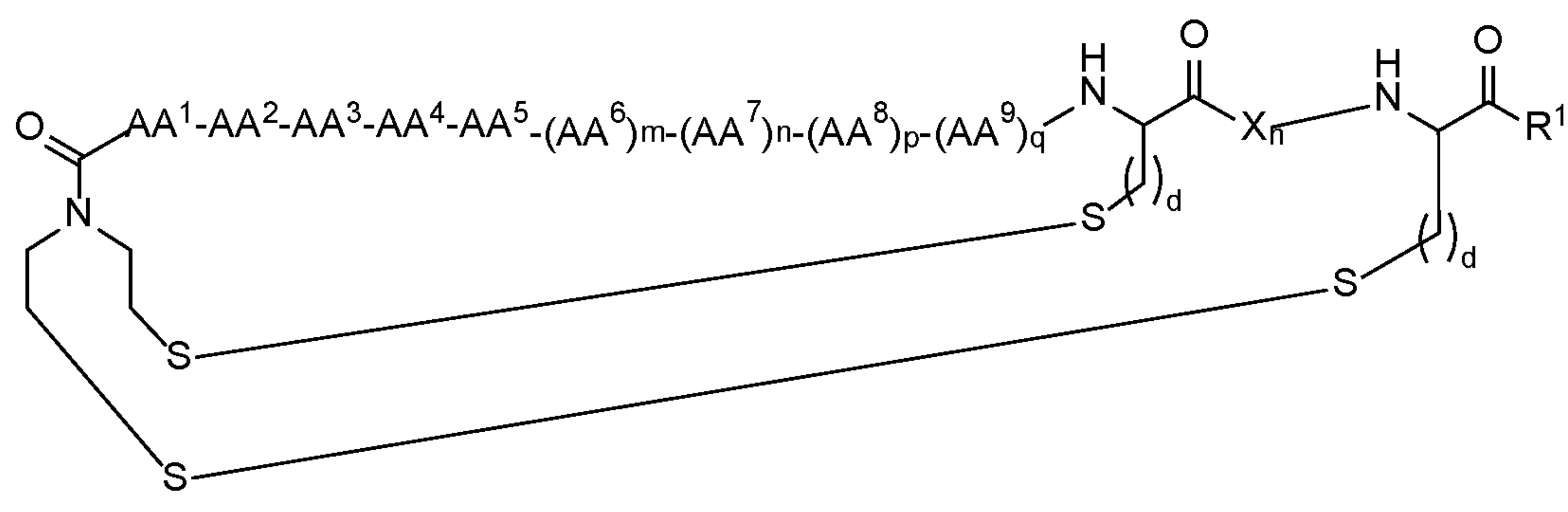
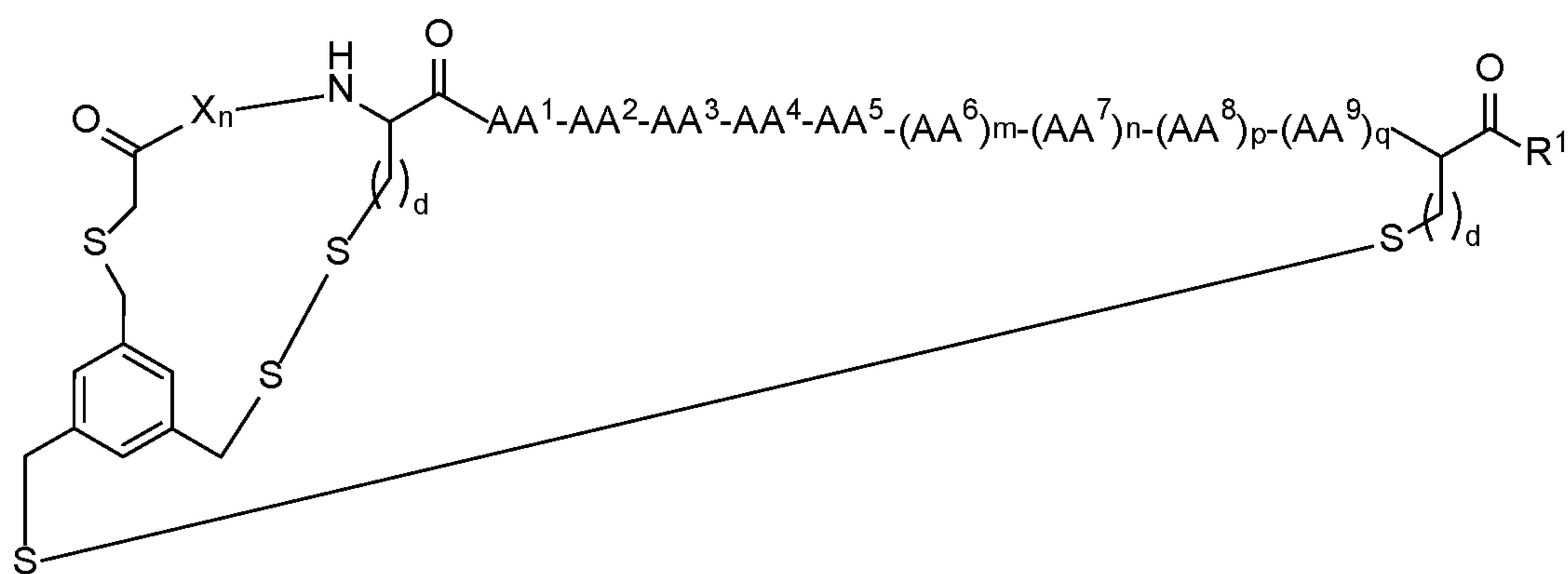
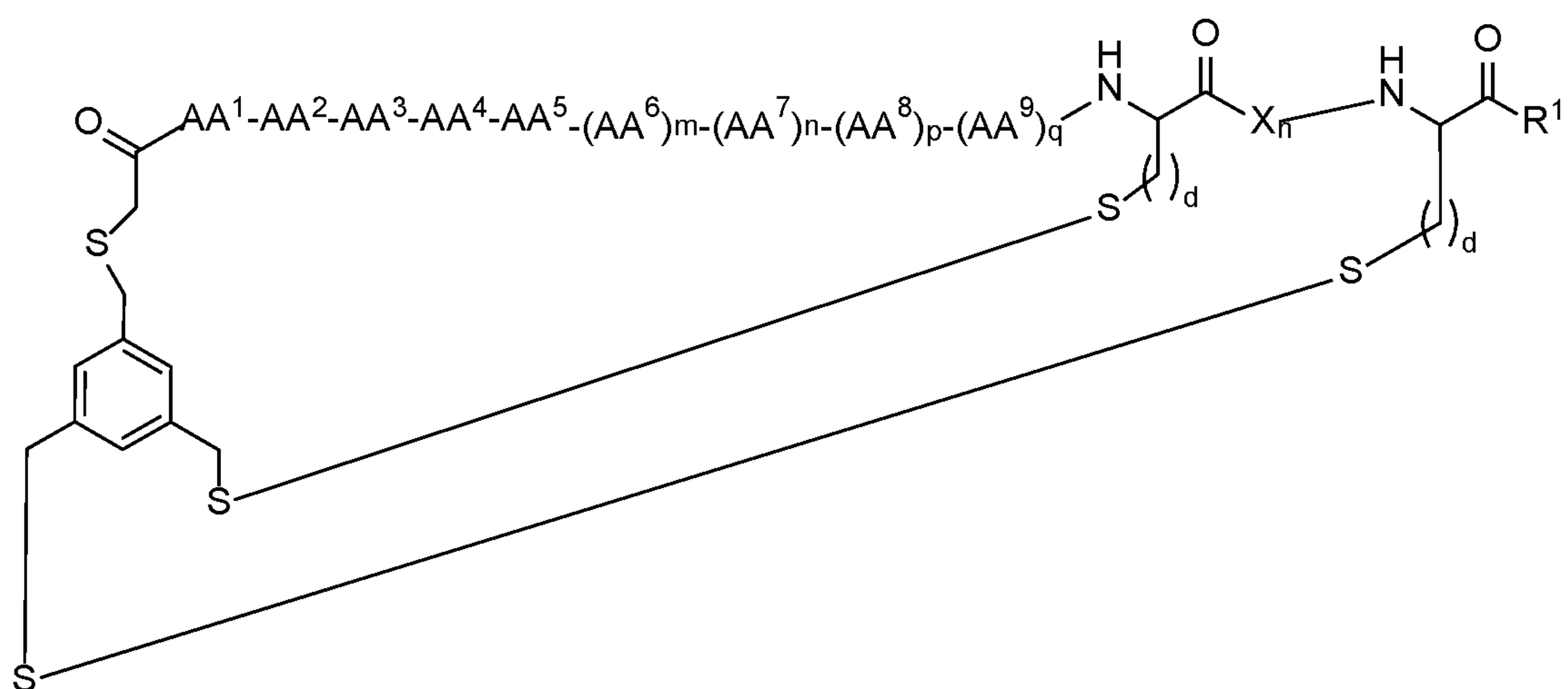


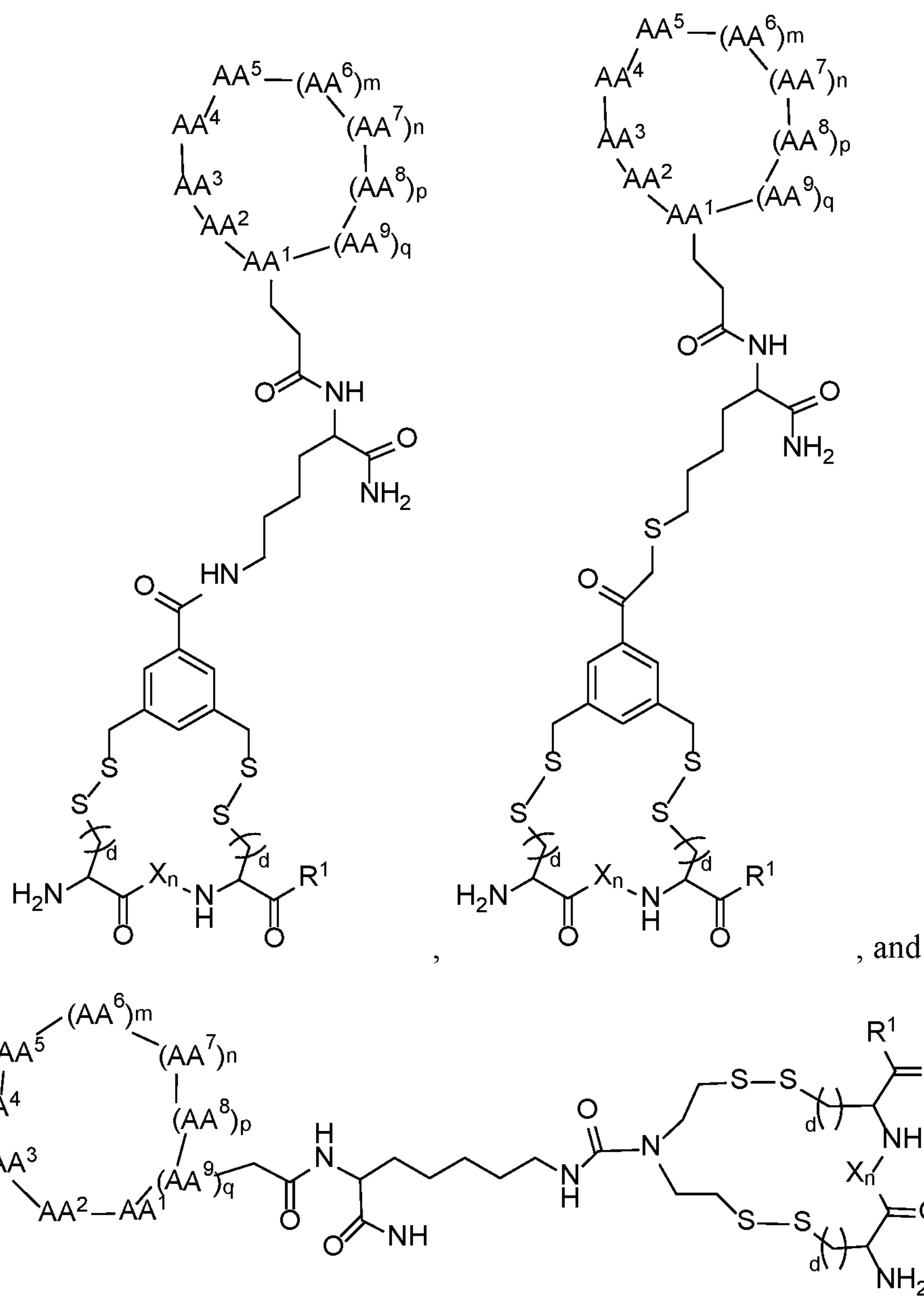
In some embodiments, L is selected from the group consisting of



In some embodiments, the compound is selected from the group consisting of:

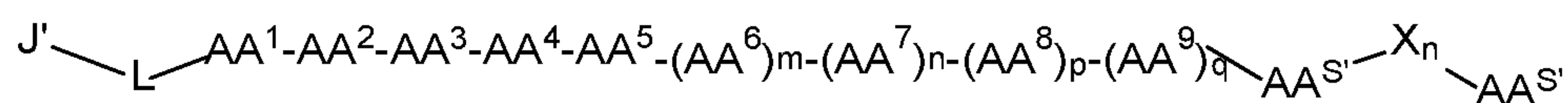




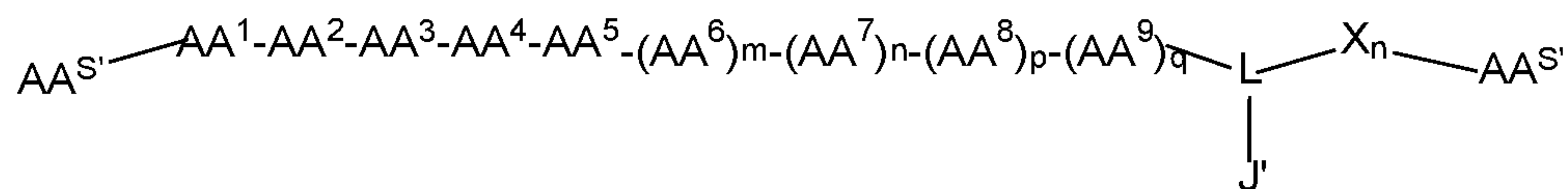


or pharmaceutically acceptable salt thereof, wherein each d is independently 1 or 2.

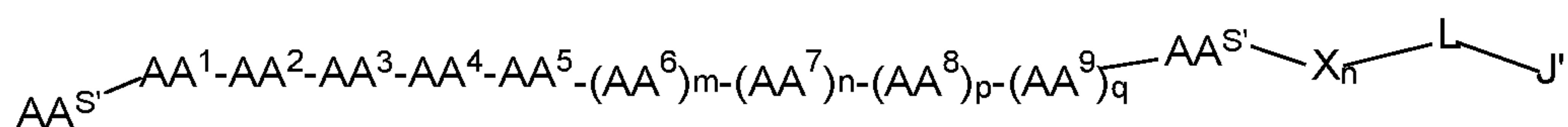
5 When compounds of Formula V, VI, VII, VIII, IX, or X are in their uncyclized form, e.g., prior to forming the disulfide bridges or after entering the cell and being acted upon by GSH, they can be represented as Formula I-A. Also disclosed are compounds according to Formula V-A, VI-A, VII-A, VIII-A, IX-A, and X-A:



V-A,

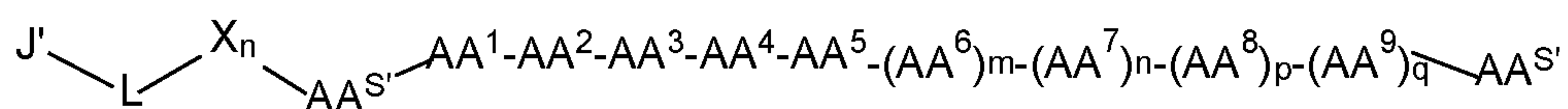


VI-A,

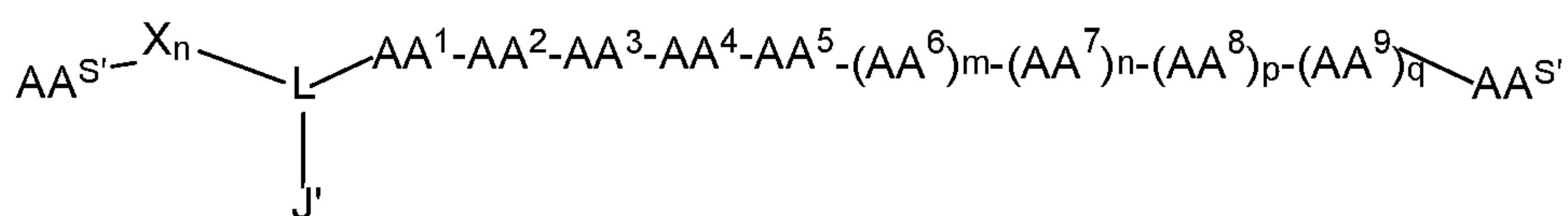


5

VII-A,

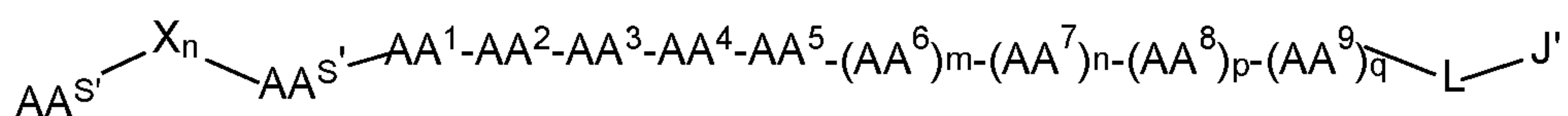


VIII-A,

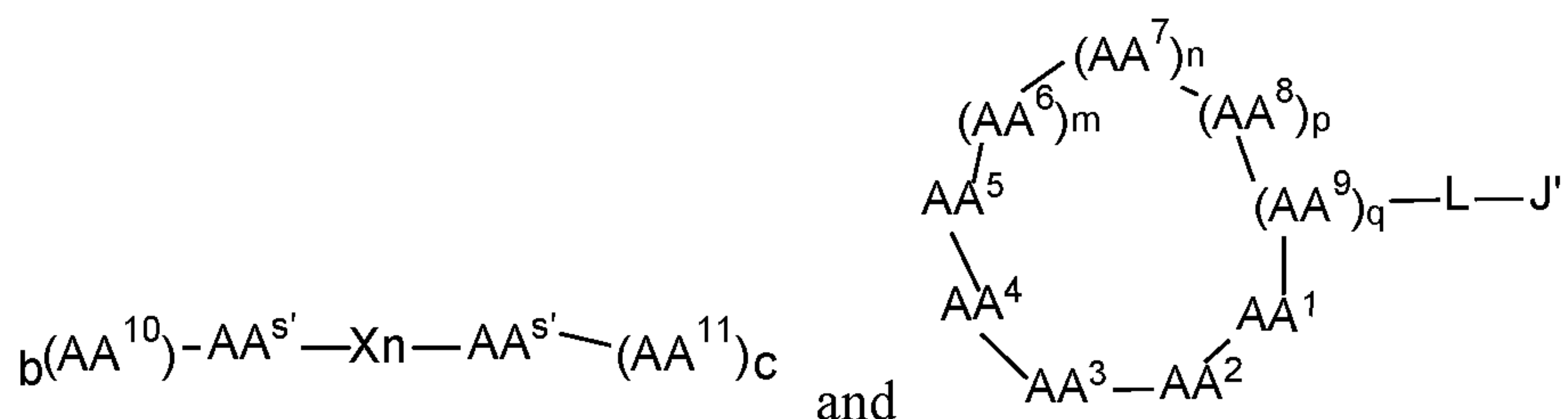


10

IX-A,



X-A, and



15

XII-A and XII-B

or a pharmaceutically acceptable salt thereof,

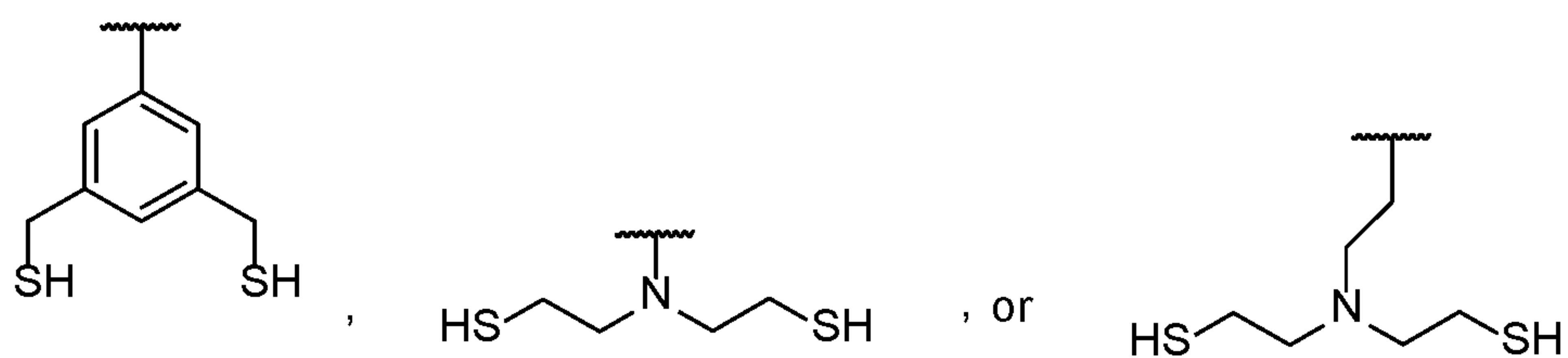
wherein:

AA^{S'} at each occurrence is independently a moiety which comprises a thiol;

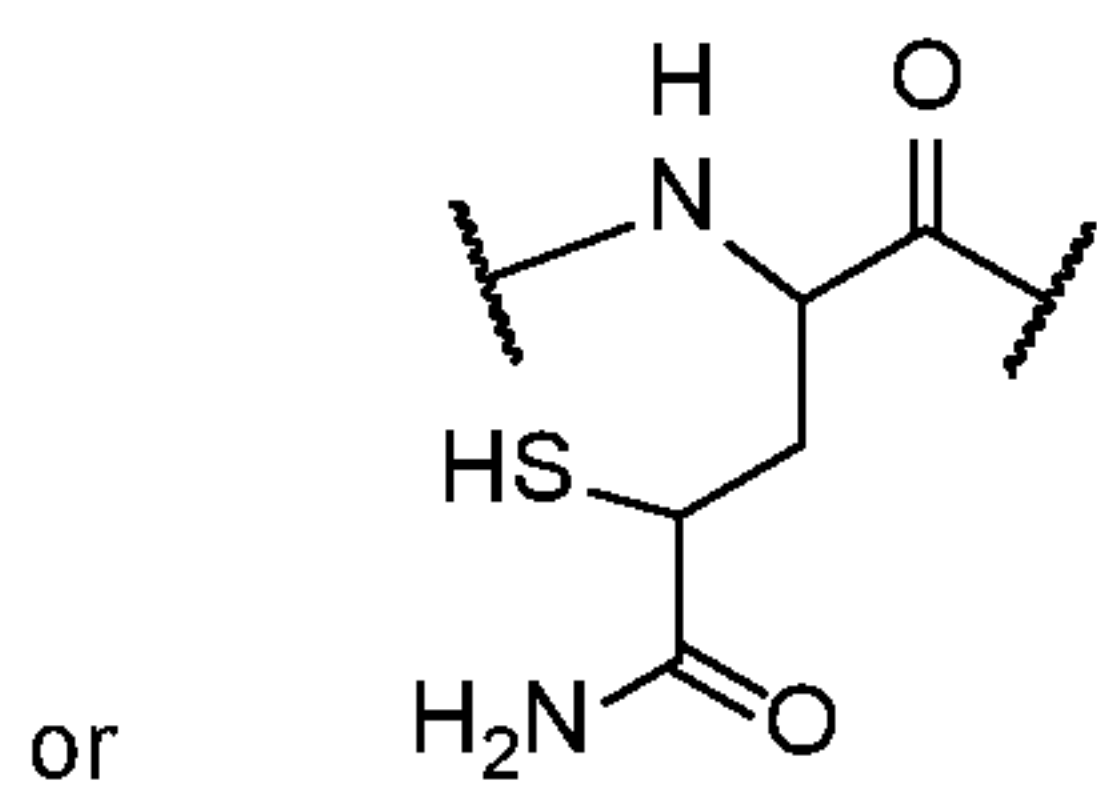
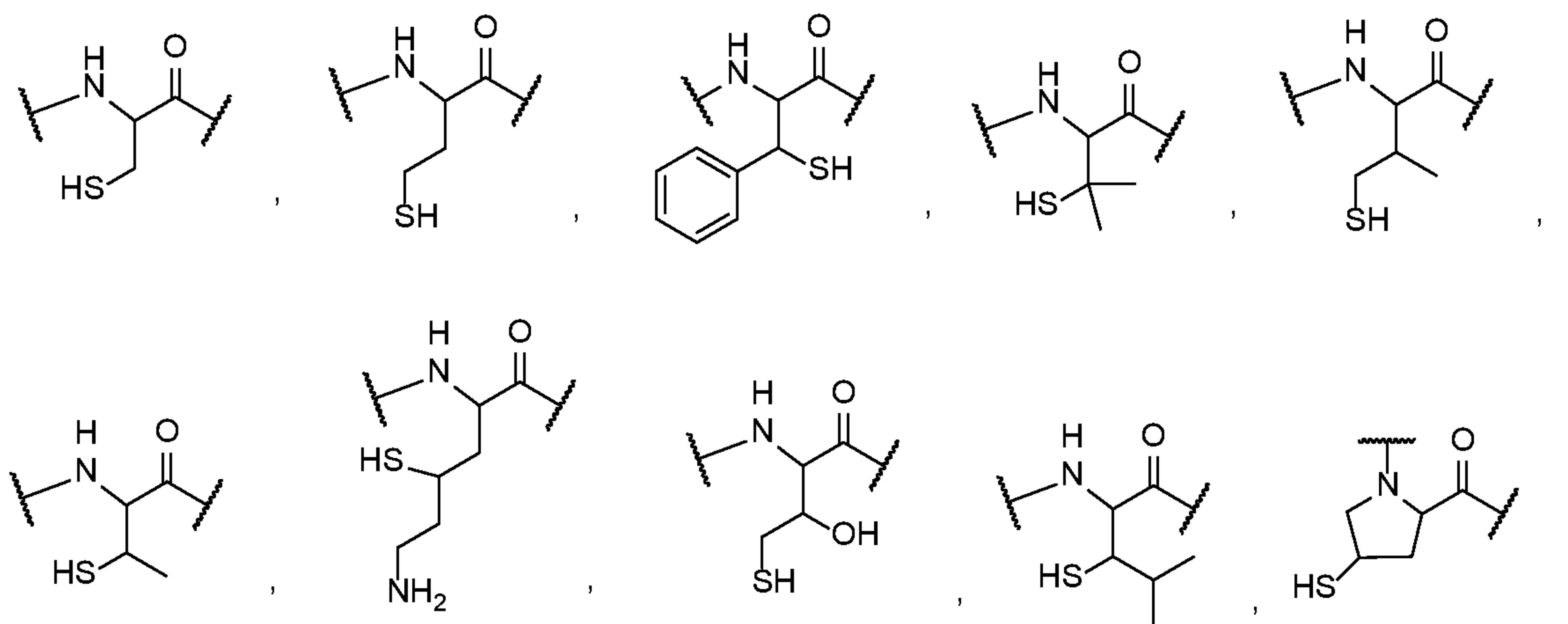
20 J' is an alkyl, *N*-alkyl, alkenyl, alkynyl, carbocyclyl, or heterocyclyl, each of which are independently substituted with at least two thiol substituents; and

X_n and L are defined herein.

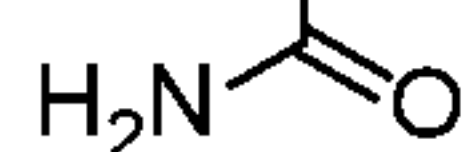
In some embodiments, J is *N*-alkyl or aryl. In some embodiments, J' is



In some embodiments, each AA^S is independently:

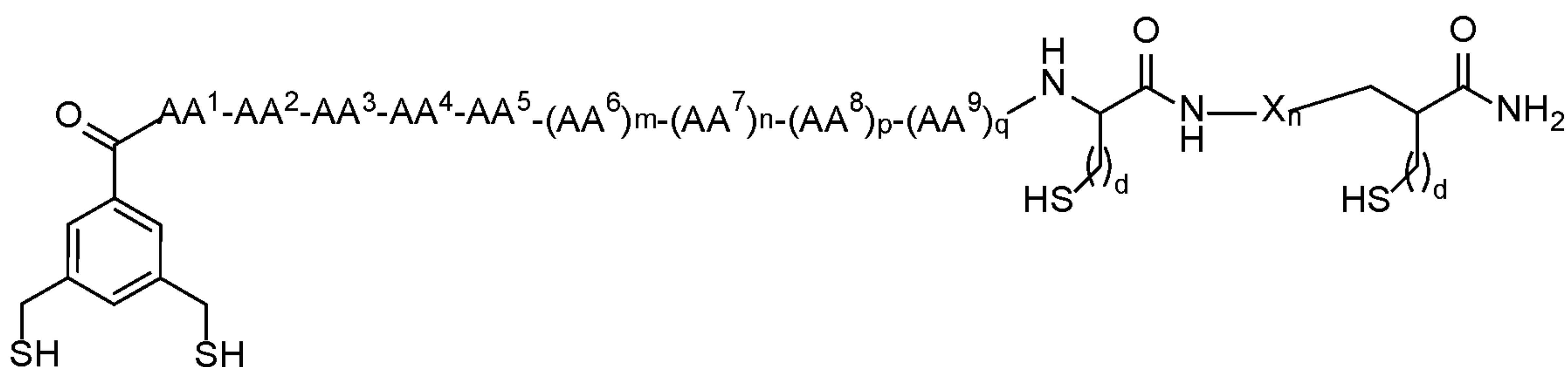


or



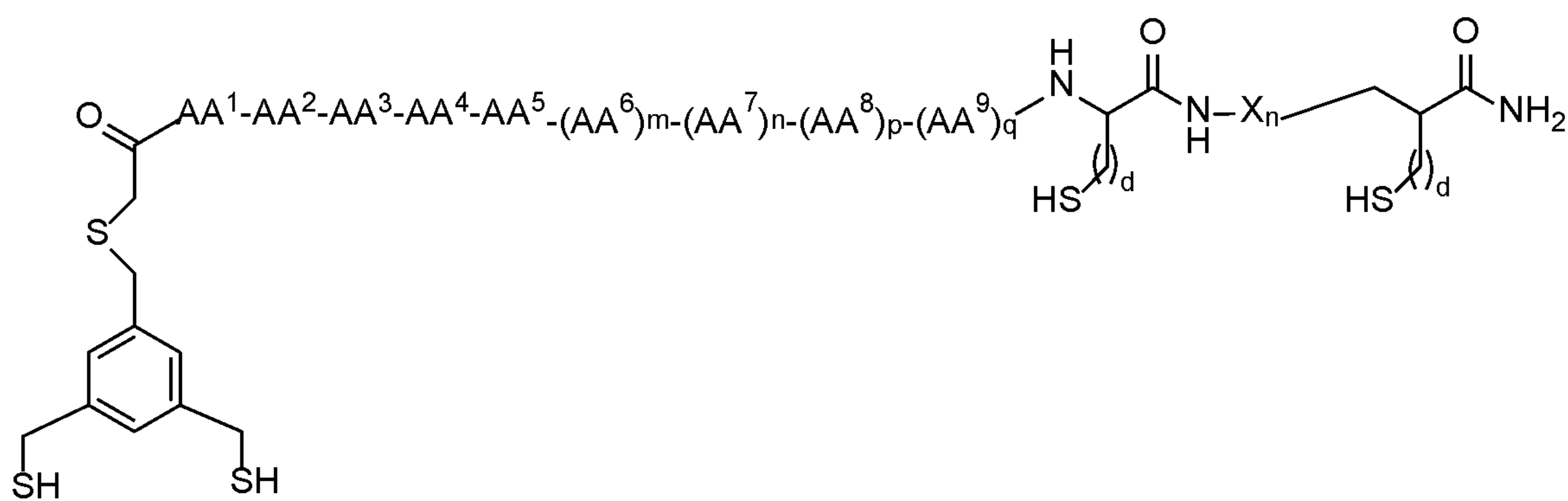
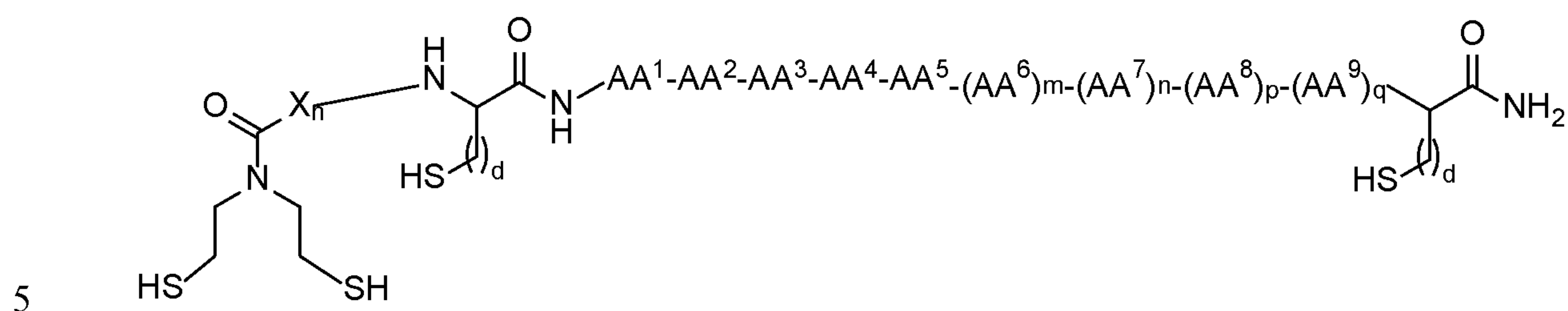
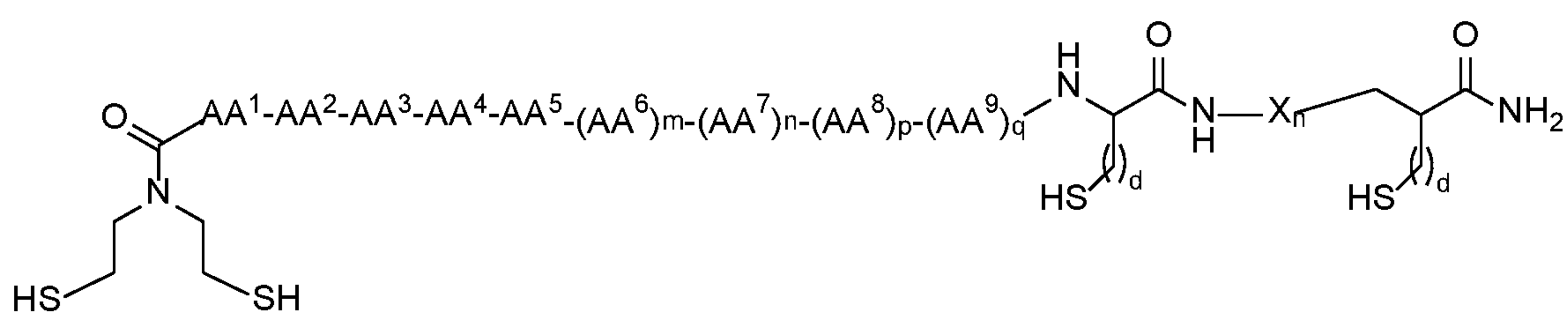
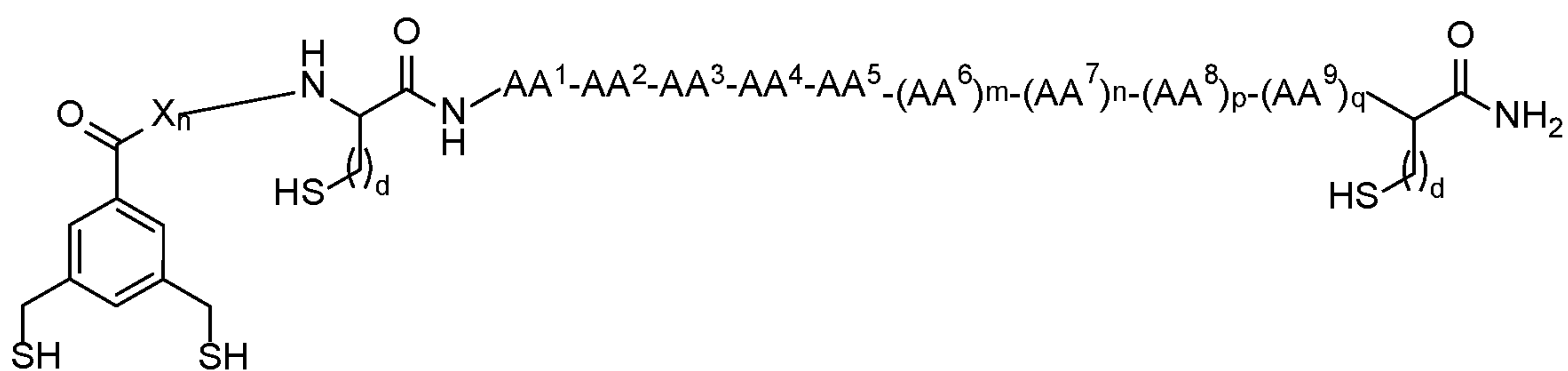
- 5 wherein the C-terminus of AA^{S'} forms an amide bond or is R¹, wherein R¹ is OH, OR², NHR²; and wherein R² is a alkyl, aryl, heteroaryl, amino acid, peptide sequence of 2 to 20 amino acid, detectable moiety, or solid support.

In some embodiments, the compound has a structure selected from the group consisting of:

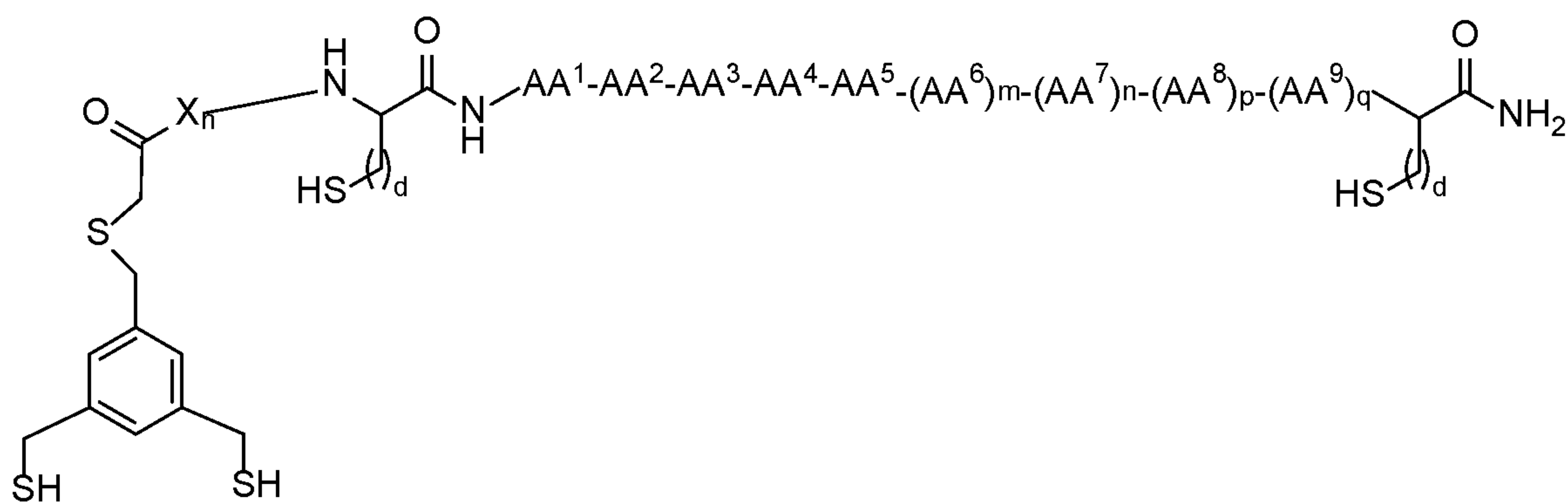


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and



or a pharmaceutically acceptable salt thereof.

X_n

The amino acid sequence X_n is a cargo peptide sequence. As discussed above, there is
5 no limitation on the number of amino acids X_n. In some embodiments, X_n may have from 1 to
50 amino acids, e.g., from 1 to 20, from 1 to 10, from 4 to 20, from 4 to 10, and all values and
subranges therein. Examples of sequences for X_n are those outlined above in Table 2 including
variants or derivatives thereof. Additional examples of cargo peptide sequences can comprise
any of those listed in Table 4 or Table 5, or derivatives or combinations thereof.

10 **Table 4.** Example Cargo Sequences

SEQ ID NO	Sequence
1	HKGFY
2	AFWTG
3	HALΩ
4	ΨYAKYFGKH-Dap
5	AFWTEKΩLAH-Dap
6	F-Dap-SVPYH-Dap
7	WFDKFNH-Dap
8	dΦ-SQ-dΦ-KFRVR-Dap
9	RRdΦ-R-fF-KFQG-Dap
10	OR-dΦ-R-fF-KFQG-Dap
11	RFZZFK
12	RDΨZNK
13	ZZPGAK
14	ZZASAK
15	ZZLPTK
16	ΨRNZIK
17	ZTEANK
18	Z-dΦ-VGQK
19	ZΨSZZK
20	ZΨMSZK
21	ZSMZGK
22	ZSΨZZK
23	ZRVDAK
24	RDΨPra-N
25	ΦRRRR-Dap
26	ΨRN-Pra-I
27	Pra-SΨKK
28	Pra-RVDA
29	AΨRN-Pra-I
30	ΨRN-Pra-IA
31	AΨRN-Pra-IA

32	AAΨRN-Pra-IA
33	AFΨRN-Pra-I-A
34	A-AbuΨRN-Pra-I-Abu
35	ΨIΨRN-Pra-I-Abu-K
36	ΨΨRN-Pra-I-Abu
37	ALΨRN-Pra-ID
38	AQΨRN-Pra-ID
39	IEΨRN-Pra-ID
40	ASΨRN-Pra-IE
41	LΨRN-Pra-IE
42	AΨΨRN-Pra-IF
43	A-OmΨRN-Pra-IF
44	A-AbuΨRN-Pra-IN
45	dA-AΨRN-Pra-IN
46	ΨNΨRN-Pra-II
47	A-AbuΨRN-Pra-I-Nle
48	WΨRN-Pra-IΨ
49	ANΨRN-Pra-IR
50	R-ΩΨRN-Pra-IS
51	HΨRN-Pra-IYK-Φ
52	A-AbuΨRN-Pra-I-Abu
53	ΨIΨRN-Pra-I-Abu
54	ALΨRN-Pra-ID
55	AQΨRN-Pra-ID
56	A-OrnΨRN-Pra-IF
57	AΨΨRN-Pra-IF
58	A-AbuΨRN-Pra-I-Abu
59	AAΨRN-Pra-IA
60	AAFRN-Pra-IA
61	ALFRN-Pra-ID
62	ΨYAKYFGKH
63	AFWTEKΩLAH

Table 5. Example cargo moieties

SEQ ID NO	Abbreviation	Sequence*
147	R ₅	RRRRR
148	A ₅	AAAAA
149	F ₄	FFFF
150	PCP	DE(pCAP)LI
151	A ₇	AAAAAAA
152		RARAR

153		DADAD
154		DΩUD
155		UTRV
156		SASAS
157		ALDWSWLQ
158		ALDASALQ
159		SFAEYWALLS

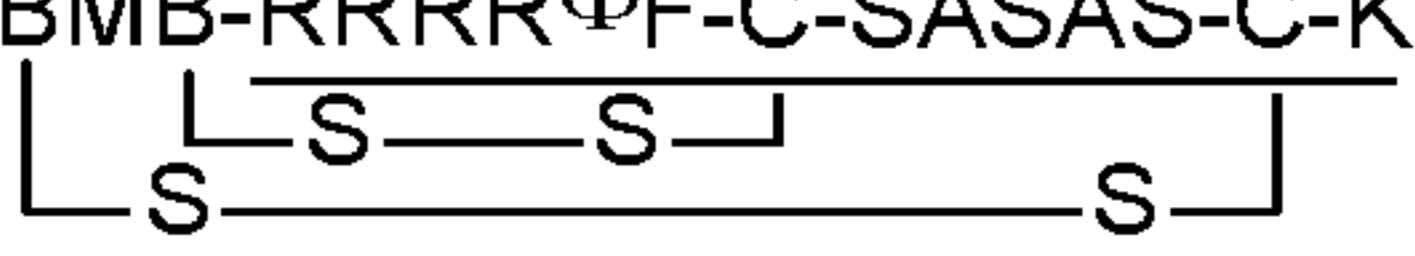
*pCAP, phosphocoumaryl amino propionic acid; Ω, norleucine; U, 2-aminobutyric acid.

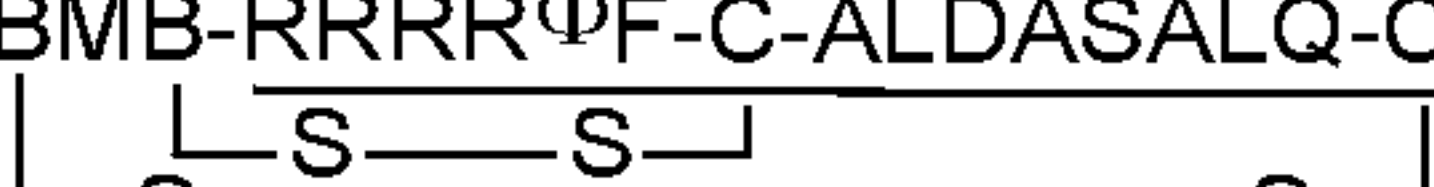
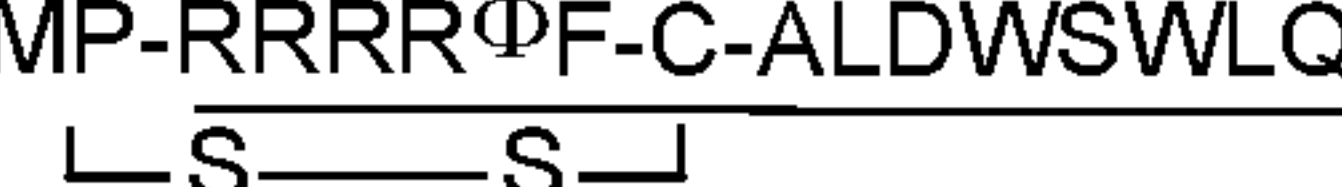
It should be understood that when referring to Formula I, the sequence X_n is coupled to a cysteine residue (C) at each end, and the amide bonds formed by said coupling are included in Formula I. Likewise, when referring to Formula II, X_m is coupled to a cystein residue at each end, and the amide bonds formed by said coupling are included in Formula II. For example, these sections can be represented as -C-X_n-C- or -C-X_m-C-, or sometimes as -C-(AA)_n-C-, where AA = an amino acid residue as defined herein and n is an interger of from 2 to 8, e.g., -C-AA¹-AA²-C-, -C-AA¹-AA²-AA³-C-, -C-AA¹-AA²-AA³-AA⁴-C-, -C-AA¹-AA²-AA³-AA⁴-AA⁵-C-, -C-AA¹-AA²-AA³-AA⁵-AA⁶-C-, -C-AA¹-AA²-AA³-AA⁵-AA⁶-AA⁷-C-, and -C-AA¹-AA²-AA³-AA⁵-AA⁶-AA⁷-AA⁸-C-. When refering to Formula I, the two terminal cystein residues attached to sequence X_n are coupled to the 3,5-(bismercaptopomethylbenzoyl) moeity of Formula I and one cycteine residue is also coupled to sequence X_m (which is also coupled to the 3,5-(bismercaptopomethylbenzoyl) moiety of Formula I). When referring to Formula II, the two terminal cystein residues attached to sequence X_m are coupled to the 3,5-(bismercaptopomethylbenzoyl) moiety of Formula II and one cycteine residue is also coupled to sequence X_n (which is also coupled to the 3,5-(bismercaptopomethylbenzoyl) moiety of Formula II).

