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(54) Title: GUANYLATE CYCLASE RECEPTOR AGONISTS FOR USE IN COLONIC CLEANSING

(57) Abstract: This invention provides a method of colonic cleansing.

AGONISTS OF GUANYLATE CYCLASE AND THEIR USES

RELATED APPLICATIONS

5   This application claims priority to, and benefit of, the U.S. Provisional Application No. 61/768,902, filed on February 25, 2013.

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FIELD OF THE INVENTION

The present invention relates to colon cleansing compositions and methods of use of such compositions.

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BACKGROUND OF THE INVENTION

Colon cleansing is important prior to numerous diagnostic and surgical procedures, for example before colonoscopy, barium enema examination or colon surgery. It is also useful for preventing infection after surgery on the lower intestine. Colon cleansing is also known as colon

20   clearing.

A variety of methods for colon cleansing are known. Dietary manipulation, laxatives, cathartics and enemas were traditionally used (Thomas, G. et al., Gastroenterology, 1982, 82, 435 437). Sodium phosphate solutions (Clarkston, W. K. et al., Gastrointestinal Endoscopy, 1996, 43, 43 48) and magnesium citrate/sodium picosulphate solutions (Regev, A. et al., Am. J.

25   Gastroenterol., 1998, 93, 1478 1482) have also been used.

Those methods suffer from various drawbacks. Dietary manipulation and laxatives are time consuming; enemas are unpleasant for the patient; and dangerous salt and water losses may occur with cathartics, enemas and with sodium phosphate solutions.

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Therefore, there is a great need to identify novel colon cleansing compositions and methods without these drawbacks.

SUMMARY OF THE INVENTION

The present invention provides a method of colonic cleansing by administering to a subject in need thereof an effective amount of a guanylate cyclase receptor agonist (GCRA) peptide or its derivative or analog.

In some embodiments, the peptide is bicyclic GCRA peptide.

In some embodiments, the method further comprises administering to the subject an effective amount of an osmotic colonic evacuant. Preferably, the osmotic colonic evacuant is magnesium citrate or a phosphate salt laxative.

In some embodiment, the method further comprises administering to the subject an effective amount of L-glucose, lubiprostone (Amitiza), prucalopride, an agent for treating chronic constipation, or any combination thereof. The effective amount of L-glucose is a unit dose of 20g-200g. Preferably, the GCRA peptide or its derivative or analog of the present invention is used in combination with an osmotic liquid prep, such as SUPREP® Bowel Prep Kit (sodium sulfate potassium sulfate, magnesium sulfate).

In some embodiment, the method further comprises administering to the subject an effective amount of a cGMP-specific phosphodiesterase inhibitor. The cGMP-specific phosphodiesterase inhibitor is selected from the group consisting of sulindac sulfone, zaprinast, motapizone, vardenafil, and sildenafil.

The effective amount of a GCRA peptide is a unit dose of 0.01 mg to 60 mg. Preferably, the effective amount of a GCRA peptide is a unit dose of 6.0 mg.

The present invention provides a formulation that comprises a mixture of (1) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at pH5.0; and (2) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at pH6.0 or pH 7.0.

In some embodiments, the inert carrier is a selected from mannitol, lactose, a microcrystalline cellulose, or starch.

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In some embodiments, the amount of GCRA peptide per unit dose is from 1 mg to 60 mg when the GCRA peptide is SP-304 (SEQ ID NO: 1) or SP-333 (SEQ ID NO: 9) or their derivatives or analogs.

In some embodiments, the amount of GCRA peptide per unit dose is from 0.3 mg to 3.0 mg when the GCRA peptide is an E. coli ST peptide, linaclotide derivative or analog.

The present invention further provides a method of colonic cleansing by administering to a subject in need thereof any formulations described herein.

In any methods or any formulations described herein, the GCRA peptide consists essentially of the sequence of any one of SEQ ID NO: 1-346. For example, the peptide is bicyclic consisting essentially of the sequence of any one of SEQ ID NO: 1-54, 99-241, and 253-346. Preferably, the GCRA peptide is SEQ ID NO: 1, 9, 55 or 56.