Specific Examples

Specific examples of bicyclic peptides disclosed herein are shown in Table 6.

Table 6. Sequences of peptides in this work^a

Peptide	SEQ ID NO ^b	Sequence
1	160	RQIKIWFQNRRMKWKKGG-TALDWSWLQTE
2	161	BMB-RRRR ^Φ F-C-SASAS-C-K 

3	162	BMB-SASAS-C-F Φ RRRR-C-K 
4	163	BMB-RRRR Φ F-C-ALDWSWLQ-C 
5	164	BMB-RRRR Φ F-C-ALDASALQ-C 
6	165	MP-RRRR Φ F-C-ALDWSWLQ 
7	166	BMB-RRRR Φ F-C-SFAEYWALLS-C 
8	167	BMB-SFAEYWALLS-C-RRRR Φ F-C 

^a BMB, 3,5-bis(mercaptomethyl)benzoyl; Φ , L-2-naphthylalanine; MP, 3-mercaptopropionyl.

^b underlined portion only.

Detectable moiety

The disclosed compounds can also comprise a detectable moiety, e.g., linked to a side chain of any amino acid in X_m or X_n or on R^1 . The detectable moiety can comprise any detectable label. Examples of suitable detectable labels include, but are not limited to, a UV-Vis label, a near-infrared label, a luminescent group, a phosphorescent group, a magnetic spin resonance label, a photosensitizer, a photocleavable moiety, a chelating center, a heavy atom, a radioactive isotope, a isotope detectable spin resonance label, a paramagnetic moiety, a chromophore, or any combination thereof. In some embodiments, the label is detectable without the addition of further reagents.

In some embodiments, the detectable moiety is a biocompatible detectable moiety, such that the compounds can be suitable for use in a variety of biological applications.

“Biocompatible” and “biologically compatible”, as used herein, generally refer to compounds that are, along with any metabolites or degradation products thereof, generally non-toxic to cells and tissues, and which do not cause any significant adverse effects to cells and tissues when cells and tissues are incubated (*e.g.*, cultured) in their presence.

The detectable moiety can contain a luminophore such as a fluorescent label or near-infrared label. Examples of suitable luminophores include, but are not limited to, metal porphyrins; benzoporphyrins; azabenzoporphyrine; naphthoporphyrin; phthalocyanine; polycyclic aromatic hydrocarbons such as perylene, perylene diimine, pyrenes; azo dyes;

xanthene dyes; boron dipyrromethene, aza-boron dipyrromethene, cyanine dyes, metal-ligand complex such as bipyridine, bipyridyls, phenanthroline, coumarin, and acetylacetonates of ruthenium and iridium; acridine, oxazine derivatives such as benzophenoxazine; aza-annulene, squaraine; 8-hydroxyquinoline, polymethines, luminescent producing nanoparticle, such as
 5 quantum dots, nanocrystals; carbostyryl; terbium complex; inorganic phosphor; ionophore such as crown ethers affiliated or derivatized dyes; or combinations thereof. Specific examples of suitable luminophores include, but are not limited to, Pd (II) octaethylporphyrin; Pt (II)-octaethylporphyrin; Pd (II) tetraphenylporphyrin; Pt (II) tetraphenylporphyrin; Pd (II) meso-tetraphenylporphyrin tetrabenzoporphine; Pt (II) meso-tetrapheny metrylbenzoporphyrin; Pd
 10 (II) octaethylporphyrin ketone; Pt (II) octaethylporphyrin ketone; Pd (II) meso-tetra(pentafluorophenyl)porphyrin; Pt (II) meso-tetra (pentafluorophenyl) porphyrin; Ru (II) tris(4,7-diphenyl-1,10-phenanthroline) (Ru (dpp)₃); Ru (II) tris(1,10-phenanthroline) (Ru(phen)₃), tris(2,2'-bipyridine)ruthenium (II) chloride hexahydrate (Ru(bpy)₃); erythrosine B; fluorescein; fluorescein isothiocyanate (FITC); eosin; iridium (III) ((N-methyl-benzimidazol-2-yl)-7-(diethylamino)-coumarin)); indium (III) ((benzothiazol-2-yl)-7-(diethylamino)-coumarin))-2-(acetylacetonate); Lumogen dyes; Macroflex fluorescent red; Macrolex fluorescent yellow; Texas Red; rhodamine B; rhodamine 6G; sulfur rhodamine; m-cresol; thymol blue; xlenol blue; cresol red; chlorophenol blue; bromocresol green; bromocresol red; bromothymol blue; Cy2; a Cy3; a Cy5; a Cy5.5; Cy7; 4-nitrophenol; alizarin;
 20 phenolphthalein; o-cresolphthalein; chlorophenol red; calmagite; bromo-xlenol; phenol red; neutral red; nitrazine; 3,4,5,6-tetrabromophenolphthalein; congo red; fluorescein; eosin; 2',7'-dichlorofluorescein; 5(6)-carboxy-fluorecsein; carboxynaphthofluorescein; 8-hydroxypyrene-1,3,6-trisulfonic acid; semi-naphthorhodafluor; semi-naphthofluorescein; tris (4,7-diphenyl-1,10-phenanthroline) ruthenium (II) dichloride; (4,7-diphenyl-1,10-phenanthroline) ruthenium
 25 (II) tetraphenylboron; platinum (II) octaethylporphyin; dialkylcarbocyanine; dioctadecylcycloxacarbocyanine; fluorenylmethyloxycarbonyl chloride; 7-amino-4-methylcourmarin (Amc); green fluorescent protein (GFP); and derivatives or combinations thereof.

In some examples, the detectable moiety can comprise Rhodamine B (Rho), fluorescein
 30 isothiocyanate (FITC), 7-amino-4-methylcourmarin (Amc), green fluorescent protein (GFP), or derivatives or combinations thereof.

The detectible moiety can be attached to the cell penetrating peptide moiety at the amino group, the carboxylate group, or the side chain of any of the amino acids of the cell

penetrating peptide moiety or cargo moiety (e.g., at the amino group, the carboxylate group, or the side chain or any of X_m or X_n or R^1).

Therapeutic moiety

The disclosed compounds can also comprise a therapeutic moiety. In some examples, the cargo moiety comprises a therapeutic moiety. The detectable moiety can be linked to a therapeutic moiety or the detectable moiety can also serve as the therapeutic moiety. Therapeutic moiety refers to a group that when administered to a subject will reduce one or more symptoms of a disease or disorder.

The therapeutic moiety can comprise a wide variety of drugs, including antagonists, for example enzyme inhibitors, and agonists, for example a transcription factor which results in an increase in the expression of a desirable gene product (although as will be appreciated by those in the art, antagonistic transcription factors can also be used), are all included. In addition, therapeutic moiety includes those agents capable of direct toxicity and/or capable of inducing toxicity towards healthy and/or unhealthy cells in the body. Also, the therapeutic moiety can be capable of inducing and/or priming the immune system against potential pathogens.

The therapeutic moiety can, for example, comprise an anticancer agent, antiviral agent, antimicrobial agent, anti-inflammatory agent, immunosuppressive agent, anesthetics, or any combination thereof.

The therapeutic moiety can comprise an anticancer agent. Example anticancer agents include 13-cis-Retinoic Acid, 2-Amino-6-Mercaptopurine, 2-CdA, 2-Chlorodeoxyadenosine, 5-fluorouracil, 6-Thioguanine, 6-Mercaptopurine, Accutane, Actinomycin-D, Adriamycin, Adrucil, Agrylin, Ala-Cort, Aldesleukin, Alemtuzumab, Alitretinoin, Alkaban-AQ, Alkeran, All-transretinoic acid, Alpha interferon, Altretamine, Amethopterin, Amifostine, Aminoglutethimide, Anagrelide, Anandron, Anastrozole, Arabinosylcytosine, Aranesp, Aredia, Arimidex, Aromasin, Arsenic trioxide, Asparaginase, ATRA, Avastin, BCG, BCNU, Bevacizumab, Bexarotene, Bicalutamide, BiCNU, Blenoxane, Bleomycin, Bortezomib, Busulfan, Busulfex, C225, Calcium Leucovorin, Campath, Camptosar, Camptothecin-11, Capecitabine, Carac, Carboplatin, Carmustine, Carmustine wafer, Casodex, CCNU, CDDP, CeeNU, Cerubidine, cetuximab, Chlorambucil, Cisplatin, Citrovorium Factor, Cladribine, Cortisone, Cosmegen, CPT-11, Cyclophosphamide, Cytadren, Cytarabine, Cytarabine liposomal, Cytosar-U, Cytosan, Dacarbazine, Dactinomycin, Darbepoetin alfa, Daunomycin, Daunorubicin, Daunorubicin hydrochloride, Daunorubicin liposomal, DaunoXome, Decadron, Delta-Cortef, Deltasone, Denileukin diftitox, DepoCyt, Dexamethasone, Dexamethasone

acetate, Dexamethasone sodium phosphate, Dexasone, Dexrazoxane, DHAD, DIC, Diodex, Docetaxel, Doxil, Doxorubicin, Doxorubicin liposomal, Droxia, DTIC, DTIC-Dome, Duralone, Efudex, Eligard, Ellence, Eloxatin, Elspar, Emcyt, Epirubicin, Epoetin alfa, Erbitux, Erwinia L-asparaginase, Estramustine, Ethyol, Etopophos, Etoposide, Etoposide phosphate, 5 Eulexin, Evista, Exemestane, Fareston, Faslodex, Femara, Filgrastim, Floxuridine, Fludara, Fludarabine, Fluoroplex, Fluorouracil, Fluorouracil (cream), Fluoxymesterone, Flutamide, Folinic Acid, FUDR, Fulvestrant, G-CSF, Gefitinib, Gemcitabine, Gemtuzumab ozogamicin, Gemzar, Gleevec, Lupron, Lupron Depot, Matulane, Maxidex, Mechlorethamine, - Mechlorethamine Hydrochlorine, Medralone, Medrol, Megace, Megestrol, Megestrol Acetate, 10 Melphalan, Mercaptopurine, Mesna, Mesnex, Methotrexate, Methotrexate Sodium, Methylprednisolone, Mylocel, Letrozole, Neosar, Neulasta, Neumega, Neupogen, Nilandron, Nilutamide, Nitrogen Mustard, Novaldex, Novantrone, Octreotide, Octreotide acetate, Oncospar, Oncovin, Ontak, Onxal, Oprevelkin, Orapred, Orasone, Oxaliplatin, Paclitaxel, Pamidronate, Panretin, Paraplatin, Pediapred, PEG Interferon, Pegaspargase, Pegfilgrastim, 15 PEG-INTRON, PEG-L-asparaginase, Phenylalanine Mustard, Platinol, Platinol-AQ, Prednisolone, Prednisone, Prelone, Procarbazine, PROCRIT, Proleukin, Prolifeprospan 20 with Carmustine implant, Purinethol, Raloxifene, Rheumatrex, Rituxan, Rituximab, Roveron-A (interferon alfa-2a), Rubex, Rubidomycin hydrochloride, Sandostatin, Sandostatin LAR, Sargramostim, Solu-Cortef, Solu-Medrol, STI-571, Streptozocin, Tamoxifen, Targretin, Taxol, 20 Taxotere, Temodar, Temozolomide, Teniposide, TESP, Thalidomide, Thalomid, TheraCys, Thioguanine, Thioguanine Tabloid, Thiophosphoamide, Thioplex, Thiotepa, TICE, Toposar, Topotecan, Toremifene, Trastuzumab, Tretinoin, Trexall, Trisenox, TSPA, VCR, Velban, Velcade, VePesid, Vesanoid, Viadur, Vinblastine, Vinblastine Sulfate, Vincasar Pfs, Vincristine, Vinorelbine, Vinorelbine tartrate, VLB, VP-16, Vumon, Xeloda, Zanosar, Zevalin, 25 Zinecard, Zoladex, Zoledronic acid, Zometa, Gliadel wafer, Glivec, GM-CSF, Goserelin, granulocyte colony stimulating factor, Halotestin, Herceptin, Hexadrol, Hexalen, Hexamethylmelamine, HMM, Hycamtin, Hydrea, Hydrocort Acetate, Hydrocortisone, Hydrocortisone sodium phosphate, Hydrocortisone sodium succinate, Hydrocortone phosphate, Hydroxyurea, Ibritumomab, Ibritumomab Tiuxetan, Idamycin, Idarubicin, Ifex, 30 IFN-alpha, Ifosfamide, IL 2, IL-11, Imatinib mesylate, Imidazole Carboxamide, Interferon alfa, Interferon Alfa-2b (PEG conjugate), Interleukin 2, Interleukin-11, Intron A (interferon alfa-2b), Leucovorin, Leukeran, Leukine, Leuprolide, Leurocristine, Leustatin, Liposomal Ara-C, Liquid Pred, Lomustine, L-PAM, L-Sarcolysin, Meticorten, Mitomycin, Mitomycin-C,

Mitoxantrone, M-Prednisol, MTC, MTX, Mustargen, Mustine, Mutamycin, Myleran, Iressa, Irinotecan, Isotretinoin, Kidrolase, Lanacort, L-asparaginase, and LCR. The therapeutic moiety can also comprise a biopharmaceutical such as, for example, an antibody.

In some examples, the therapeutic moiety can comprise an antiviral agent, such as
 5 ganciclovir, azidothymidine (AZT), lamivudine (3TC), *etc.*

In some examples, the therapeutic moiety can comprise an antibacterial agent, such as
 acedapsone; acetosulfone sodium; alamecin; alexidine; amdinocillin; amdinocillin pivoxil;
 amicycline; amifloxacin; amifloxacin mesylate; amikacin; amikacin sulfate; aminosalicylic
 acid; aminosalicylate sodium; amoxicillin; amphomycin; ampicillin; ampicillin sodium;
 10 apalcillin sodium; apramycin; aspartocin; astromicin sulfate; avilamycin; avoparcin;
 azithromycin; azlocillin; azlocillin sodium; bacampicillin hydrochloride; bacitracin; bacitracin
 methylene disalicylate; bacitracin zinc; bambermycins; benzoylpas calcium; berythromycin;
 betamicin sulfate; biapenem; biniramycin; biphenamine hydrochloride; bispyrithione
 magsulfex; butikacin; butirosin sulfate; capreomycin sulfate; carbadox; carbenicillin disodium;
 15 carbenicillin indanyl sodium; carbenicillin phenyl sodium; carbenicillin potassium;
 carumonam sodium; cefaclor; cefadroxil; cefamandole; cefamandole nafate; cefamandole
 sodium; cefaparole; cefatrizine; cefazaflur sodium; cefazolin; cefazolin sodium;
 cefbuperazone; cefdinir; cefepime; cefepime hydrochloride; cefetecol; cefixime; cefmenoxime
 hydrochloride; cefmetazole; cefmetazole sodium; cefonicid monosodium; cefonicid sodium;
 20 cefoperazone sodium; ceforanide; cefotaxime sodium; cefotetan; cefotetan disodium; cefotiam
 hydrochloride; cefoxitin; cefoxitin sodium; cefpimizole; cefpimizole sodium; cefpiramide;
 cefpiramide sodium; cefpirome sulfate; cefpodoxime proxetil; cefprozil; cefroxadine;
 cefsulodin sodium; ceftazidime; ceftibuten; ceftizoxime sodium; ceftriaxone sodium;
 cefuroxime; cefuroxime axetil; cefuroxime pivoxetil; cefuroxime sodium; cephacetrile sodium;
 25 cephalixin; cephalixin hydrochloride; cephaloglycin; cephaloridine; cephalothin sodium;
 cephapirin sodium; cephradine; cetocycline hydrochloride; cetophenicol; chloramphenicol;
 chloramphenicol palmitate; chloramphenicol pantothenate complex; chloramphenicol sodium
 succinate; chlorhexidine phosphanilate; chloroxylenol; chlortetracycline bisulfate;
 chlortetracycline hydrochloride; cinoxacin; ciprofloxacin; ciprofloxacin hydrochloride;
 30 cirolemycin; clarithromycin; clinafloxacin hydrochloride; clindamycin; clindamycin
 hydrochloride; clindamycin palmitate hydrochloride; clindamycin phosphate; clofazimine;
 cloxacillin benzathine; cloxacillin sodium; cloxyquin; colistimethate sodium; colistin sulfate;
 coumermycin; coumermycin sodium; cyclacillin; cycloserine; dalfopristin; dapson;

daptomycin; demeclocycline; demeclocycline hydrochloride; demecycline; denofungin; diaveridine; dicloxacillin; dicloxacillin sodium; dihydrostreptomycin sulfate; dipyrithione; dirithromycin; doxycycline; doxycycline calcium; doxycycline fosfatex; doxycycline hyclate; droxacin sodium; enoxacin; epicillin; epitetracycline hydrochloride; erythromycin;

5 erythromycin acistrate; erythromycin estolate; erythromycin ethylsuccinate; erythromycin gluceptate; erythromycin lactobionate; erythromycin propionate; erythromycin stearate; ethambutol hydrochloride; ethionamide; fleroxacin; floxacillin; fludalanine; flumequine; fosfomycin; fosfomycin tromethamine; fumoxicillin; furazolium chloride; furazolium tartrate; fusidate sodium; fusidic acid; gentamicin sulfate; gloximonam; gramicidin; haloprogin;

10 hetacillin; hetacillin potassium; hexedine; ibafloxacin; imipenem; isoconazole; isepamicin; isoniazid; josamycin; kanamycin sulfate; kitasamycin; levofuraltadone; levopropylcillin potassium; lexithromycin; lincomycin; lincomycin hydrochloride; lomefloxacin; Lomefloxacin hydrochloride; lomefloxacin mesylate; loracarbef; mafenide; meclocycline; meclocycline sulfosalicylate; megalomicin potassium phosphate; mequidox; meropenem; methacycline;

15 methacycline hydrochloride; methenamine; methenamine hippurate; methenamine mandelate; methicillin sodium; metioprime; metronidazole hydrochloride; metronidazole phosphate; mezlocillin; mezlocillin sodium; minocycline; minocycline hydrochloride; mirincamycin hydrochloride; monensin; monensin sodium; nafcillin sodium; nalidixate sodium; nalidixic acid; naltrexone; nebramycin; neomycin palmitate; neomycin sulfate; neomycin undecylenate;

20 netilmicin sulfate; neutramycin; nifuradene; nifuraldehyde; nifuratel; nifuratrone; nifurdazil; nifurimide; nifurpirinol; nifurquinazone; nifurthiazole; nitrocyline; nitrofurantoin; nitromide; norfloxacin; novobiocin sodium; ofloxacin; onnetoprime; oxacillin; oxacillin sodium; oximonam; oximonam sodium; oxolinic acid; oxytetracycline; oxytetracycline calcium; oxytetracycline hydrochloride; paldimycin; parachlorophenol; paulomycin; pefloxacin;

25 pefloxacin mesylate; penamecillin; penicillin G benzathine; penicillin G potassium; penicillin G procaine; penicillin G sodium; penicillin V; penicillin V benzathine; penicillin V hydrabamine; penicillin V potassium; pentizidone sodium; phenyl aminosalicylate; piperacillin sodium; pirbenicillin sodium; piridicillin sodium; pirlimycin hydrochloride; pivampicillin hydrochloride; pivampicillin pamoate; pivampicillin probenate; polymyxin B sulfate;

30 porfiromycin; propikacin; pyrazinamide; pyrrithione zinc; quindecamine acetate; quinupristin; racephenicol; ramoplanin; ranimycin; relomycin; repromicin; rifabutin; rifametane; rifamexil; rifamide; rifampin; rifapentine; rifaximin; rolitetracycline; rolitetracycline nitrate; rosaramicin; rosaramicin butyrate; rosaramicin propionate; rosaramicin sodium phosphate; rosaramicin

5 stearate; rosoxacin; roxarsone; roxithromycin; sancycline; sanfetrinem sodium; sarmoxicillin;
 sarpicillin; scopafungin; sisomicin; sisomicin sulfate; sparfloxacin; spectinomycin
 hydrochloride; spiramycin; stallimycin hydrochloride; steffimycin; streptomycin sulfate;
 streptonicozid; sulfabenz; sulfabenzamide; sulfacetamide; sulfacetamide sodium; sulfacytine;
 10 sulfadiazine; sulfadiazine sodium; sulfadoxine; sulfalene; sulfamerazine; sulfameter;
 sulfamethazine; sulfamethizole; sulfamethoxazole; sulfamonomethoxine; sulfamoxole;
 sulfanilate zinc; sulfanitran; sulfasalazine; sulfasomizole; sulfathiazole; sulfazamet;
 sulfisoxazole; sulfisoxazole acetyl; sulfisboxazole diolamine; sulfomyxin; sulopenem;
 sultamricillin; suncillin sodium; talampicillin hydrochloride; teicoplanin; temafloxacin
 15 hydrochloride; temocillin; tetracycline; tetracycline hydrochloride; tetracycline phosphate
 complex; tetroxoprim; thiamphenicol; thiphencillin potassium; ticarcillin cresyl sodium;
 ticarcillin disodium; ticarcillin monosodium; ticlatone; tiodonium chloride; tobramycin;
 tobramycin sulfate; tosufloxacin; trimethoprim; trimethoprim sulfate; trisulfapyrimidines;
 troleandomycin; trospectomycin sulfate; tyrothricin; vancomycin; vancomycin hydrochloride;
 20 virginiamycin; or zorbamycin.

In some examples, the therapeutic moiety can comprise an anti-inflammatory agent.

In some examples, the therapeutic moiety can comprise dexamethasone (Dex).

25 In other examples, the therapeutic moiety comprises a therapeutic protein. For
 example, some people have defects in certain enzymes (e.g., lysosomal storage disease). It is
 disclosed herein to deliver such enzymes/proteins to human cells by linking to the
 enzyme/protein to one of the disclosed cell penetrating peptides. The disclosed cell
 penetrating peptides have been tested with proteins (e.g., GFP, PTP1B, actin, calmodulin,
 troponin C) and shown to work.

Targeting moieties

30 The disclosed compounds can also comprise a targeting moiety. In some examples, the
 cargo moiety comprises a targeting moiety. The targeting moiety can comprise, for example, a
 sequence of amino acids that can target one or more enzyme domains. In some examples, the
 targeting moiety can comprise an inhibitor against an enzyme that can play a role in a disease,
 such as cancer, cystic fibrosis, diabetes, obesity, or combinations thereof. For example, the
 targeting moiety can comprise any of the sequences listed in Table 7.

Table 7. Example targeting moieties

SEQ ID NO	Abbreviation *	Sequence
168	POGLYR	Pro-Pip-Gly-F ₂ Pmp-Tyr-
169	SOILMR	Ser-Pip-Ile-F ₂ Pmp-F ₂ Pmp-
170	IHILIR	Ile-His-Ile-F ₂ Pmp-Ile-
171	AaIALOR	Ala-(D-Ala)-Ile-F ₂ Pmp-Pip-
172	ΣSOLvR	Fpa-Ser-Pip-F ₂ Pmp-(D-Val)-
173	ΘnPΛAR	Pip-(D-Asn)-Pro-F ₂ Pmp-Ala-
174	TΨAAGR	Tyr-Phg-Ala-F ₂ Pmp-Gly-
175	AHILaR	Ala-His-Ile- F ₂ Pmp-(D-Ala)-
176	GnGLpR	Gly-(D-Asn)-Gly-F ₂ Pmp-(D-Pro)-
177	fQOLIR	(D-Phe)-Gln-Pip-F ₂ Pmp-Ile-
178	SPGLHR	Ser-Pro-Gly-F ₂ Pmp-His-
179	ΘYILHR	Pip-Tyr-Ile-F ₂ Pmp-His-
180	SvPΛHR	Ser-(D-Val)-Pro-F ₂ Pmp-His-
181	AIPΛnR	Ala-Ile-Pro-F ₂ Pmp-(D-Asn)-
182	ΣSILQF	Fpa-Ser-Ile-F ₂ Pmp-Gln-
183	AaΨΛfR	Ala-(D-Ala)-Phg-F ₂ Pmp-(D-Phe)-
184	ntΨΛΨR	(D-Asn)-(D-Thr)-Phg-F ₂ Pmp-Phg-
185	IPΨΛΩR	Ile-Pro-Phg-F ₂ Pmp-Nle-
186	QΘΣΛOR	Gln-Pip-Fpa-F ₂ Pmp-Pip-
187	nAΣAGR	(D-Asn)-Ala-Fpa-F ₂ Pmp-Gly-
188	ntYΛAR	(D-Asn)-(D-Thr)-Tyr-F ₂ Pmp-Ala-
189	eAΨΛvR	(D-Glu)-Ala-Phg-F ₂ Pmp-(D-Val)-
190	IvΨΛAR	Ile-(D-Val)-Phg-F ₂ Pmp-Ala-
191	YtΨΛAR	Tyr-(D-Thr)-Phg-F ₂ Pmp-Ala-
192	nΘΨΛIR	(D-Asn)-Pip-Phg-F ₂ Pmp-Ile-
193	ΘnWΛHR	Pip-(D-Asn)-Trp-F ₂ Pmp-His-
194	YΘvΛIR	Tyr-Pip-(D-Val)-F ₂ Pmp-Ile-
195	nSAAGR	(D-Asn)-Ser-(D-Ala)-F ₂ Pmp-Gly-
196	tnvΛaR	(D-Thr)-(D-Asn)-(D-Val)-F ₂ Pmp-(D-Ala)-

SEQ ID NO	Abbreviation *	Sequence
197	ntvΛtR	(D-Asn)-(D-Thr)-(D-Val)-F ₂ Pmp-(D-Thr)-
198	SItΛYR	Ser-Ile-(D-Thr)-F ₂ Pmp-Tyr-
199	nΣnΛIR	(D-Asn)-Fpa-(D-Asn)-F ₂ Pmp-(D-Leu)-
200	YnnΛΩR	Tyr-(D-Asn)-(D-Asn)-F ₂ Pmp-Nle-
201	nYnΛGR	(D-Asn)-Tyr-(D-Asn)-F ₂ Pmp-Gly-
202	AWnΛAR	Ala-Trp-(D-Asn)-F ₂ Pmp-Ala-
203	vtHΛYR	(D-Val)-(D-Thr)-His-F ₂ Pmp-Tyr-
204	PΨHΛΘR	Pro-Phg-His-F ₂ Pmp-Pip-
205	nΨHΛGR	(D-Asn)-Phg-His-F ₂ Pmp-Gly-
206	PAHΛGR	Pro-Ala-His-F ₂ Pmp-Gly-
207	AYHΛIR	Ala-Tyr-His-F ₂ Pmp-Ile-
208	nΘeΛYR	(D-Asn)-Pip-(D-Glu)-F ₂ Pmp-Tyr-
209	vSSΛtR	(D-Val)-Ser-Ser-F ₂ Pmp-(D-Thr)-
210	aΞt' ϑ Φ'YNK	((D-Ala)-Sar-(D-pThr)-Pp-Nal-Tyr-Gln)-Lys
211	Tm(aΞt'ϑΦ'RA)Dap	Tm((D-Ala)-Sar-(D-pThr)-Pp-Nal-Arg-Ala)-Dap
212	Tm(aΞt'ϑΦ'RAa)Dap	Tm((D-Ala)-Sar-(D-pThr)-Pp-Nal-Arg-Ala-(D-Ala))-Dap
213	Tm(aΞtϑΦ'RAa)Dap	Tm((D-Ala)-Sar-(D-Thr)-Pp-Nal-Arg-Ala-(D-Ala))-Dap
214	Tm(aΞtaΦ'RAa)Dap	Tm((D-Ala)-Sar-(D-Thr)-(D-Ala)-Nal-Arg-Ala-(D-Ala))-Dap

*Fpa, Σ = L-4-fluorophenylalanine; Pip, Θ = L-homoproline; Nle, Ω = L-norleucine; Phg, Ψ = L-phenylglycine; F₂Pmp, Λ = L-4-(phosphonodifluoromethyl)phenylalanine; Dap = L-2,3-diaminopropionic acid; Nal, Φ' = L-β-naphthylalanine; Pp, ϑ = L-pipecolic acid; Sar, Ξ = sarcosine; Tm = trimesic acid.

5

In some examples, the targeting moiety can be any of SEQ ID NO:168 to SEQ ID NO:214. In some examples, the targeting moiety can be a variant of any of SEQ ID NO:168 to SEQ ID NO:214.

The targeting moiety and cell penetrating peptide moiety can overlap, that is residues that form the cell penetrating peptide moiety can also be part of the sequence that forms the targeting moiety, and vice a versa.

5 The therapeutic moiety can be attached to the cell penetrating peptide moiety at the amino group, the carboxylate group, or the side chain of any of the amino acids of the cell penetrating peptide moiety or cargo moiety (e.g., at the amino group, the carboxylate group, or the side chain or any of X_m , X_n or R^1). In some examples, the therapeutic moiety can be attached to the detectable moiety.

10 In some examples, the therapeutic moiety can comprise a targeting moiety that can act as an inhibitor against Ras (e.g., K-Ras), PTP1B, Pin1, Grb2 SH2, CAL PDZ, and the like, or combinations thereof.

Ras is a protein that in humans is encoded by the RAS gene. The normal Ras protein performs an essential function in normal tissue signaling, and the mutation of a Ras gene is implicated in the development of many cancers. Ras can act as a molecular on/off switch, once
15 it is turned on Ras recruits and activates proteins necessary for the propagation of growth factor and other receptors' signal. Mutated forms of Ras have been implicated in various cancers, including lung cancer, colon cancer, pancreatic cancer, and various leukemias.

Protein-tyrosine phosphatase 1B (PTP1B) is a prototypical member of the PTP superfamily and plays numerous roles during eukaryotic cell signaling. PTP1B is a negative
20 regulator of the insulin signaling pathway, and is considered a promising potential therapeutic target, in particular for the treatment of type II diabetes. PTP1B has also been implicated in the development of breast cancer.

Pin1 is an enzyme that binds to a subset of proteins and plays a role as a post phosphorylation control in regulating protein function. Pin1 activity can regulate the outcome
25 of proline-directed kinase signaling and consequently can regulate cell proliferation and cell survival. Deregulation of Pin1 can play a role in various diseases. The up-regulation of Pin1 may be implicated in certain cancers, and the down-regulation of Pin1 may be implicated in Alzheimer's disease. Inhibitors of Pin1 can have therapeutic implications for cancer and immune disorders.

30 Grb2 is an adaptor protein involved in signal transduction and cell communication. The Grb2 protein contains one SH2 domain, which can bind tyrosine phosphorylated sequences. Grb2 is widely expressed and is essential for multiple cellular functions. Inhibition of Grb2

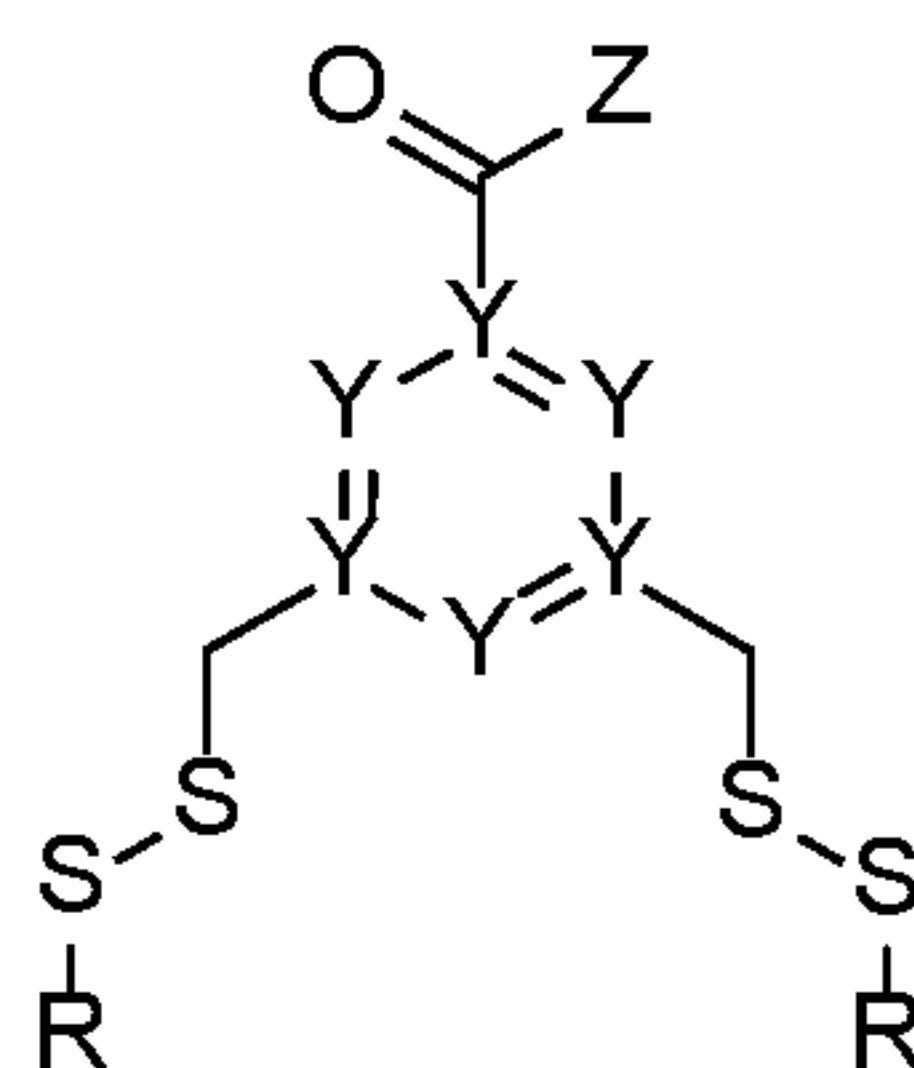
function can impair developmental processes and can block transformation and proliferation of various cell types.

It was recently reported that the activity of cystic fibrosis membrane conductance regulator (CFTR), a chloride ion channel protein mutated in cystic fibrosis (CF) patients, is negatively regulated by CFTR-associated ligand (CAL) through its PDZ domain (CAL-PDZ) (Wolde, M et al. *J. Biol. Chem.* 2007, 282, 8099). Inhibition of the CFTR/CAL-PDZ interaction was shown to improve the activity of Δ Phe508-CFTR, the most common form of CFTR mutation (Cheng, SH et al. *Cell* 1990, 63, 827; Kerem, BS et al. *Science* 1989, 245, 1073), by reducing its proteasome-mediated degradation (Cushing, PR et al. *Angew. Chem. Int. Ed.* 2010, 49, 9907). Thus, disclosed herein is a method for treating a subject having cystic fibrosis by administering an effective amount of a compound or composition disclosed herein. The compound or composition administered to the subject can comprise a therapeutic moiety that can comprise a targeting moiety that can act as an inhibitor against CAL PDZ. Also, the compositions or compositions disclosed herein can be administered with a molecule that corrects the CFTR function.

In some examples the targeting moiety can comprise E-T-G-E-F-L (SEQ ID NO:215) or LDPETGE (SEQ ID NO:216).

Linking Moiety

The disclosure provides for a compound according to Formula IV':



IV'

wherein:

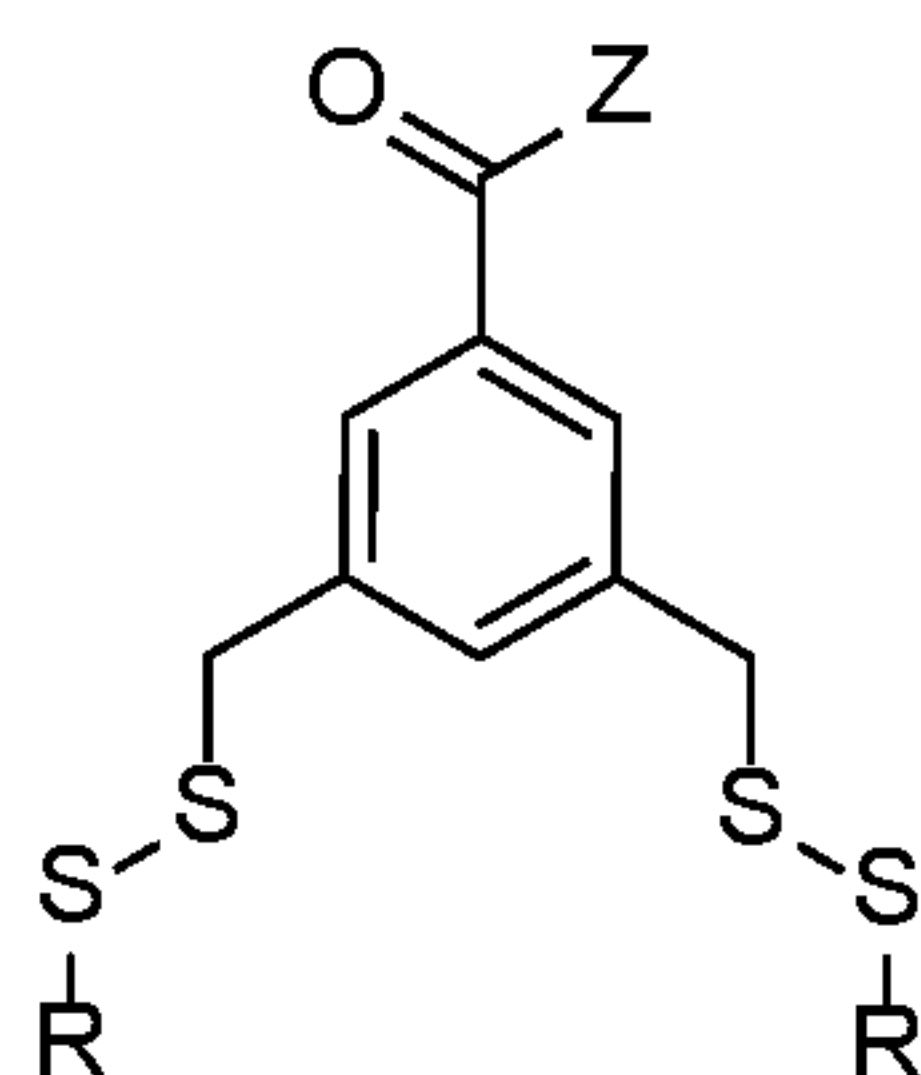
each Y is independently CH or N, provided no more than four Y are N;

Z is OR_a , hydrogen, halogen, carbocyclyl, heterocyclyl, or an amino acid;

each R is independently an alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, or an amino acid; and

R_a is independently H, $\text{C}(\text{O})$ alkyl, alkyl, alkenyl, alkynyl, carbocyclic, or heterocyclyl.

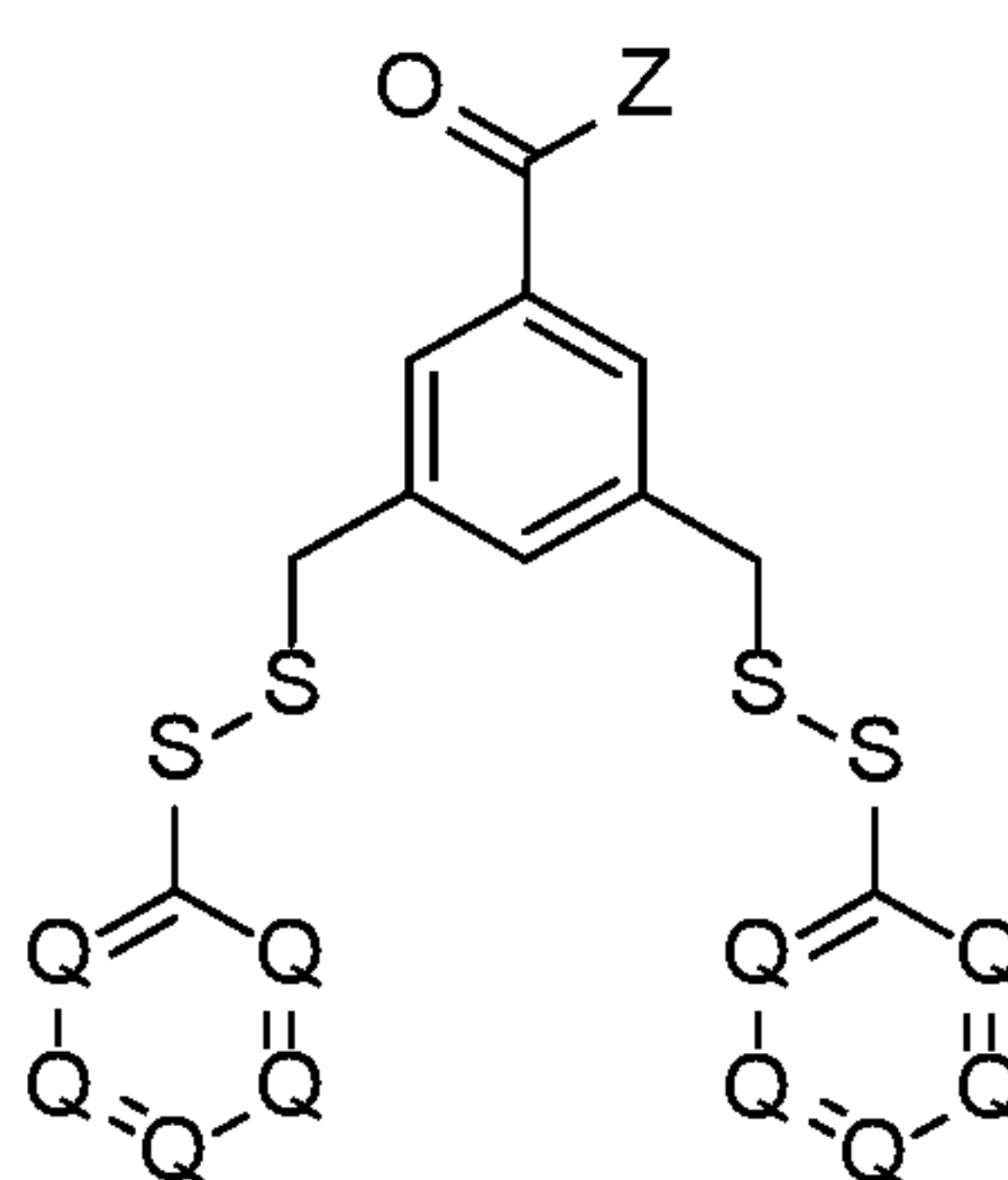
In embodiments, the compound of Formula IV has a structure according to Formula IV'a:



IV'a

In some embodiments, wherein Z is OH. In some embodiments, R is independently aryl or heteroaryl.

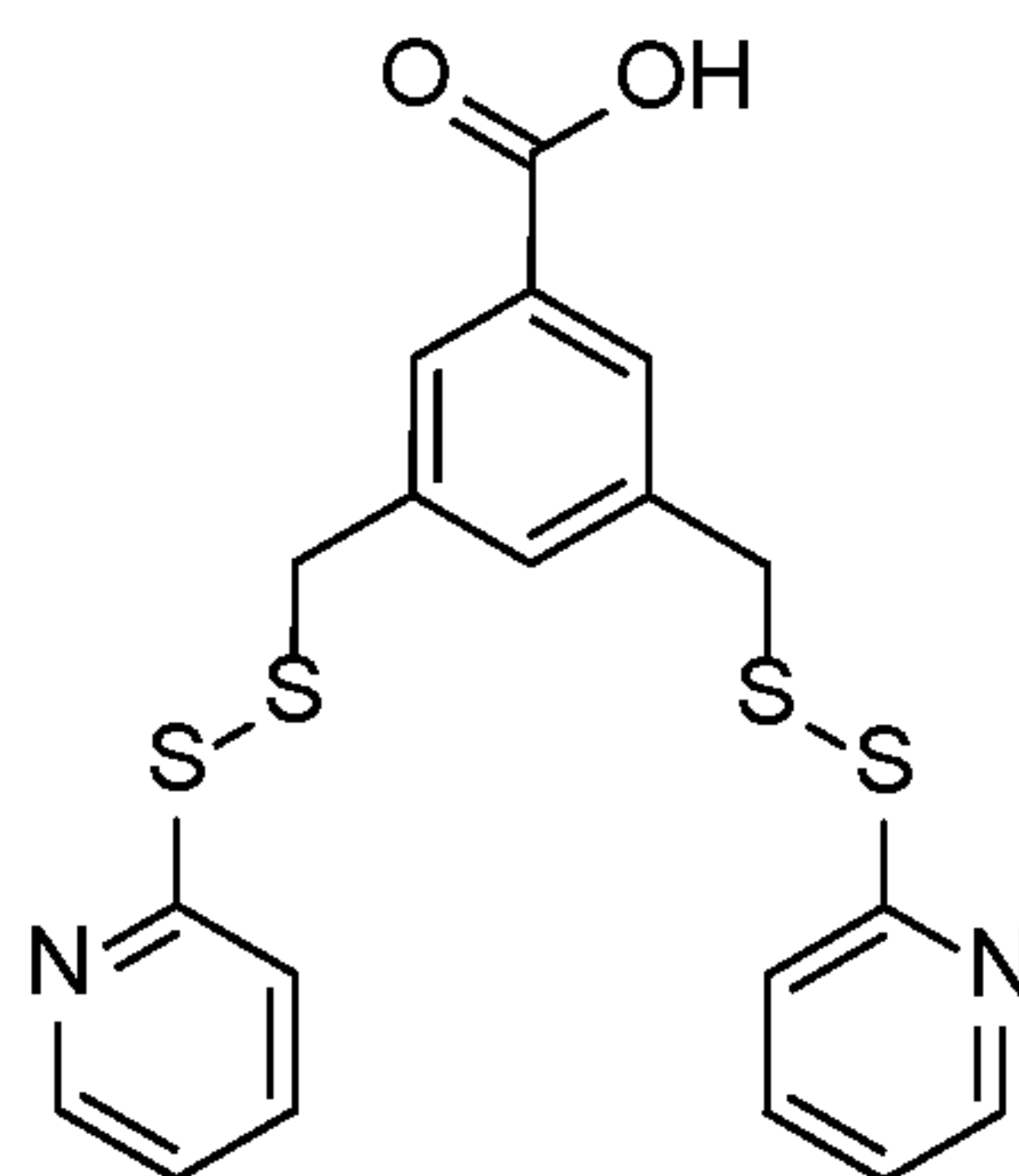
- 5 In some embodiments, the compound of Formula IV has a structure according to Formula IV'b



IV'b

wherein Q at each instance is independently CH or N.

- 10 In some embodiments, the compound has the following structure



Methods of Making

- The compounds described herein can be prepared using synthetic techniques known to one skilled in the art of organic synthesis or variations thereon as appreciated by those skilled in the art. The compounds described herein can be prepared from readily available starting materials. Optimum reaction conditions can vary with the particular reactants or solvents used, but such conditions can be determined by one skilled in the art.
- 15

Variations on the compounds described herein include the addition, subtraction, or movement of the various constituents as described for each compound. Similarly, when one or more chiral centers are present in a molecule, the chirality of the molecule can be changed. Additionally, compound synthesis can involve the protection and deprotection of various chemical groups. The use of protection and deprotection, and the selection of appropriate protecting groups can be determined by one skilled in the art. The chemistry of protecting groups can be found, for example, in Wuts and Greene, Protective Groups in Organic Synthesis, 4th Ed., Wiley & Sons, 2006, which is incorporated herein by reference in its entirety.