Other features and advantages of the invention will be apparent from and are encompassed by the following detailed description and claims.

DETAILED DESCRIPTION

The present invention is based upon the development of agonists of guanylate cyclase-C (GC-C). The agonists are analogs of uroguanylin, guanylin, lymphoguanylin and ST peptides.

Physicians and surgeons have developed a variety of means to achieve the desired level of colon cleansing. The use of dietary restrictions, laxatives, enemas, and whole-bowel lavage solutions, alone or in combinations has been employed.

However, these preparations have several drawbacks. For example, because most of commercially available solutions are isotonic, patients are required to ingest a significant amount of volume of these solutions, up to one eight ounce glass every ten minutes for a total of one gallon of fluid, to achieve effective purging. Sodium sulfate and phosphate salts have been used as laxatives. However, because of their small volumes, when used in this fashion they do not sufficiently clean the colon for diagnostic or surgical procedures. Another drawback of these preparations is their unpleasant, bitter, saline taste. This can promote nausea and vomiting in sensitive patients--thereby preventing ingestion.

The gualylate cyclase-C agonists of the present invention provide unexpected and superior effect than previous means for colon cleansing. These agonists are very specific and are relatively more stable in gastrointestinal (GI) tract, because they have relatively higher resistance

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to degradation at the N-terminus and C-terminus from carboxypeptidases and/or by other proteolytic enzymes such as those present in the stimulated human intestinal fluid (SIF). In addition, these agonists can significantly increase intestinal motility and decrease water absorption. Therefore, they are excellent colon cleansing compositions with high specificity,

5   high efficiency, low volume/dosage, and no unpleasant taste, thus providing improved patients compliance. This is particularly true when the GCRA peptide or its derivative or analog of the present invention or any composition/formulation described herein is used in combination with a colon cleansing agent.

Preferably, the GCRA peptide or its derivative or analog of the present invention or any

10   composition/formulation described herein is used in combination with L-glucose, cholera toxin, osmotic colonic evacuants, cathartic, laxatives, agents for treating chronic constipation and/or an osmotic liquid prep. For example, an osmotic liquid prep is SUPREP® Bowel Prep Kit (sodium sulfate potassium sulfate, magnesium sulfate).

Accordingly, the present invention provides compositions comprising at least one GCRA

15   peptide (*i.e.*, GCC agonist peptide), at least one enteric coating which releases the peptide at a specific pH (*e.g.*, pH 4.0, pH 5.0, pH 6.0, or pH 7) and an inert carrier.

The present invention also provides a formulation comprising a mixture of (1) a composition having an inert carrier coated with GCRA and an enteric coating that releases the peptides at pH5.0 and (2) a composition having an inert carrier coated with GCRA peptides and

20   an enteric coating that releases the peptides at pH6.0 or pH7.0.

In some embodiments, the GCRA peptide is any one of SEQ ID NO: 1-346. In some embodiments, the GCRA peptide is SEQ ID NO: 1, 9, 55 or 56. In some embodiments, the inert carrier is selected from the group consisting of sorbitol, mannitol, EMDEX, and starch. In some embodiments, the carrier is mannitol (*e.g.*, MANNOGEM) or microcrystalline cellulose (*e.g.*

25   PROSOLV, CELPHERE®, CELPHERE® beads). In a preferred embodiment, the carrier is microcrystalline cellulose sphere or spherical microcrystalline cellulose, such as Celphere® SCP-100.

A composition may comprise an enteric coating which releases drug at pH 5 and an inert carrier coated with GCRA peptides.

30   A composition may comprise an enteric coating which releases drug at pH 6 and an inert carrier coated with GCRA peptides.

A composition may comprise an enteric coating which releases drug at pH 7 and an inert carrier coated with GCRA peptides.

A composition may comprise an enteric coating which releases drug in a pH range of 4.5 to 5.5 or in a pH range of 5.5 to 6.5 at duodenum or jejunum and an inert carrier coated with GCRA peptides.

A composition may comprise an enteric coating which releases drug in a pH range of 5.5 to 6.5 or in a pH range of 6.5 to 7.5 at ileum, terminal ileum, or ascending colon and an inert carrier coated with GCRA peptides.

A composition may comprise a mixture of enteric coatings which release drug at pH 5 and pH 6 or pH 7 and an inert carrier coated with GCRA peptides.

The present invention further provides compositions comprising a mixture of compositions that contain different peptides and/or that release the peptides at different pH levels, so that a specific composition can be released at a specific region of the GI tract (*e.g.*, duodenum, jejunum, ileum, terminal ileum, or ascending colon) at a specific amount and time to maximize the cleansing effect. Preferred pH for duodenum or jejunum release is pH 4.5-5.5 or pH 5.5-6.5. Preferred pH for ileum, terminal ileum, or ascending colon release is pH 5.5-6.5 or pH 6.5-7.5.

The mixture may comprise at least 2, 3, 4 or more compositions that release the peptides at different pH levels (*e.g.*, pH5, pH6, or pH7). The mixture may comprise at least 2, 3, 4 or more compositions that contain different GCRA peptides. A skilled artisan can determine the ratio of these compositions within the mixture, for example, according to the activity of each peptide, solubility of each peptide, and/or the targeting region of the GI tract.

The present invention also provides methods for colonic cleansing by administering to a subject in need thereof an effective amount of a GCRA peptide.

The GCRA peptides (*i.e.*, gualylate cyclase-C agonists) according to the invention include amino acid sequences represented by Formulae I-XXI, their corresponding α-aminoadipic acid (Aad) derivatives (*e.g.*, Formulae I-Aad, II-Aad, III-Aad, IV-Aad, V-Aad, VI-Aad, VII-a-Aad, VII-b-Aad, VIII-Aad, IX-Aad, XVIII-Aad or XXI-Aad), as well as those amino acid sequence summarized below in Tables 1-8. The gualylate cyclase-C agonists according to the invention are collectively referred to herein as "GCRA peptides".

Table 1. GCRA Peptides (SP-304 and Derivatives)

Name	Position of Disulfide bonds	Structure	SEQ ID NO
SP-304	C4:C12, C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	1
SP-326	C3:C11, C6:C14	Asp^1-Glu^2-Cys^3-Glu^4-Leu^5-Cys^6-Val^7-Asn^8-Val^9-Ala^{10}-Cys^{11}-Thr^{12}-Gly^{13}-Cys^{14}-Leu^{15}	2
SP-327	C3:C11, C6:C14	Asp^1-Glu^2-Cys^3-Glu^4-Leu^5-Cys^6-Val^7-Asn^8-Val^9-Ala^{10}-Cys^{11}-Thr^{12}-Gly^{13}-Cys^{14}	3
SP-328	C2:C10, C5:C13	Glu^1-Cys^2-Glu^3-Leu^4-Cys^5-Val^6-Asn^7-Val^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-Leu^{14}	4
SP-329	C2:C10, C5:C13	Glu^1-Cys^2-Glu^3-Leu^4-Cys^5-Val^6-Asn^7-Val^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}	5
SP-330	C1:C9, C4:C12	Cys^1-Glu^2-Leu^3-Cys^4-Val^5-Asn^6-Val^7-Ala^8-Cys^9-Thr^{10}-Gly^{11}-Cys^{12}-Leu^{13}	6
SP-331	C1:C9, C4:C12	Cys^1-Glu^2-Leu^3-Cys^4-Val^5-Asn^6-Val^7-Ala^8-Cys^9-Thr^{10}-Gly^{11}-Cys^{12}	7
SP332	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	8
SP-333	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	9
SP-334	C4:C12,C7:C15	dAsn^1-dAsp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	10
SP-335	C4:C12,C7:C15	dAsn^1-dAsp^2-dGlu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	11
SP-336	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	12
SP-337	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-dLeu^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	13
SP-338	C4:C12, C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}	14
SP-342	C4:C12, C7:C15	PEG3-Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	15
SP-343	C4:C12, C7:C15	PEG3-dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	16
SP-344	C4:C12, C7:C15	PEG3-dAsn^1-dAsp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	17
SP-347	C4:C12, C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	18
SP-348	C4:C12, C7:C15	PEG3-Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	19
SP-350	C4:C12, C7:C15	PEG3-dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	20