The starting materials and reagents used in preparing the disclosed compounds and compositions are either available from commercial suppliers such as Aldrich Chemical Co., (Milwaukee, WI), Acros Organics (Morris Plains, NJ), Fisher Scientific (Pittsburgh, PA), Sigma (St. Louis, MO), Pfizer (New York, NY), GlaxoSmithKline (Raleigh, NC), Merck (Whitehouse Station, NJ), Johnson & Johnson (New Brunswick, NJ), Aventis (Bridgewater, NJ), AstraZeneca (Wilmington, DE), Novartis (Basel, Switzerland), Wyeth (Madison, NJ), Bristol-Myers-Squibb (New York, NY), Roche (Basel, Switzerland), Lilly (Indianapolis, IN), Abbott (Abbott Park, IL), Schering Plough (Kenilworth, NJ), or Boehringer Ingelheim (Ingelheim, Germany), or are prepared by methods known to those skilled in the art following procedures set forth in references such as Fieser and Fieser's Reagents for Organic Synthesis, Volumes 1-17 (John Wiley and Sons, 1991); Rodd's Chemistry of Carbon Compounds, Volumes 1-5 and Supplementals (Elsevier Science Publishers, 1989); Organic Reactions, Volumes 1-40 (John Wiley and Sons, 1991); March's Advanced Organic Chemistry, (John Wiley and Sons, 4th Edition); and Larock's Comprehensive Organic Transformations (VCH Publishers Inc., 1989). Other materials, such as the pharmaceutical carriers disclosed herein can be obtained from commercial sources.

Reactions to produce the compounds described herein can be carried out in solvents, which can be selected by one of skill in the art of organic synthesis. Solvents can be substantially nonreactive with the starting materials (reactants), the intermediates, or products under the conditions at which the reactions are carried out, *i.e.*, temperature and pressure.

Reactions can be carried out in one solvent or a mixture of more than one solvent. Product or intermediate formation can be monitored according to any suitable method known in the art. For example, product formation can be monitored by spectroscopic means, such as nuclear magnetic resonance spectroscopy (*e.g.*, ^1H or ^{13}C) infrared spectroscopy, spectrophotometry

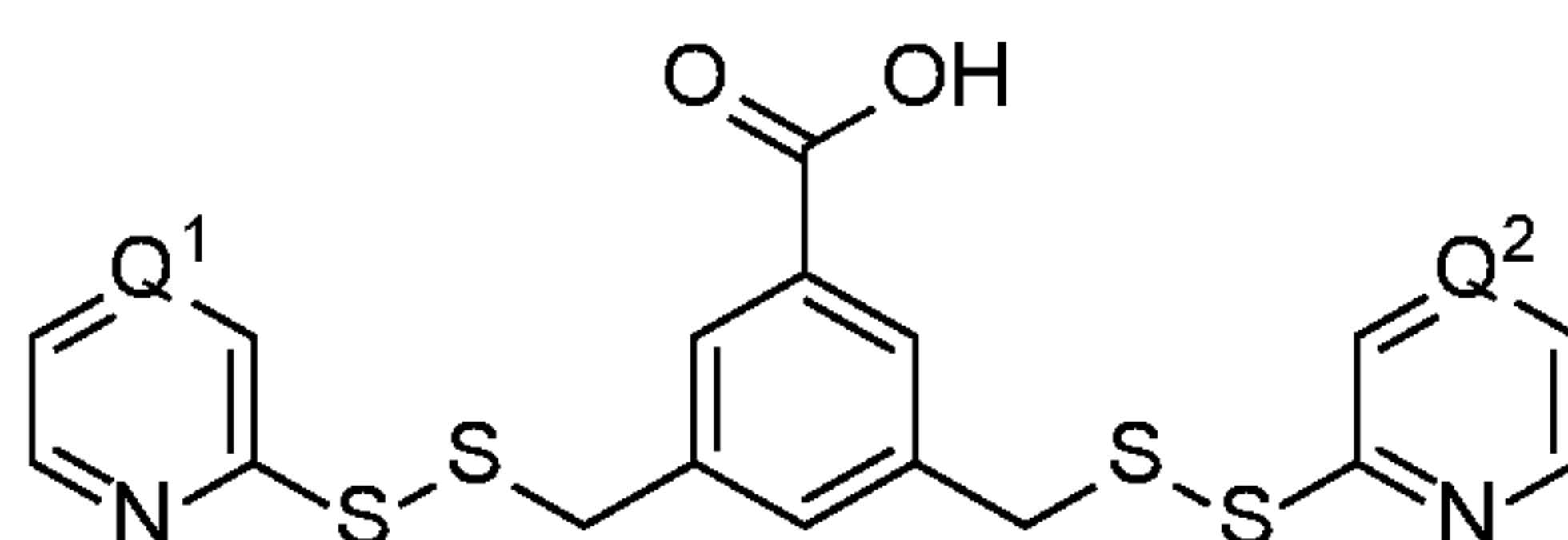
(e.g., UV-visible), or mass spectrometry, or by chromatography such as high performance liquid chromatography (HPLC) or thin layer chromatography.

The disclosed compounds can be prepared by solid phase peptide synthesis wherein the amino acid α -N-terminal is protected by an acid or base protecting group. Such protecting groups should have the properties of being stable to the conditions of peptide linkage formation while being readily removable without destruction of the growing peptide chain or racemization of any of the chiral centers contained therein. Suitable protecting groups are 9-fluorenylmethyloxycarbonyl (Fmoc), t-butyloxycarbonyl (Boc), benzyloxycarbonyl (Cbz), biphenylisopropyloxycarbonyl, t-amylloxycarbonyl, isobornyloxycarbonyl, α,α -dimethyl-3,5-dimethoxybenzyloxycarbonyl, o-nitrophenylsulfenyl, 2-cyano-t-butyloxycarbonyl, and the like. The 9-fluorenylmethyloxycarbonyl (Fmoc) protecting group is particularly preferred for the synthesis of the disclosed compounds. Other preferred side chain protecting groups are, for side chain amino groups like lysine and arginine, 2,2,5,7,8-pentamethylchroman-6-sulfonyl (pmc), nitro, p-toluenesulfonyl, 4-methoxybenzene-sulfonyl, Cbz, Boc, and adamantyloxycarbonyl; for tyrosine, benzyl, o-bromobenzyloxy-carbonyl, 2,6-dichlorobenzyl, isopropyl, t-butyl (t-Bu), cyclohexyl, cyclopentyl and acetyl (Ac); for serine, t-butyl, benzyl and tetrahydropyranyl; for histidine, trityl, benzyl, Cbz, p-toluenesulfonyl and 2,4-dinitrophenyl; for tryptophan, formyl; for aspartic acid and glutamic acid, benzyl and t-butyl and for cysteine, triphenylmethyl (trityl). In the solid phase peptide synthesis method, the α -C-terminal amino acid is attached to a suitable solid support or resin. Suitable solid supports useful for the above synthesis are those materials which are inert to the reagents and reaction conditions of the stepwise condensation-deprotection reactions, as well as being insoluble in the media used. Solid supports for synthesis of α -C-terminal carboxy peptides is 4-hydroxymethylphenoxymethyl-copoly(styrene-1% divinylbenzene) or 4-(2',4'-dimethoxyphenyl-Fmoc-aminomethyl)phenoxyacetamidoethyl resin available from Applied Biosystems (Foster City, Calif.). The α -C-terminal amino acid is coupled to the resin by means of N,N'-dicyclohexylcarbodiimide (DCC), N,N'-diisopropylcarbodiimide (DIC) or O-benzotriazol-1-yl-N,N,N',N'-tetramethyluroniumhexafluorophosphate (HBTU), with or without 4-dimethylaminopyridine (DMAP), 1-hydroxybenzotriazole (HOBT), benzotriazol-1-yloxy-tris(dimethylamino)phosphoniumhexafluorophosphate (BOP) or bis(2-oxo-3-oxazolidinyl)phosphine chloride (BOPCl), mediated coupling for from about 1 to about 24 hours at a temperature of between 10°C and 50°C in a solvent such as dichloromethane or DMF. When the solid support is 4-(2',4'-dimethoxyphenyl-Fmoc-aminomethyl)phenoxy-

acetamidoethyl resin, the Fmoc group is cleaved with a secondary amine, preferably piperidine, prior to coupling with the α -C-terminal amino acid as described above. One method for coupling to the deprotected 4 (2',4'-dimethoxyphenyl-Fmoc-aminomethyl)phenoxy-acetamidoethyl resin is O-benzotriazol-1-yl-N,N,N',N'-

5 tetramethyluroniumhexafluorophosphate (HBTU, 1 equiv.) and 1-hydroxybenzotriazole (HOBT, 1 equiv.) in DMF. The coupling of successive protected amino acids can be carried out in an automatic polypeptide synthesizer. In one example, the α -N-terminal in the amino acids of the growing peptide chain are protected with Fmoc. The removal of the Fmoc protecting group from the α -N-terminal side of the growing peptide is accomplished by
10 treatment with a secondary amine, preferably piperidine. Each protected amino acid is then introduced in about 3-fold molar excess, and the coupling is preferably carried out in DMF. The coupling agent can be O-benzotriazol-1-yl-N,N,N',N'-tetramethyluroniumhexafluorophosphate (HBTU, 1 equiv.) and 1-hydroxybenzotriazole (HOBT, 1 equiv.). At the end of the solid phase synthesis, the polypeptide is removed from the
15 resin and deprotected, either in successively or in a single operation. Removal of the polypeptide and deprotection can be accomplished in a single operation by treating the resin-bound polypeptide with a cleavage reagent comprising thianisole, water, ethanedithiol and trifluoroacetic acid. In cases wherein the α -C-terminal of the polypeptide is an alkylamide, the resin is cleaved by aminolysis with an alkylamine. Alternatively, the peptide can be removed
20 by transesterification, *e.g.* with methanol, followed by aminolysis or by direct transamidation. The protected peptide can be purified at this point or taken to the next step directly. The removal of the side chain protecting groups can be accomplished using the cleavage cocktail described above. The fully deprotected peptide can be purified by a sequence of chromatographic steps employing any or all of the following types: ion exchange on a weakly
25 basic resin (acetate form); hydrophobic adsorption chromatography on underivitized polystyrene-divinylbenzene (for example, Amberlite XAD); silica gel adsorption chromatography; ion exchange chromatography on carboxymethylcellulose; partition chromatography, *e.g.* on Sephadex G-25, LH-20 or countercurrent distribution; high performance liquid chromatography (HPLC), especially reverse-phase HPLC on octyl- or
30 octadecylsilyl-silica bonded phase column packing.

In a specific method disclosed herein are methods of making a bicyclic peptide comprising, contacting a compound of Formula IV:



IV

wherein Q^1 and Q^2 are, independent of one another, chosen from CH or N; with a solid supported peptide having from 8 to 20 amino acid residues, wherein at least two residues are cysteine residues; and cleaving the peptide from the solid support. Examples of suitable solid supports are polystyrene, polyacrylamide, polyethylene glycol supports. Rink, Wang, or Tentagel resins are suitable examples of solid supports that can be used. Cleaving the peptide from the solid supports can typically be accomplished with mild acid or base.

Methods of Use

Also provided herein are methods of use of the compounds or compositions described herein. Also provided herein are methods for treating a disease or pathology in a subject in need thereof comprising administering to the subject an effective amount of any of the compounds or compositions described herein.

Also provided herein are methods of treating, preventing, or ameliorating cancer in a subject. The methods include administering to a subject an effective amount of one or more of the compounds or compositions described herein, or a pharmaceutically acceptable salt thereof. The compounds and compositions described herein or pharmaceutically acceptable salts thereof are useful for treating cancer in humans, *e.g.*, pediatric and geriatric populations, and in animals, *e.g.*, veterinary applications. The disclosed methods can optionally include identifying a patient who is or can be in need of treatment of a cancer. Examples of cancer types treatable by the compounds and compositions described herein include bladder cancer, brain cancer, breast cancer, colorectal cancer, cervical cancer, gastrointestinal cancer, genitourinary cancer, head and neck cancer, lung cancer, ovarian cancer, pancreatic cancer, prostate cancer, renal cancer, skin cancer, and testicular cancer. Further examples include cancer and/or tumors of the anus, bile duct, bone, bone marrow, bowel (including colon and rectum), eye, gall bladder, kidney, mouth, larynx, esophagus, stomach, testis, cervix, mesothelioma, neuroendocrine, penis, skin, spinal cord, thyroid, vagina, vulva, uterus, liver, muscle, blood cells (including lymphocytes and other immune system cells). Further examples of cancers treatable by the compounds and compositions described herein include carcinomas, Karposi's sarcoma, melanoma, mesothelioma, soft tissue sarcoma, pancreatic cancer, lung cancer, leukemia (acute lymphoblastic, acute myeloid, chronic lymphocytic, chronic myeloid,

and other), and lymphoma (Hodgkin's and non-Hodgkin's), and multiple myeloma. Further examples of cancers treatable by the disclosed compounds are p53 cancers, e.g., by using compounds where the cargo moiety is SEQ ID NO.: 156, e.g., SEQ ID NO.:166 and SEQ ID NO.:167.

5 The methods of treatment or prevention of cancer described herein can further include treatment with one or more additional agents (*e.g.*, an anti-cancer agent or ionizing radiation). The one or more additional agents and the compounds and compositions or pharmaceutically acceptable salts thereof as described herein can be administered in any order, including simultaneous administration, as well as temporally spaced order of up to several days apart.

10 The methods can also include more than a single administration of the one or more additional agents and/or the compounds and compositions or pharmaceutically acceptable salts thereof as described herein. The administration of the one or more additional agents and the compounds and compositions or pharmaceutically acceptable salts thereof as described herein can be by the same or different routes. When treating with one or more additional agents, the compounds
15 and compositions or pharmaceutically acceptable salts thereof as described herein can be combined into a pharmaceutical composition that includes the one or more additional agents.

For example, the compounds or compositions or pharmaceutically acceptable salts thereof as described herein can be combined into a pharmaceutical composition with an additional anti-cancer agent.

20 The compounds disclosed herein can also be used alone or in combination with anticancer or antiviral agents, such as ganciclovir, azidothymidine (AZT), lamivudine (3TC), *etc.*, to treat patients infected with a virus that can cause cellular transformation and/or to treat patients having a tumor or cancer that is associated with the presence of viral genome in the cells. The compounds disclosed herein can also be used in combination with viral based
25 treatments of oncologic disease.

Also described herein are methods of killing a tumor cell in a subject. The method includes contacting the tumor cell with an effective amount of a compound or composition as described herein, and optionally includes the step of irradiating the tumor cell with an effective amount of ionizing radiation. Additionally, methods of radiotherapy of tumors are provided
30 herein. The methods include contacting the tumor cell with an effective amount of a compound or composition as described herein, and irradiating the tumor with an effective amount of ionizing radiation. As used herein, the term ionizing radiation refers to radiation comprising particles or photons that have sufficient energy or can produce sufficient energy via

nuclear interactions to produce ionization. An example of ionizing radiation is x-radiation. An effective amount of ionizing radiation refers to a dose of ionizing radiation that produces an increase in cell damage or death when administered in combination with the compounds described herein. The ionizing radiation can be delivered according to methods as known in the art, including administering radiolabeled antibodies and radioisotopes.

The methods and compounds as described herein are useful for both prophylactic and therapeutic treatment. As used herein the term treating or treatment includes prevention; delay in onset; diminution, eradication, or delay in exacerbation of signs or symptoms after onset; and prevention of relapse. For prophylactic use, a therapeutically effective amount of the compounds and compositions or pharmaceutically acceptable salts thereof as described herein are administered to a subject prior to onset (*e.g.*, before obvious signs of cancer), during early onset (*e.g.*, upon initial signs and symptoms of cancer), or after an established development of cancer. Prophylactic administration can occur for several days to years prior to the manifestation of symptoms of an infection. Prophylactic administration can be used, for example, in the chemopreventative treatment of subjects presenting precancerous lesions, those diagnosed with early stage malignancies, and for subgroups with susceptibilities (*e.g.*, family, racial, and/or occupational) to particular cancers. Therapeutic treatment involves administering to a subject a therapeutically effective amount of the compounds and compositions or pharmaceutically acceptable salts thereof as described herein after cancer is diagnosed.

In some examples of the methods of treating of treating, preventing, or ameliorating cancer or a tumor in a subject, the compound or composition administered to the subject can comprise a therapeutic moiety that can comprise a targeting moiety that can act as an inhibitor against Ras (*e.g.*, K-Ras), PTP1B, Pin1, Grb2 SH2, or combinations thereof.

The disclosed subject matter also concerns methods for treating a subject having a metabolic disorder or condition. In one embodiment, an effective amount of one or more compounds or compositions disclosed herein is administered to a subject having a metabolic disorder and who is in need of treatment thereof. In some examples, the metabolic disorder can comprise type II diabetes. In some examples of the methods of treating of treating, preventing, or ameliorating the metabolic disorder in a subject, the compound or composition administered to the subject can comprise a therapeutic moiety that can comprise a targeting moiety that can act as an inhibitor against PTP1B. In one particular example of this method

the subject is obese and the method comprises treating the subject for obesity by administering a composition as disclosed herein.

The disclosed subject matter also concerns methods for treating a subject having an immune disorder or condition. In one embodiment, an effective amount of one or more compounds or compositions disclosed herein is administered to a subject having an immune disorder and who is in need of treatment thereof. In some examples of the methods of treating of treating, preventing, or ameliorating the immune disorder in a subject, the compound or composition administered to the subject can comprise a therapeutic moiety that can comprise a targeting moiety that can act as an inhibitor against Pin1.

The disclosed subject matter also concerns methods for treating a subject having cystic fibrosis. In one embodiment, an effective amount of one or more compounds or compositions disclosed herein is administered to a subject having cystic fibrosis and who is in need of treatment thereof. In some examples of the methods of treating the cystic fibrosis in a subject, the compound or composition administered to the subject can comprise a therapeutic moiety that can comprise a targeting moiety that can act as an inhibitor against CAL PDZ.

Compositions, Formulations and Methods of Administration

In vivo application of the disclosed compounds, and compositions containing them, can be accomplished by any suitable method and technique presently or prospectively known to those skilled in the art. For example, the disclosed compounds can be formulated in a physiologically- or pharmaceutically-acceptable form and administered by any suitable route known in the art including, for example, oral, nasal, rectal, topical, and parenteral routes of administration. As used herein, the term parenteral includes subcutaneous, intradermal, intravenous, intramuscular, intraperitoneal, and intrasternal administration, such as by injection. Administration of the disclosed compounds or compositions can be a single administration, or at continuous or distinct intervals as can be readily determined by a person skilled in the art.

The compounds disclosed herein, and compositions comprising them, can also be administered utilizing liposome technology, slow release capsules, implantable pumps, and biodegradable containers. These delivery methods can, advantageously, provide a uniform dosage over an extended period of time. The compounds can also be administered in their salt derivative forms or crystalline forms.

The compounds disclosed herein can be formulated according to known methods for preparing pharmaceutically acceptable compositions. Formulations are described in detail in a

number of sources which are well known and readily available to those skilled in the art. For example, *Remington's Pharmaceutical Science* by E.W. Martin (1995) describes formulations that can be used in connection with the disclosed methods. In general, the compounds disclosed herein can be formulated such that an effective amount of the compound is combined
5 with a suitable carrier in order to facilitate effective administration of the compound. The compositions used can also be in a variety of forms. These include, for example, solid, semi-solid, and liquid dosage forms, such as tablets, pills, powders, liquid solutions or suspension, suppositories, injectable and infusible solutions, and sprays. The preferred form depends on the intended mode of administration and therapeutic application. The compositions also
10 preferably include conventional pharmaceutically-acceptable carriers and diluents which are known to those skilled in the art. Examples of carriers or diluents for use with the compounds include ethanol, dimethyl sulfoxide, glycerol, alumina, starch, saline, and equivalent carriers and diluents. To provide for the administration of such dosages for the desired therapeutic treatment, compositions disclosed herein can advantageously comprise between about 0.1%
15 and 100% by weight of the total of one or more of the subject compounds based on the weight of the total composition including carrier or diluent.

Formulations suitable for administration include, for example, aqueous sterile injection solutions, which can contain antioxidants, buffers, bacteriostats, and solutes that render the formulation isotonic with the blood of the intended recipient; and aqueous and nonaqueous
20 sterile suspensions, which can include suspending agents and thickening agents. The formulations can be presented in unit-dose or multi-dose containers, for example sealed ampoules and vials, and can be stored in a freeze dried (lyophilized) condition requiring only the condition of the sterile liquid carrier, for example, water for injections, prior to use. Extemporaneous injection solutions and suspensions can be prepared from sterile powder,
25 granules, tablets, *etc.* It should be understood that in addition to the ingredients particularly mentioned above, the compositions disclosed herein can include other agents conventional in the art having regard to the type of formulation in question.

Compounds disclosed herein, and compositions comprising them, can be delivered to a cell either through direct contact with the cell or via a carrier means. Carrier means for
30 delivering compounds and compositions to cells are known in the art and include, for example, encapsulating the composition in a liposome moiety. Another means for delivery of compounds and compositions disclosed herein to a cell comprises attaching the compounds to a protein or nucleic acid that is targeted for delivery to the target cell. U.S. Patent No.

6,960,648 and U.S. Application Publication Nos. 20030032594 and 20020120100 disclose amino acid sequences that can be coupled to another composition and that allows the composition to be translocated across biological membranes. U.S. Application Publication No. 20020035243 also describes compositions for transporting biological moieties across cell
5 membranes for intracellular delivery. Compounds can also be incorporated into polymers, examples of which include poly (D-L lactide-co-glycolide) polymer for intracranial tumors; poly[bis(p-carboxyphenoxy) propane:sebacic acid] in a 20:80 molar ratio (as used in GLIADEL); chondroitin; chitin; and chitosan.

For the treatment of oncological disorders, the compounds disclosed herein can be
10 administered to a patient in need of treatment in combination with other antitumor or anticancer substances and/or with radiation and/or photodynamic therapy and/or with surgical treatment to remove a tumor. These other substances or treatments can be given at the same as or at different times from the compounds disclosed herein. For example, the compounds disclosed herein can be used in combination with mitotic inhibitors such as taxol or
15 vinblastine, alkylating agents such as cyclophosphamide or ifosfamide, antimetabolites such as 5-fluorouracil or hydroxyurea, DNA intercalators such as adriamycin or bleomycin, topoisomerase inhibitors such as etoposide or camptothecin, antiangiogenic agents such as angiostatin, antiestrogens such as tamoxifen, and/or other anti-cancer drugs or antibodies, such as, for example, GLEEVEC (Novartis Pharmaceuticals Corporation) and HERCEPTIN
20 (Genentech, Inc.), respectively, or an immunotherapeutic such as ipilimumab and bortezomib.

In certain examples, compounds and compositions disclosed herein can be locally administered at one or more anatomical sites, such as sites of unwanted cell growth (such as a tumor site or benign skin growth, *e.g.*, injected or topically applied to the tumor or skin growth), optionally in combination with a pharmaceutically acceptable carrier such as an inert
25 diluent. Compounds and compositions disclosed herein can be systemically administered, such as intravenously or orally, optionally in combination with a pharmaceutically acceptable carrier such as an inert diluent, or an assimilable edible carrier for oral delivery. They can be enclosed in hard or soft shell gelatin capsules, can be compressed into tablets, or can be incorporated directly with the food of the patient's diet. For oral therapeutic administration, the active
30 compound can be combined with one or more excipients and used in the form of ingestible tablets, buccal tablets, troches, capsules, elixirs, suspensions, syrups, wafers, aerosol sprays, and the like.

The disclosed compositions are bioavailable and can be delivered orally. Oral compositions can be tablets, troches, pills, capsules, and the like, and can also contain the following: binders such as gum tragacanth, acacia, corn starch or gelatin; excipients such as dicalcium phosphate; a disintegrating agent such as corn starch, potato starch, alginic acid and the like; a lubricant such as magnesium stearate; and a sweetening agent such as sucrose, fructose, lactose or aspartame or a flavoring agent such as peppermint, oil of wintergreen, or cherry flavoring can be added. When the unit dosage form is a capsule, it can contain, in addition to materials of the above type, a liquid carrier, such as a vegetable oil or a polyethylene glycol. Various other materials can be present as coatings or to otherwise modify the physical form of the solid unit dosage form. For instance, tablets, pills, or capsules can be coated with gelatin, wax, shellac, or sugar and the like. A syrup or elixir can contain the active compound, sucrose or fructose as a sweetening agent, methyl and propylparabens as preservatives, a dye and flavoring such as cherry or orange flavor. Of course, any material used in preparing any unit dosage form should be pharmaceutically acceptable and substantially non-toxic in the amounts employed. In addition, the active compound can be incorporated into sustained-release preparations and devices.

Compounds and compositions disclosed herein, including pharmaceutically acceptable salts or prodrugs thereof, can be administered intravenously, intramuscularly, or intraperitoneally by infusion or injection. Solutions of the active agent or its salts can be prepared in water, optionally mixed with a nontoxic surfactant. Dispersions can also be prepared in glycerol, liquid polyethylene glycols, triacetin, and mixtures thereof and in oils. Under ordinary conditions of storage and use, these preparations can contain a preservative to prevent the growth of microorganisms.

The pharmaceutical dosage forms suitable for injection or infusion can include sterile aqueous solutions or dispersions or sterile powders comprising the active ingredient, which are adapted for the extemporaneous preparation of sterile injectable or infusible solutions or dispersions, optionally encapsulated in liposomes. The ultimate dosage form should be sterile, fluid and stable under the conditions of manufacture and storage. The liquid carrier or vehicle can be a solvent or liquid dispersion medium comprising, for example, water, ethanol, a polyol (for example, glycerol, propylene glycol, liquid polyethylene glycols, and the like), vegetable oils, nontoxic glyceryl esters, and suitable mixtures thereof. The proper fluidity can be maintained, for example, by the formation of liposomes, by the maintenance of the required particle size in the case of dispersions or by the use of surfactants. Optionally, the prevention

of the action of microorganisms can be brought about by various other antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, sorbic acid, thimerosal, and the like. In many cases, it will be preferable to include isotonic agents, for example, sugars, buffers or sodium chloride. Prolonged absorption of the injectable compositions can be brought about by the inclusion of agents that delay absorption, for example, aluminum monostearate and gelatin.

Sterile injectable solutions are prepared by incorporating a compound and/or agent disclosed herein in the required amount in the appropriate solvent with various other ingredients enumerated above, as required, followed by filter sterilization. In the case of sterile powders for the preparation of sterile injectable solutions, the preferred methods of preparation are vacuum drying and the freeze drying techniques, which yield a powder of the active ingredient plus any additional desired ingredient present in the previously sterile-filtered solutions.

For topical administration, compounds and agents disclosed herein can be applied in as a liquid or solid. However, it will generally be desirable to administer them topically to the skin as compositions, in combination with a dermatologically acceptable carrier, which can be a solid or a liquid. Compounds and agents and compositions disclosed herein can be applied topically to a subject's skin to reduce the size (and can include complete removal) of malignant or benign growths, or to treat an infection site. Compounds and agents disclosed herein can be applied directly to the growth or infection site. Preferably, the compounds and agents are applied to the growth or infection site in a formulation such as an ointment, cream, lotion, solution, tincture, or the like.

Useful solid carriers include finely divided solids such as talc, clay, microcrystalline cellulose, silica, alumina and the like. Useful liquid carriers include water, alcohols or glycols or water-alcohol/glycol blends, in which the compounds can be dissolved or dispersed at effective levels, optionally with the aid of non-toxic surfactants. Adjuvants such as fragrances and additional antimicrobial agents can be added to optimize the properties for a given use. The resultant liquid compositions can be applied from absorbent pads, used to impregnate bandages and other dressings, or sprayed onto the affected area using pump-type or aerosol sprayers, for example.

Thickeners such as synthetic polymers, fatty acids, fatty acid salts and esters, fatty alcohols, modified celluloses or modified mineral materials can also be employed with liquid

carriers to form spreadable pastes, gels, ointments, soaps, and the like, for application directly to the skin of the user.

Useful dosages of the compounds and agents and pharmaceutical compositions disclosed herein can be determined by comparing their *in vitro* activity, and *in vivo* activity in
5 animal models. Methods for the extrapolation of effective dosages in mice, and other animals, to humans are known to the art.

The dosage ranges for the administration of the compositions are those large enough to produce the desired effect in which the symptoms or disorder are affected. The dosage should not be so large as to cause adverse side effects, such as unwanted cross-reactions, anaphylactic
10 reactions, and the like. Generally, the dosage will vary with the age, condition, sex and extent of the disease in the patient and can be determined by one of skill in the art. The dosage can be adjusted by the individual physician in the event of any counterindications. Dosage can vary, and can be administered in one or more dose administrations daily, for one or several days.

Also disclosed are pharmaceutical compositions that comprise a compound disclosed
15 herein in combination with a pharmaceutically acceptable carrier. Pharmaceutical compositions adapted for oral, topical or parenteral administration, comprising an amount of a compound constitute a preferred aspect. The dose administered to a patient, particularly a human, should be sufficient to achieve a therapeutic response in the patient over a reasonable time frame, without lethal toxicity, and preferably causing no more than an acceptable level of
20 side effects or morbidity. One skilled in the art will recognize that dosage will depend upon a variety of factors including the condition (health) of the subject, the body weight of the subject, kind of concurrent treatment, if any, frequency of treatment, therapeutic ratio, as well as the severity and stage of the pathological condition.

Also disclosed are kits that comprise a compound disclosed herein in one or more
25 containers. The disclosed kits can optionally include pharmaceutically acceptable carriers and/or diluents. In one embodiment, a kit includes one or more other components, adjuncts, or adjuvants as described herein. In another embodiment, a kit includes one or more anti-cancer agents, such as those agents described herein. In one embodiment, a kit includes instructions or packaging materials that describe how to administer a compound or composition of the kit.
30 Containers of the kit can be of any suitable material, *e.g.*, glass, plastic, metal, *etc.*, and of any suitable size, shape, or configuration. In one embodiment, a compound and/or agent disclosed herein is provided in the kit as a solid, such as a tablet, pill, or powder form. In another embodiment, a compound and/or agent disclosed herein is provided in the kit as a liquid or

solution. In one embodiment, the kit comprises an ampoule or syringe containing a compound and/or agent disclosed herein in liquid or solution form.

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and
5 scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

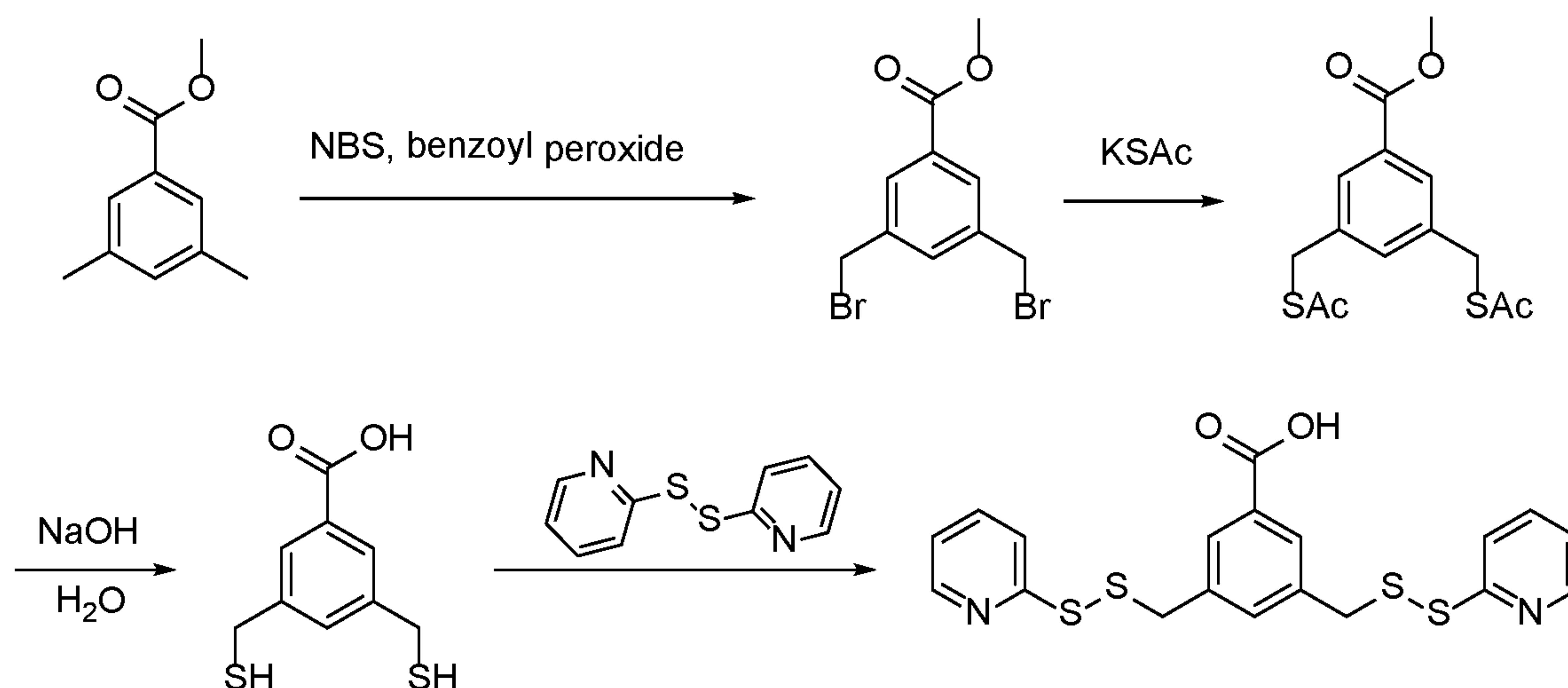
EXAMPLES

The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how the compounds, compositions, articles,
10 devices and/or methods claimed herein are made and evaluated, and are intended to be purely exemplary of the invention and are not intended to limit the scope of what the inventors regard as their invention. However, those of skill in the art should, in light of the present disclosure, appreciate that many changes can be made in the specific embodiments which are disclosed and still obtain a like or similar result without departing from the spirit and scope
15 of the invention.

Efforts have been made to ensure accuracy with respect to numbers (*e.g.*, amounts, temperature, etc.), but some errors and deviations should be accounted for. Unless indicated otherwise, parts are parts by weight, temperature is in °C or is at ambient temperature, and pressure is at or near atmospheric.

20 **Example 1. Synthesis of Bicyclizatoin Scaffold.**

Reagents for peptide synthesis were purchased from Chem-Impex (Wood Dale, IL), NovaBiochem (La Jolla, CA), or Anaspec (San Jose, CA). Rink amide resin LS (100-200 mesh, 0.2 mmol/g) was purchased from Advanced ChemTech. Cell culture media, fetal bovine serum, penicillin-streptomycin, 0.25% trypsin-EDTA, and DPBS were purchased from
25 Invitrogen (Carlsbad, CA). Methyl 3,5-dimethylbenzoate, *N*-bromosuccinimide, diethyl phosphite, 2,2'-dipyridyl disulfide, and other organic reagents/solvents were purchased from Sigma-Aldrich (St. Louis, MO). Anti-GST-Tb and streptavidin-d2 were purchased from Cisbio (Bedford, MA). The NF-κB reporter (Luc)-HEK293 cell line and One-StepTM luciferase assay system were purchased from BPS Bioscience (San Diego, CA).



Scheme 2. Synthesis of the Bicyclization Scaffold.

Synthesis of Methyl 3,5-bis(bromomethyl)benzoate. The overall synthetic plan for the bicyclization scaffold is shown in **Scheme 2**. To a 50-mL round-bottom flask charged with methyl 3,5-dimethylbenzoate (2.0 g, 12.2 mmol) in carbon tetrachloride (20 mL, sparged with nitrogen) was added *N*-bromosuccinimide (4.25 g, 23.9 mmol) and benzoyl peroxide (~60 mg) as an initiator. The reaction was refluxed for 3 h under nitrogen atmosphere. The reaction mixture was cooled, and filtered. The filtrate was washed with water (20 mL), dried with MgSO_4 , and concentrated *in vacuo*. The crude product was recrystallized in petroleum ether to yield the title compound (1.2 g, 3.8 mmol) in 30% yield. ^1H NMR (300 MHz, CDCl_3): δ 7.99 (s, 2H), 7.62 (s, 1H), 4.50 (s, 4H), 3.94 (s, 3H).

Synthesis of Methyl 3,5-bis((acetylthio)methyl)benzoate. To a 50-mL round-bottom flask charged with crude methyl 3,5-bis(bromomethyl)benzoate (1.0 g, 3.1 mmol) from above was added acetone (20 mL) and potassium thioacetate (0.86 g, 7.52 mmol). The reaction was refluxed for 3 h under nitrogen atmosphere and allowed to cool. 20 mL water was added to quench the reaction and the mixture was extracted with ethyl acetate. The combined organic layer was dried with MgSO_4 , concentrated, and purified by silica gel chromatography to afford 0.72 g of an orange-brown solid (74.2% yield). ^1H NMR (300 MHz, CDCl_3): δ 7.83 (s, 2H), 7.41 (s, 1H), 4.12 (s, 4H), 3.90 (s, 3H), 2.36 (s, 6H).

Synthesis of 3,5-bis((pyridin-2-yl)disulfanylmethyl)benzoic acid. A 50-mL round-bottom flask under nitrogen atmosphere was charged with methyl 3,5-bis((acetylthio)methyl)benzoate (0.5 g, 1.6 mmol) dissolved in MeOH (15 mL). A solution of NaOH (832 mg, 20.8 mmol) in H_2O (3 mL) was added and the reaction was allowed to react overnight at room temperature. The reaction solution was acidified with AcOH (2.38 mL, 41.6

mmol) and 2, 2'-dipyridyl disulfide (1.41 g, 6.4 mmol) was added. The reaction mixture was filtered to remove the orange precipitate formed and allowed to stir for 1 h at room temperature. After the reaction was complete, the methanol was removed by evaporation *in vacuo* and the residue was quickly loaded onto a silica gel column. The column was first eluted with 20% to 50% EtOAc in hexanes to remove any low polarity species, after which the desired product was eluted with 1:1 (v/v) EtOAc in hexanes containing 1% AcOH. Evaporation of the solvents gave a brown solid (222 mg, 32% yield over two steps). ¹H NMR (400 MHz, CDCl₃): δ 8.43 (m, 2H), 7.83 (s, 2H), 7.53-7.43 (m, 5H), 7.04 (m, 2H), 3.97 (s, 4H). HRMS (ESI⁺): calcd for C₁₉H₁₇N₂O₂S₄ (M+H⁺): 433.0173; Found: 433.0176.

Example 2. Synthesis of Bicyclic Peptides

Peptide Preparation and Characterization. Peptides were synthesized on Rink amide resin LS (0.2 mmol/g) using standard Fmoc chemistry. A typical coupling reaction contained 5 equiv of Fmoc-amino acid, 5 equiv of 2-(7-aza-1H-benzotriazole-1-yl)-1,1,3,3-tetramethyluronium hexafluorophosphate (HATU), and 10 equiv of diisopropylethylamine (DIPEA) and was allowed to proceed for 45 min with gentle mixing. The peptides were deprotected and released from the resin by treatment with 90:2.5:2.5:2.5:2.5 (v/v) TFA/1,2-ethanedithiol/water/phenol/triisopropylsilane (TIPS) for 2 h. The peptides were triturated with cold ethyl ether (3x) and purified by reversed-phase HPLC equipped with a C₁₈ column. Peptide labeling with fluorescein isothiocyanate (FITC) was performed by dissolving the purified peptides (~1 mg each) in 300 μL of 1:1:1 DMSO/DMF/150 mM sodium bicarbonate (pH 8.5) and mixing with 10 μL of FITC in DMSO (100 mg/mL). After 20 min at room temperature, the reaction mixture was purified again by reversed-phase HPLC to isolate the FITC-labeled peptide.

To synthesize the disulfide-mediated bicyclic peptides, the corresponding linear peptides containing two Ac_m-protected Cys residues were first prepared using standard Fmoc/HATU chemistry. The Ac_m groups were removed by treating the resin with 2 M mercury(II) acetate in DMF overnight. The resin was then incubated in 20% β-mercaptoethanol in DMF for 2 h (twice) to release the free thiol. After exhaustive washing with DMF to remove all of the reducing agents, the resin was incubated overnight with 1 equiv. of 3,5-bis((pyridin-2-yl)disulfanyl)methyl)benzoic acid in methanol containing 1% (v/v) acetic acid. The reaction progress was monitored by removing a small portion of the resin and analyzing the deprotected/released peptide product by MALDI-TOF MS. Peptide deprotection

and release were achieved by treating the resin with 85:10:2.5:2.5 (v/v) TFA/DCM/water/TIPS for 2 h, followed by ether trituration and HPLC purification as described above (**Figure 5A**).

All of the final peptides used in this work had $\geq 95\%$ purity as judged by analytical HPLC (**Figure 5B** and **Figure 7**). The authenticity of the peptides was confirmed by MALDI-TOF

5 MS analysis. To further characterize the biologically active peptide **4**, the peptide was be dissolved in H₂O/D₂O (9:1, 500 μ L; final sample concentration 2 mM). NMR spectra were recorded on a Bruker Ascend 700 MHz spectrometer at 298 K.

Example 3. Cell-Based Assays

Cell Culture. HeLa cells were maintained in media consisting of DMEM, 10% fetal
10 bovine serum (FBS) and 1% penicillin/streptomycin. The NF- κ B reporter (Luc)-HEK293 cells were maintained in media consisting of DMEM, 10% FBS, 1% penicillin/streptomycin, and 100 μ g/ml of hygromycin B. Cells were cultured in a humidified incubator at 37 °C in the presence of 5% CO₂.

Protein Expression and Purification. *Escherichia coli* BL21(DE3) cells were
15 transformed with a pGEX4T3-GST-NEMO(1-196) plasmid and grown at 37 °C in Luria broth supplemented with 0.05 mg/mL ampicillin to an OD₆₀₀ of 0.4. Expression was induced by the addition of isopropyl β -D-1-thiogalactopyranoside (150 μ M final concentration). After five hours at 30 °C, the cells were harvested by centrifugation. The cell pellet was suspended in 40 mL of lysis buffer (50 mM Tris-HCl, 100 mM NaCl, 0.5 mM MgCl₂, 5 mM β -
20 mercaptoethanol, 0.1% Triton-X-100, pH 8.0), 100 μ g/mL lysozyme, 100 μ l DNase I (New England BioLabs), and 100 μ l of Halt Protease Inhibitor cocktail (EDTA-free) (Thermo Scientific). This mixture was stirred at 4 °C for 30 min and briefly sonicated (2 $\times$ 10 s pulses). The crude lysate was centrifuged to yield a clear supernatant, which was directly loaded onto a glutathione-Sepharose 4B column (GE Healthcare). The bound protein was eluted from the
25 column with 10 mM Glutathione in 50 mM Tris-HCl (pH 8.0) (40 mL), concentrated to 0.5 mL with the use of Amicon Ultra-15 centrifugal filter units (MWCO 10kDa), and dialyzed against PBS (2.67 mM potassium chloride, 1.47 mM potassium phosphate monobasic, 137 mM sodium chloride, and 8.06 mM sodium phosphate dibasic). To generate NEMO without the GST tag, the protein was treated with thrombin (GE Healthcare) for 16 h at 4 °C prior to
30 concentration. Protein concentration was determined using Bradford assay with bovine serum albumin as the standard. The protein was quickly frozen and stored at -80 °C.

An engineered prokaryotic expression plasmid pJCC04a,1 which encodes a fusion protein containing an N-terminal six-histidine tag, thioredoxin, a TEV protease cleavage site, and the K703R/K704R mutant form of IKK β C-terminal fragment (amino acids 701-745) [His-thx-IKK β _{KK/RR}(701-745)], was kindly provided by Dr. Maria Pellegrini (Dartmouth College).

His-thx-IKK β _{KK/RR}(701-745) was similarly expressed in *E. coli* BL21 (DE3) cells and purified by affinity chromatography using a HisTrap FF column (GE Healthcare). The fusion protein was eluted with 50 mM Tris-HCl (pH 8.0), 300 mM NaCl, 250 mM Imadizole, 2 mM β -mercaptoethanol and treated with TEV protease (150 units for 1 mg of fusion protein) for 16 h at 4 °C to remove the thioredoxin (thx). The resulting protease digestion mixture was re-loaded onto the HisTrap column. The flow-through fraction was collected and concentrated to ~2 mg/mL using Amicon Ultra-15 centrifugal filter units (MWCO 10kDa). The IKK β _{KK/RR}(701-745) protein was biotinylated by treatment with a 10-fold molar excess of biotin-NHS at 4 °C overnight. The biotinylated IKK β _{KK/RR}(701-745) was purified by reversed-phase HPLC equipped with a C₁₈ column and stored frozen at -80 °C.

Flow Cytometry. HeLa cells were cultured in six-well plates (5 x 10⁵ cells per well) for 24 h. On the day of experiment, the cells were incubated with 5 μ M FITC-labeled peptide in clear DMEM with 1% FBS at 37 °C for 2 h. The cells were washed with DPBS, detached from plate with 0.25% trypsin, diluted into clear DMEM containing 10% FBS, pelleted at 250g for 5 min, washed once with DPBS and resuspended in DPBS containing 1% bovine serum albumin, and analyzed on a BD LSR II flow cytometer. Data were analyzed with Flowjo software (Tree Star).

Serum Stability Test. The stability tests were carried by modifying a previously reported procedure.² Diluted human serum (25%) was centrifuged at 15,000 rpm for 10 min, and the supernatant was collected. A peptide stock solution was diluted into the supernatant to a final concentration of 5 μ M and incubated at 37 °C. At various time points (0-20 h), 200- μ L aliquots were withdrawn and mixed with 50 μ L of 15% trichloroacetic acid and 200 μ L of acetonitrile, and the mixture was incubated at 4 °C overnight. The final mixture was centrifuged at 15,000 rpm for 10 min in a microcentrifuge, and the supernatant was analyzed by reversed-phase HPLC equipped with an analytical C₁₈ column (Waters). The amount of remaining peptide (% , relative to the time zero control) was determined by integrating the area underneath the peptide peak (monitored at 214 nm).

HTRF Assay. Recombinant GST-NEMO (30 nM), biotin-IKK β _{KK/RR}(701-745) (50 nM), streptavidin labeled with d2 acceptor (2.5 μ g/mL), anti-GST monoclonal antibody

labeled with Tb donor (2.5 $\mu\text{g/mL}$), and varying concentrations of peptide (0-100 μM) were mixed in PBS containing 5 mM TCEP and 0.01% Triton X-100 (total volume 20 μL) in a 384-well plate. The plate was incubated for 2 h at room temperature. The HTRF signals were measured on a Tecan infinite M1000 Pro microplate reader and plotted as a function of the peptide concentration. The data was analyzed using GraphPad Prism 6.0 and IC_{50} values were obtained by fitting the data to the dose-response inhibition curves.

NF- κB Luciferase Assay. NF- κB reporter (Luc)-HEK293 cells were seeded in 96-well microplate in 45 μL of assay medium (DMEM, 10% FBS, and 1% penicillin/streptomycin, ~1500 cells per well) and cultured overnight. Five μL of NEMO inhibitor in assay medium was added to cells and the cells were incubated for 2 h. Recombinant $\text{TNF}\alpha^3$ in 5 μL of assay medium was added to the wells at the final concentration of 5 ng/mL. After 4 h of incubation, 55 μL of ONE-Step luciferase assay reagent was added to each well. Luminescence was measured after 10 min of incubation using a Tecan Infinite M1000 Pro microplate reader. Luciferase activities of $\text{TNF}\alpha$ unstimulated and stimulated cells were recorded as AU^- and AU^+ , respectively. Luciferase activities of $\text{TNF}\alpha$ stimulated cells after incubating with different concentrations of NEMO inhibitors were recorded as AU^{pep} . The inhibition of NF- κB signaling activation is calculated by the percentage of luciferase activity induction based on the equation:

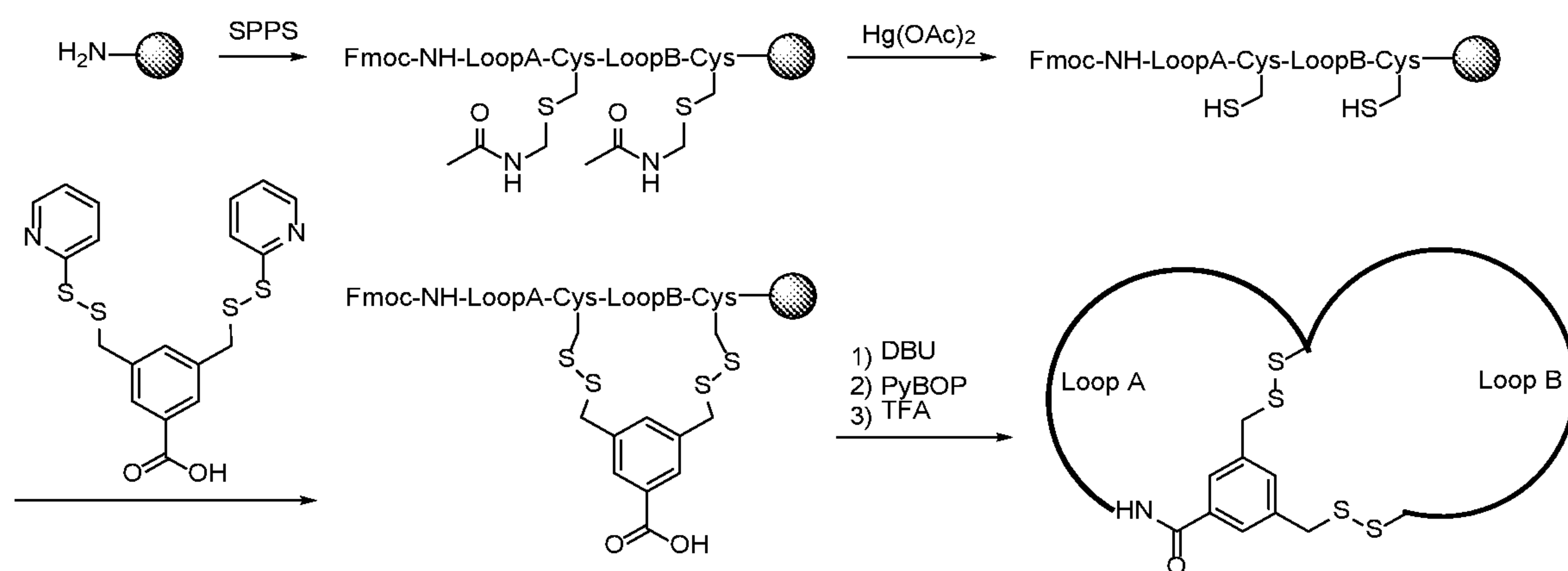
$$\text{Inhibition of TNF}\alpha \text{ Activation (\%)} = (\text{AU}^{\text{pep}} - \text{AU}^-) / (\text{AU}^+ - \text{AU}^-) \times 100\%$$

Results. To test the validity of the reversible bicyclization strategy, two model peptides comprising the CPP motif (RRRR Φ F (SEQ ID NO.:68) or F Φ RRRR (SEQ ID NO.:69) and a mock cargo motif (SASAS ((SEQ ID NO.:156)) fused to its N- or C-terminus (Table 6, peptides **2** and **3**, **Figure 3** for detailed structures) were designed. Two cysteine residues were also incorporated into the sequences for later cyclization, one at the junction between the CPP and cargo motifs and one at the C-terminus. The linear peptides were synthesized by standard Fmoc solid-phase peptide synthesis (SPPS) chemistry on Rink amide resin (**Scheme 1**). The acetamidomethyl (Acm) groups on the two cysteine side chains were selectively removed by treatment with $\text{Hg}(\text{OAc})_2$ and the exposed free thiols were then reacted on-resin with 3,5-bis((pyridin-2-yl)disulfanyl)methyl)benzoic acid, which was readily prepared from commercially available starting materials (**Scheme 2**). Formation of two disulfide bonds between the cysteine side chains and the 3,5-bis(mercaptomethyl)benzoic acid (BMB) scaffold resulted in cyclization of the peptide. Next, the N-terminal Fmoc group was removed by 1,8-

diazabicyclo[5.4.0]undec-7-ene (DBU) and the peptide was bicyclized by forming a lactam between the carboxyl group of BMB and the N-terminal amine (**Scheme 1**). BMB is ideally suited as the scaffold, because its structural symmetry ensures that a single bicyclic product is formed following the disulfide exchange reactions. Additionally, the rigidity of the scaffold prevents the formation of any intramolecular disulfide bond, simplifying both the synthesis of the scaffold and its reaction with the cysteine-containing peptides.

To monitor their cellular uptake, peptides **2** and **3** were labeled with fluorescein isothiocyanate (FITC) on the side chain of a C-terminal lysine. Flow cytometry analysis of HeLa cells treated with 5 μ M peptides cF Φ R₄ (SEQ ID NO.:72), **2** and **3** for 2 h showed mean fluorescence intensity (MFI) values of 3020, 5180, and 4100, respectively (**Figure 1A**). Thus, bicyclic peptides **2** and **3** entered HeLa cells with 72% and 36% higher efficiencies, respectively, than cF Φ R₄ (SEQ ID NO.:72).

The reversible bicyclization strategy was applied to generate a cell-permeable, biologically active peptidyl inhibitor against the NEMO-IKK interaction. Despite of its *in vivo* efficacy, the linear Antp-NBD peptide has poor pharmacokinetics, due to rapid proteolytic degradation in serum ($t_{1/2}$ ~15 min). Conversion of Antp-NBD into a conformationally constrained bicyclic structure was envisioned to substantially increase its proteolytic stability. The CPP motif RRRR Φ F (SEQ ID NO.:68) was fused to the N-terminus of NBD and the N- and C-terminal threonine residues were replaced with two cysteines (Table 6, peptide **4**, **Figure 4** for detailed structure ((SEQ ID NO.:216). The peptide fusion was bicyclized around the BMB scaffold via two disulfide bonds as described above, to give bicyclic peptide **4** as the predominant product (**Figure 5A**). As a control, peptide **5** (**Figure 4** for detailed structure) was also prepared, which is structurally similar to peptide **4** but contains two Ala residues in place of the two Trp residues. It was previously shown that replacement of the Trp residues with alanine largely abolished NEMO binding (M. J. May, et al., *Science* 2000, 289, 1550).



Scheme 1. Solid-phase synthesis of disulfide-mediated bicyclic peptides

Peptides **4** and **5** were labeled with FITC at the side chain of a lysine added to their C-termini and their cellular entry was assessed by flow cytometry. Both peptides entered HeLa cells efficiently, exhibiting MFI values that were 3- and 2-fold higher than that of cFΦR₄, respectively (**Figure 1A**). The NEMO-binding affinity of peptides **4** and **5** was determined using a homogenous time-resolved fluorescence (HTRF) assay (M. Rushe, et al., *Structure* 2008, 16, 798; Y. Gotoh, et al., *Anal. Biochem.* 2010, 405, 19). Briefly, in the presence of an anti-glutathione-S-transferase (GST) antibody labeled with a fluorescence donor (Tb) and streptavidin labeled with a fluorescence acceptor (d2), binding of GST-NEMO to a biotinylated IKKβ fragment (amino acids 701-745) (B. Gao, et al., *Biochemistry* 2014, 53, 677) results in a resonance energy transfer. Addition of a NEMO inhibitor blocks the NEMO-IKKβ interaction and reduces the HTRF signal. In the presence of 5 mM tris(carboxylethyl)phosphine (TCEP), which is expected to completely reduce the disulfide bonds in peptides **4** and **5**, peptide **4** inhibited the NEMO-IKKβ interaction in a concentration-dependent manner, with a half-maximal inhibitory concentration (IC₅₀) value of 3.5 ± 0.2 μM (**Figure 1B**). Under the same conditions, Antp-NBD showed an IC₅₀ value of ~50 μM, in agreement with the previously reported binding affinity (M. Rushe, et al., *Structure* 2008, 16, 798; Y. Gotoh, et al., *Anal. Biochem.* 2010, 405, 19). As expected, up to 100 μM peptide **5** caused only minor inhibition of the interaction. Since substitution of the two cysteine residues for threonine did not significantly change the NEMO binding affinity (**Figure 6**), the enhanced NEMO binding of peptide **4** relative to Antp-NBD is likely caused by additional interactions between the phenylalanine of the CPP motif (RRRRΦF (SEQ ID NO.:68)) and the NEMO protein surface. IKKβ contains a phenylalanine at the same position (Phe-734). The crystal structure of the NEMO-IKKβ complex shows that the side chain of Phe-734 inserts into a

hydrophobic pocket on the NEMO surface (Id.). Thus, the phenylalanine in peptide **4** likely plays dual roles of cellular entry and NEMO binding.

The ability of the bicyclic peptides to modulate the NEMO-IKK interaction inside the cell was assessed by monitoring the TNF α -induced activation of NF- κ B. HEK293 cells

transfected with a luciferase reporter gene under the control of NF- κ B were first treated with varying concentrations of a peptide for 2 h and then TNF α (M. J. May, et al., *Science* 2000, 289, 1550; A. Gaurnier-Hausser, et al., *Clin. Cancer Res.* 2011, 17, 4661). In the absence of any inhibitory peptide, treatment with 5 ng/mL TNF α increased the luciferase activity from a basal level of 177 arbitrary units (AU) to 715 AU. Peptide **4** reduced the TNF α -induced

luciferase activity in a dose-dependent manner, with an IC₅₀ value of ~20 μ M (**Figure 1C**). In contrast, the control peptide **5** had no significant effect on NF- κ B signaling at 20 μ M and resulted in ~10% inhibition at the highest concentration tested (40 μ M). Consistent with the earlier report (M. J. May, et al., *Science* 2000, 289, 1550), Antp-NBD (peptide **1**) also caused concentration-dependent inhibition, but showed an IC₅₀ value of 140 μ M. The higher potency of bicyclic peptide **4** relative to Antp-NBD in the cellular assay is likely the results of both improved cellular entry efficiency (**Figure 1A**) and greater NEMO-binding affinity (**Figure 1B**). In vitro treatment of bicyclic peptide **4** with 5 mM glutathione for 2 h completely reduced the disulfide bonds (**Figure 5B**), suggesting that peptides **2-5** should undergo complete reduction upon cytosolic entry.

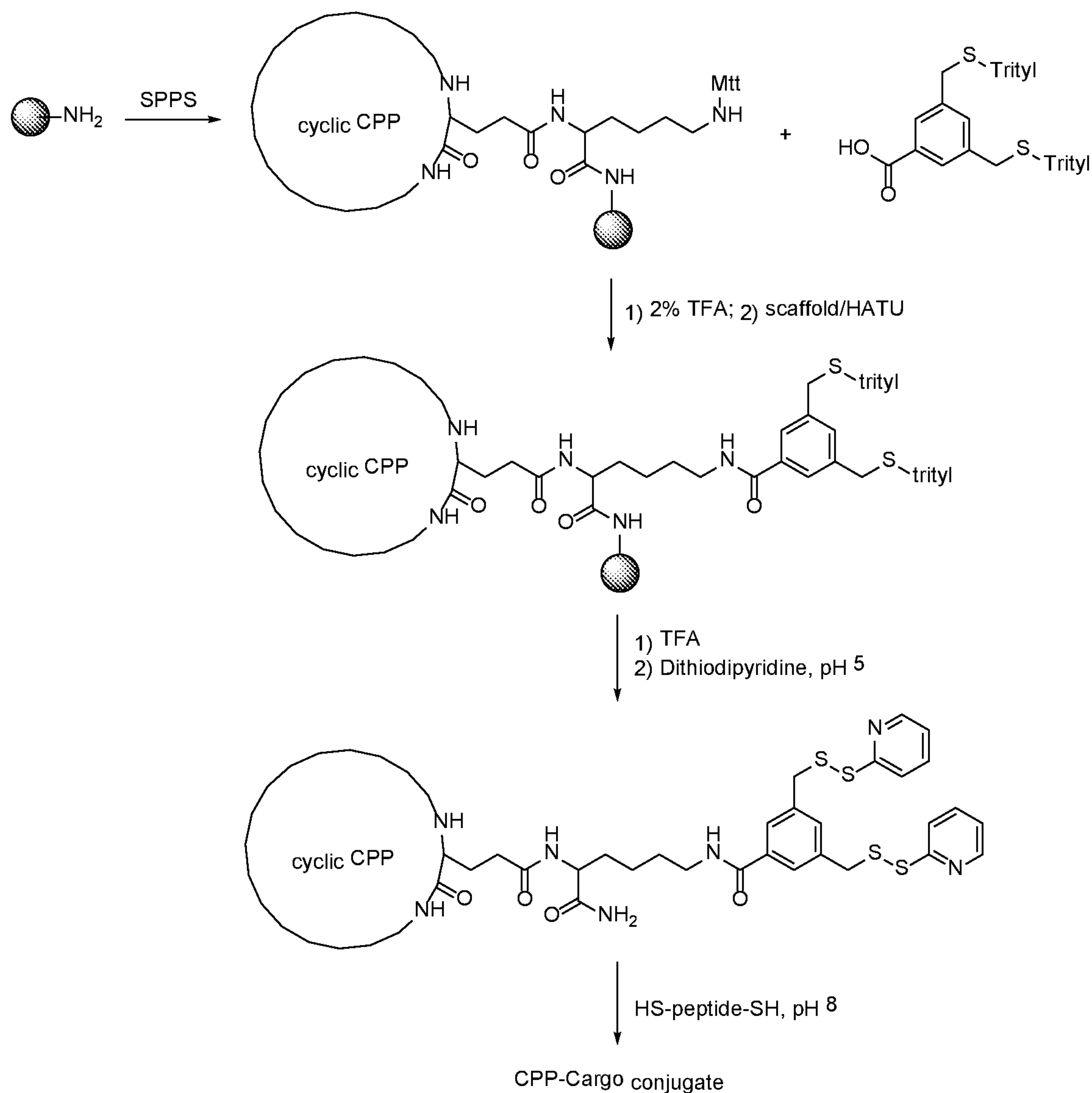
Finally, the proteolytic stability of peptide **4** and Antp-NBD was tested by incubating the peptides in human serum for varying lengths of time and the remaining amounts of intact peptides were quantitated by analytical HPLC. For comparison, a control peptide (Table 6, peptide **6**) was synthesized, which has the same sequence as peptide **4** but only its CPP motif was cyclized. In agreement with the previous reports (E. Jimi, et al., *Nat. Med.* 2004, 10, 617; S. Dai, et al., *J. Biol. Chem.* 2004, 279, 37219; W. Shibata, et al., *J. Immunol.* 2007, 179, 2681; S. H. Dave, et al., *J. Immunol.* 2007, 179, 7852; A. Gaurnier-Hausser, et al., *Clin. Cancer Res.* 2011, 17, 4661; J. M. Peterson, et al., *Mol. Med.* 2011, 17, 508; D. A. Delfin, et al., *J. Transl. Med.* 2011, 9, 68; D. P. Reay, et al., *Neurobiol. Dis.* 2011, 43, 598; J. N. Kornegay, et al., *Skelet. Muscle* 2014, 4, 18; G. Habineza Ndikuyeze, et al., *PLoS One*, 2014, 9, e95404), Antp-NBD was rapidly degraded by human serum, with a half-life of ~15 min (**Figure 1D**). In contrast, bicyclic peptide **4** showed a half-life of ~10 h, and 23% of the peptide remained intact after 20 h of incubation at 37 °C. The monocyclic control peptide **6** was also rapidly degraded (with a half-life of ~30 min), likely due to proteolysis of the linear NBD sequence. It was

previously shown that linear peptidyl cargos attached to the Gln side chain of cF Φ R₄ were rapidly degraded in human serum (Z. Qian, et al., *Angew. Chem. Int. Ed.* 2015, 54, 5874; *Angew. Chem.* 2015, 127, 5972).

5 In conclusion, a simple method has been developed to efficiently deliver peptidyl ligands into mammalian cells, by fusing the peptide with a short CPP motif and reversibly cyclizing the fusion peptide through disulfide bonds. The resulting bicyclic peptide has greatly enhanced cellular uptake as well as proteolytic stability. This strategy should be applicable to delivering any linear peptides.

10 **Example 4. Synthesis of Bicyclic Peptide that Releases Peptidyl Cargo from the Cyclic Cell-Penetrating Peptide in the Cytosol**

As shown below in **Scheme 2**, the desired cyclic CPP was first synthesized by standard solid-phase peptide synthesis using the Fmoc/HATU chemistry and anchored to the support through a Lys(Mtt) linker. While still on resin, the Mtt group is removed with 2% TFA and the exposed Lys side chain is coupled to the bis(mercaptomethyl)benzoic acid scaffold by using
15 HATU. The cyclic CPP is then cleaved off the resin and deprotected by TFA. The free thiols are protected/activated by reacting the peptide in solution (pH 5) with dithiodipyridine to generate the CPP-scaffold. Finally, the desired CPP-peptide cargo conjugate is prepared by simply mixing the CPP-scaffold and a thiol-containing peptide in an aqueous buffer at pH 8.



Scheme 2. Solid-phase synthesis of disulfide-mediated bicyclic peptides

Various bicyclic peptides synthesized according to Scheme 2. Specifically, cyclic
 5 CPP12 (FfΦRrRr) was conjugated to a peptidyl inhibitor against Keap1-Nrf2 (**FIG. 10A**), a
 peptidyl inhibitor against Pin1 (**FIG. 11**), peptidyl inhibitor against the CAL PDZ-CFTR
 (PDZ) interaction (**FIG. 12A**), and a peptidyl inhibitor against the MDM2-p53 interaction
 (PMI) (**FIG. 13A**). Fluorescent labels were attached using methods known in the art as
 necessary to quantify cellular uptake efficiency.

10

Cellular Uptake Assay. The various bicyclic peptides (cyclic CPP + peptidyl cargo)
 synthesized according to **Scheme 2** were assayed for cellular uptake efficiency using flow

cytometry and compared to cellular uptake efficiency of linear peptidyl cargo (without the cyclic CPP).

All measurements were performed in triplicates and in the presence of 10% fetal bovine serum (FBS). Attachment of a cargo peptide (e.g., a negatively charged peptide such as the
5 Keap1 peptide) increases the cellular uptake (relative to CPP12).

Serum Stability. The serum stability of the bicyclic peptides (cyclic CPP + peptidyl cargo) synthesized according to **Scheme 2** were assayed and compared to cellular uptake efficiency of linear peptidyl cargo (without the cyclic CPP). Unconjugated peptides and
10 CPP12-peptide conjugates were incubated in 25% human serum for varying periods of time (min) and the remaining intact peptide was quantitated by analytical HPLC. Specifically, the serum stability of a bicyclic peptide comprising a cyclic CPP12 (FfΦRrRr) conjugated to a peptidyl inhibitor against the MDM2-p53 interaction (PMI) (**Figure 17**), or conjugated to a peptidyl inhibitor against the Keap1-Nrf2 interaction (**Figure 18**), or conjugated to a peptidyl
15 inhibitor against Pin-1 (P1) (**Figure 19**), compared serum stability of the respective linear peptidyl inhibitors.

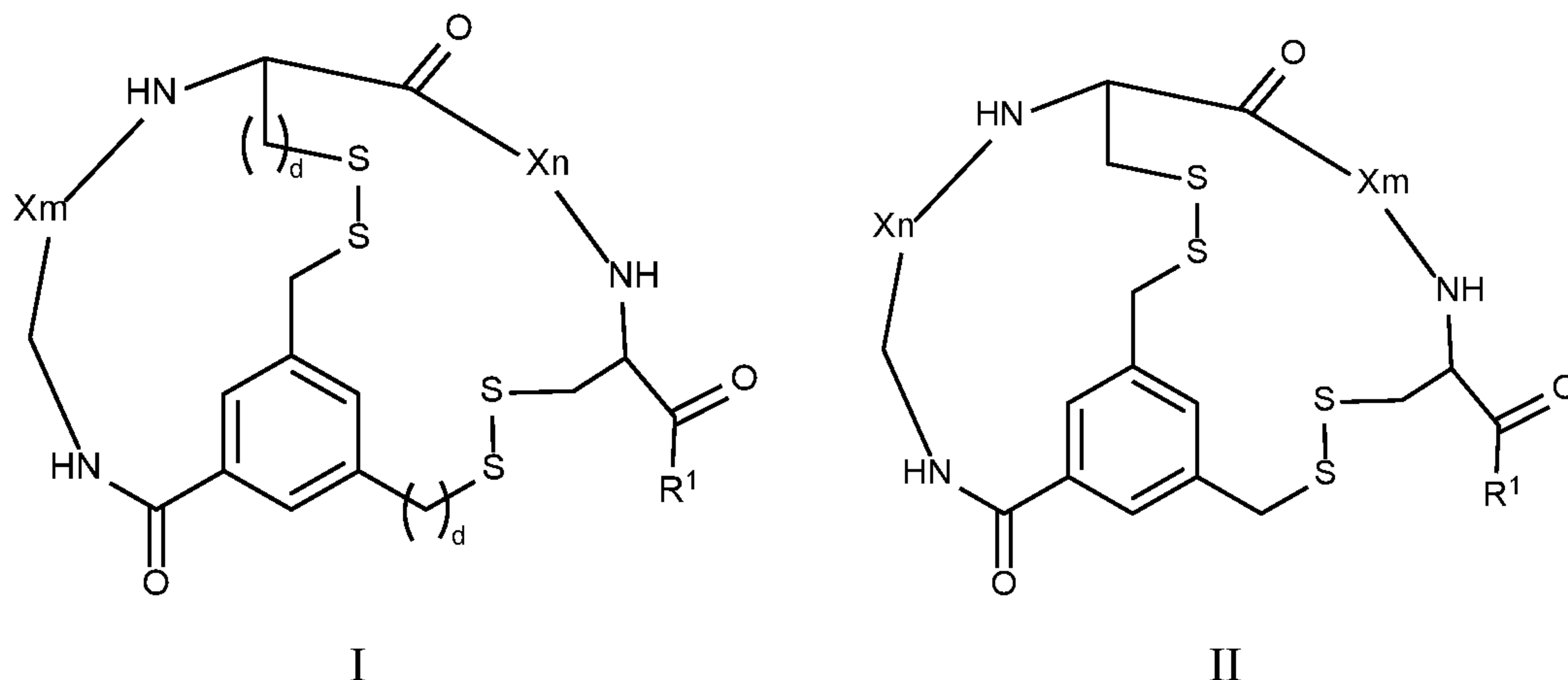
Conjugation with CPP12 (via cyclization) greatly increases serum stability of all peptides.

20 Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. Such equivalents are intended to be encompassed by the following claims.

CLAIMS

What is claimed is:

1. A bicyclic peptide comprising Formula I or II:

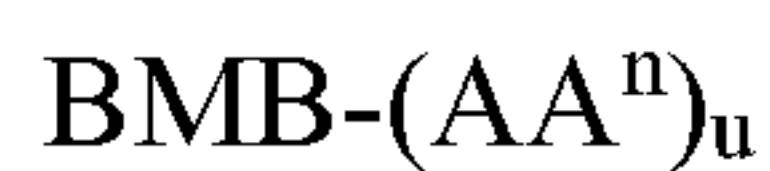


wherein:

X_m and X_n independently comprise a sequence of 1-20 amino acids; each d is independently 1 or 2; and R^1 is OH, OR^2 , or NHR^2 , and wherein R^2 is a C_{1-20} alkyl, C_{6-10} aryl or 5-20 membered heteroaryl, amino acid, peptide sequence of 2 to 20 amino acids, detectable moiety, or solid support.

2. The bicyclic peptide of claim 1, wherein X_m is a cell penetrating peptide sequence.
3. The bicyclic peptide of any one of the previous claims, wherein X_m is from 4 to 10 amino acids in length.
4. The bicyclic peptide of any one of the previous claims, wherein at least one, at least two, or at least three amino acids in X_m have a hydrophobic side chain.
5. The bicyclic peptide of any one of the previous claims, wherein X_m comprises one or more phenylalanine, naphthylalanine, tryptophan, or an analog or derivative thereof.
6. The bicyclic peptide of any one of the previous claims, wherein X_m comprises at least one arginine or an analogue or derivative thereof.
7. The bicyclic peptide of any one of the previous claims, wherein X_m comprises a sequence listed in Table 2 (SEQ ID NO:62 through SEQ ID NO:146).

8. The bicyclic peptide of any one of the previous claims, wherein X_m is or comprises RRRR Φ F or F Φ RRRR.
9. The bicyclic peptide of any one of the previous claims, wherein X_n comprises a sequence listed in Table 5 (SEQ ID NO:147 through SEQ ID NO:159).
10. The bicyclic peptide of any one of the previous claims, wherein the bicyclic peptide has a sequence listed in Table 6 (SEQ ID NO:160 through SEQ ID NO:167).
11. A peptide sequence comprising Formula III



III

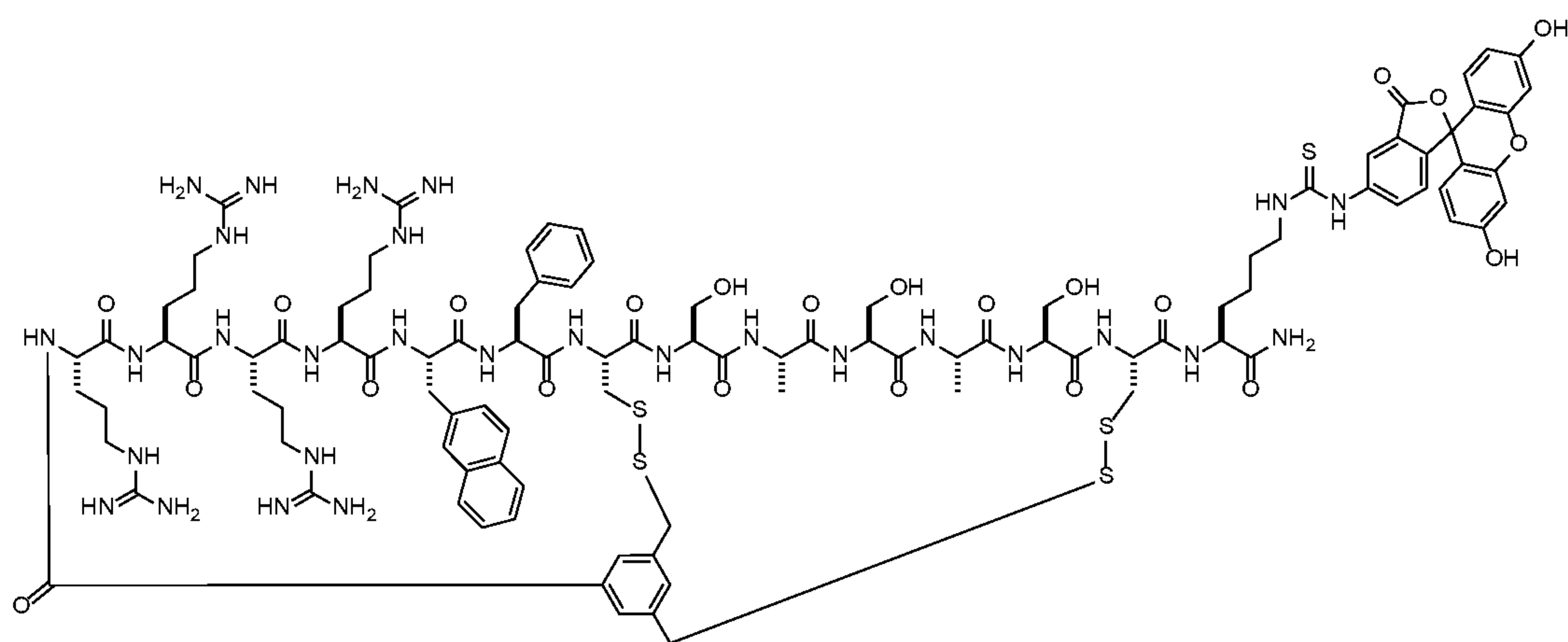
wherein:

n is an integer of from 4 to 20;

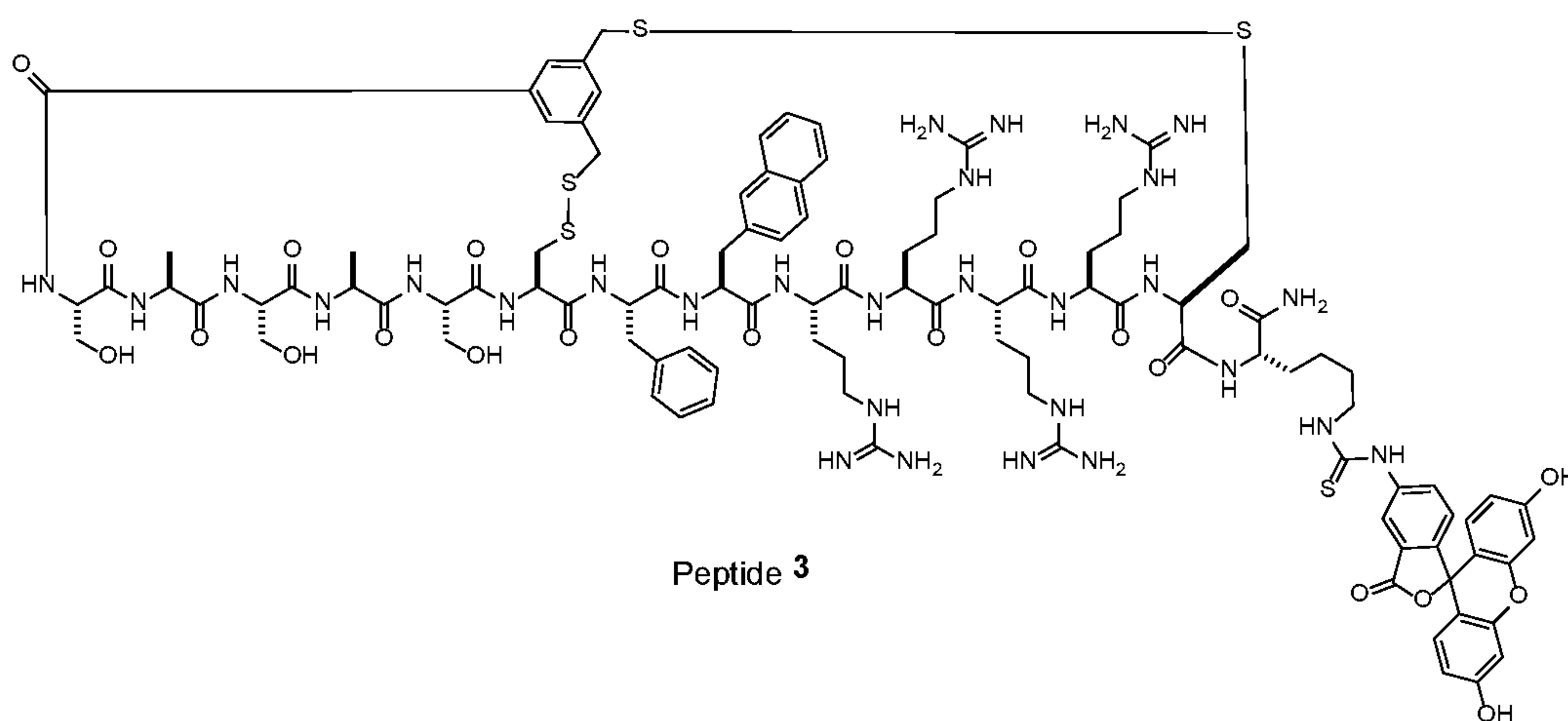
each AA^n is, independently, an acid, with at least two AA^n independently selected from the group consisting of cysteine, homocysteine, an amino acid having a thiol group; and

BMB is 3,5-bis(mercaptomethyl)benzoic acid residue.

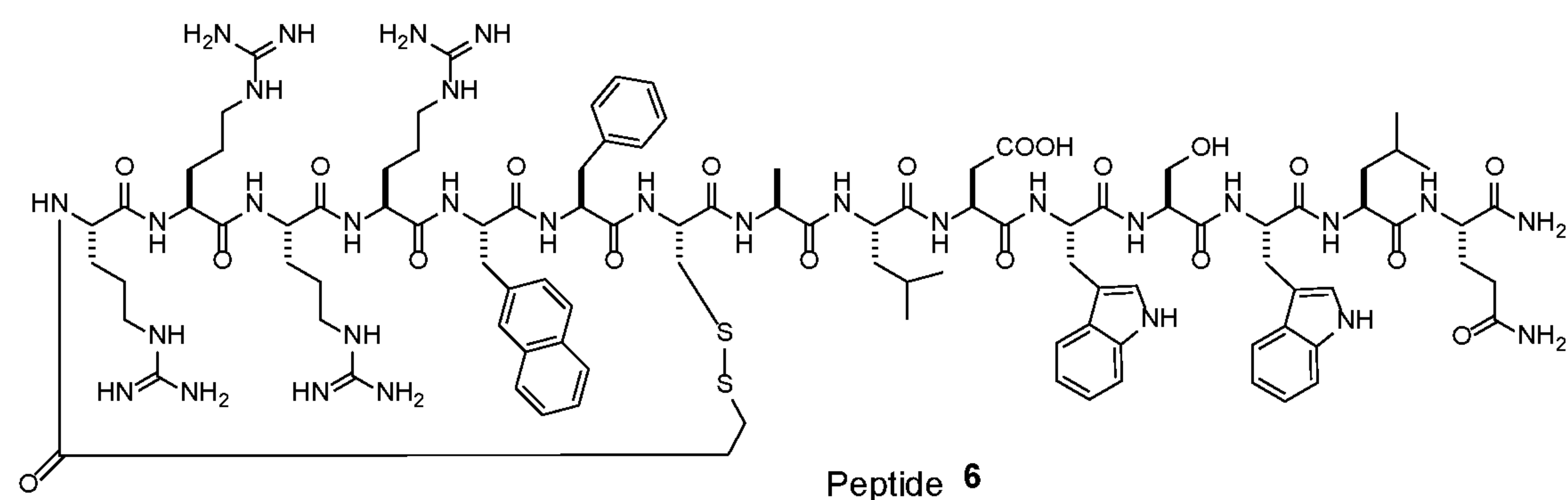
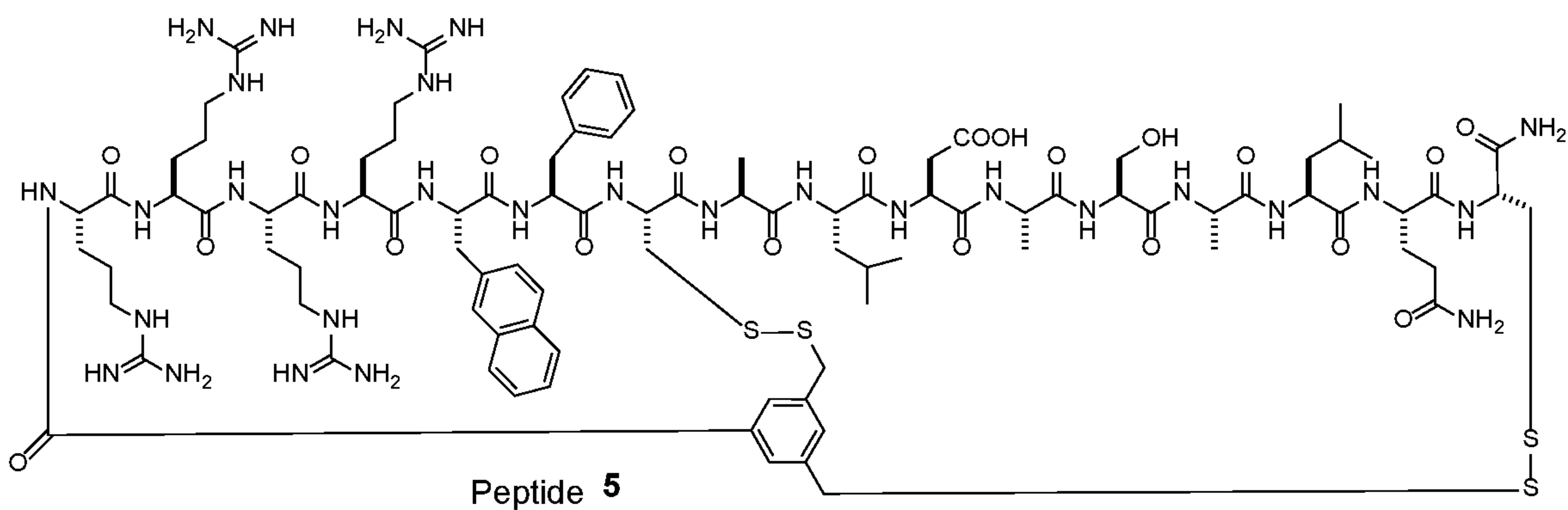
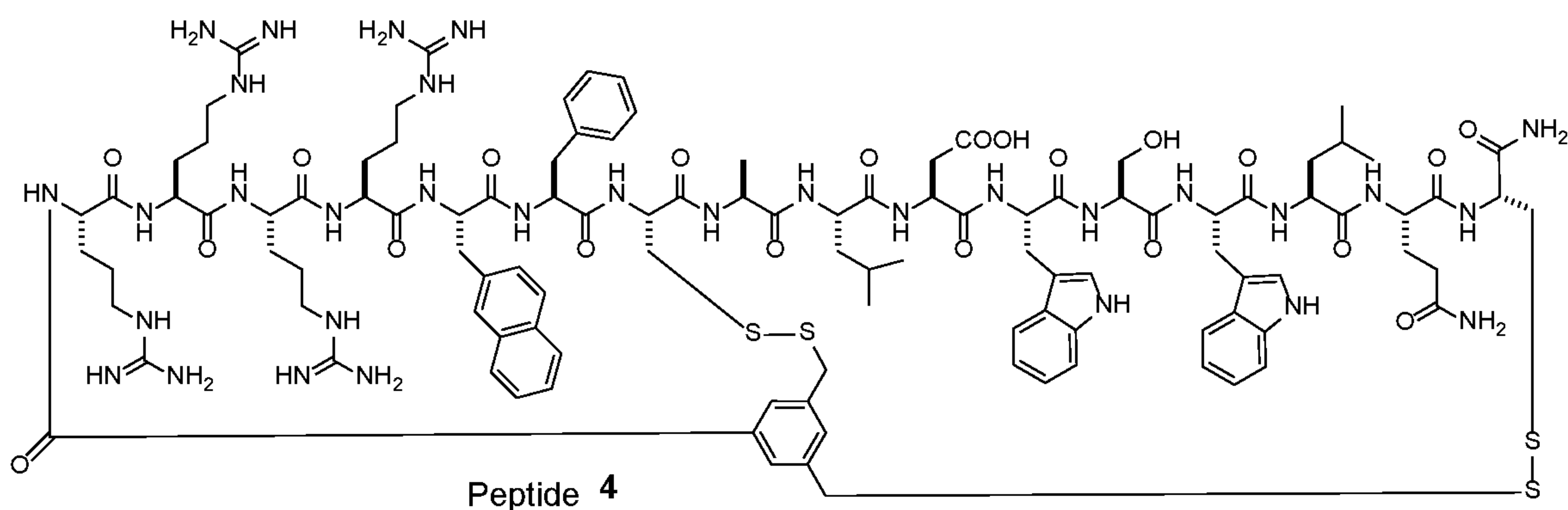
12. A peptide chosen from one of the following structures:



Peptide 2



Peptide 3

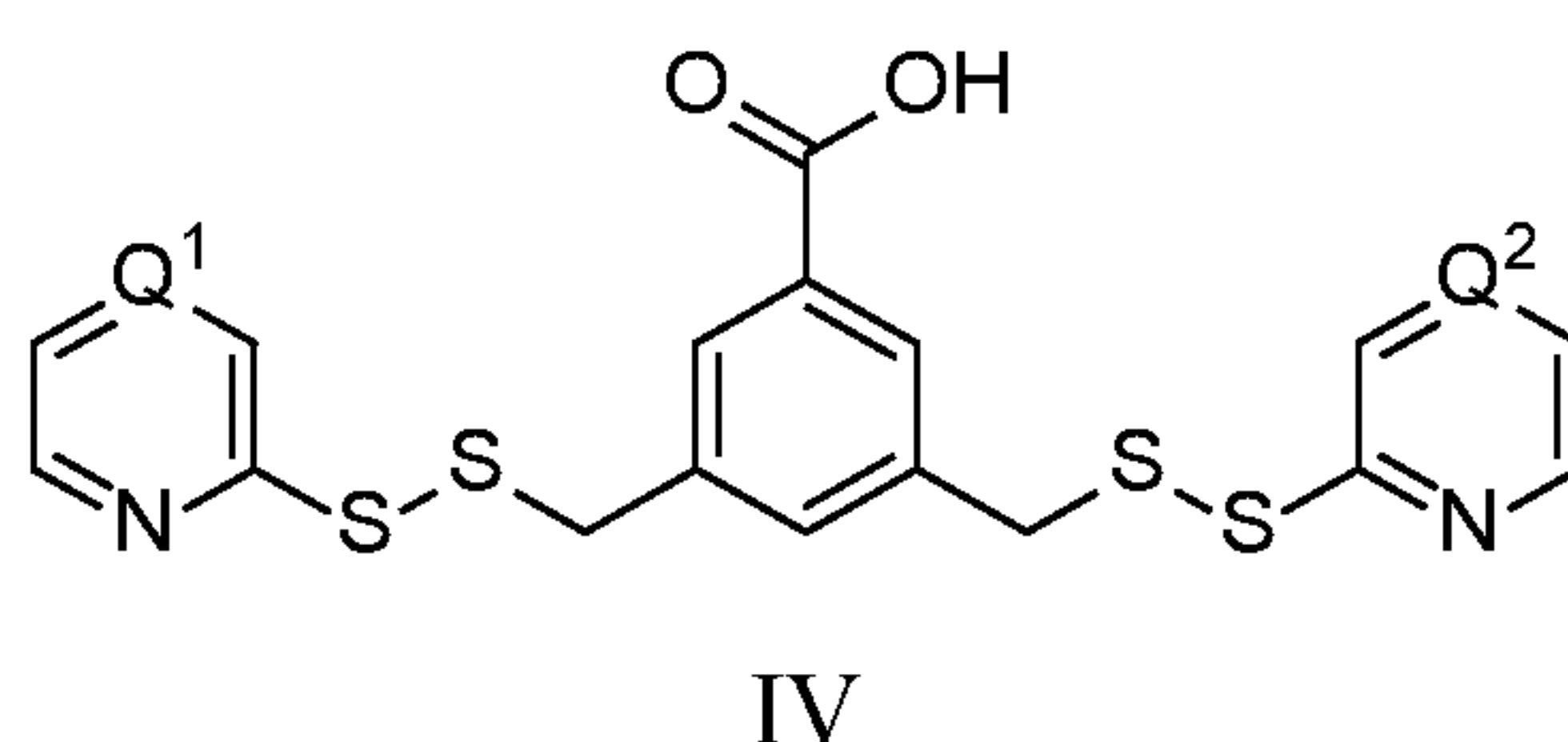


13. A pharmaceutical composition comprising the bicyclic peptide of any one of claims 1-12 and a pharmaceutical carrier.
14. A method for treatment of an inflammatory disorder, the method comprising the step of administering a therapeutically effective amount of any of the compounds of claims 1-13 to a subject identified as having a need for treatment of the disorder.
15. A method for treatment of an autoimmune disorder, the method comprising the step of administering a therapeutically effective amount of any of the compounds of claims 1-13 to a subject identified as having a need for treatment of the disorder.

16. A method for treatment of a disorder of uncontrolled cellular proliferation, the method comprising the step of administering a therapeutically effective amount of any of the compounds of claims 1-13 to a subject identified as having a need for treatment of the disorder.