Name	Lipid	Sequence	No.
SP-352	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	21
SP-358	C4:C12,C7:C15	PEG3-dAsn^1-dAsp^2-dGlu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	22
SP-359	C4:C12,C7:C15	PEG3-dAsn^1-dAsp^2-dGlu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	23
SP-360	C4:C12,C7:C15	dAsn^1-dAsp^2-dGlu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	24
SP-361	C4:C12,C7:C15	dAsn^1-dAsp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	25
SP-362	C4:C12,C7:C15	PEG3-dAsn^1-dAsp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	26
SP-368	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dNal^{16}	27
SP-369	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-AIB^9-Asn^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	28
SP-370	C4:C12, 7:15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Asp[Lactam]^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Orn^{15}-dLeu^1	29
SP-371	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	30
SP-372	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Ser^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	31
N1	C4:C12,C7:C15	PEG3-dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	32
N2	C4:C12,C7:C15	PEG3-dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	33
N3	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	34
N4	C4:C12,C7:C15	PEG3-dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Ser^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	35
N5	C4:C12,C7:C15	PEG3-dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Ser^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	36
N6	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Ser^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	37
N7	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	38
N8	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}-PEG3	39
N9	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	40
N10	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}-PEG3	41
N11	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer^{16}-PEG3	42
N12	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer^{16}	43
N13	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer^{16}-PEG3	44

Formula I	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-Xaa^{16}	45
Formula II	C4:C12,C7:C15	Xaa_{n1}-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-Xaa_{n2}^{16}	46
Formula III	4:12,7:15	Xaa_{n1}-Maa^4-Glu^5-Xaa^6-Maa^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Maa^{12}-Thr^{13}-Gly^{14}-Maa^{15}-Xaa_{n2}	47
Formula IV	4:12,7:15	Xaa_{n1}-Maa^4-Xaa^5-Xaa^6-Maa^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Maa^{12}-Xaa^{13}-Xaa^{14}-Maa^{15}-Xaa_{n2}	48
Formula V	C4:C12,C7:C15	Asn^1-Asp^2-Asp^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Asn^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-Xaa^{16}	49
Formula VI	C4:C12,C7:C15	$dAsn^1$-Glu^2-Glu^3-Cys^4-Xaa^5-Xaa^6-Cys^7-$X3^8$-Asn^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	50
Formula VII-a	C4:C12,C7:C15	$dAsn^1$-$dGlu^2$-Asp^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Asn^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	51
Formula VII-b	C4:C12,C7:C15	$dAsn^1$-$dAsp^2$-Glu^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Asn^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	52
Formula VIII	C4:C12,C7:C15	$dAsn^1$-$dAsp^2$-$dGlu^3$-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Tyr^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	53
Formula IX	C4:C12,C7:C15	$dAsn^1$-$dGlu^2$-$dGlu^3$-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Tyr^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	54
Formula XXI	C4:C12,C7:C15	Xaa_{n1}-Cys^4-Xaa^5-Xaa^6-Xaa^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Xaa^{15}-Xaa_{n2}^{16}	250