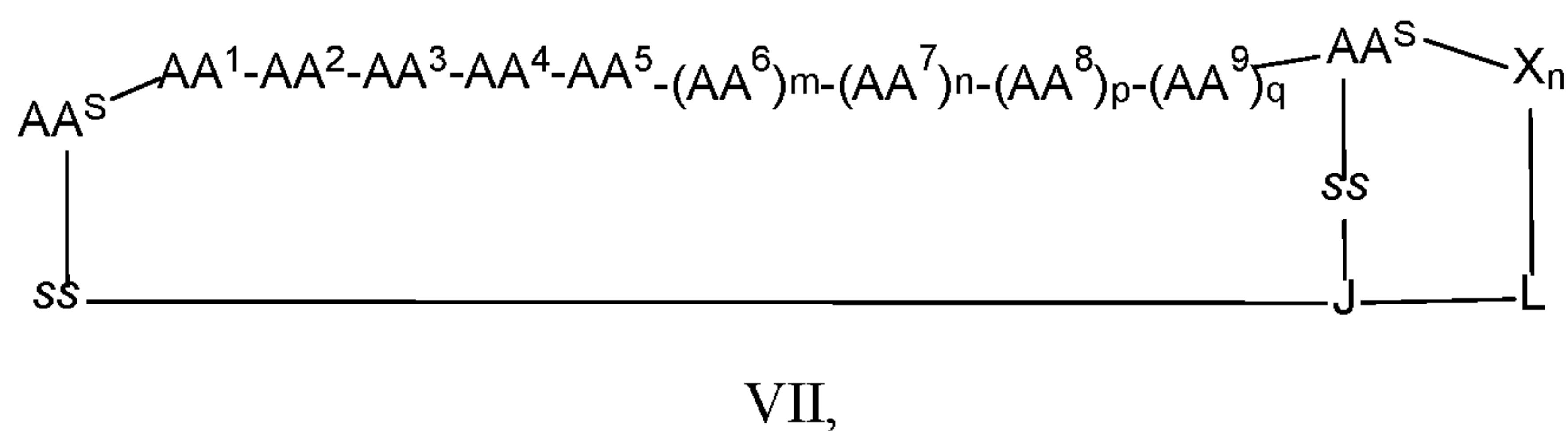
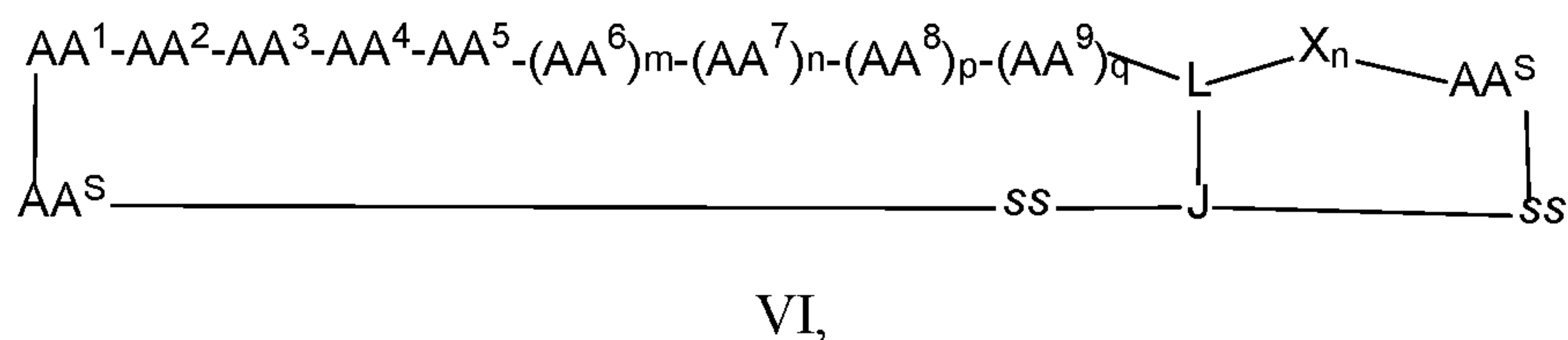
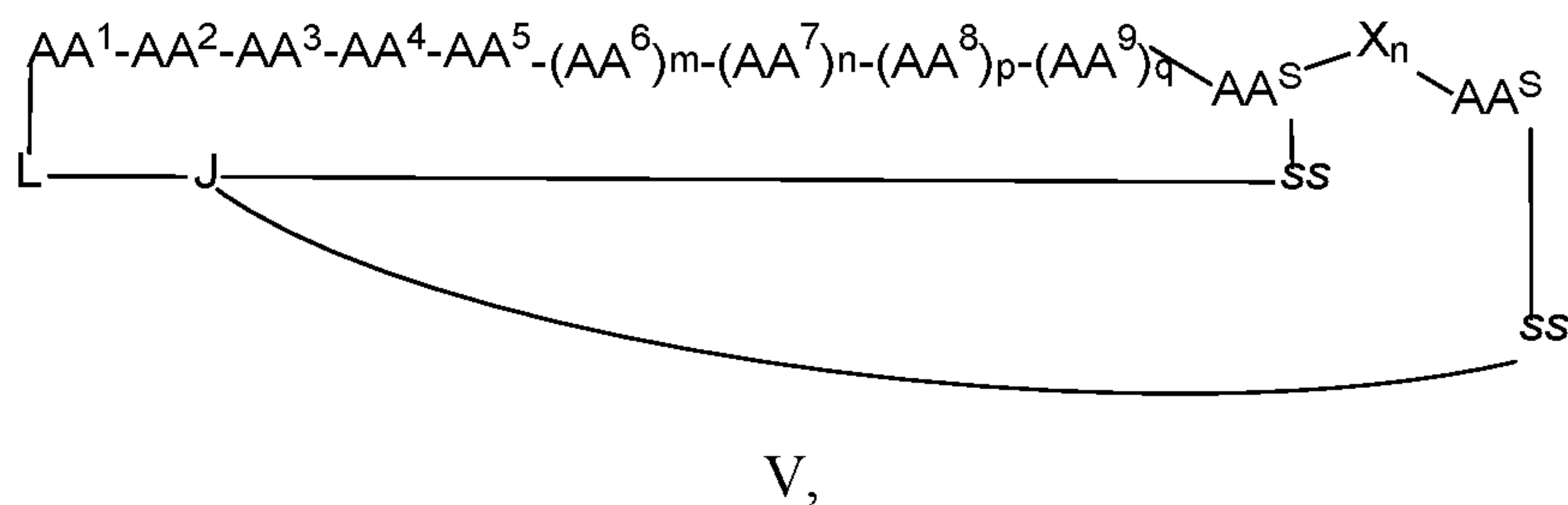
17. A method of making a bicyclic peptide, comprising:

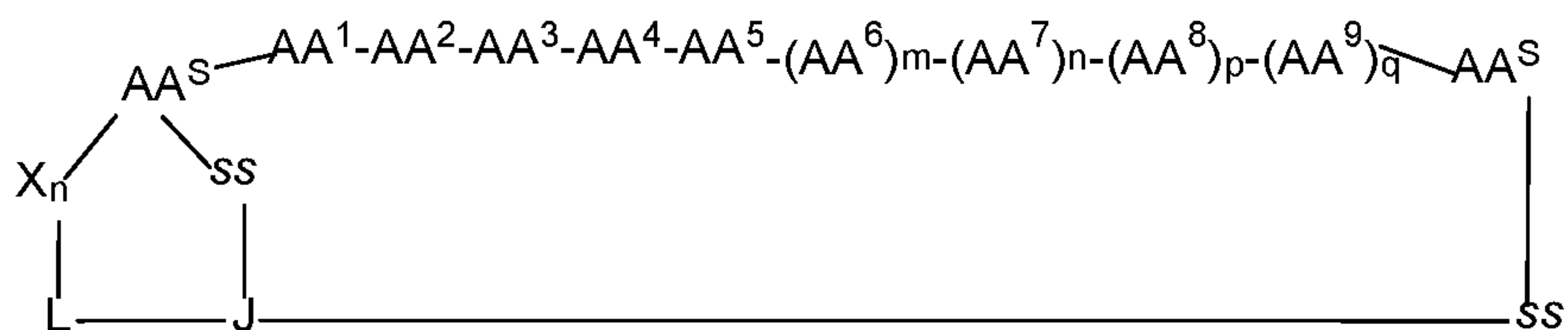
(a) contacting a solid supported peptide having from 8 to 40 amino acid, wherein at least two amino acids are independently selected from the group consisting of a cysteine, homocysteine, and an amino acid having a thiol group, with a compound of Formula IV:



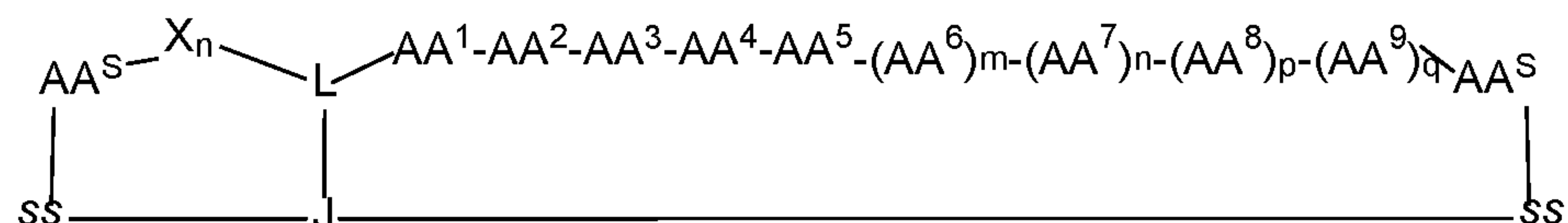
wherein Q^1 and Q^2 are, independent of one another, chosen from CH or N; and
(b) cleaving the peptide from the solid support.

18. A bicyclic peptide comprising Formula V, VI, VII, VIII, IX, X, or XII:

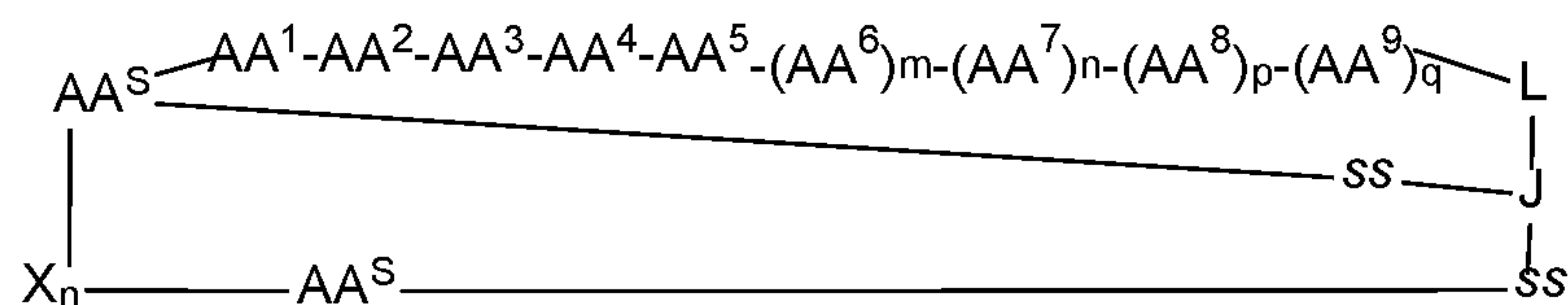




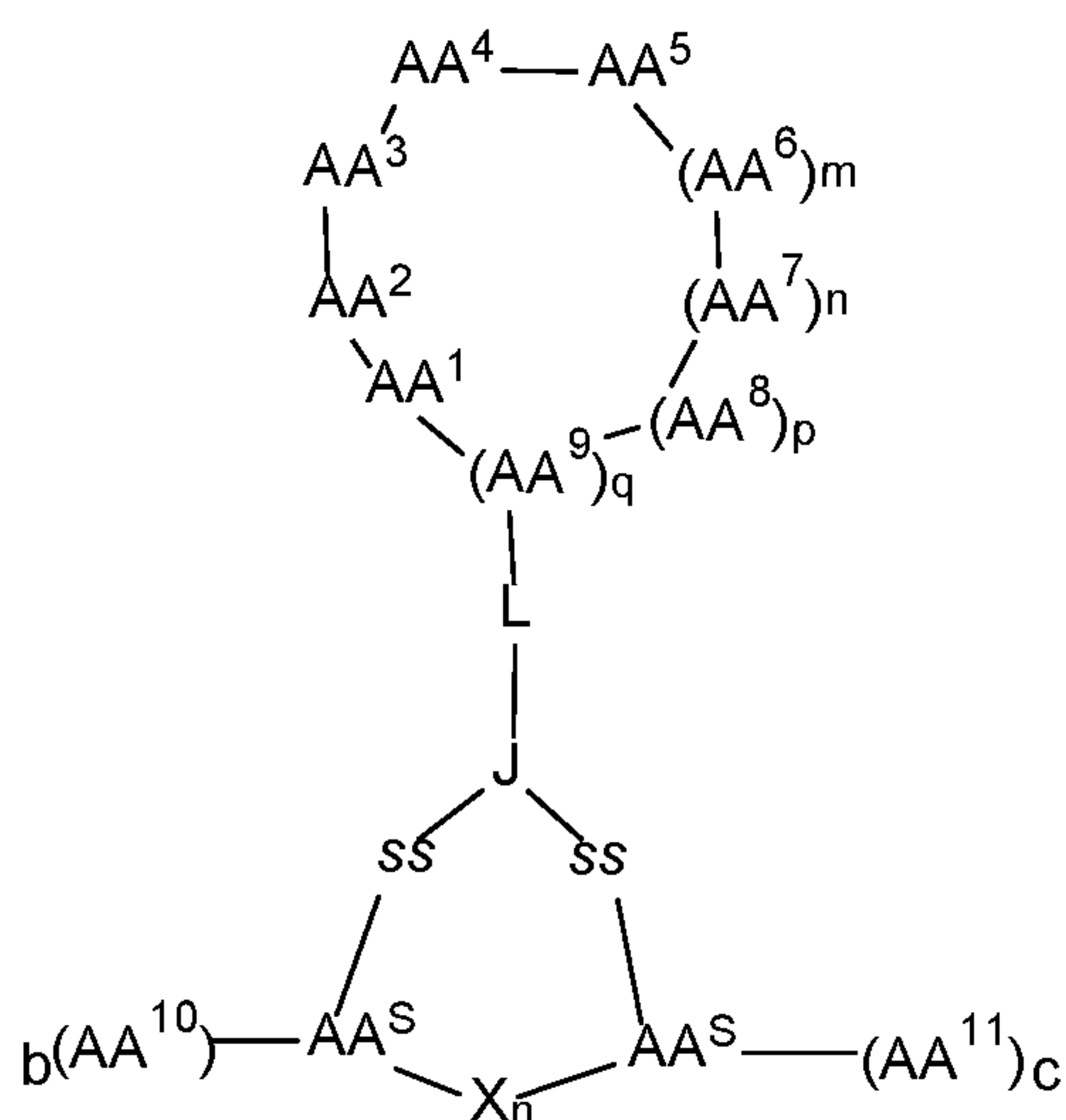
VIII,



IX,



X,



XII

or a pharmaceutically acceptable salt thereof,

wherein:

AA¹, AA², AA³, AA⁴, AA⁵, AA⁶, AA⁷, AA⁸, and AA⁹ are each independently an amino acid, where at least three amino acids are arginine and at least two amino acids independently comprise a hydrophobic side chain;

m, n, p, and q are independently selected from 0 and 1;

AA¹⁰, and AA¹¹, are each independently an amino acid;

b and c are independently an integer from 0 to 20;

AA^S at each occurrence is independently a moiety which forms a disulfide bond with J;

J is an alkyl, *N*-alkyl, alkenyl, alkynyl, carbocyclyl, or heterocyclyl, each of which are independently substituted with at least two substituents which independently form a disulfide bond with AA^S at each occurrence;

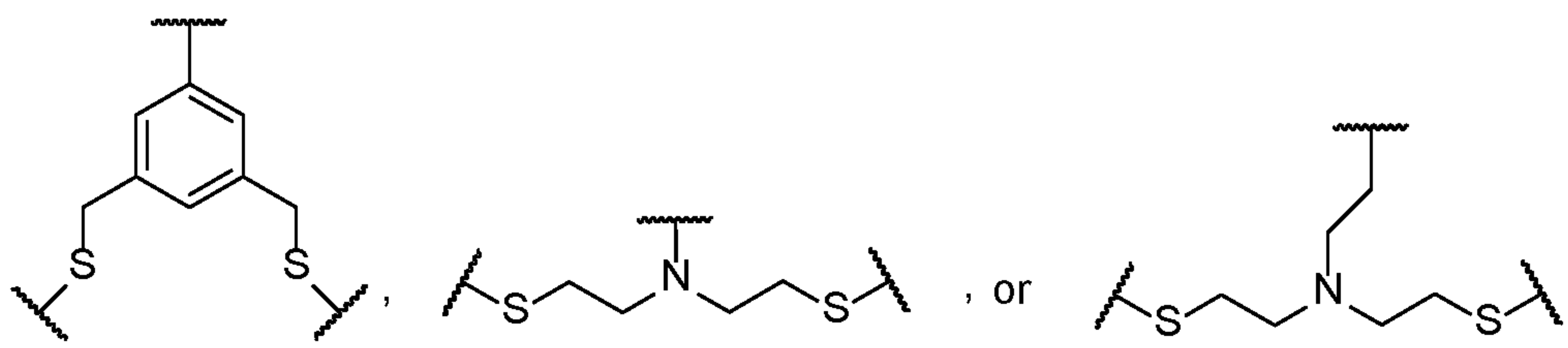
ss at each instance represents a disulfide bond; and

L is a moiety which links J to an amino acid, X_n, or a combination thereof; and

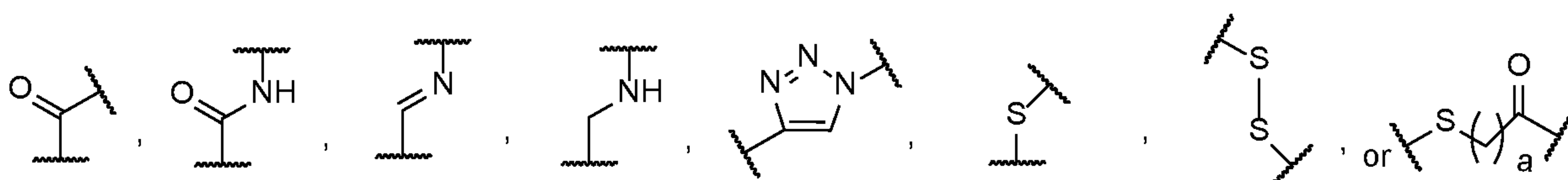
X_n is a cargo moiety comprising a peptide sequence having from 1 to 20 amino acids.

19. The bicyclic peptide of claim 18, wherein J is *N*-alkyl, aryl, or heteroaryl, each of which are independently substituted with at least two substituents which independently form a disulfide bond with AA^S at each occurrence.

20. The bicyclic peptide of claim 18, wherein J is

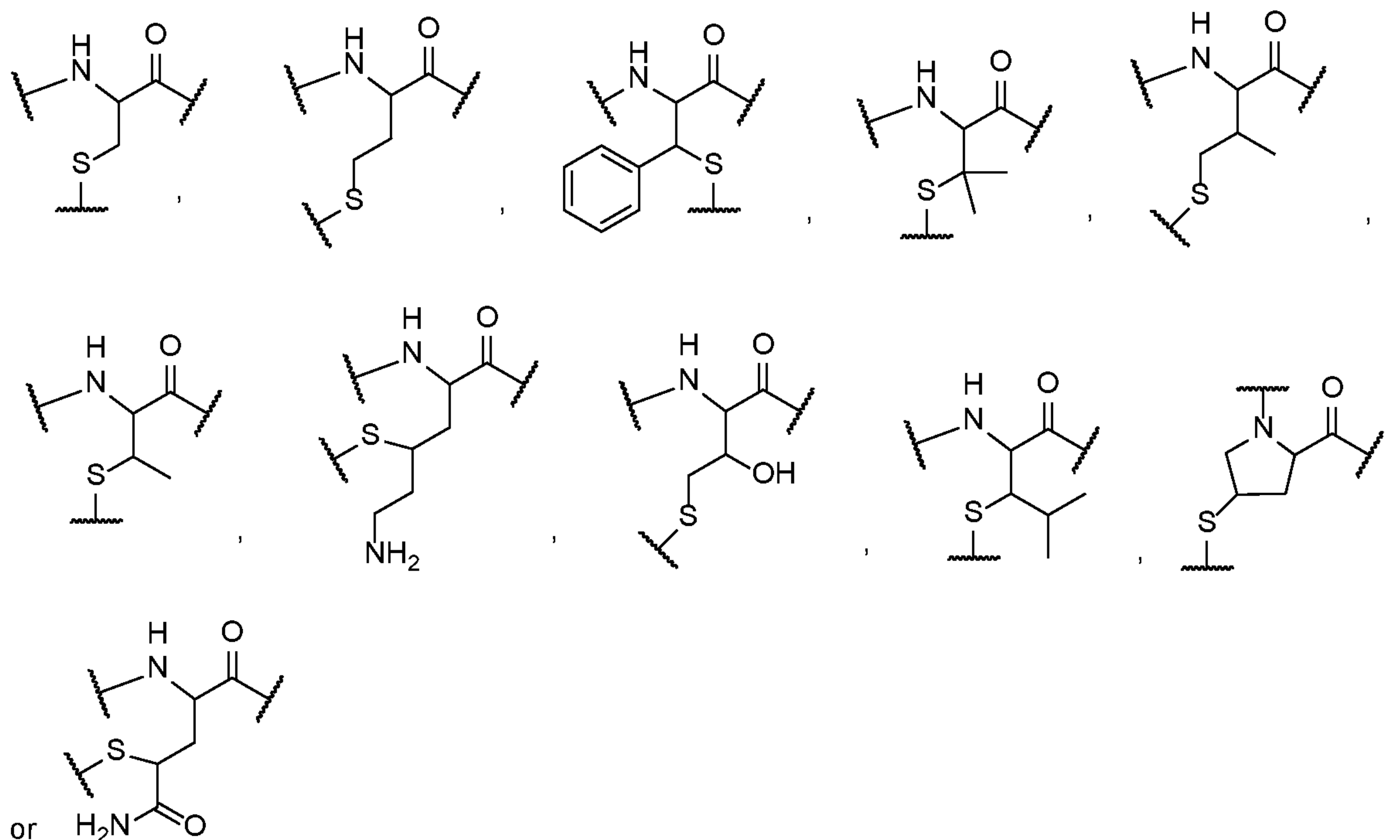


21. The bicyclic peptide of claim 18, wherein L is a bond, an amino acid,



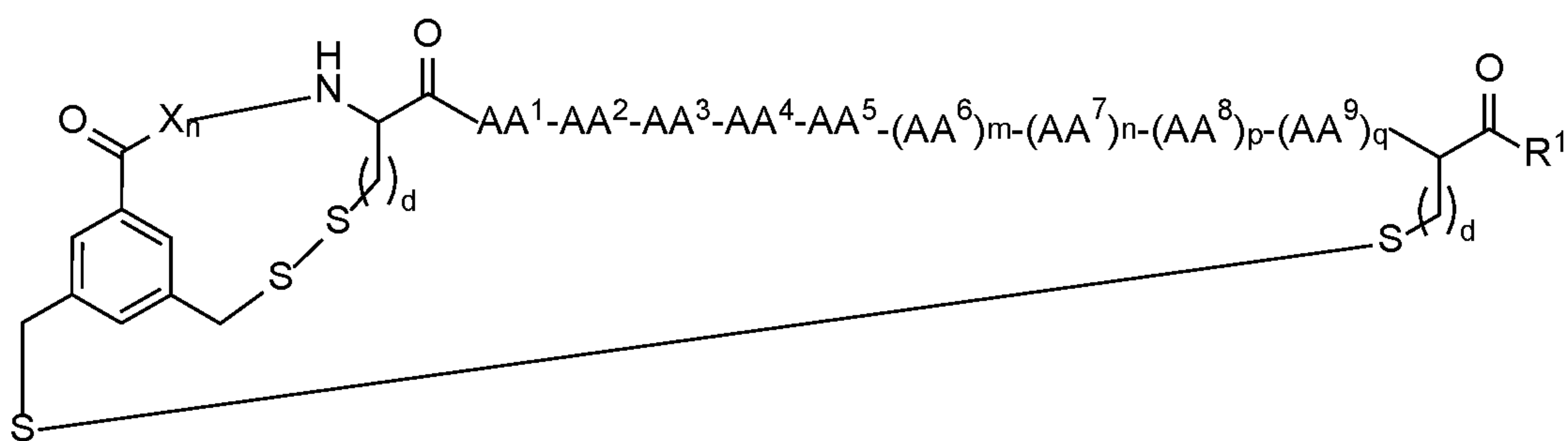
, wherein a is an integer from 0 to 10.

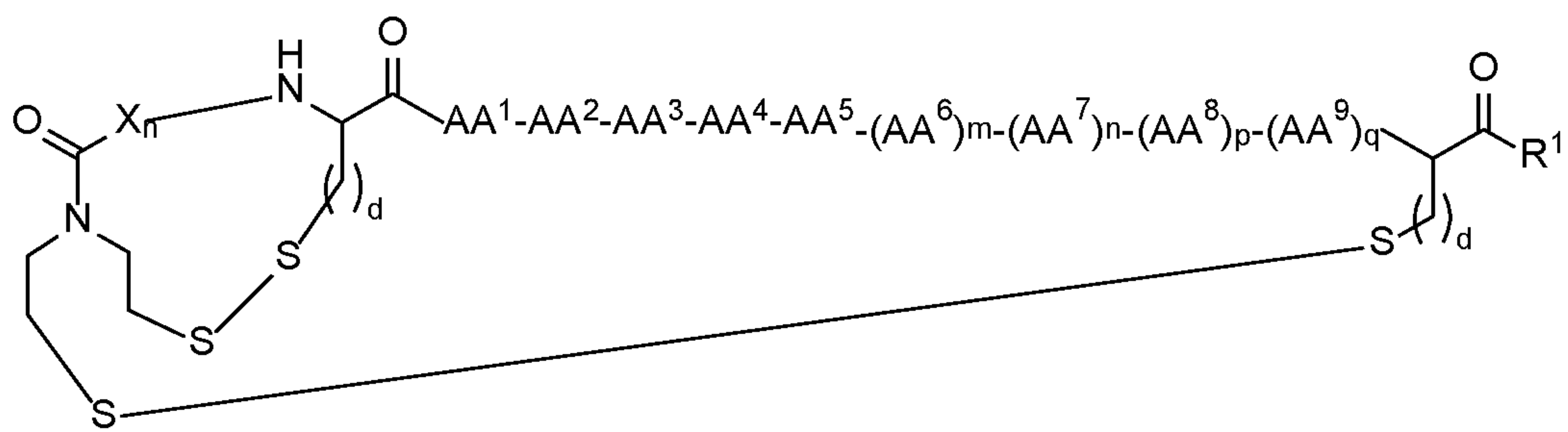
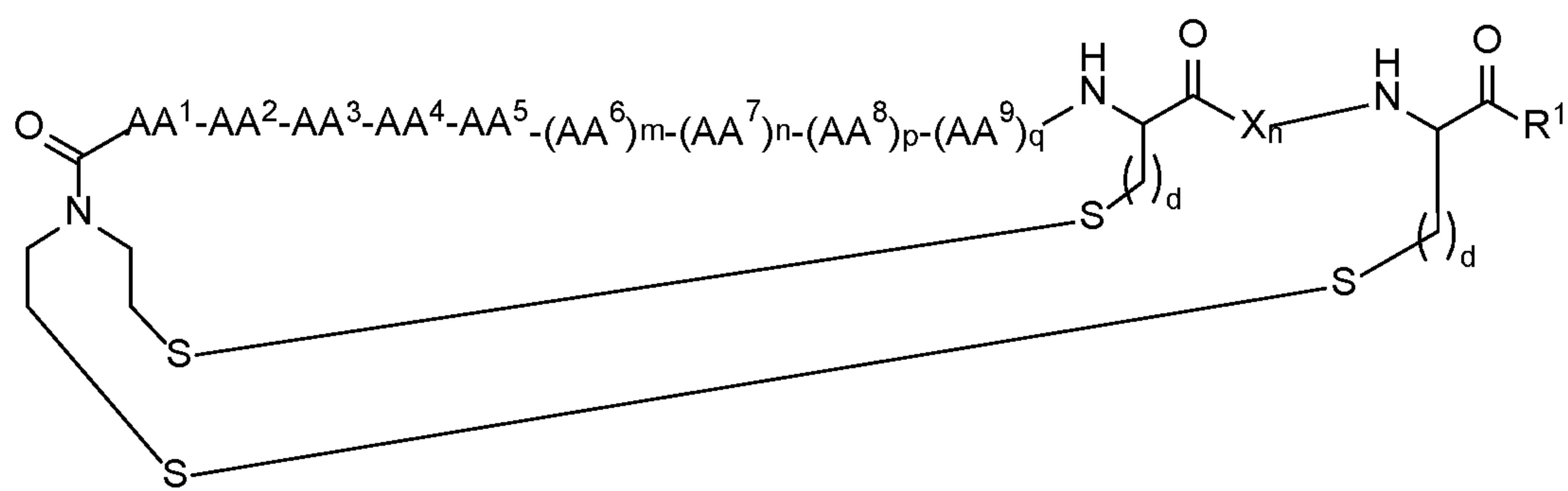
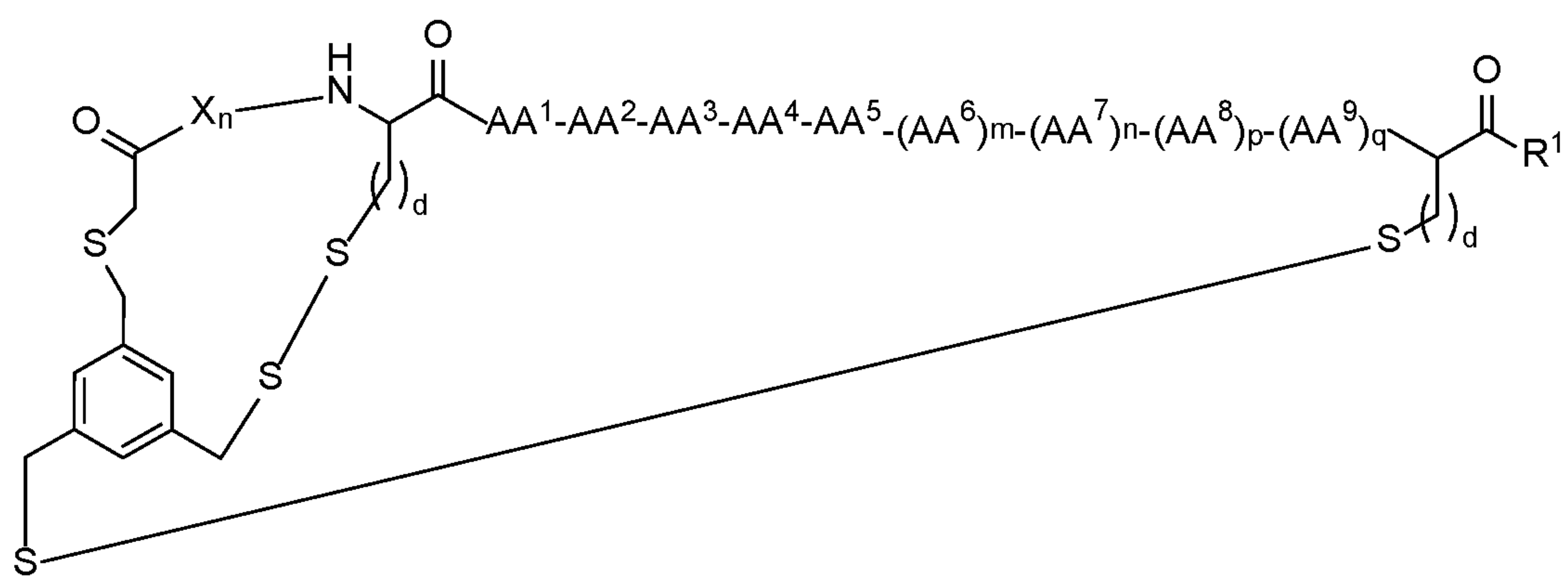
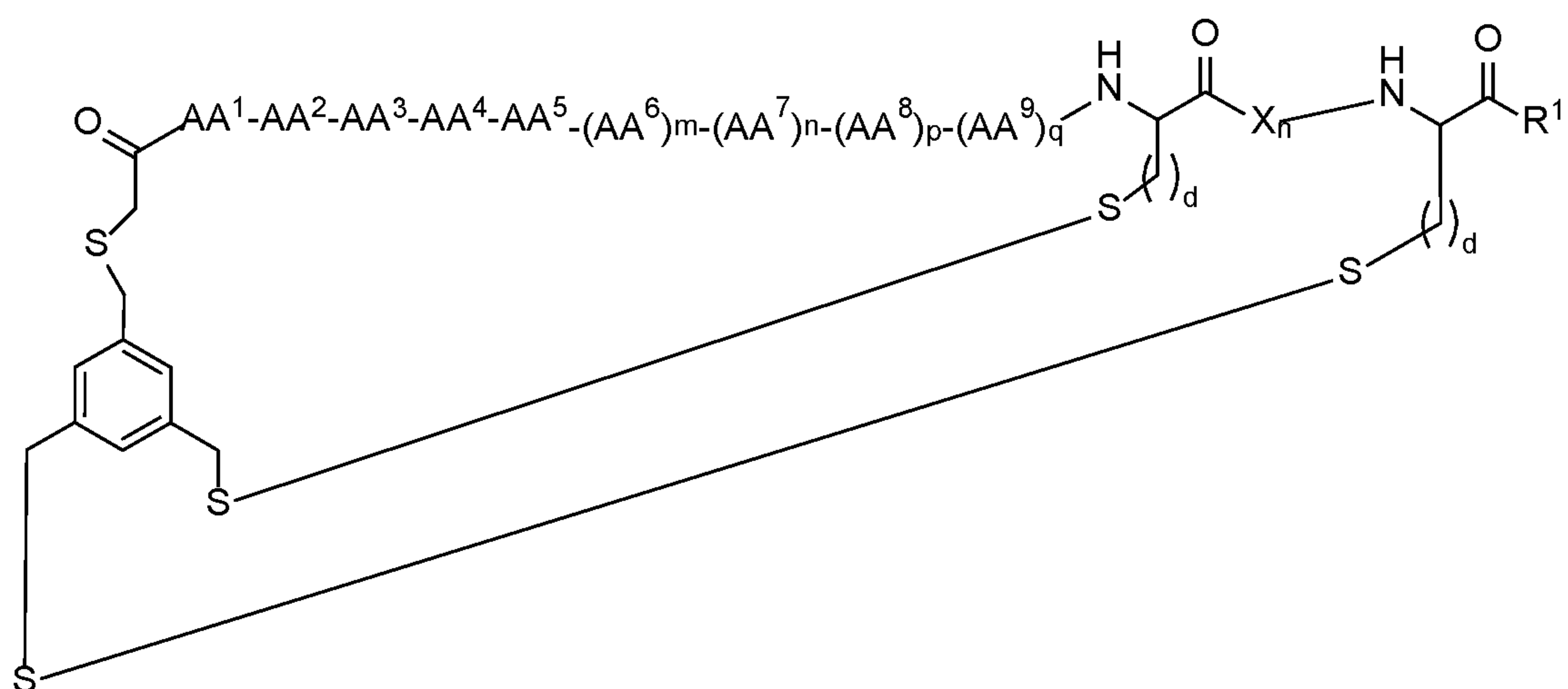
22. The bicyclic peptide of claim 18, wherein each AA^S independently is

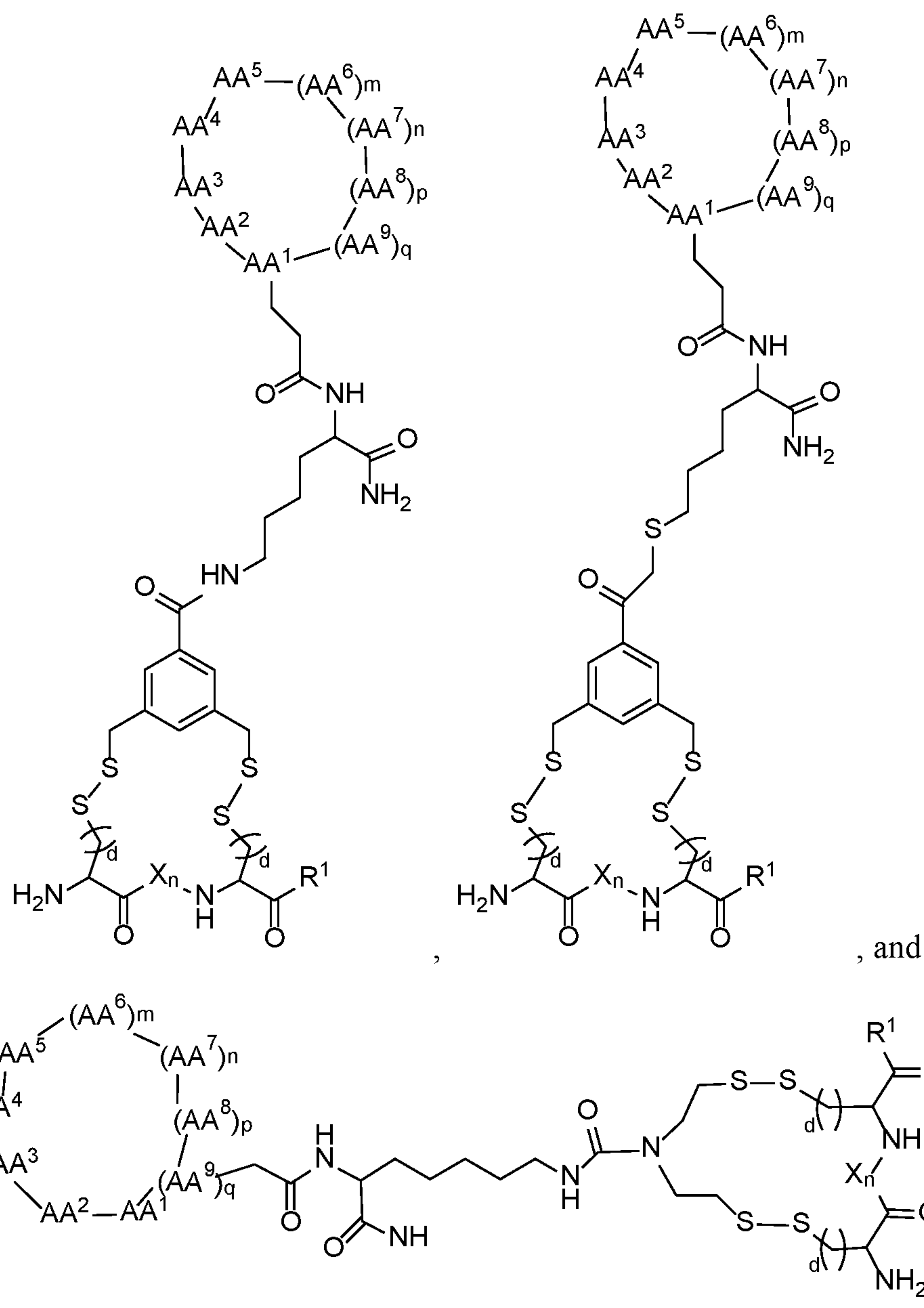


wherein the C-terminus of AA^S forms an amide bond or is R¹, wherein R¹ is OH, OR², or NHR², wherein R² is an alkyl, aryl, heteroaryl, amino acid, peptide sequence of 2 to 20 amino acids, detectable moiety, or solid support.

23. The bicyclic peptide of claim 18, selected from the group consisting of:







or a pharmaceutically acceptable salt thereof,

wherein each d is independently 1 or 2; and

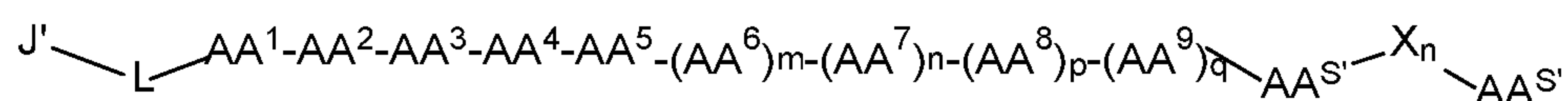
wherein R¹ is OH, OR², NHR²; and R² is a alkyl, aryl, heteroaryl, amino acid, peptide sequence of 2 to 20 amino acid, detectable moiety, or solid support.

24. The bicyclic peptide of any one of claims 18-23, wherein the at least two amino acid which independently comprise a hydrophobic side chain are selected from the group consisting of glycine, phenylglycine, alanine, valine, leucine, isoleucine, norleucine, phenylalanine, tryptophan, naphthylalanine, proline, and combinations thereof, wherein the aromatic side chains on phenylglycine, phenylalanine, tryptophan, or naphthylalanine are each optionally substituted with a halogen.

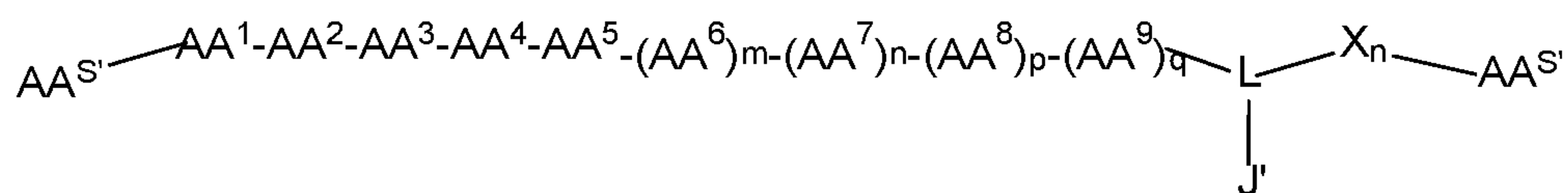
25. The bicyclic peptide of claim 24, wherein the at least two amino acid which independently comprise a hydrophobic side chain are independently selected from the group consisting of phenylalanine, naphthylalanine, and combinations thereof.
26. The bicyclic peptide of any one of claims 18-25, wherein the at least two amino acids which independently comprise a hydrophobic residue are consecutive amino acids.
27. The bicyclic peptide of any one of claims 18-25, wherein:
 - AA¹ is L arginine;
 - AA² is L-arginine;
 - AA³ is L-arginine;
 - AA⁴ is L-phenylalanine;
 - AA⁵ is L phenylalanine; and
 - m, n, p, and q, are each 0.
28. The bicyclic peptide of any one of claims 18-25, wherein:
 - AA¹ is L-phenylalanine;
 - AA² is L-naphthylalanine;
 - AA³ is L-arginine;
 - AA⁴ is L-arginine;
 - AA⁵ is L-arginine;
 - m is 1 and AA⁶ is L-arginine; and
 - n, p, and q are each 0.
29. The bicyclic peptide of any one of claims 18-25, wherein:
 - AA¹ is L-arginine;
 - AA² is L-arginine;
 - AA³ is L-arginine;
 - AA⁴ is L-arginine;
 - AA⁵ is L- naphthylalanine;
 - m is 1 and AA⁶ is L- phenylalanine; and
 - n, p, and q are each 0.
30. The bicyclic peptide of any one of claims 18-25, wherein at least three consecutive amino acids have alternating chirality.

31. The bicyclic peptide of claim 30, wherein the at least three consecutive amino acids having alternating chirality are arginines.
32. The bicyclic peptide of claim 31, wherein:
 - AA¹ is D-phenylalanine;
 - AA² is L-naphthylalanine;
 - AA³ is L-arginine;
 - AA⁴ is D-arginine;
 - AA⁵ is L-arginine;
 - m is 1 and AA⁶ is D-arginine; and
 - n, p, and q are each 0.
33. The bicyclic peptide of claim 31, wherein:
 - AA¹ is D-phenylalanine;
 - AA² is L-naphthylalanine;
 - AA³ is L-arginine;
 - AA⁴ is D-arginine;
 - AA⁵ is L-arginine;
 - m and n are each 1, and AA⁶ is D-arginine and AA⁷ is L-arginine; and
 - p and q are each 0.
34. The bicyclic peptide of claim 31, wherein:
 - AA¹ is D-phenylalanine;
 - AA² is L-naphthylalanine;
 - AA³ is L-arginine;
 - AA⁴ is D-arginine;
 - AA⁵ is L-arginine;
 - m and n are each 1, and AA⁶ is D-arginine and AA⁷ is L-phenylalanine; and
 - p and q are each 0.
35. The bicyclic peptide of any one of claims 18-34, wherein the peptide sequence in X_n inhibits at least one protein-protein interaction.
36. The bicyclic peptide of claim 35, wherein the protein-protein interaction is an interaction between a κ B-kinase (IKK) complex and a regulatory protein NF- κ B essential modifier (NEMO).

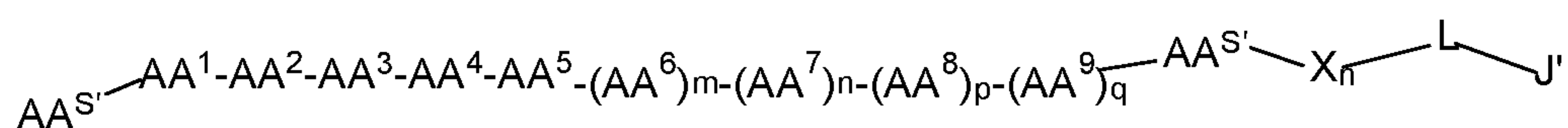
37. The bicyclic peptide of claim 35, wherein the peptide sequence in X_n is an inhibitor against Ras, PTP1 B, Pin 1, Grb2 SH2, MDM2, or combinations thereof.
38. The bicyclic peptide of any one of claims 18-34, wherein the peptide sequence in X_n is a wild-type peptidyl ligand or a peptide mimetic.
39. A method for delivering a therapeutic agent to cytoplasm of a cell, comprising administering a compound of any one of claims 18-38.
40. A method of treating a disease in a subject in need thereof, comprising administering a compound of any one of claims 18-38.
41. A compound according to Formula V-A, VI-A, VII-A, VIII-A, IX-A, X-A, or XII-A and XII-B:



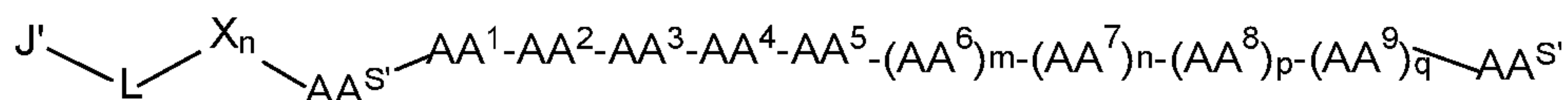
V-A,



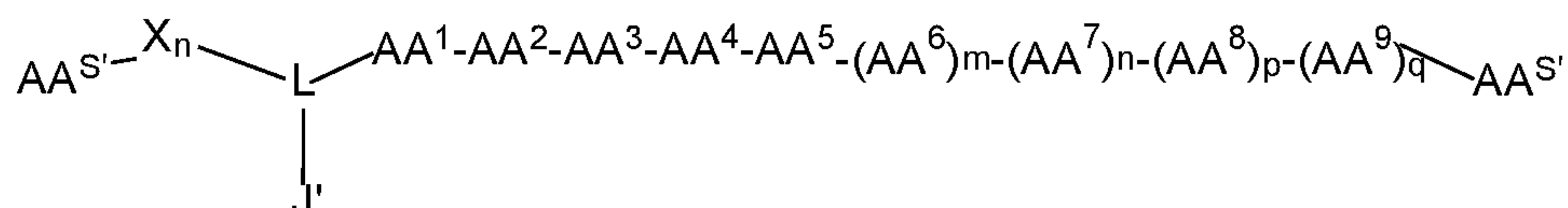
VI-A,



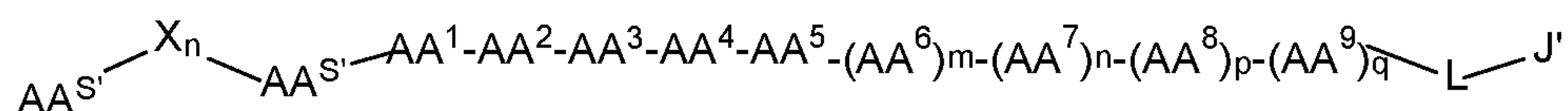
VII-A,



VIII-A,

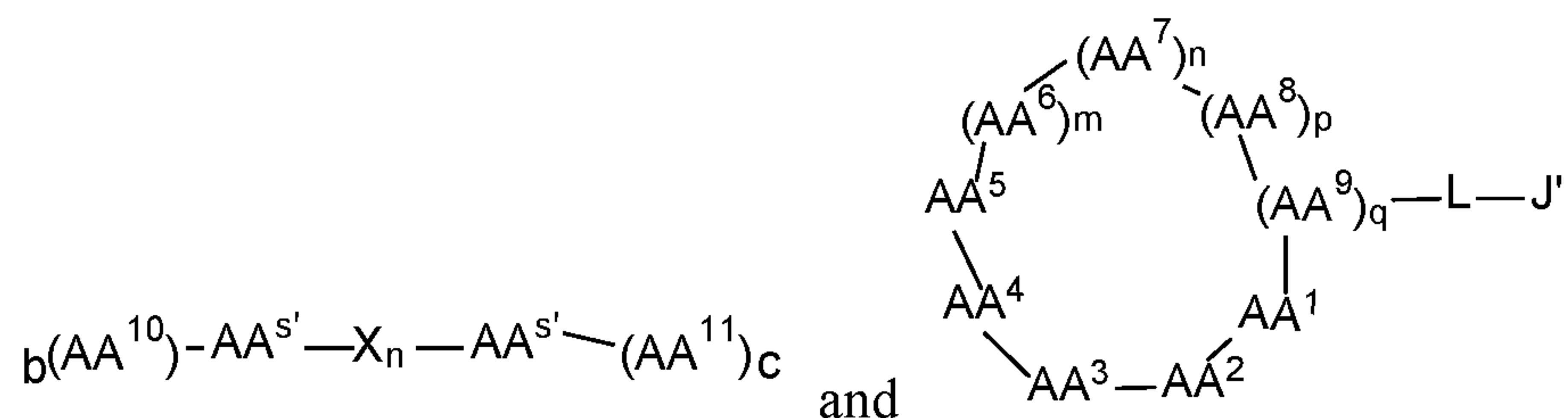


IX-A,



X-A,

and



XII-A and XII-B

or a pharmaceutically acceptable salt thereof,

wherein:

at least three amino acids are arginine;

at least two amino acids independently comprise a hydrophobic side chain;

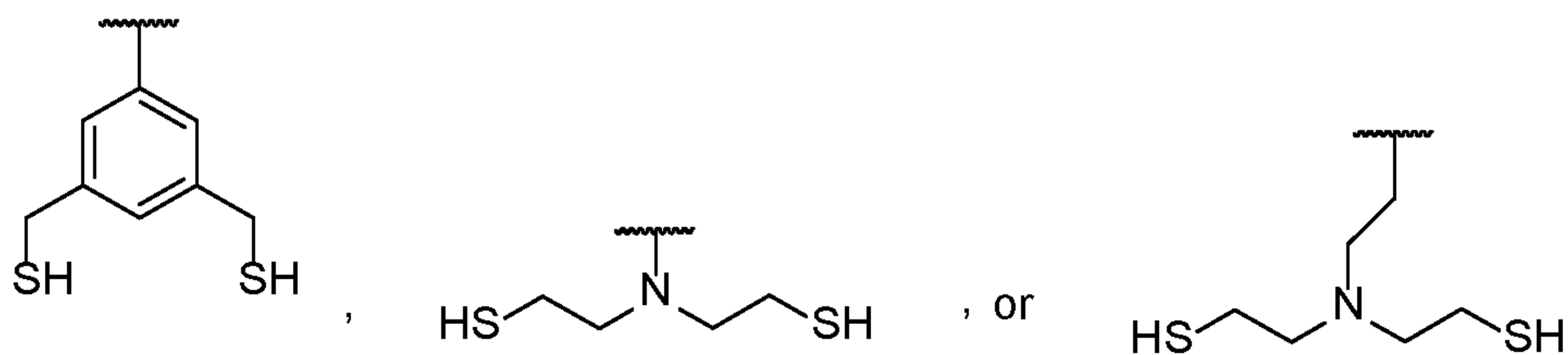
m, n, p, or q are independently selected from 0 and 1;

AA^{S'} at each occurrence is independently a moiety which comprises a thiol;J' is an alkyl, *N*-alkyl, alkenyl, alkynyl, carbocyclyl, or heterocyclyl, each of

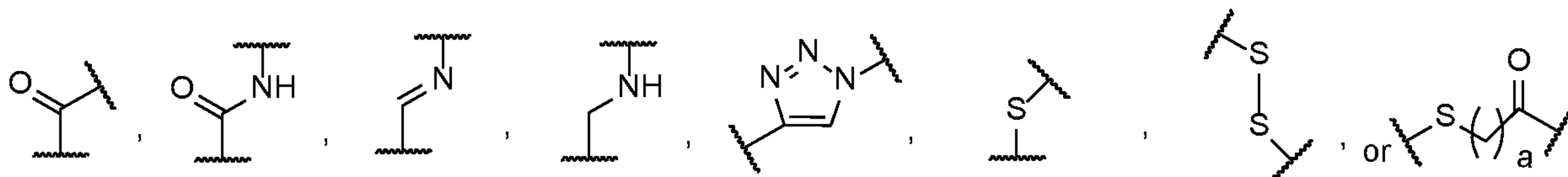
which are independently substituted with at least two thiol substituents; and

L is an optional moiety which links AA^{S'} to an amino acid, X_n, or a combination thereof; andX_n is a cargo moiety comprising a peptide sequence having from 4 to 20 amino acids.42. The compound of claim 41, wherein J' is *N*-alkyl, aryl, or heteroaryl.

43. The compound of claim 41, wherein J' is

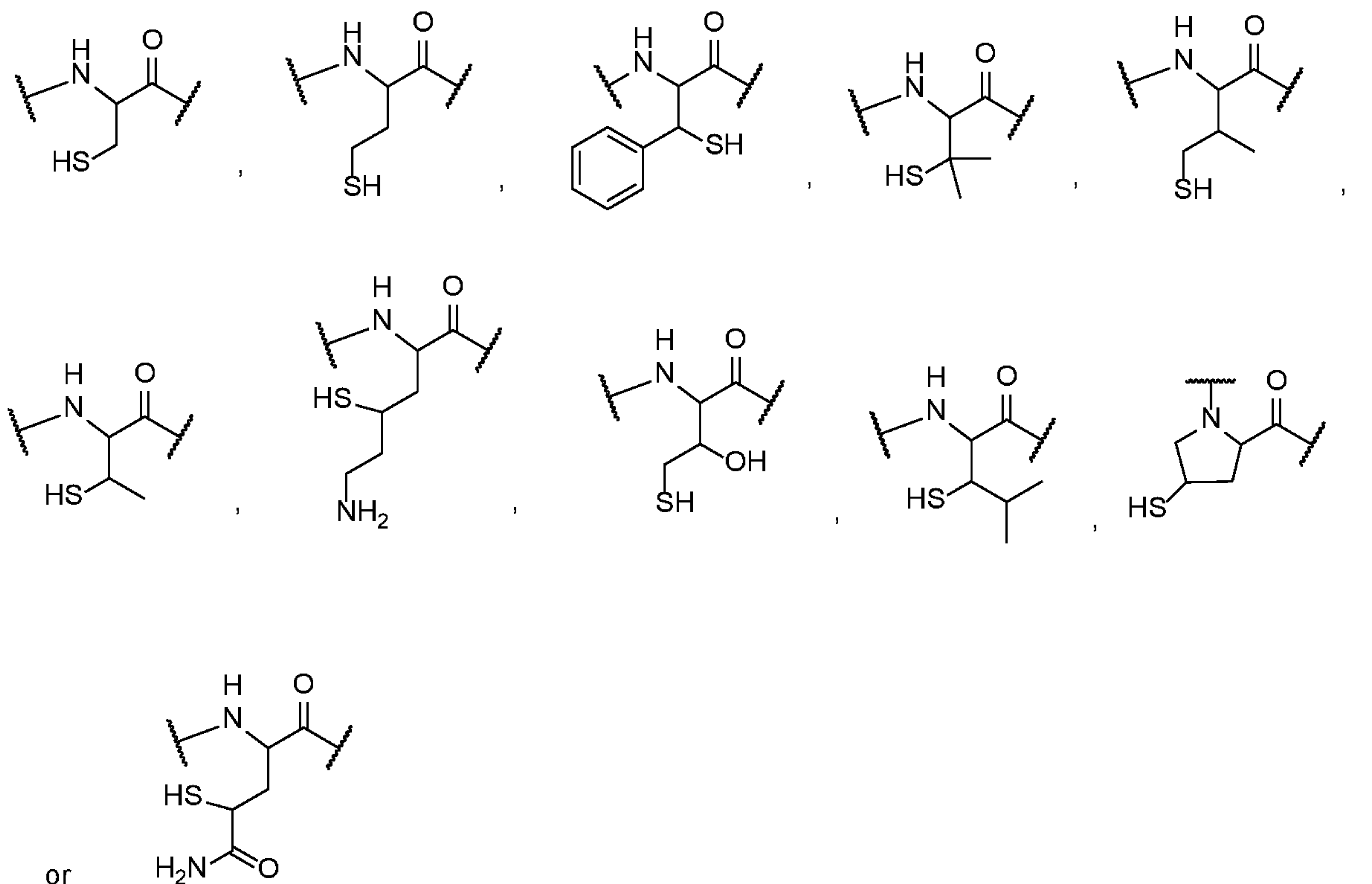


44. The compound of claim 41, wherein L is absent, an amino acid,



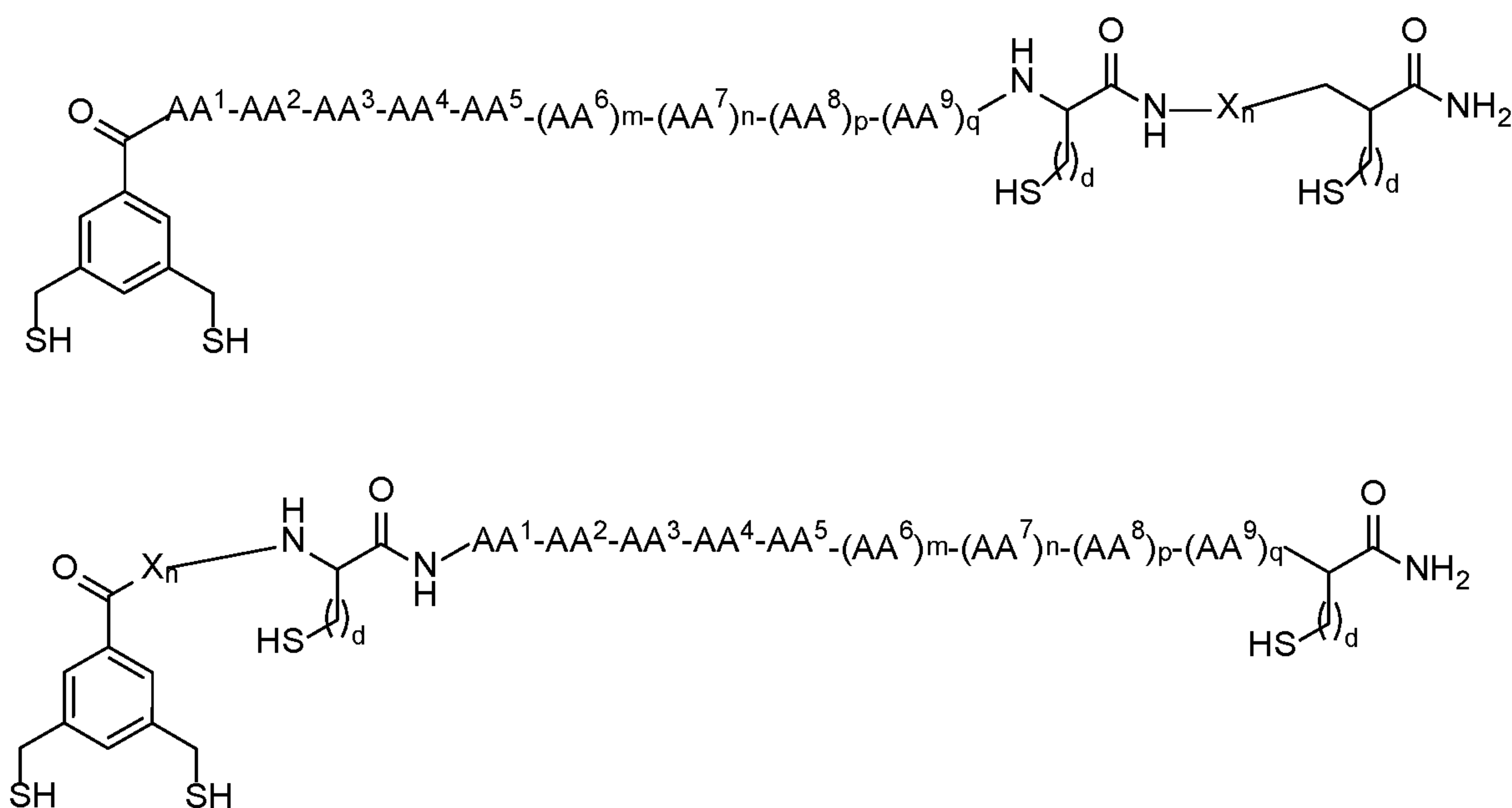
wherein a is an integer from 0 to 20.

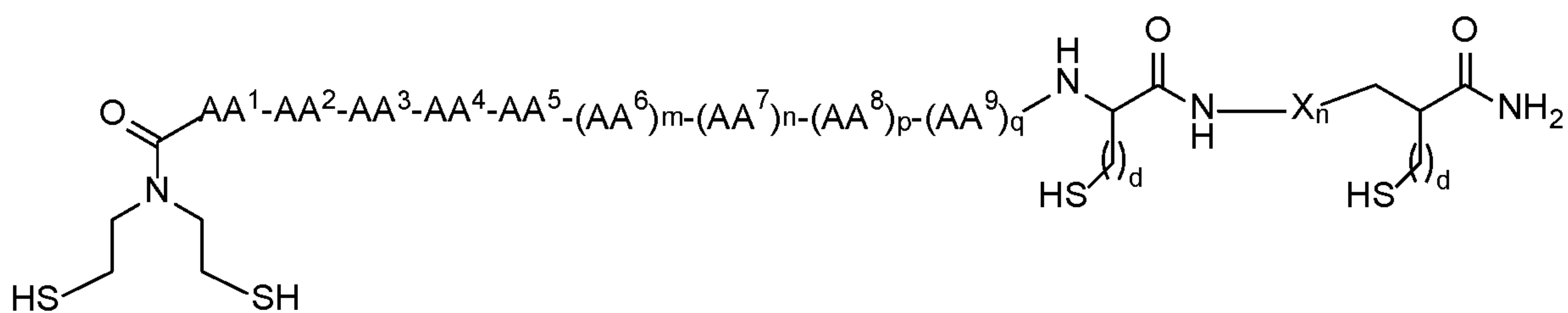
45. The compound of claim 41, wherein AA^{S'} each is independently:



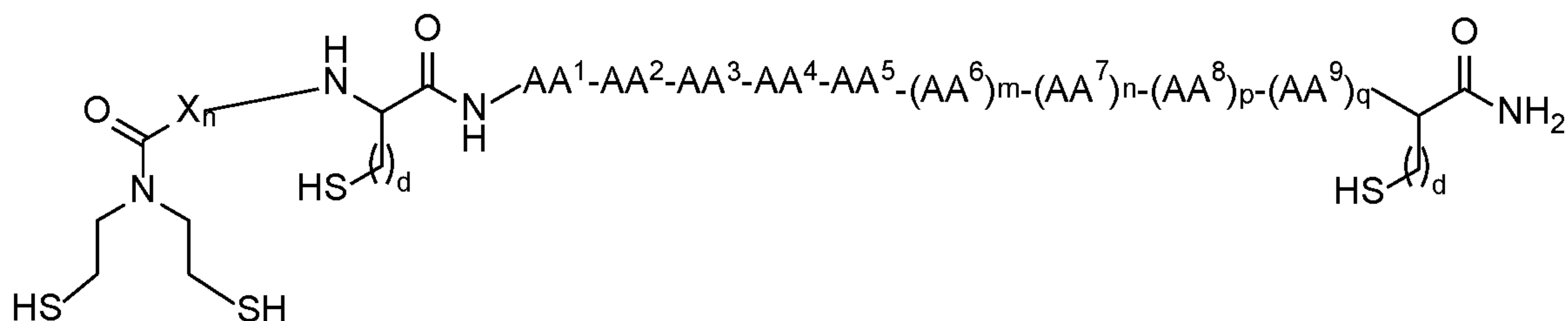
wherein the C-terminus of AA^{S'} forms an amide bond or is R¹, wherein R¹ is OH, OR², NHR²; and wherein R² is a alkyl, aryl, heteroaryl, amino acid residue, peptide sequence of 2 to 20 amino acid residues, detectable moiety, or solid support.

46. The compound of any one of claims 41-45, having a structure selected from the group consisting of

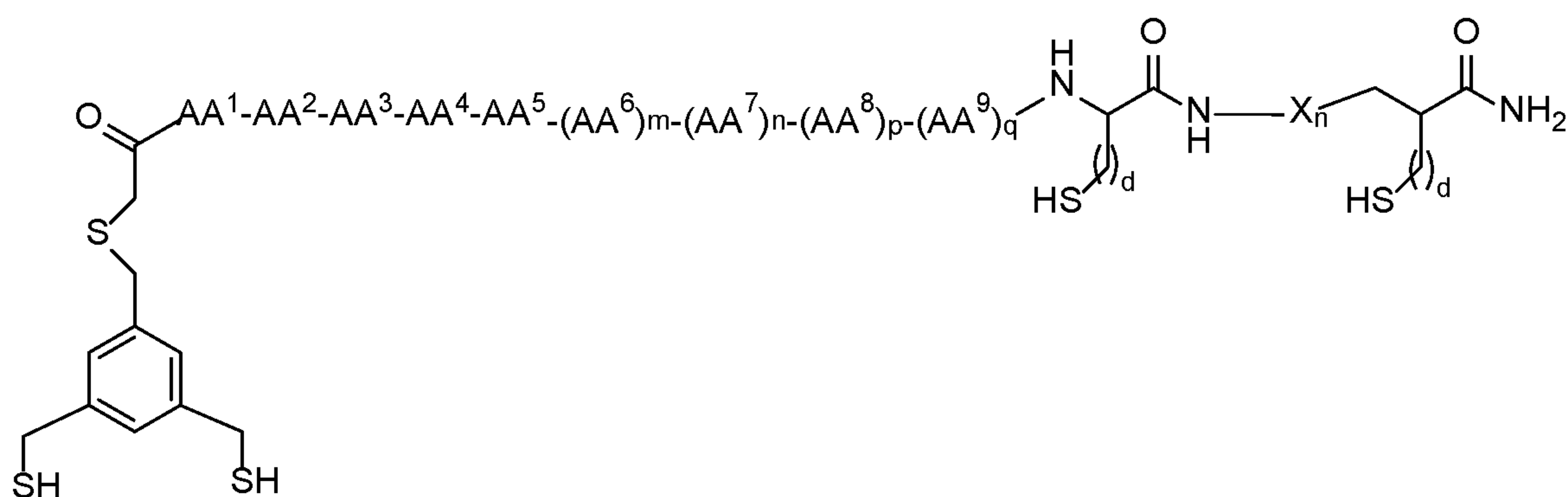




,

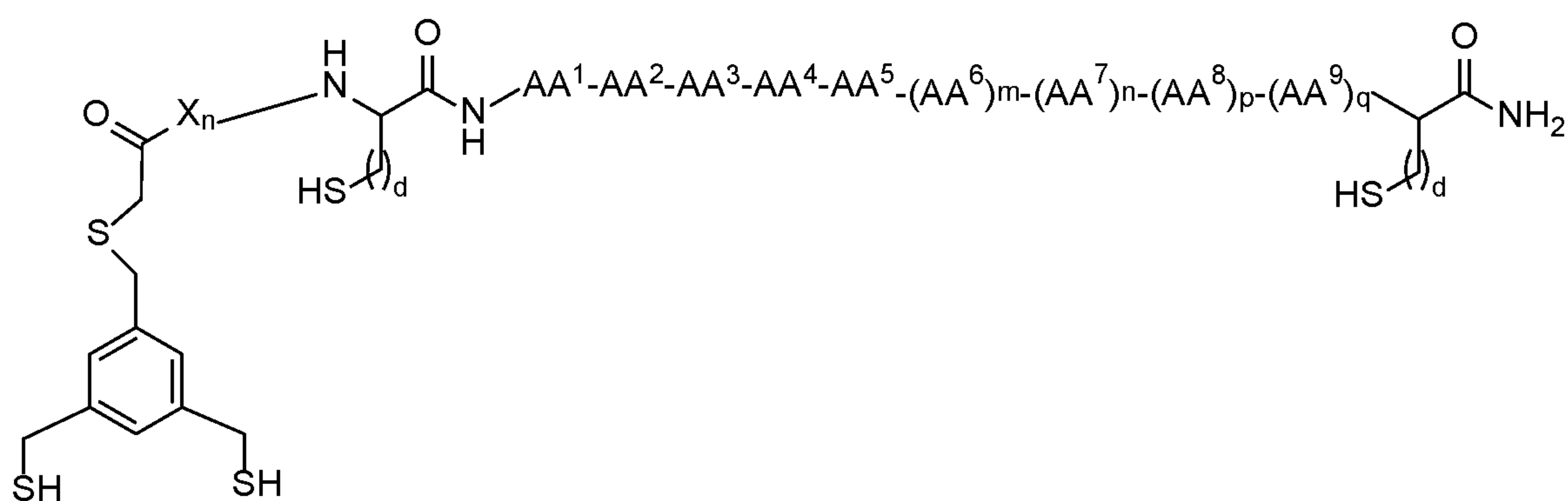


,



,

and



,

or a pharmaceutically acceptable salt thereof, wherein each d is independently 1 or 2.

47. The compound of any one of claims 41-46, wherein the at least two amino acids which independently comprise a hydrophobic side chain are selected from the group consisting of glycine, phenylglycine, alanine, valine, leucine, isoleucine, norleucine,

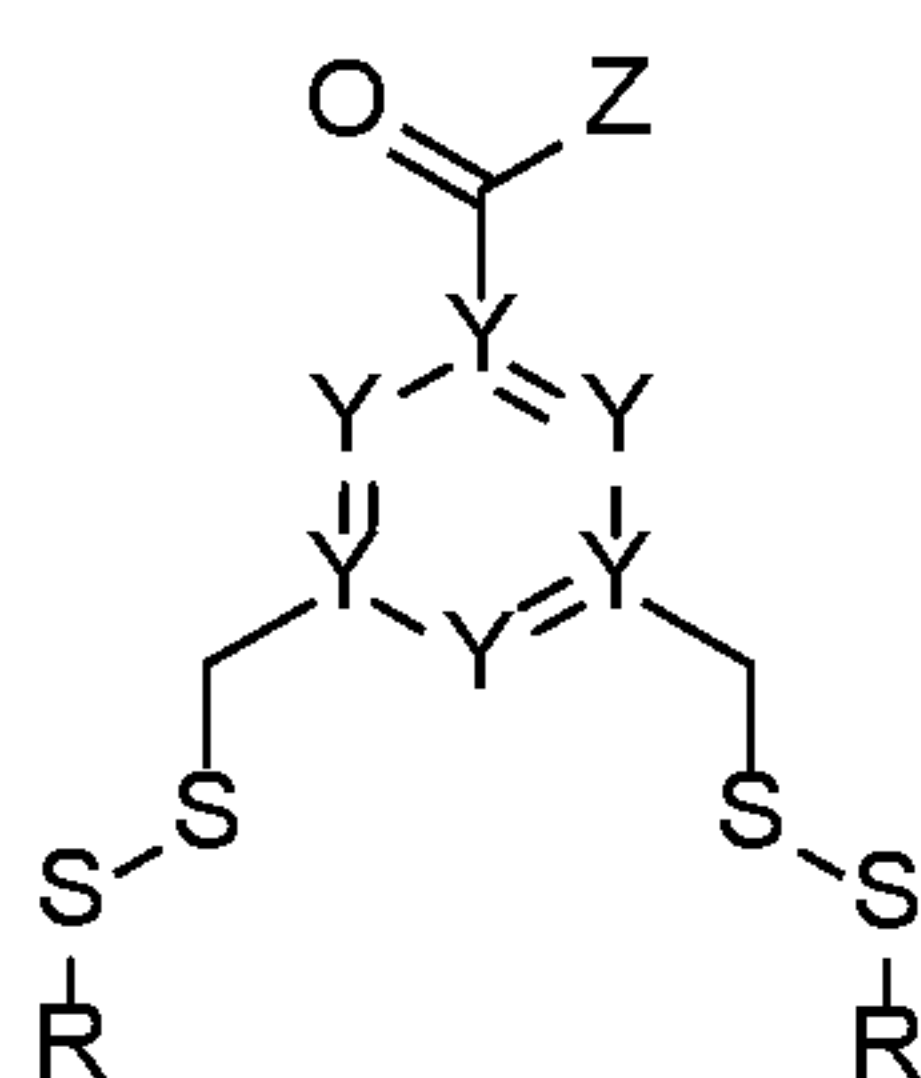
phenylalanine, tryptophan, naphthylalanine, proline, and combinations thereof, wherein the aromatic residues on phenylglycine, phenylalanine, tryptophan, naphthylalanine are optionally substituted.

48. The compound of claim 47, wherein the at least two amino acids which independently comprise a hydrophobic side chain are selected from the group consisting of phenylalanine, naphthylalanine, and combinations thereof.
49. The compound of any one of claims 41-48, wherein the at least two amino acids which independently comprise a hydrophobic side chain are consecutive amino acids.
50. The compound of any one of claims 41-49, wherein:
 - AA¹ is L arginine;
 - AA² is L-arginine;
 - AA³ is L-arginine;
 - AA⁴ is L-phenylalanine;
 - AA⁵ is L phenylalanine; and
 - m, n, p, and q, are each 0.
51. The compound of any one of claims 41-49, wherein:
 - AA¹ is L-phenylalanine;
 - AA² is L-naphthylalanine;
 - AA³ is L-arginine;
 - AA⁴ is L-arginine;
 - AA⁵ is L-arginine;
 - m is 1 and AA⁶ is L-arginine; and
 - n, p, and q are each 0.
52. The compound of any one of claims 41-49, wherein:
 - AA¹ is L-arginine;
 - AA² is L-arginine;
 - AA³ is L-arginine;
 - AA⁴ is L-arginine;
 - AA⁵ is L- naphthylalanine;
 - m is 1 and AA⁶ is L-phenylalanine; and

n, p, and q are each 0.

53. The compound of any one of claims 41-49, wherein at least three consecutive amino acids have alternating chirality.
54. The compound of claim 53, wherein the at least three consecutive amino acids having alternating chirality are arginines.
55. The compound of claim 54, wherein:
 - AA¹ is D-phenylalanine;
 - AA² is L-naphthylalanine;
 - AA³ is L-arginine;
 - AA⁴ is D-arginine;
 - AA⁵ is L-arginine;
 - m is 1 and AA⁶ is D-arginine; and
 - n, p, and q are each 0.
56. The compound of claim 54, wherein:
 - AA¹ is D-phenylalanine;
 - AA² is L-naphthylalanine;
 - AA³ is L-arginine;
 - AA⁴ is D-arginine;
 - AA⁵ is L-arginine;
 - m and n are each 1, and AA⁶ is D-arginine and AA⁷ is L-arginine; and
 - p and q are each 0.
57. The compound of claim 54, wherein:
 - AA¹ is D-phenylalanine;
 - AA² is L-naphthylalanine;
 - AA³ is L-arginine;
 - AA⁴ is D-arginine;
 - AA⁵ is L-arginine;
 - m and n are each 1, and AA⁶ is D-arginine and AA⁷ is L-phenylalanine; and
 - p and q are each 0.
58. The compound of any one of claims 41-57, wherein the peptide sequence in X_n inhibits at least one protein-protein interaction.

59. The compound of claim 58, wherein the protein-protein interaction is an interaction between a κ B-kinase (IKK) complex and a regulatory protein NF- κ B essential modifier (NEMO)
60. The compound of claim 58, wherein the peptide sequence in X_n is an inhibitor against Ras, PTP1 B, Pin 1, Grb2 SH2, MDM2, or combinations thereof.
61. The compound of any one of claims 41-57, wherein the peptide sequence in X_n is a peptidyl is a wild-type peptide ligand or a peptide mimetic.
62. A compound according to Formula XI:



XI

wherein:

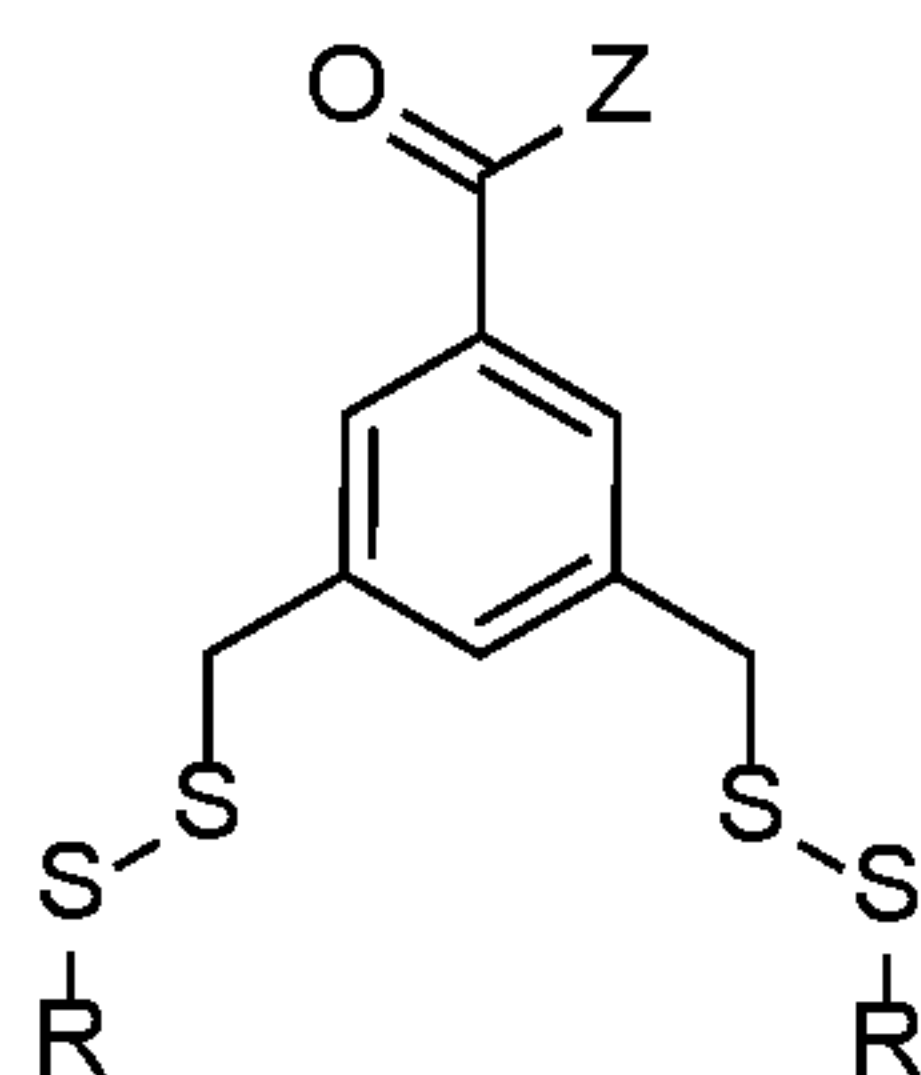
Y at each instance is independently CH, N, O or S, provided no more than four Y are N, O, S, or combinations thereof;

Z is OR_a , hydrogen, halogen, carbocyclyl, heterocyclyl, or an amino acid;

R at each instance is independently an alkyl, alkenyl, alkynyl, carbocyclyl, heterocyclyl, or an amino acid; and

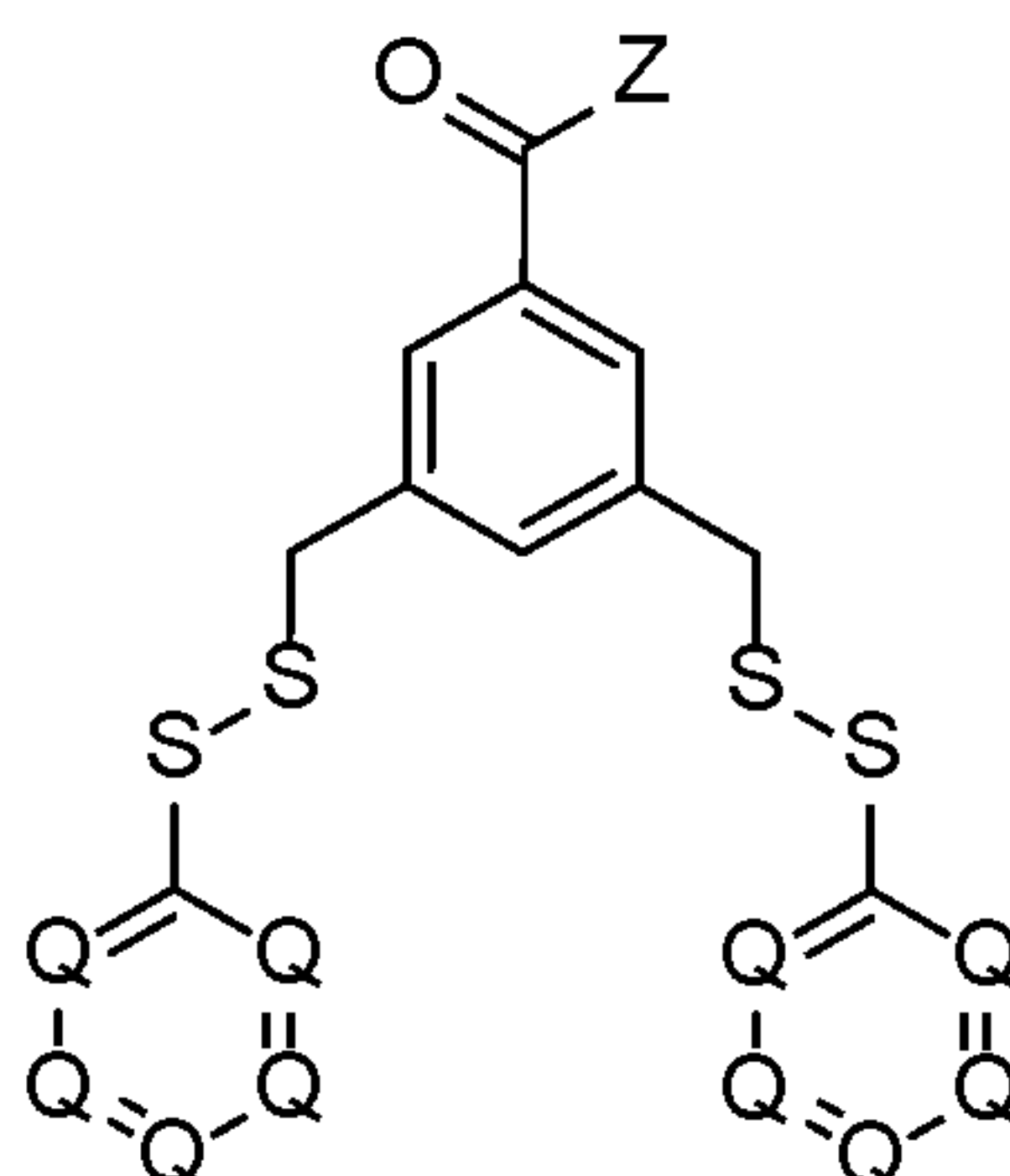
R_a is independently H, $C(O)$ alkyl, alkyl, alkenyl, alkynyl, carbocyclic, or heterocyclyl.

63. The compound of claim 62, wherein each Y is independently CH.
64. The compound of claim 63, wherein the compound has a structure according to Formula XI-A:



XI-A.

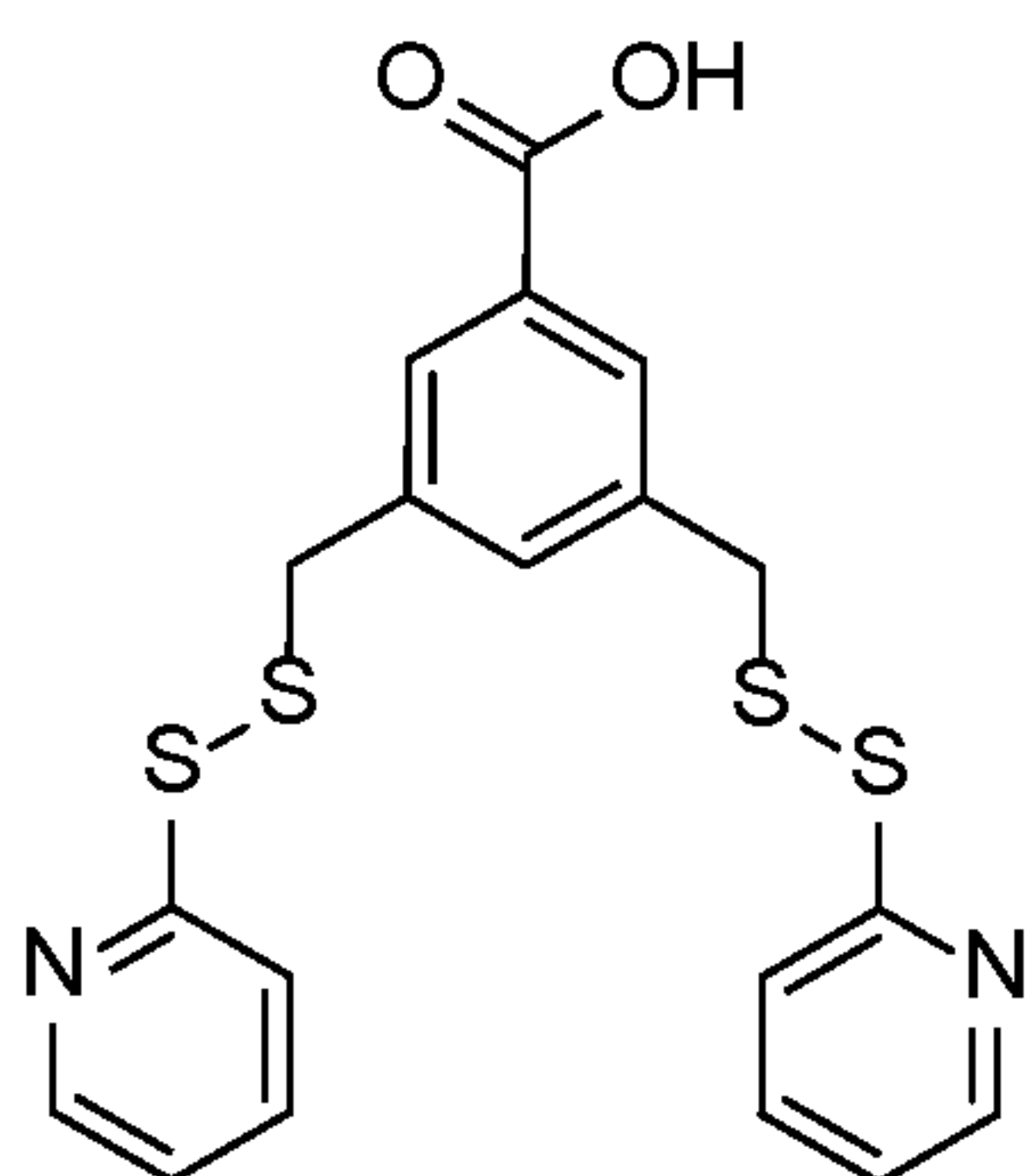
65. The compound of claim 64, wherein each R is independently aryl or heteroaryl.
66. The compound of claim 64, wherein the compound has a structure according to Formula XI-B:



XI-B

wherein Q at each instance is independently CH or N.

67. The compound of claim 66, wherein Z is OH.
68. The compound of claim 66, wherein the compound has the following structure:



69. The compound of any one of claims 18-38 or 41-61, wherein AA¹, AA², AA³, AA⁴, AA⁵, AA⁶, AA⁷, AA⁸, and AA⁹ is selected from SEQ ID NO:62 through SEQ ID NO:146.
70. A bicyclic peptide comprising: (a) a first cyclic peptide comprising a cell-penetrating peptide sequence (X_m); (b) a second cyclic peptide comprising a peptidyl ligand (X_n); and (c) at least one disulfide bond which forms at least one of the first cyclic peptide or the second cyclic peptide, wherein the first cyclic peptide is conjugated to the second cyclic peptide.
71. The bicyclic peptide of claim 70, wherein X_m comprises the following peptide sequence:



wherein:

AA¹, AA², AA³, AA⁴, AA⁵, AA⁶, AA⁷, AA⁸, and AA⁹, are each independently an amino acid, which is optionally substituted, and where at least three amino acids are arginine and at least two amino acids independently comprise a hydrophobic side chain; and

m, n, p, and q are independently selected from 0 and 1.

72. The bicyclic peptide of claim 70, further comprising a linking moiety which is conjugated, directly or indirectly, to X_m and X_n,
73. The bicyclic peptide of claim 72, wherein X_m is cyclized through the linking moiety, the C- or N-terminus of X_n is conjugated to the linking moiety, and X_n is cyclized through the disulfide bond, thereby forming the bicyclic peptide.
74. The bicyclic peptide of claim 72, wherein the linking moiety is conjugated to the side chain of an amino acid in the first cyclic peptide, the C- or N-terminus of X_n is conjugated to the linking moiety, and wherein X_n is cyclized through the disulfide bond, thereby forming the bicyclic peptide.
75. The bicyclic peptide of claim 72, wherein the bicyclic peptide comprises a first disulfide bond and a second disulfide bond.
76. The bicyclic peptide of claim 75, wherein the linking moiety comprises a first substituent which forms the first disulfide bond and a second substituent which forms the second disulfide bond.
77. The bicyclic peptide of claim 76, wherein X_m is cyclized through the first disulfide bond, and X_n is cyclized through the second disulfide bond, thereby forming the bicyclic peptide.
78. The bicyclic peptide of claim 76, wherein the linking moiety is conjugated to the side chain of the first cyclic peptide, and X_n is cyclized through the first disulfide bond and the second disulfide bond, thereby forming the bicyclic peptide.

79. The bicyclic peptide of claim 76, wherein the C- or N- terminus of X_m is conjugated to the linking moiety and X_m is cyclized through the first disulfide bond, and wherein the C- or N- terminus of X_n is conjugated to the linking moiety and X_n is cyclized through the second disulfide bond, thereby forming the bicyclic peptide.
80. The bicyclic peptide of claim 76, wherein the C- or N- terminus of X_n is conjugated to the linking moiety, and wherein X_m is cyclized through the first disulfide bond and X_n is cyclized through the second disulfide bond, thereby forming the bicyclic peptide.
81. The bicyclic peptide of claim 75, wherein the bicyclic peptide comprises a third disulfide bond.
82. The bicyclic peptide of claim 81, wherein the linker moiety comprises a first substituent which forms the first disulfide bond, a second substituent which forms the second disulfide bond, and third substituent which forms the third disulfide bond.
83. The bicyclic peptide of claim 82, wherein X_m is fused to X_n , thereby forming a fused X_m - X_n peptide, and the linking moiety is conjugated to the fused X_m - X_n peptide through the third disulfide bond, and wherein X_m is cyclized through the first disulfide bond and X_n is cyclized through the second disulfide bond, thereby forming the bicyclic peptide.
84. The bicyclic peptide of claim 81, wherein the bicyclic peptide comprises a fourth disulfide bond.
85. The bicyclic peptide of claim 84, wherein the linker moiety comprises a first substituent which forms the first disulfide bond, a second substituent which forms the second disulfide bond, third substituent which forms the third disulfide bond comprises, and a fourth substituent which forms a forth disulfide bond.