Table 2. Linaclotide and Derivatives

Name	Position of Disulfide Bonds	Structure	SEQ ID NO:
SP-339 (linaclotide)	C1:C6, C2:C10, C5:C13	Cys^1-Cys^2-Glu3-Tyr^4-Cys^5-Cys^6-Asn^7-Pro^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-Tyr^{14}	55
SP-340	C1:C6, C2:C10, C5:C13	Cys^1-Cys^2-Glu^3-Tyr^4-Cys^5-Cys^6-Asn^7-Pro^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}	56
SP-349	C1:C6, C2:C10, C5:C13	PEG3-Cys^1-Cys^2-Glu^3-Tyr^4-Cys^5-Cys^6-Asn^7-Pro^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-Tyr^{14}-PEG3	57
SP-353	C3:C8, C4:C12, C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Ser^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	58
SP-354	C3:C8, C4:C12, C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Phe^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	59
SP-355	C1:C6, C2:C10, C5:C13	Cys^1-Cys^2-Glu^3-Tyr^4-Cys^5-Cys^6-Asn^7-Pro^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-$dTyr^{14}$	60
SP-357	C1:C6, C2:C10, C5:C13	PEG3-Cys^1-Cys^2-Glu^3-Tyr^4-Cys^5-Cys^6-Asn^7-Pro^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-Tyr^{14}	61
SP-374	C3:C8, C4:C12, C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Thr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	62
SP-375	C3:C8, C4:C12, C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Ser^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dTyr^{16}$	63
SP-376	C3:C8, C4:C12, C7:C15	$dAsn^1$-Phe^2-Cys^3-Cys^4-Glu^5-Ser^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	64
SP-377	C3:C8, C4:C12, C7:C15	$dAsn^1$-Phe^2-Cys^3-Cys^4-Glu^5-Ser^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dTyr^{16}$	65
SP-378	C3:C8, C4:C12, C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Thr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dTyr^{16}$	66
SP-379	C3:C8, C4:C12, C7:C15	$dAsn^1$-Phe^2-Cys^3-Cys^4-Glu^5-Thr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	67
SP-380	C3:C8, C4:C12, C7:C15	$dAsn^1$-Phe^2-Cys^3-Cys^4-Glu^5-Thr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dTyr^{16}$	68
SP-381	C3:C8, C4:C12, C7:15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Phe^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-	69

		dTyr^{16}	
SP-382	C3:C8, C4:C12, C7:15	dAsn^{1}-Phe^{2}-Cys^{3}-Cys^{4}-Glu^{5}-Phe^{6}-Cys^{7}-Cys^{8}-Asn^{9}-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	70
SP-383	C3:C8, C4:C12, C7:15	dAsn^{1}-Phe^{2}-Cys^{3}-Cys^{4}-Glu^{5}-Phe^{6}-Cys^{7}-Cys^{8}-Asn^{9}-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dTyr^{16}	71
SP384	C1:C6, C2:C10, C5:C13	Cys^{1}-Cys^{2}-Glu^{3}-Tyr^{4}-Cys^{5}-Cys^{6}-Asn^{7}-Pro^{8}-Ala^{9}-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-Tyr^{14}-PEG3	72
N14	C1:C6, C2:C10, C5:C13	PEG3-Cys^{1}-Cys^{2}-Glu^{3}-Tyr^{4}-Cys^{5}-Cys^{6}-Asn^{7}-Pro^{8}-Ala^{9}-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-PEG3	73
N15	C1:C6, C2:C10, C5:C13	PEG3-Cys^{1}-Cys^{2}-Glu^{3}-Tyr^{4}-Cys^{5}-Cys^{6}-Asn^{7}-Pro^{8}-Ala^{9}-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}	74
N16	C1:C6, C2:C10, C5:C13	Cys^{1}-Cys^{2}-Glu^{3}-Tyr^{4}-Cys^{5}-Cys^{6}-Asn^{7}-Pro^{8}-Ala^{9}-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-PEG3	75
N17	C3:C8, C4:C12, C7:C15	PEG3-Asn^{1}-Phe^{2}-Cys^{3}-Cys^{4}-Glu^{5}-Ser^{6}-Cys^{7}-Cys^{8}-Asn^{9}-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}-PEG3	76
N18	C3:C8, C4:C12, C7:C15	PEG3-Asn^{1}-Phe^{2}-Cys^{3}-Cys^{4}-Glu^{5}-Ser^{6}-Cys^{7}-Cys^{8}-Asn^{9}-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	77
N19	C3:C8, C4:C12, C7:C15	Asn^{1}-Phe^{2}-Cys^{3}-Cys^{4}-Glu^{5}-Ser^{6}-Cys^{7}-Cys^{8}-Asn^{9}-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}-PEG3	78
N20	C3:C8, C4:C12, C7:C15	PEG3-Asn^{1}-Phe^{2}-Cys^{3}-Cys^{4}-Glu^{5}-Phe^{6}-Cys^{7}-Cys^{8}-Asn^{9}-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}-PEG3	79
N21	C3:C8, C4:C12, C7:C15	PEG3-Asn^{1}-Phe^{2}-Cys^{3}-Cys^{4}-Glu^{5}-Phe^{6}-Cys^{7}-Cys^{8}-Asn^{9}-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	80
N22	C3:C8, C4:C12, C7:C15	Asn^{1}-Phe^{2}-Cys^{3}-Cys^{4}-Glu^{5}-Phe^{6}-Cys^{7}-Cys^{8}-Asn^{9}-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}-PEG3	81
N23	C3:C8, C4:C12, C7:C15	PEG3-Asn^{1}-Phe^{2}-Cys^{3}-Cys^{4}-Glu^{5}-Tyr^{6}-Cys^{7}-Cys^{8}-Asn^{9}-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}-PEG3	82