86. The bicyclic peptide of claim 85, wherein X_m is cyclized through the first disulfide bond and the second disulfide bond, and X_n is cyclized through the third disulfide bond and the fourth disulfide bond, thereby forming the bicyclic peptide.
87. The bicyclic peptide of any of claims 70-86, having a structure according to any of Formulae 1-12

Number	Formula
1	
2	
3	
4	
5	
6	
7	

8	
9	
10	
11	
12	

wherein:

AA^S at each occurrence is independently a moiety which forms a disulfide bond with J;

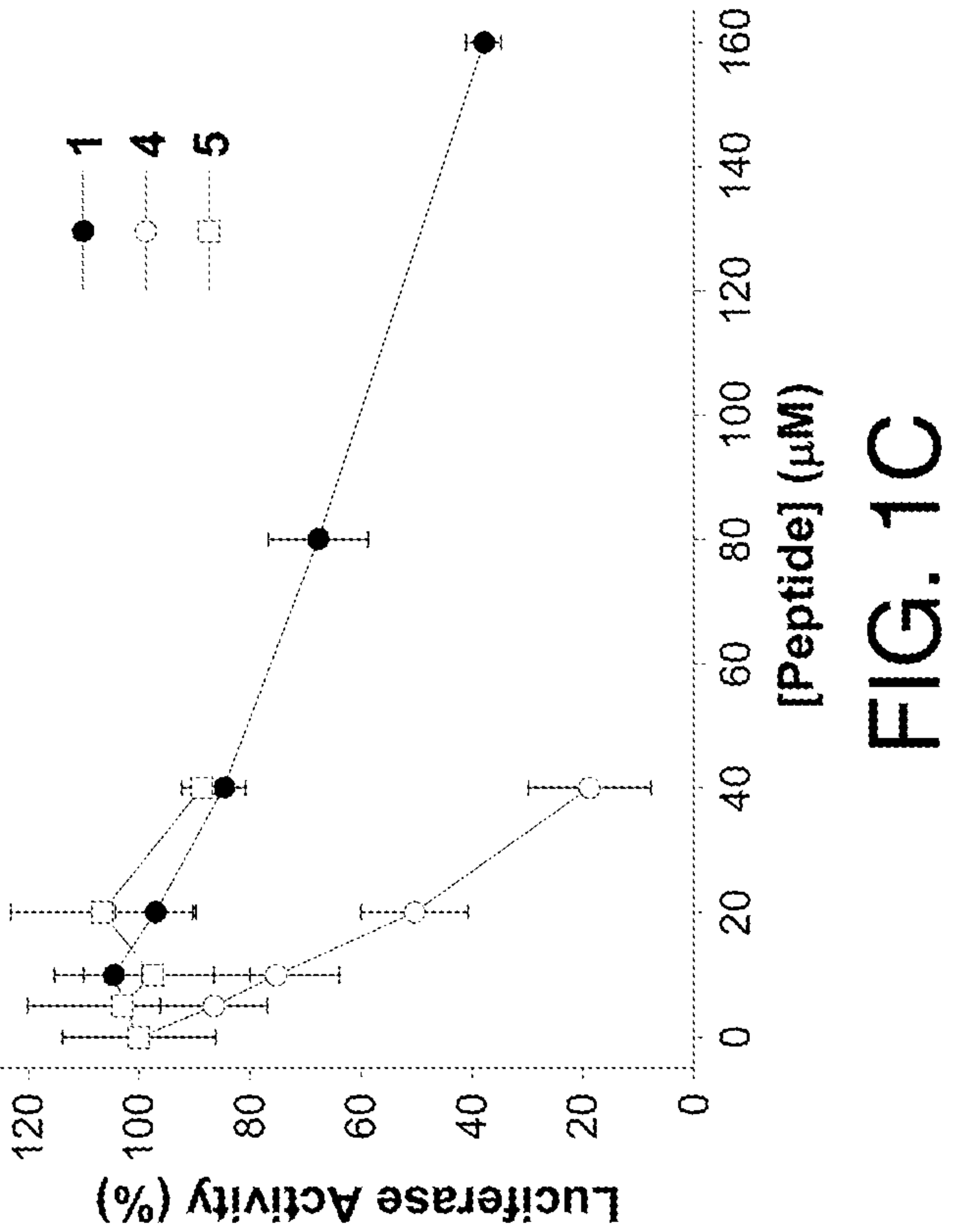
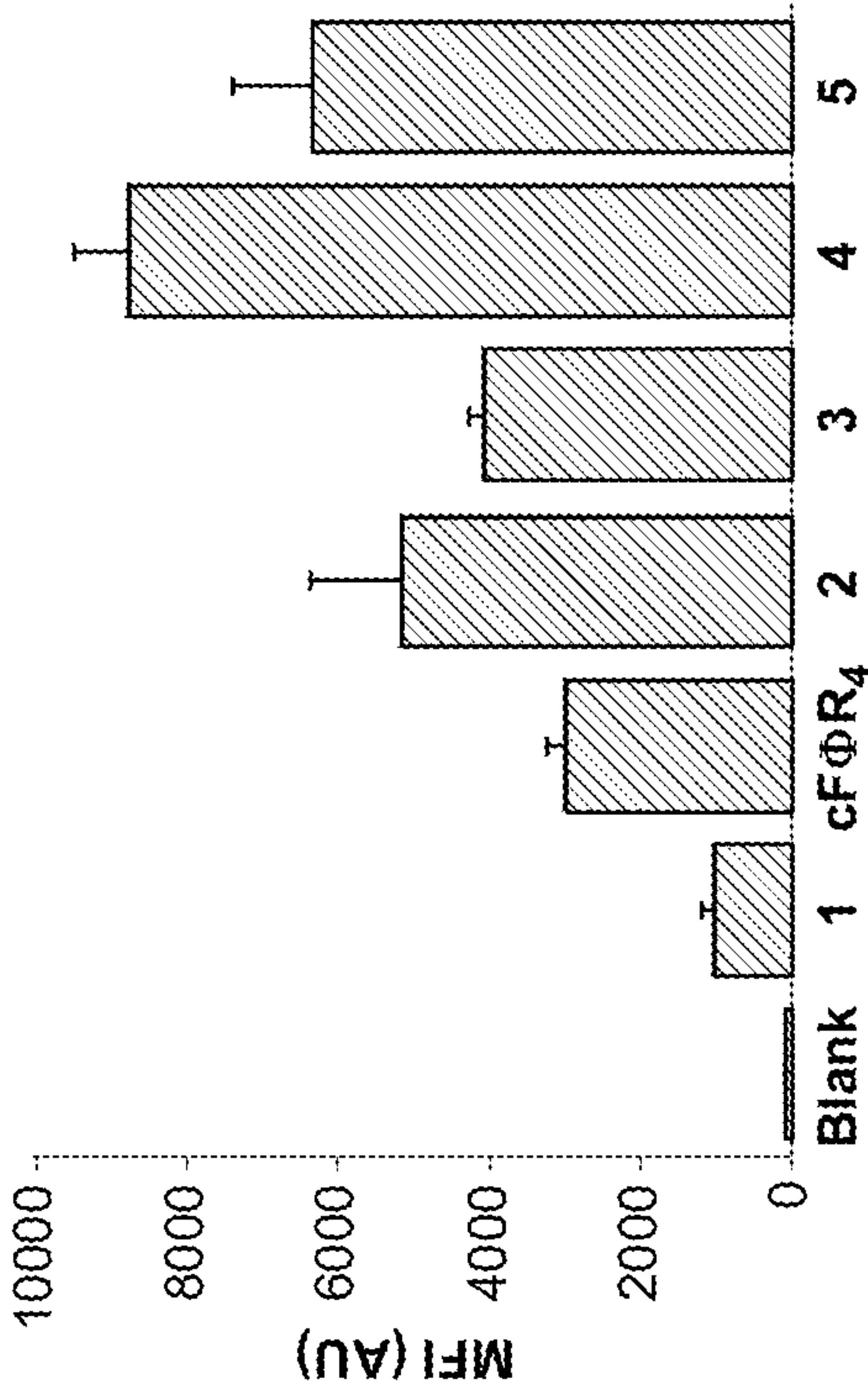
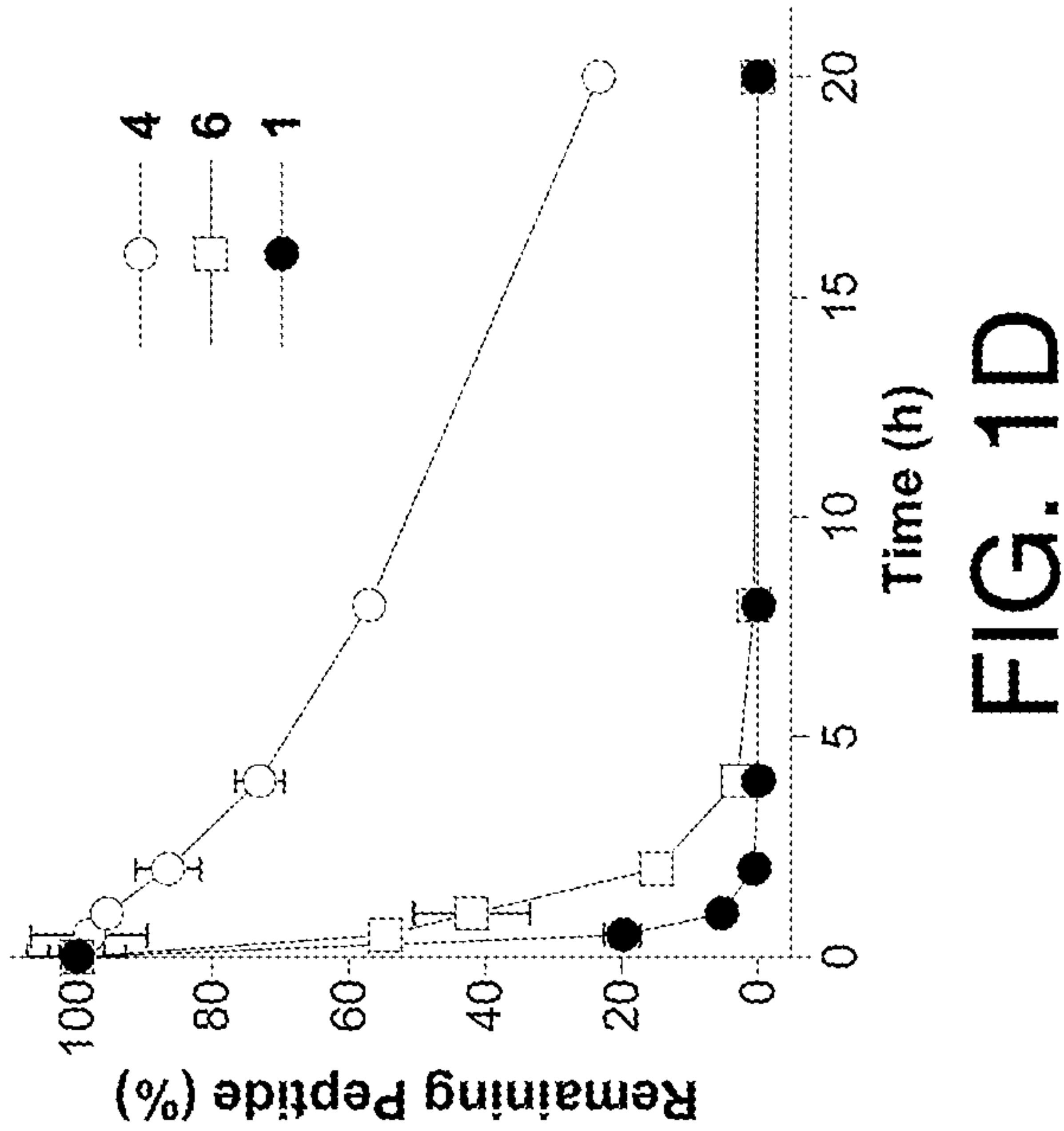
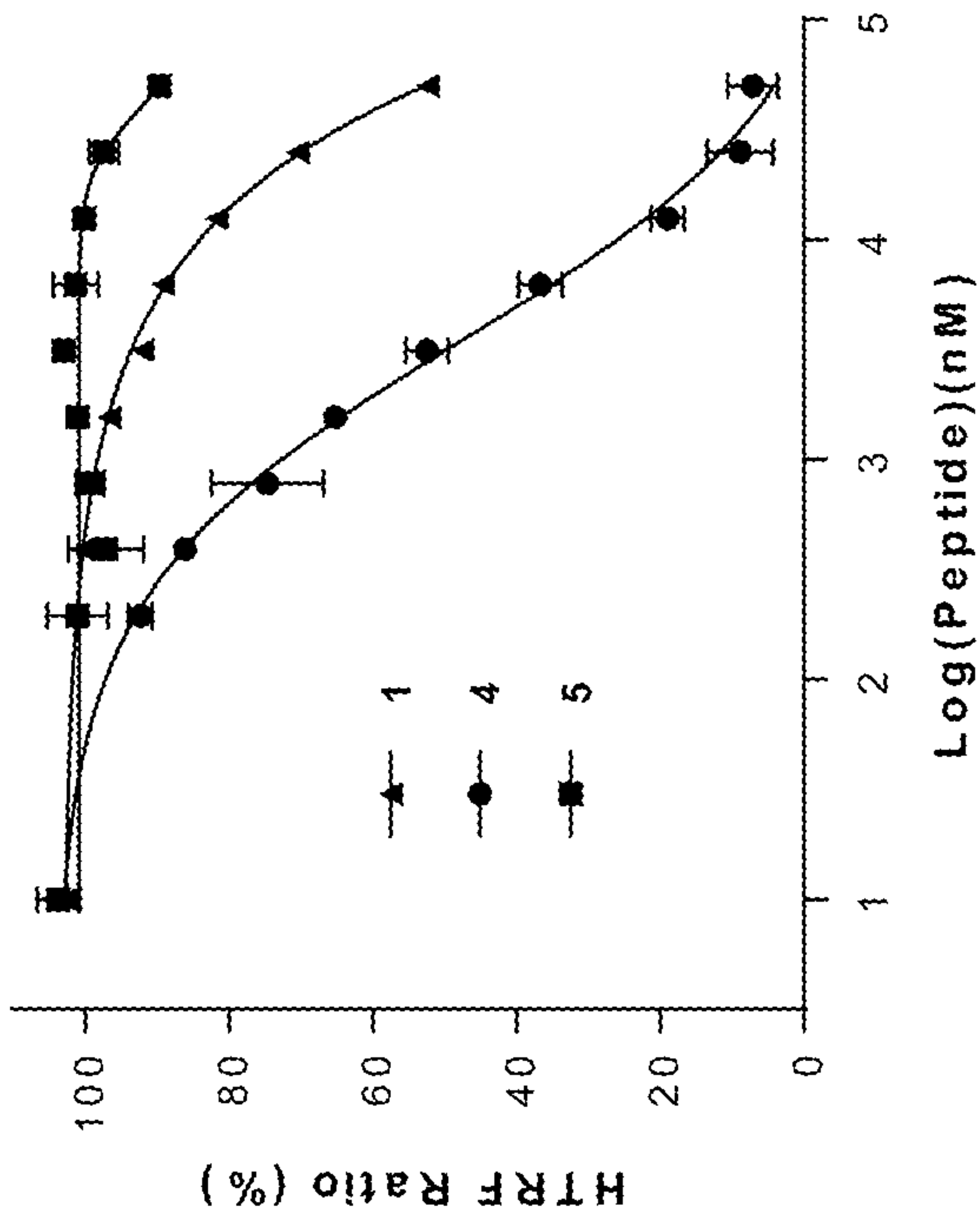
L-J is the linking moiety, wherein:

J is absent, or an alkyl, *N*-alkyl, alkenyl, alkynyl, carbocyclyl, or heterocyclyl, each of which are independently substituted with at least two substituents which independently form a disulfide bond with AA^S at each occurrence; and

L is absent or a moiety which links AA^S to an amino acid in X_m , X_n , or a combination thereof; and

SS at each instance represents a disulfide bond.

88. The bicyclic peptide of any of claims 70-87, wherein the bicyclic peptide has a structure according to any of Formula I, II, V, VI, VII, VIII, IX, X, and XII.



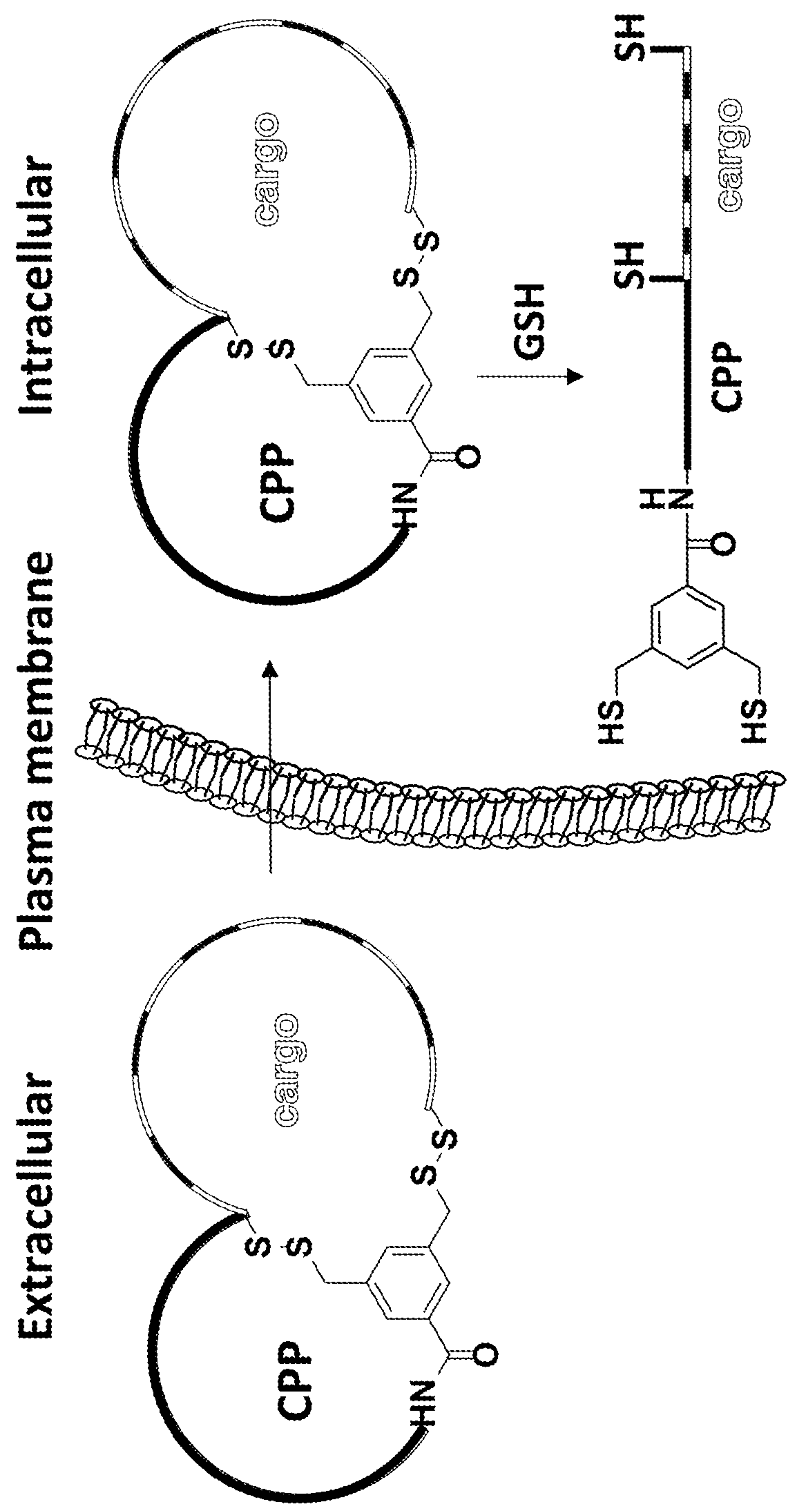
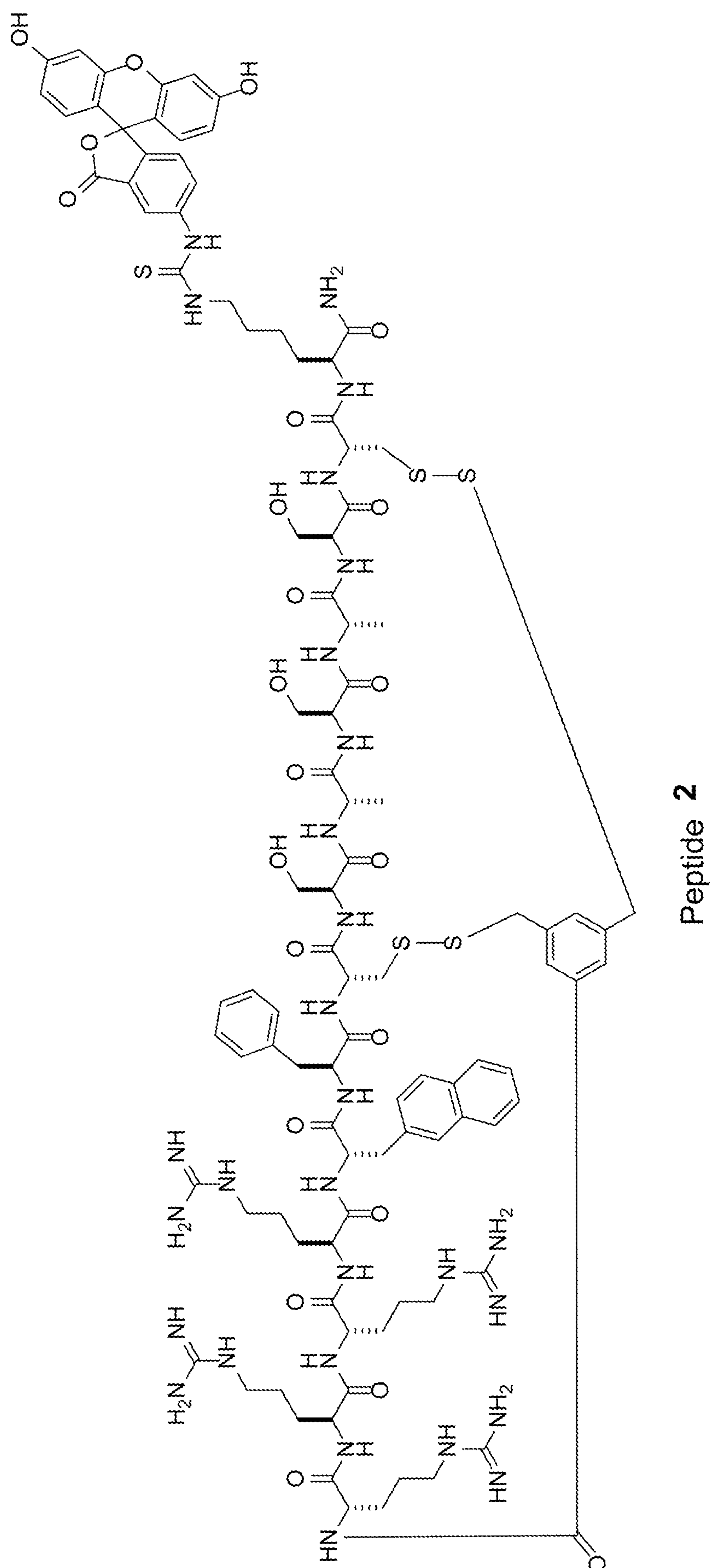
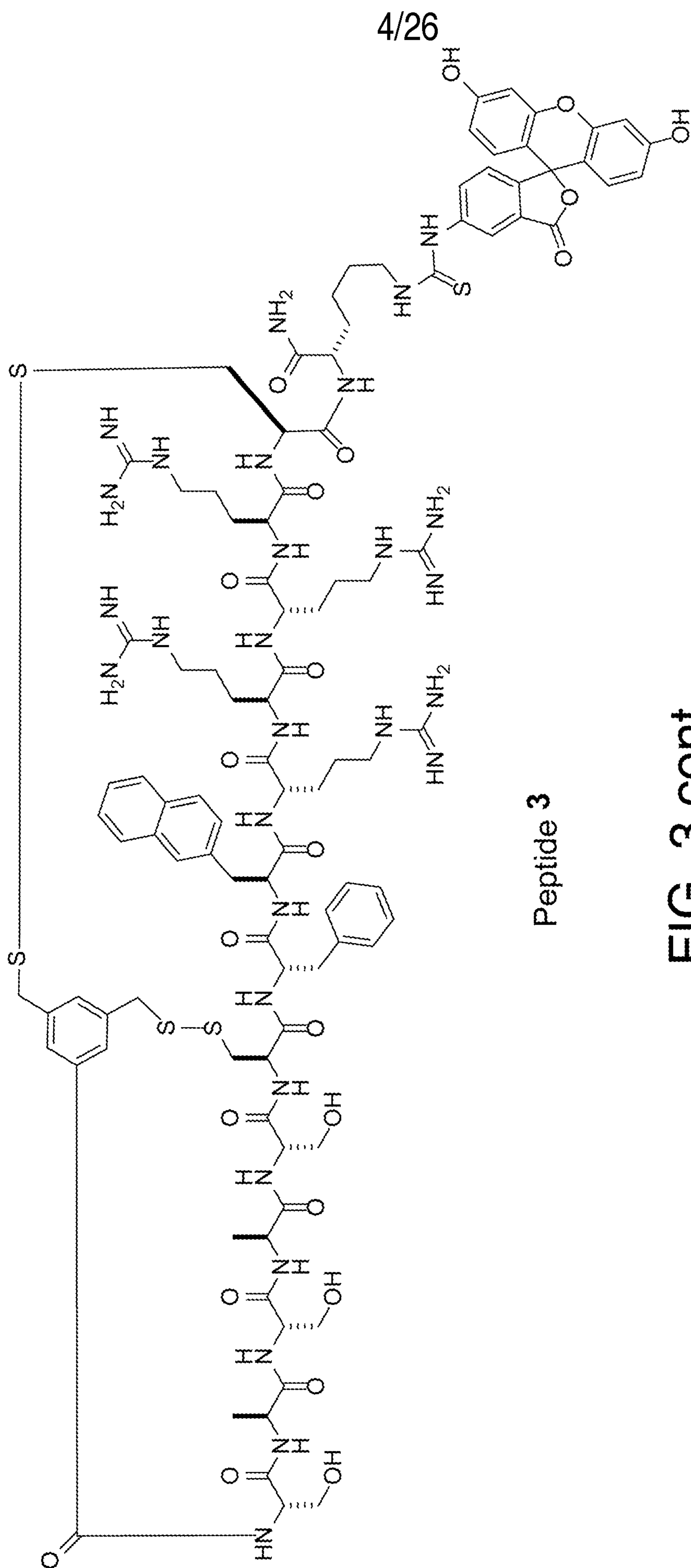


FIG. 2

3/26



3
G.
L



Peptide 3

FIG. 3 cont.

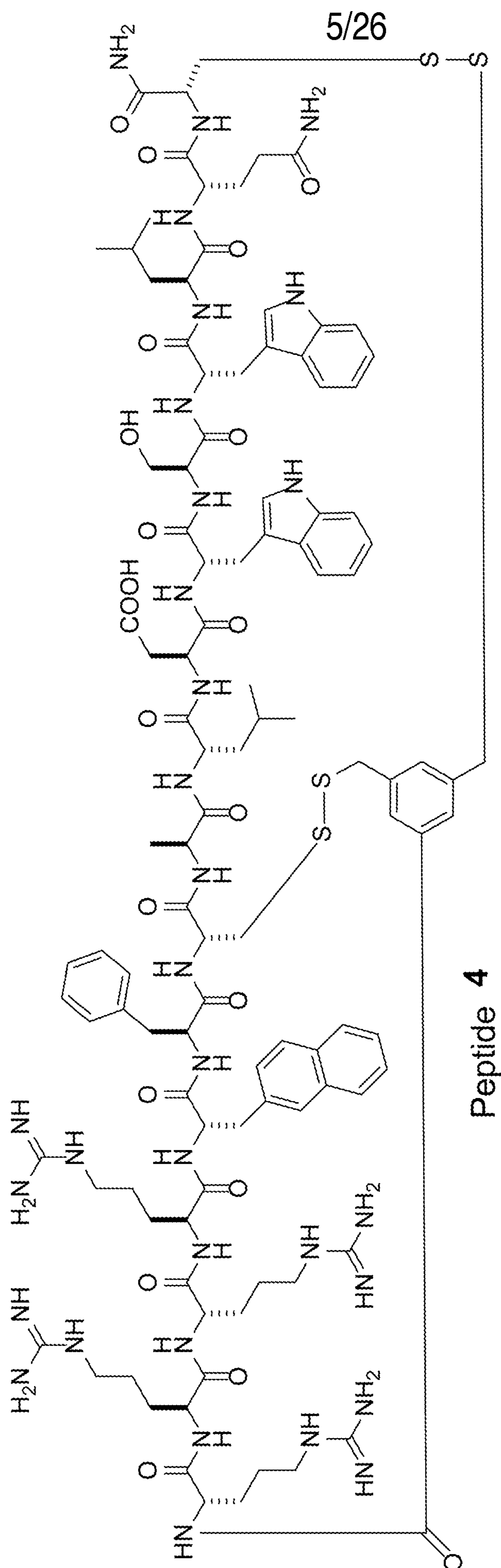


FIG. 4

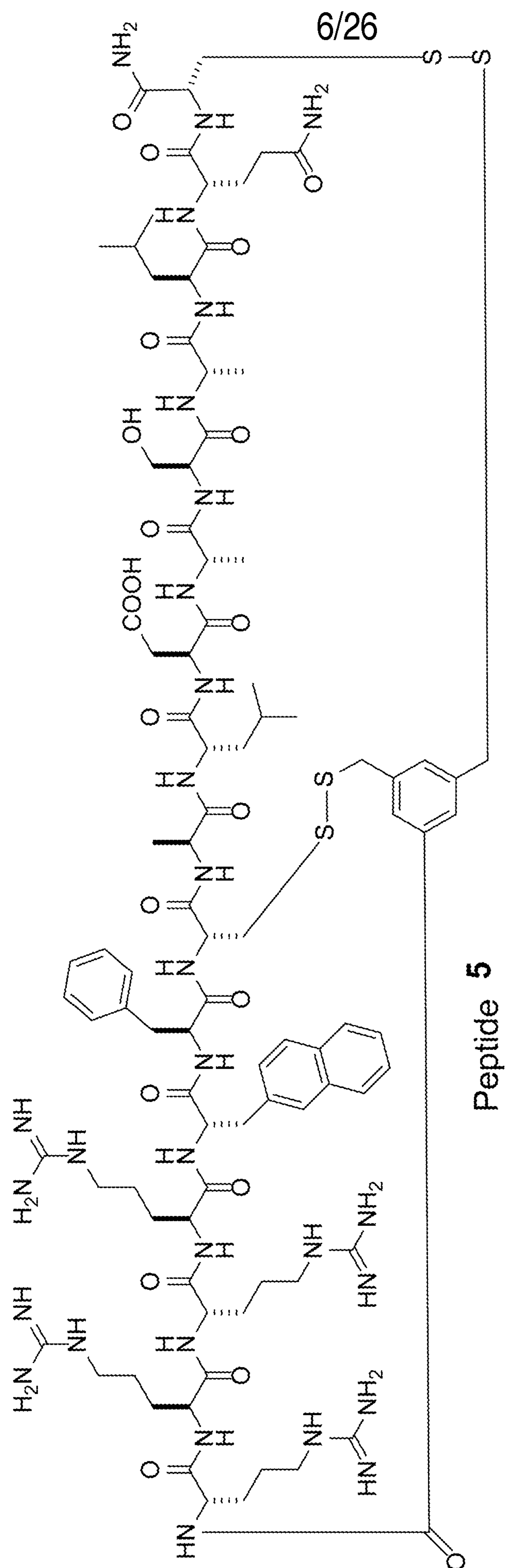


FIG. 4 cont.

7/26

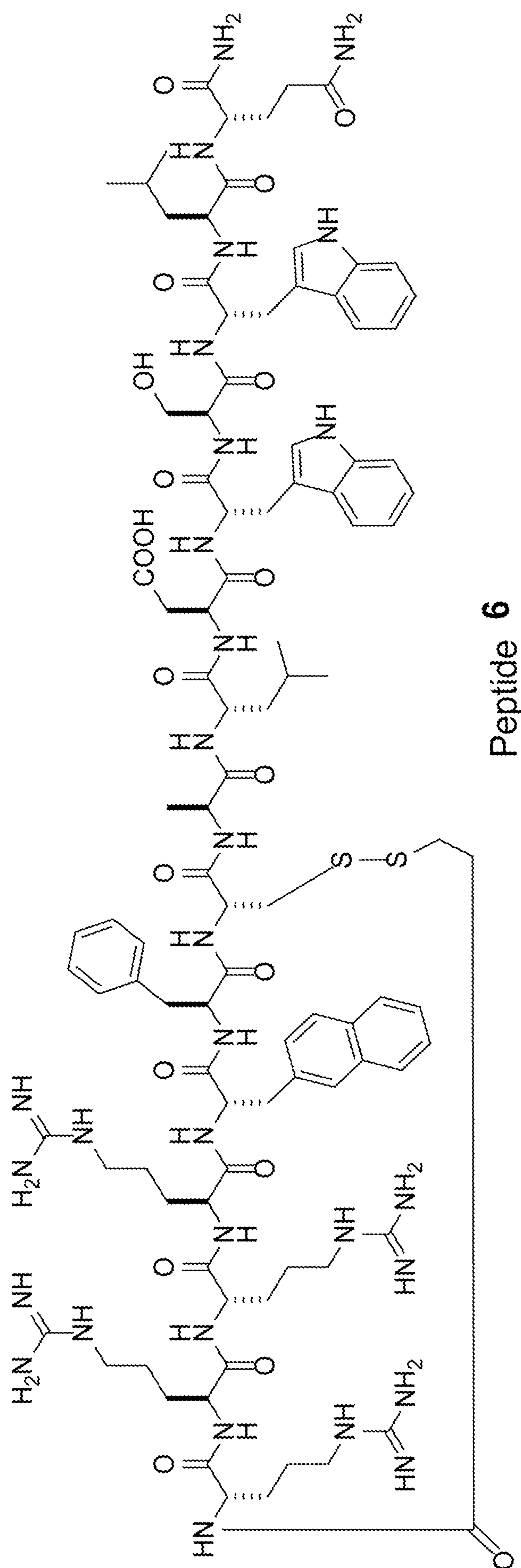


FIG. 4 cont.

8/26

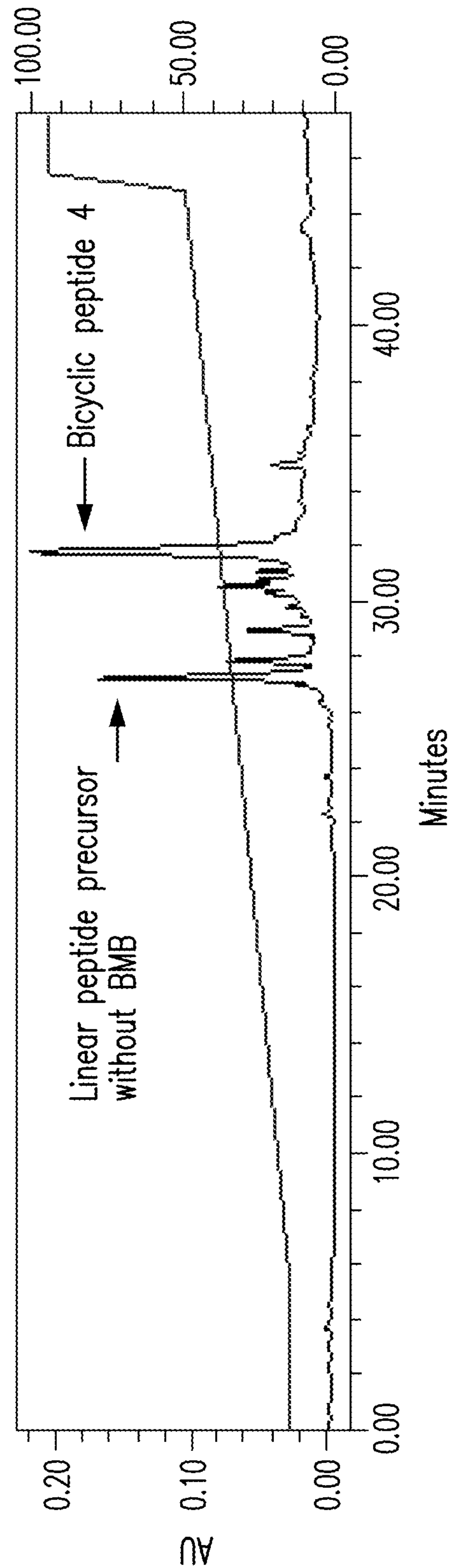


FIG. 5A

9/26

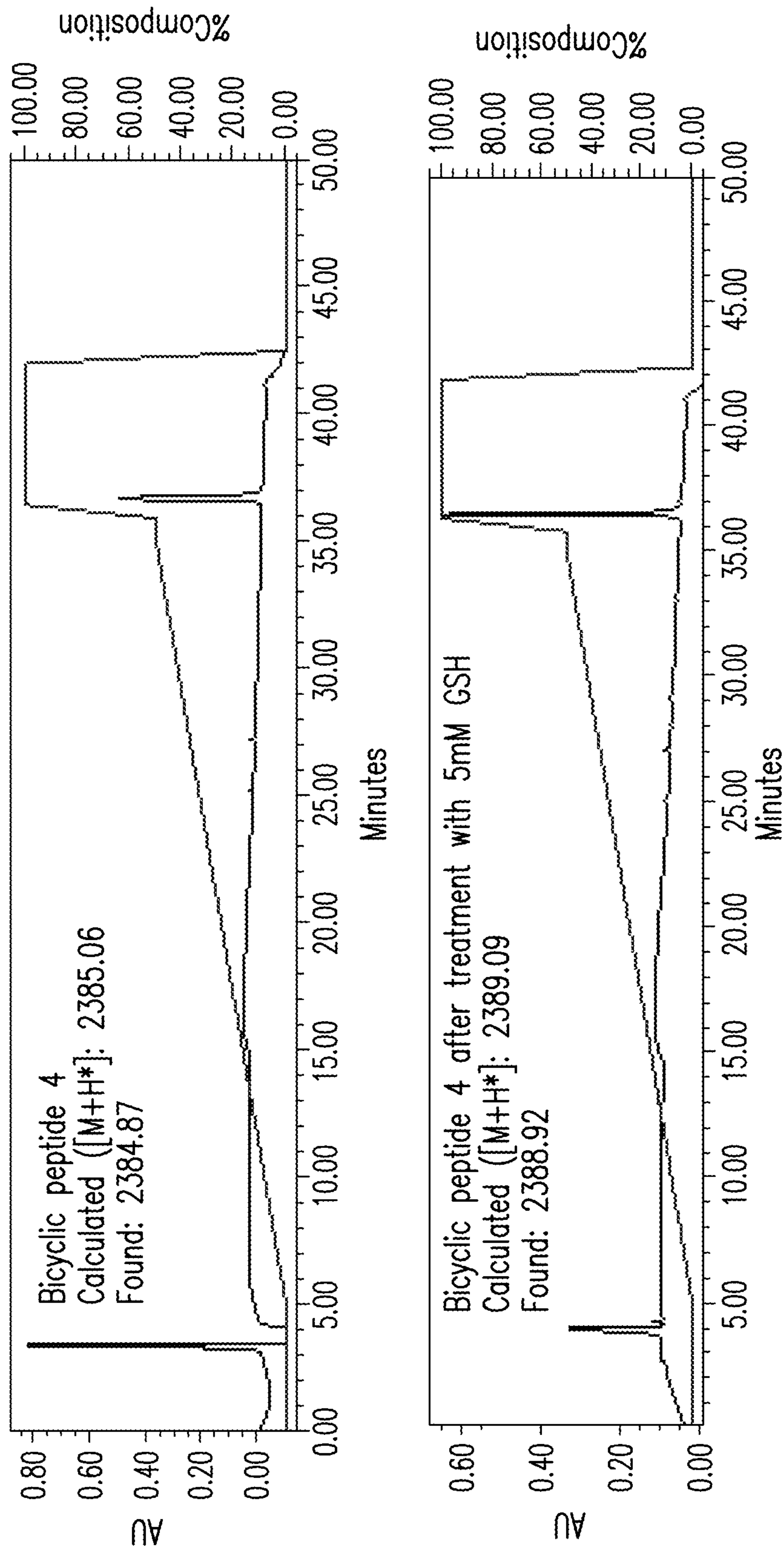


FIG. 5B

10/26

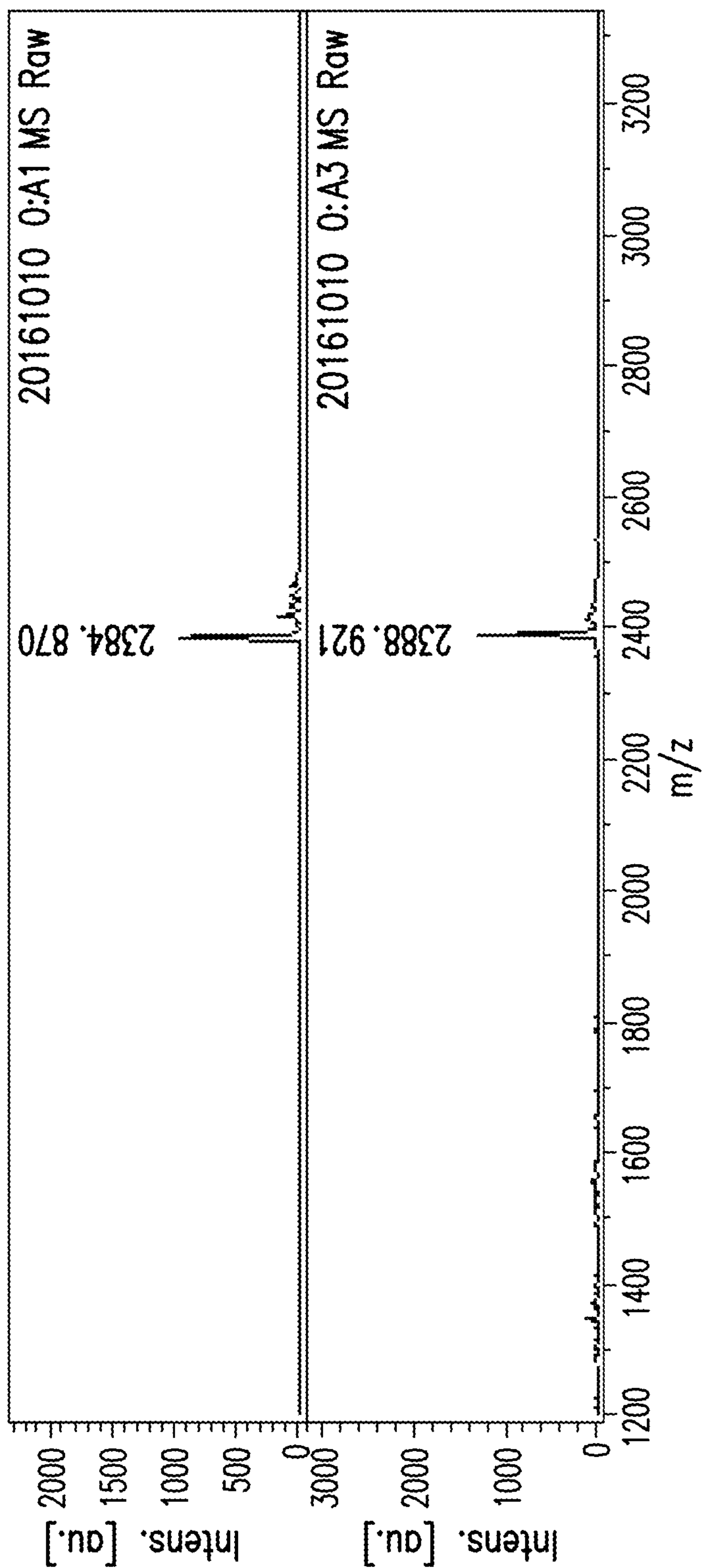


FIG. 5B Continued

11/26

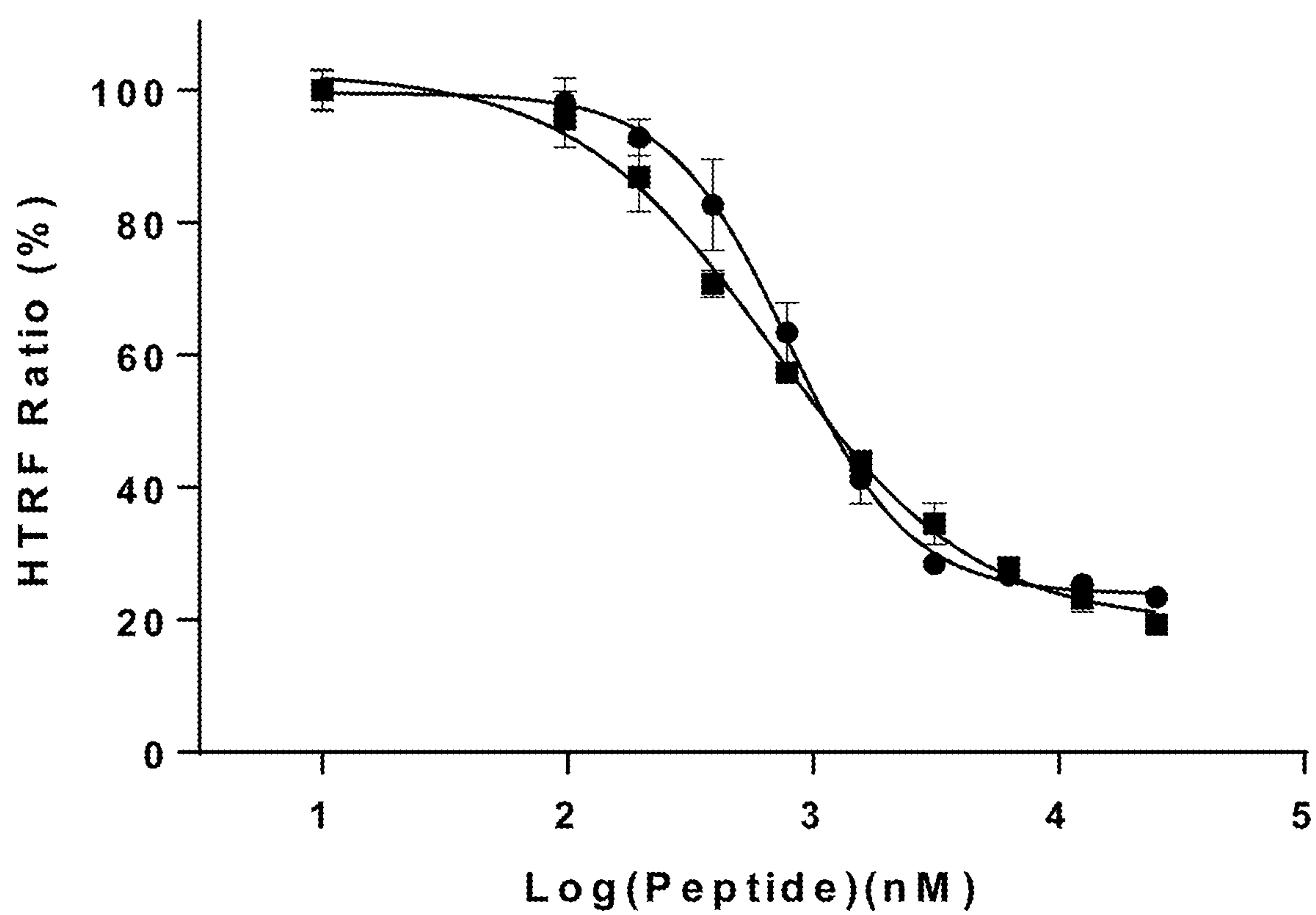


FIG. 6

12/26

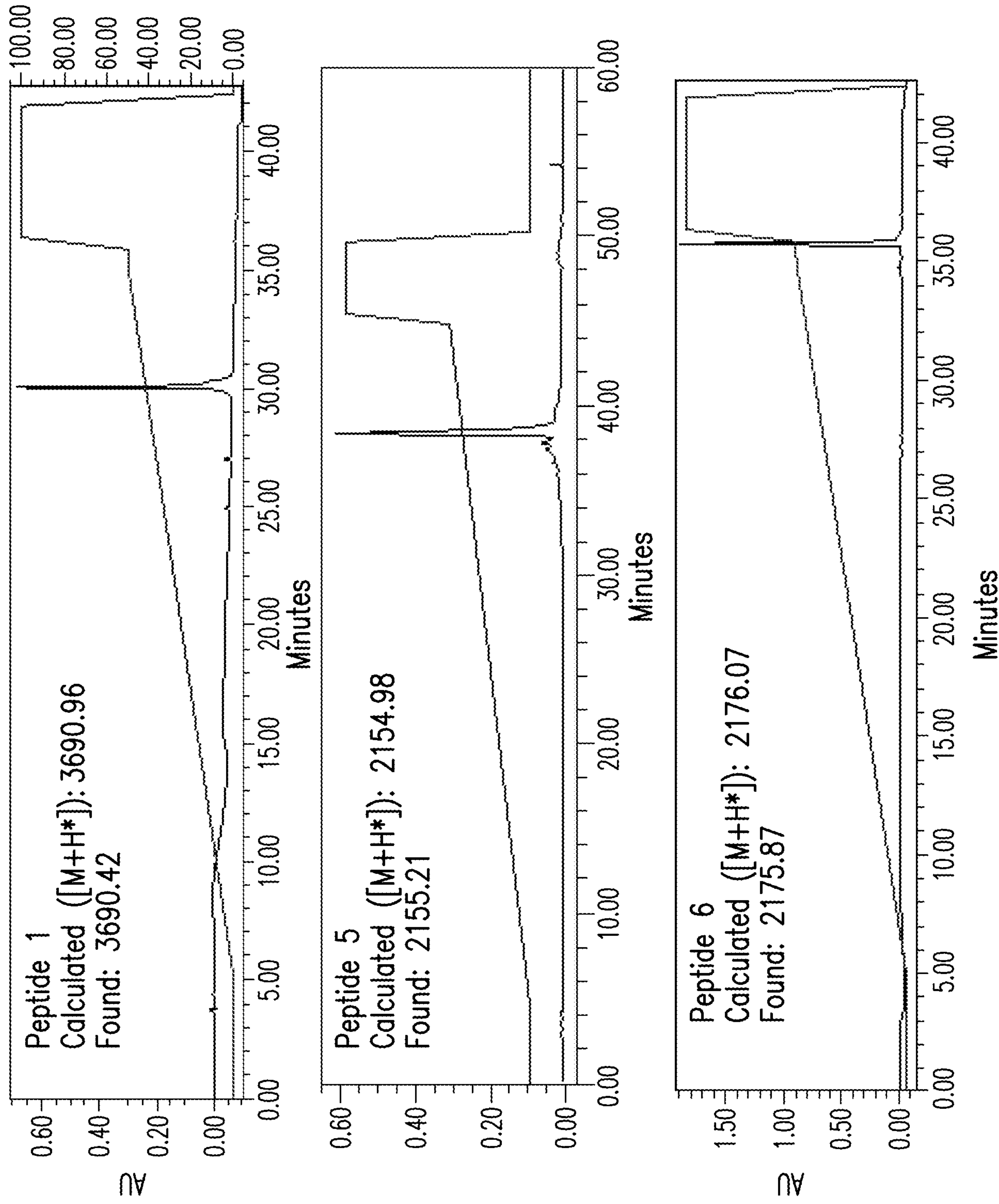


FIG. 7

13/26

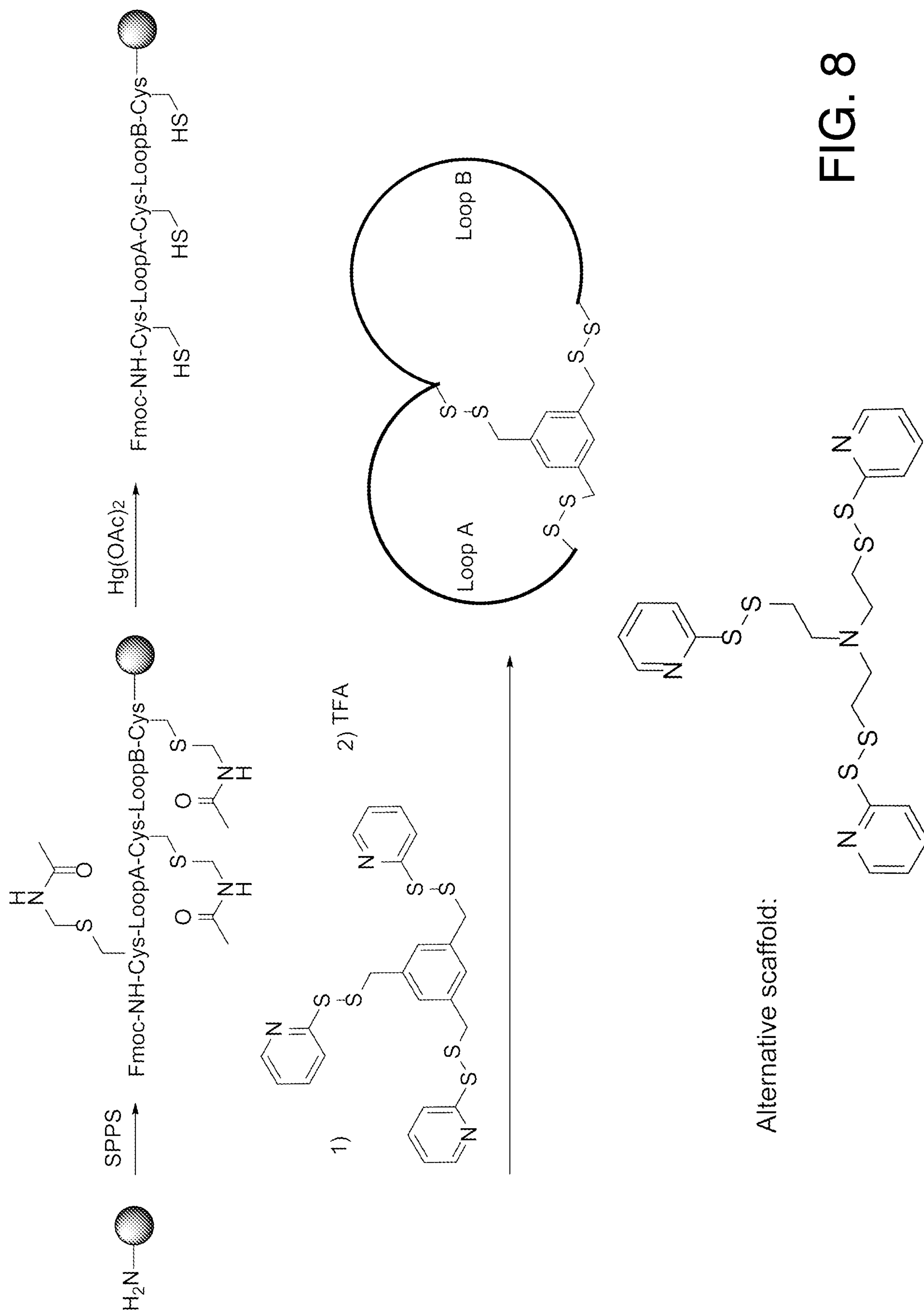


FIG. 8

14/26

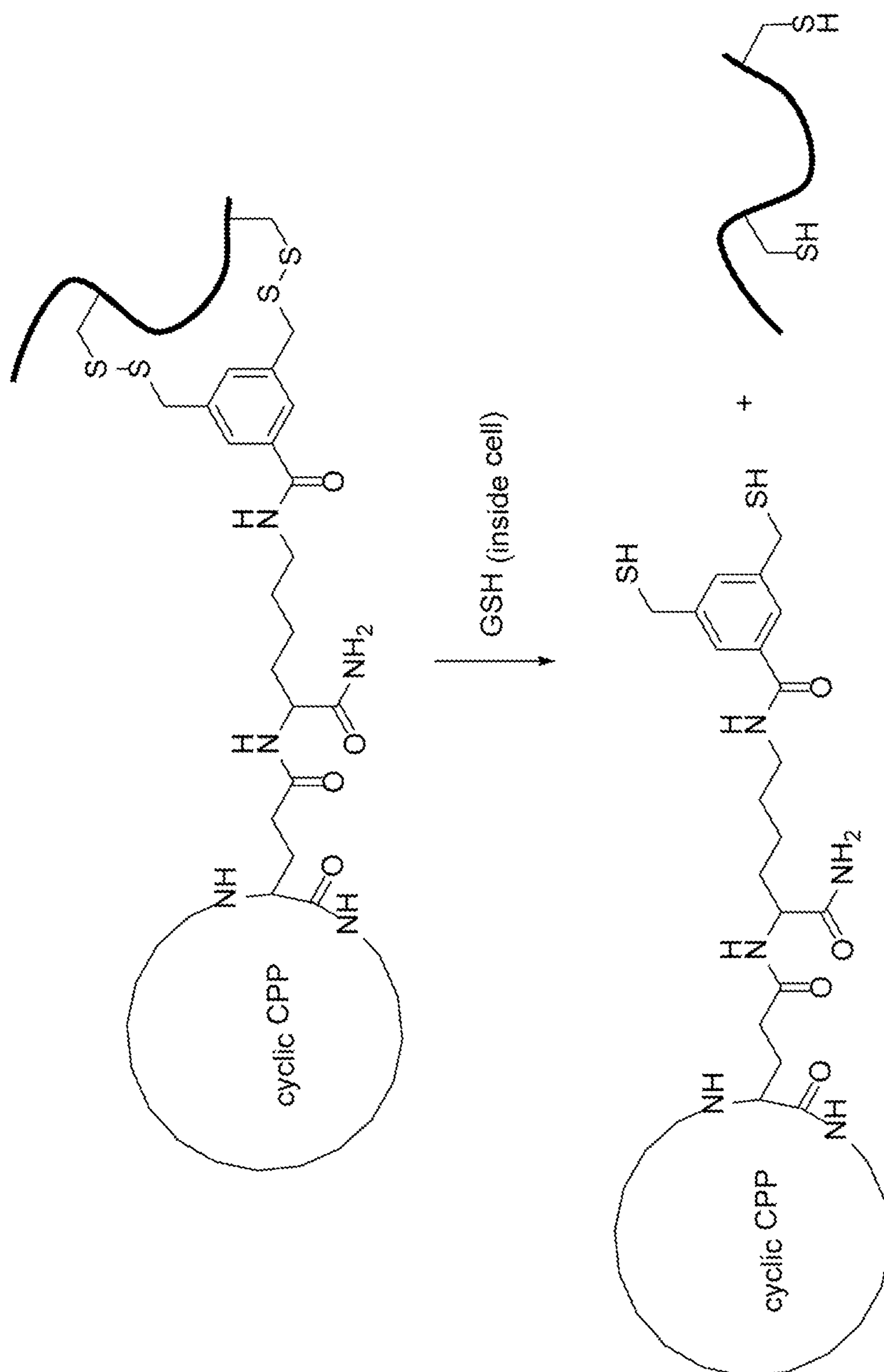


FIG. 9

15/26

CPP12-Keap1 NFL

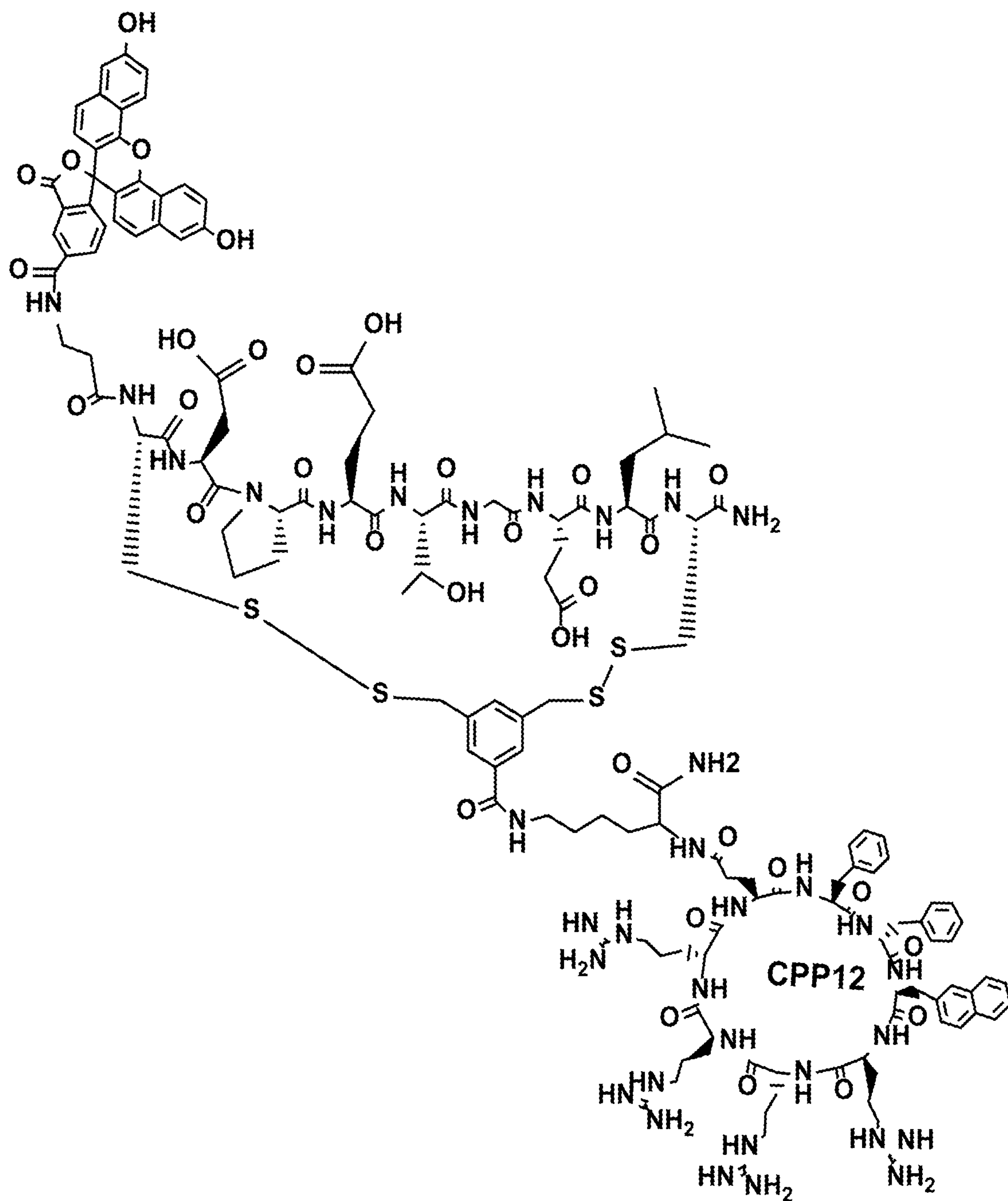
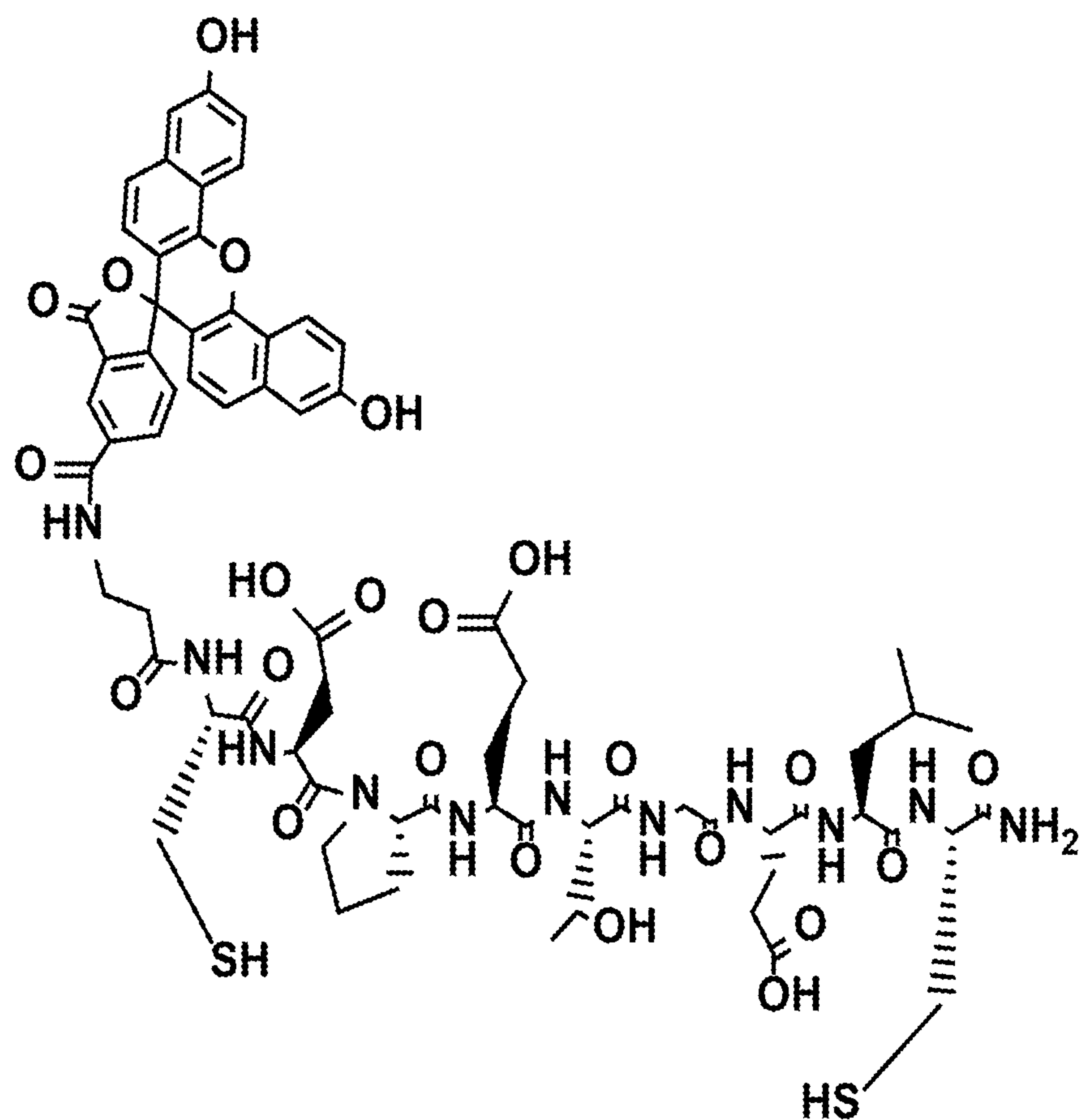


FIG. 10A

16/26

Keap1 NFL**FIG. 10B**

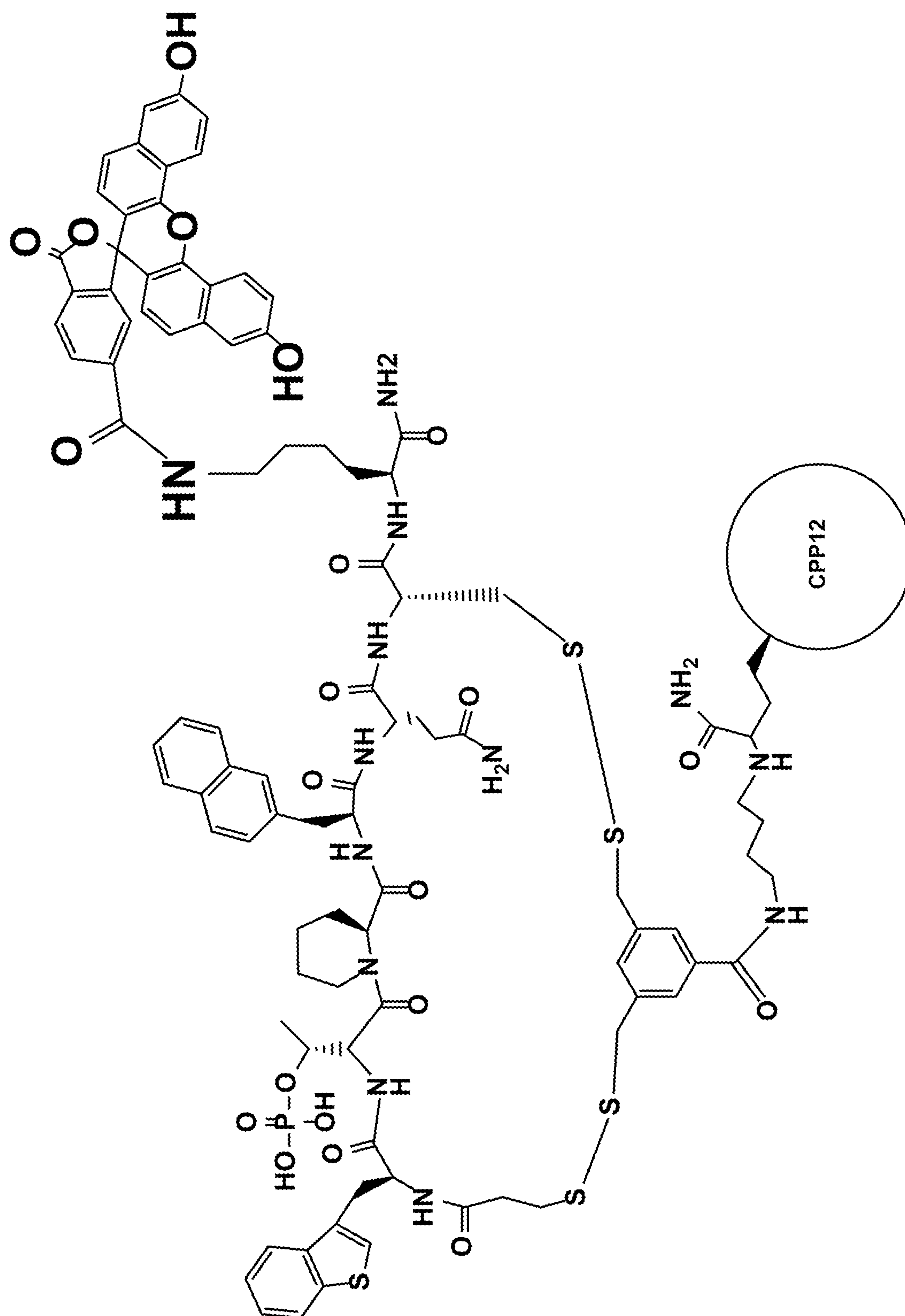


FIG. 11

18/26

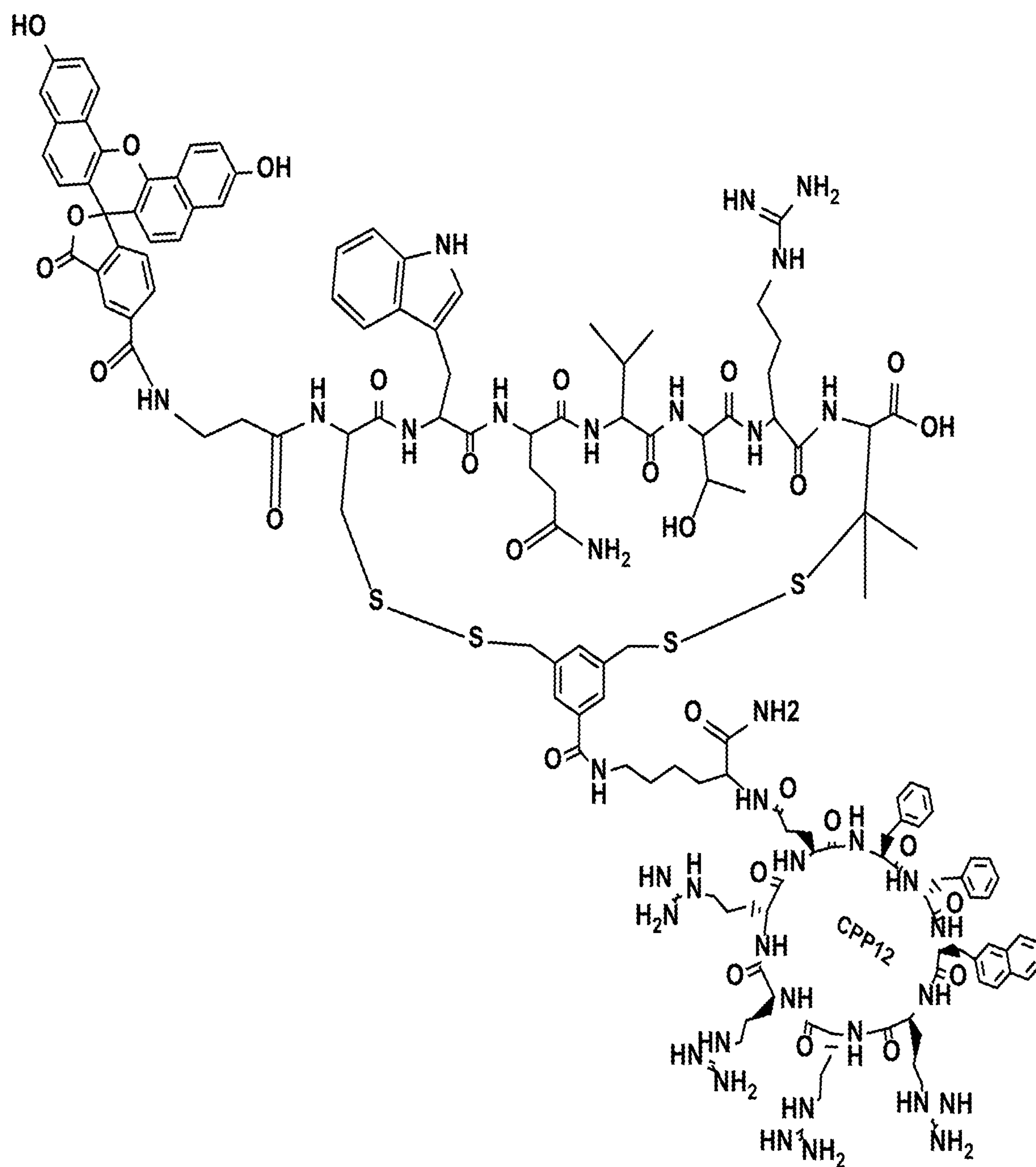


FIG. 12A



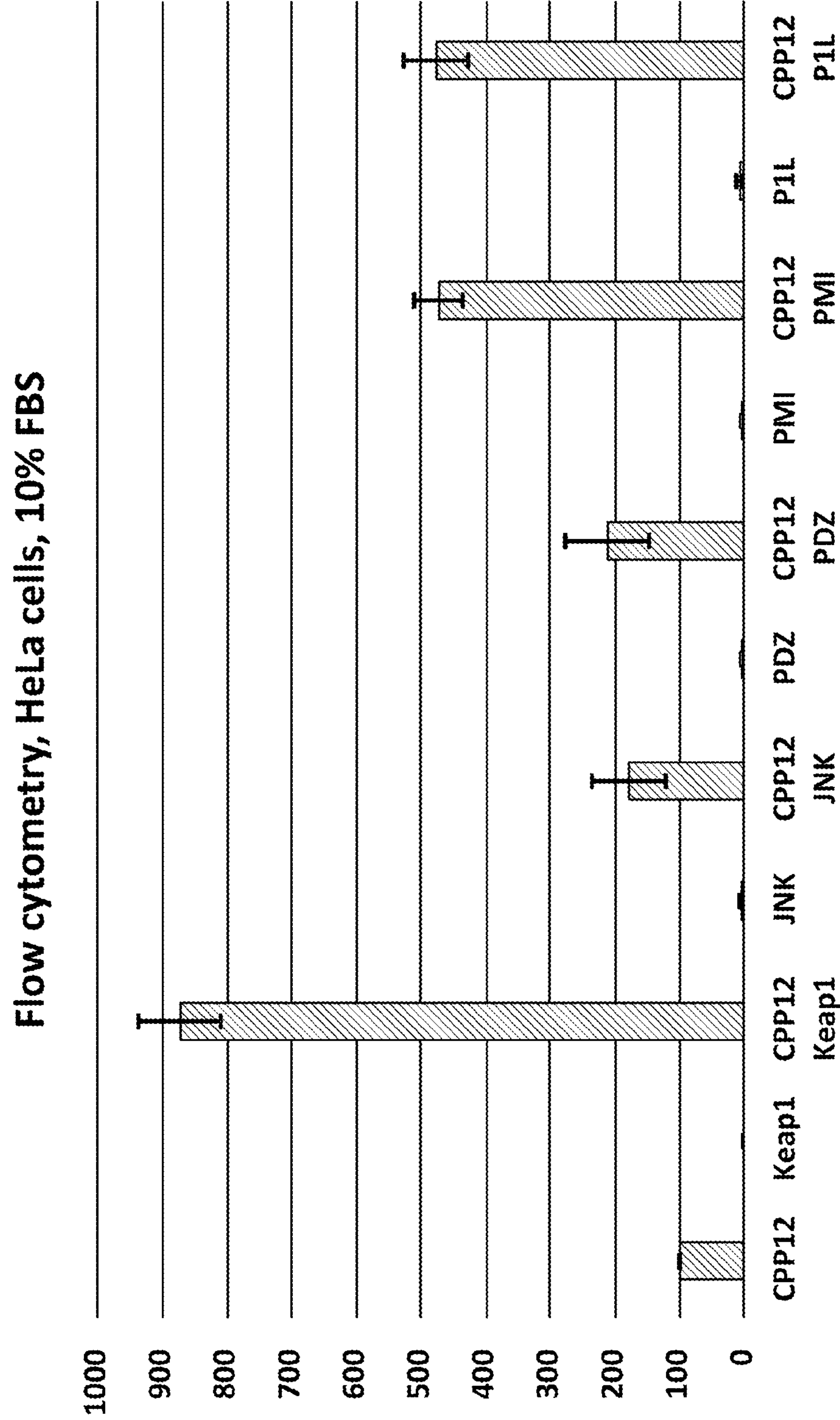
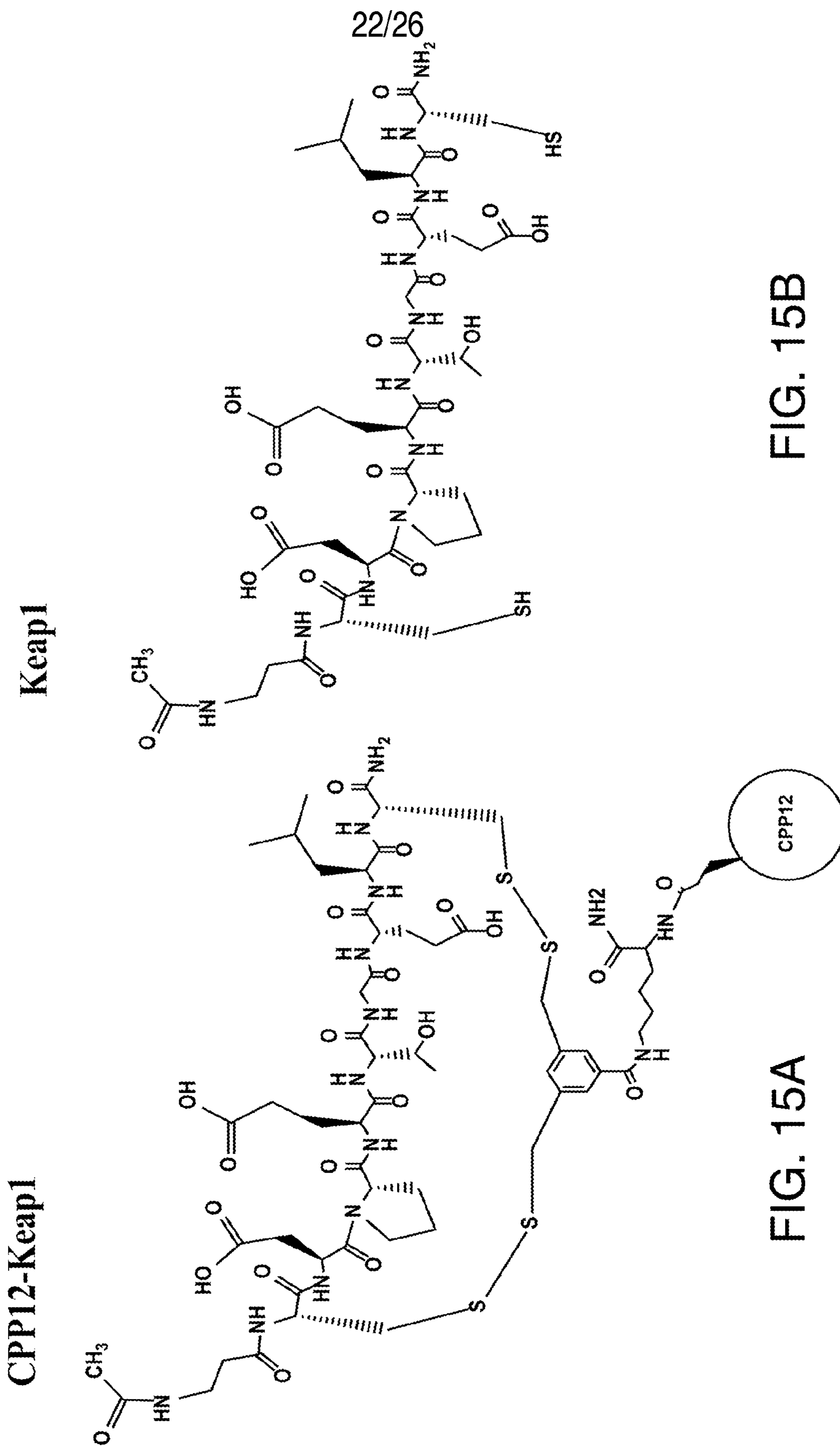


FIG. 14



23/26

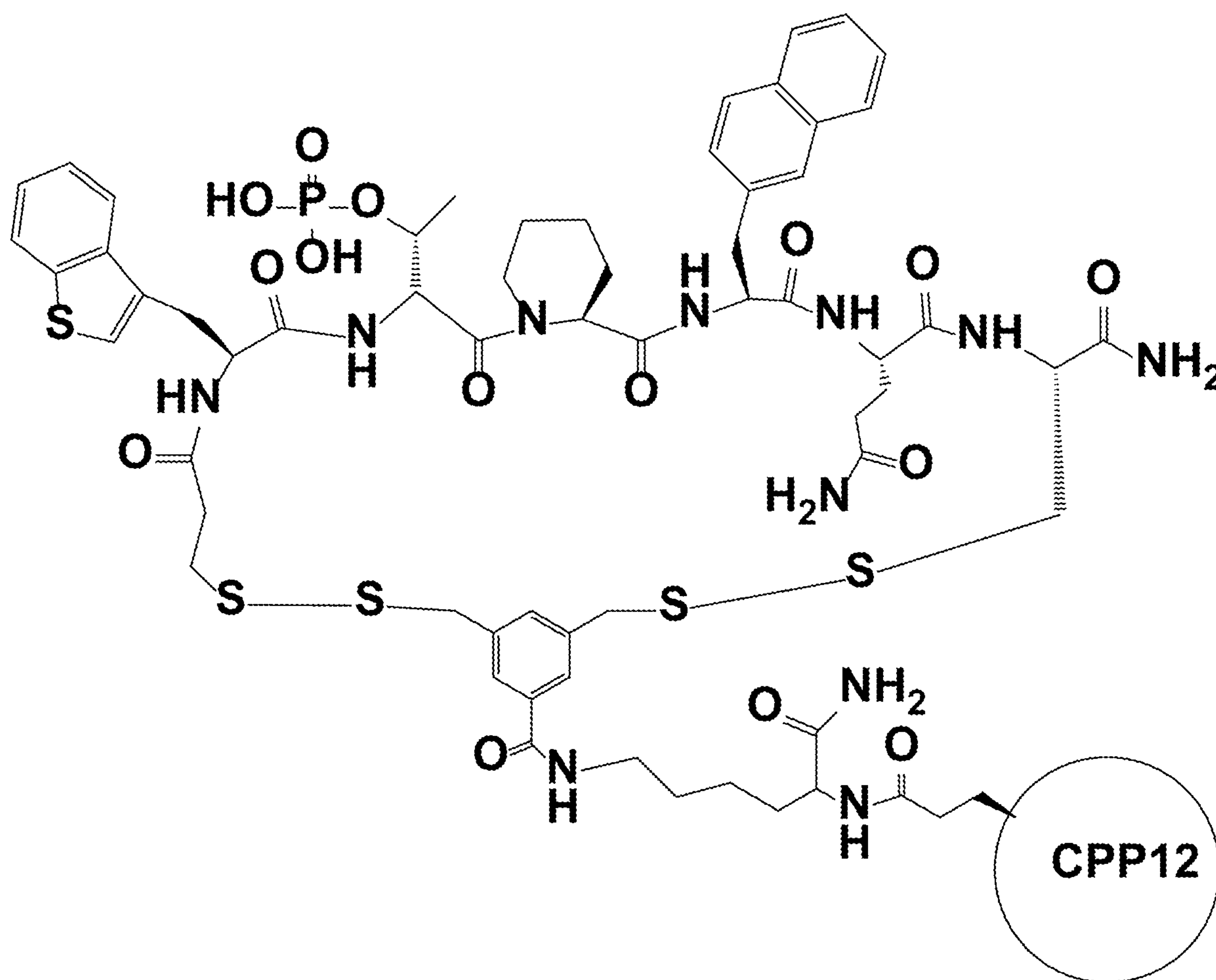


FIG. 16

24/26

Serum stability assay
CPP12-PMI Vs PMI

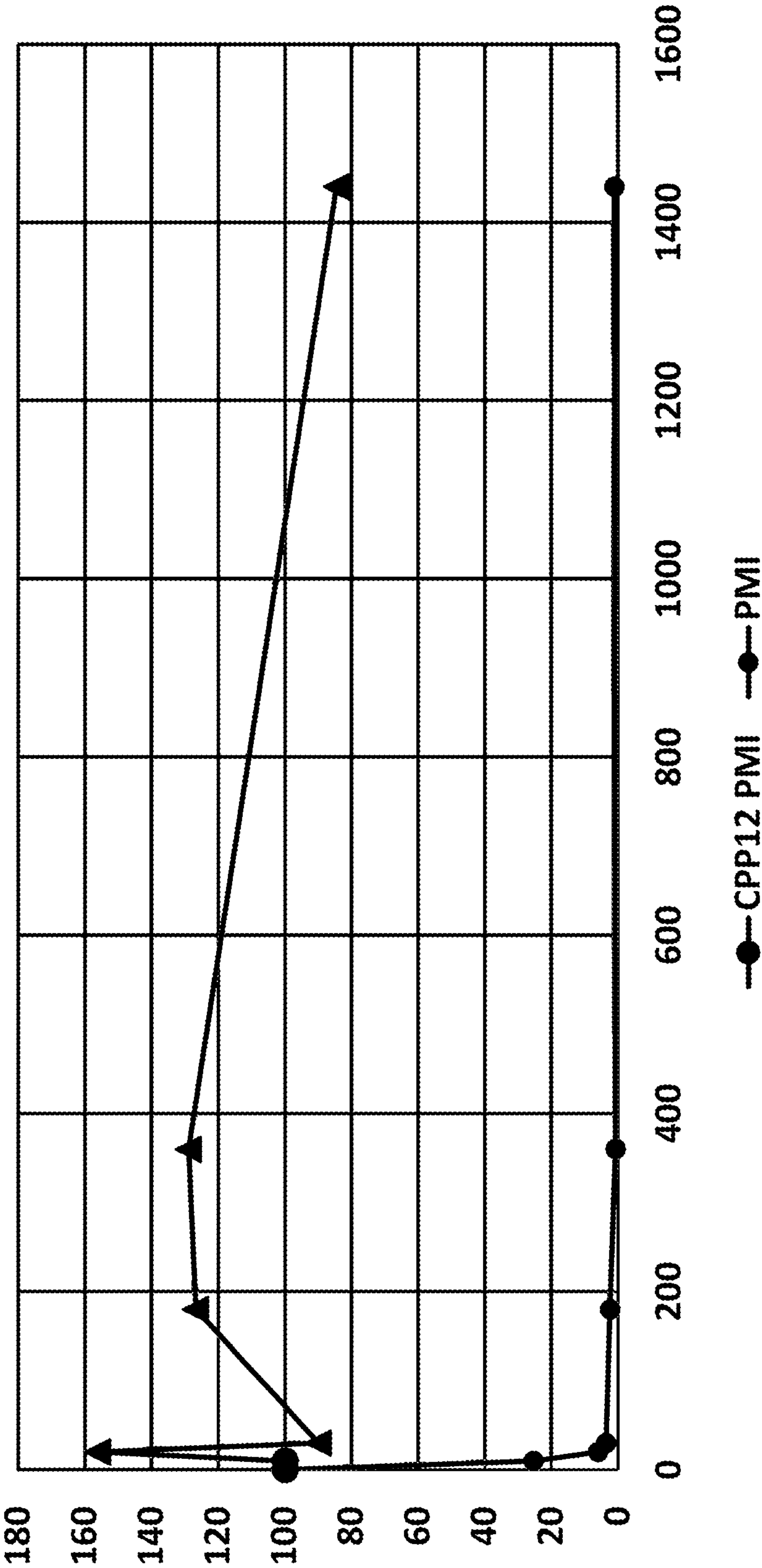


FIG. 17

25/26

Serum stability assay
CPP12-Keap1 Vs Keap1

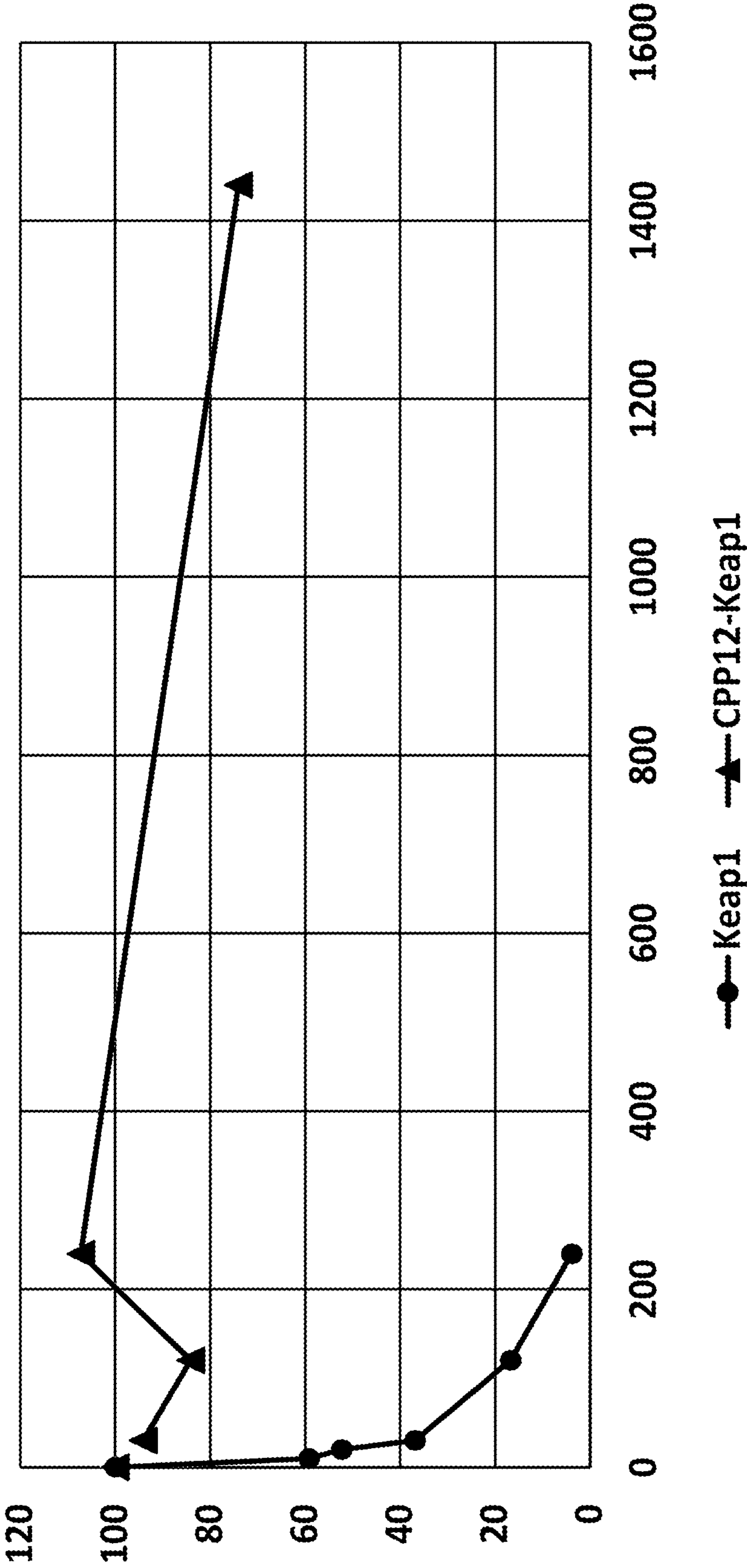


FIG. 18

Serum Stability assay
CPP12-P1 Vs P1

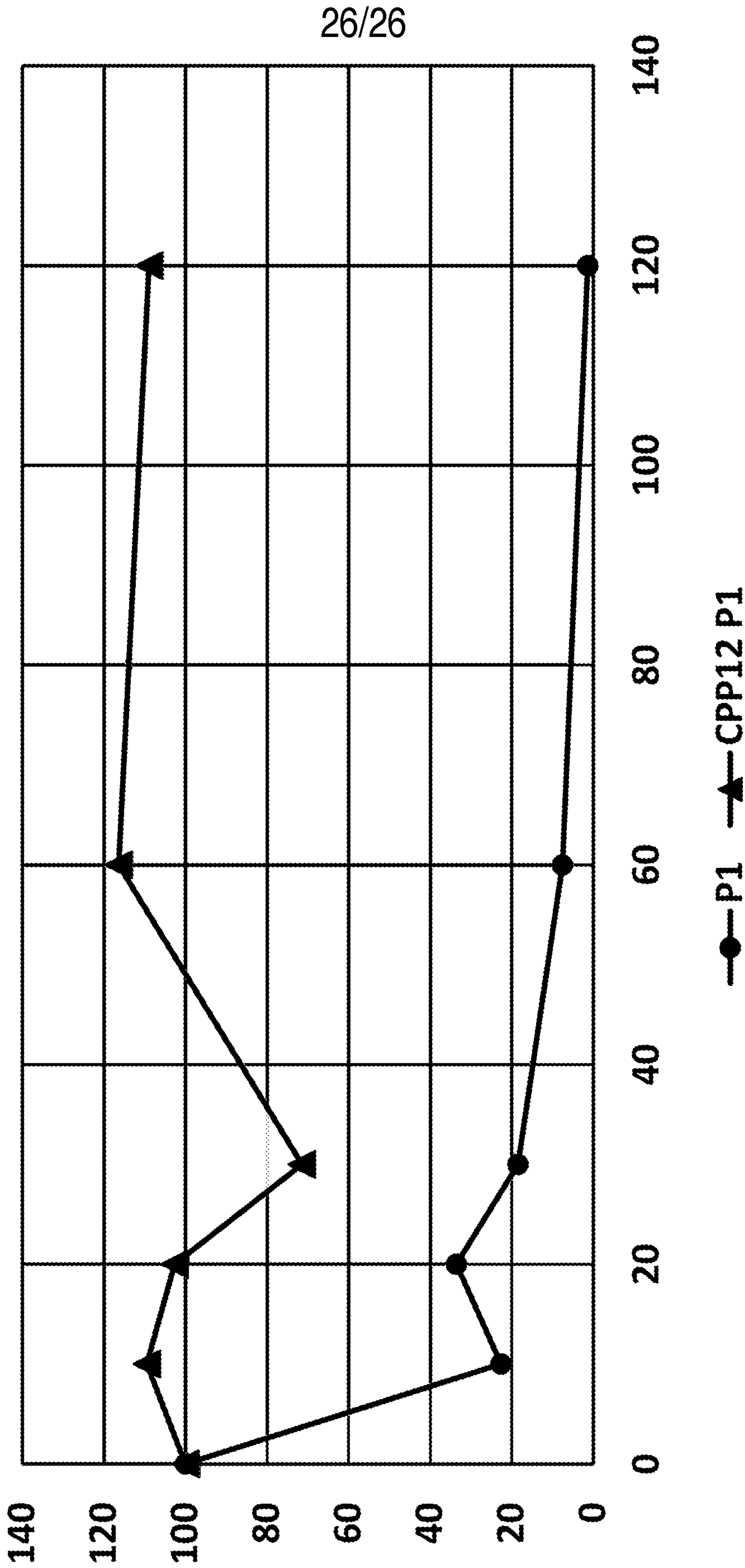


FIG. 19

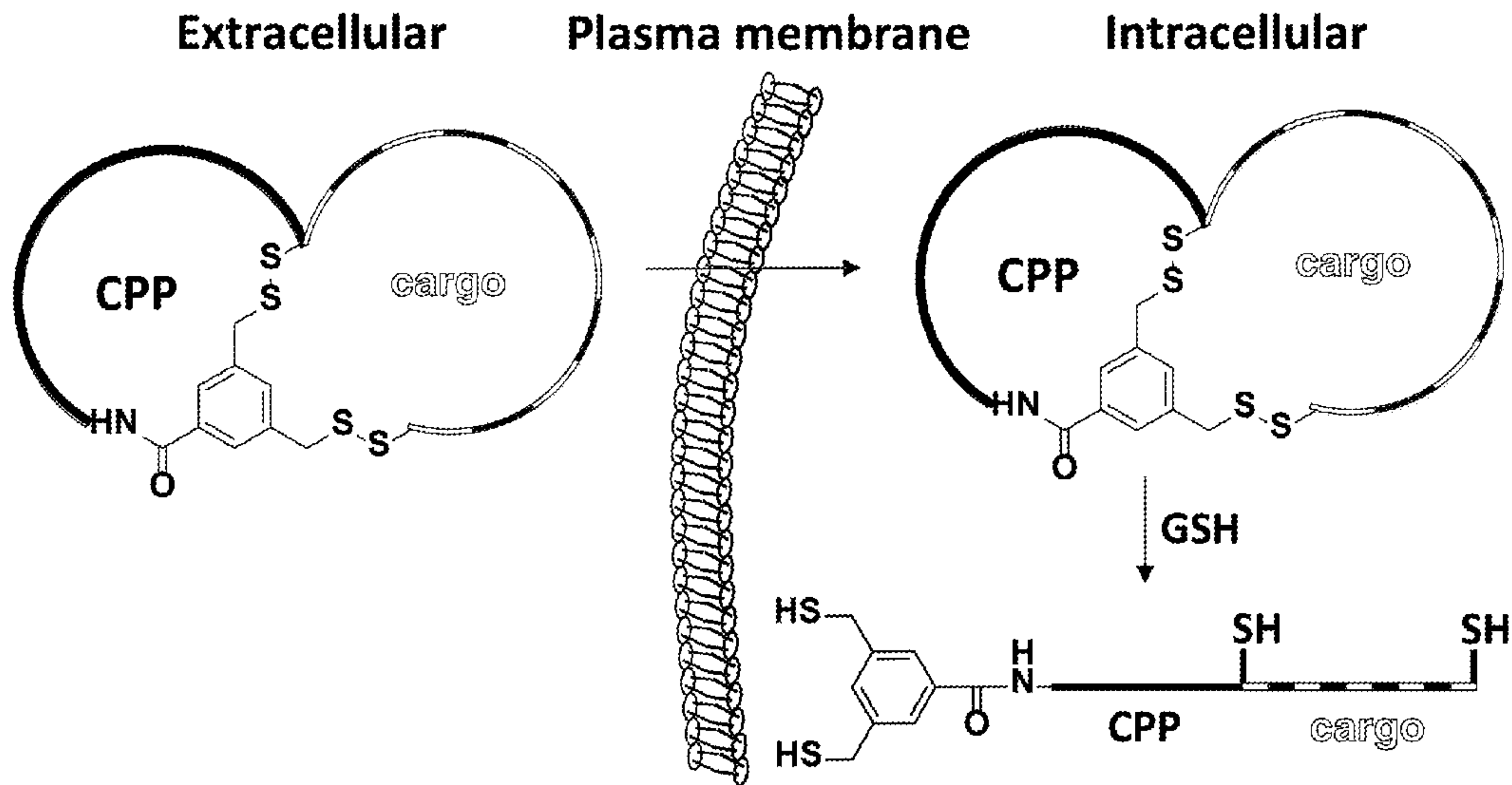


FIG. 2