ID	Bridge	Sequence	No.
N24	C3:C8, C4:C12, C7:C15	PEG3-Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Tyr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	83
N25	C3:C8, C4:C12, C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Tyr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}-PEG3	84
N26	C1:C6, C2:C10, C5:C13	Cys^1-Cys^2-Glu3-Ser^4-Cys^5-Cys^6-Asn^7-Pro^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-Tyr^{14}	85
N27	C1:C6, C2:C10, C5:C13	Cys^1-Cys^2-Glu3-Phe^4-Cys^5-Cys^6-Asn^7-Pro^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-Tyr^{14}	86
N28	C1:C6, C2:C10, C5:C13	Cys^1-Cys^2-Glu3-Ser^4-Cys^5-Cys^6-Asn^7-Pro^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-	87
N29	C1:C6, C2:C10, C5:C13	Cys^1-Cys^2-Glu3-Phe^4-Cys^5-Cys^6-Asn^7-Pro^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}	88
N30	1:6, 2:10, 5:13	Pen^1-Pen^2-Glu3-Tyr^4-Pen^5-Pen^6-Asn^7-Pro^8-Ala^9-Pen^{10}-Thr^{11}-Gly^{12}-Pen^{13}-Tyr^{14}	89
N31	1:6, 2:10, 5:13	Pen^1-Pen^2-Glu3-Tyr^4-Pen^5-Pen^6-Asn^7-Pro^8-Ala^9-Pen^{10}-Thr^{11}-Gly^{12}-Pen^{13}	90
Formula X	C9:C14, C10:C18, C13:C21	Xaa^1-Xaa^2-Xaa^3-Xaa^4-Xaa^5-Xaa^6-Asn^7-Tyr^8-Cys^9-Cys^{10}-Xaa^{11}-Tyr^{12}-Cys^{13}-Cys^{14}-Xaa^{15}-Xaa^{16}-Xaa^{17}-Cys^{18}-Xaa^{19}-Xaa^{20}-Cys^{21}-Xaa^{22}	91
Formula XI	C9:C14, C10:C18, C13:C21	Xaa^1-Xaa^2-Xaa^3-Xaa^4-Xaa^5-Xaa^6-Asn^7-Phe^8-Cys^9-Cys^{10}-Xaa^{11}-Phe^{12}-Cys^{13}-Cys^{14}-Xaa^{15}-Xaa^{16}-Xaa^{17}-Cys^{18}-Xaa^{19}-Xaa^{20}-Cys^{21}-Xaa^{22}	92
Formula XII	C3:C8, C4:C12, C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Xaa^5-Phe^6-Cys^7-Cys^8-Xaa^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-Xaa^{16}	93
Formula XIII	3:8, 4:12, 7:15	Asn^1-Phe^2-Pen^3-Cys^4-Xaa^5-Phe^6-Cys^7-Pen^8-Xaa^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-Xaa^{16}	94
Formula XIV	3:8, 4:12, 7:15	Asn^1-Phe^2-Maa^3-Maa^4-Xaa^5-Xaa^6-Maa^7-Maa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Maa^{12}-Xaa^{13}-Xaa^{14}-Maa^{15}-Xaa^{16}	95
Formula XV	1:6, 2:10, 5:13	Maa^1-Maa^2-Glu3-Xaa^4-Maa^5-Maa^6-Asn^7-Pro^8-Ala^9-Maa^{10}-Thr^{11}-Gly^{12}-Maa^{13}-Tyr^{14}	96
Formula XVI	1:6, 2:10, 5:13	Maa^1-Maa^2-Glu3-Xaa^4-Maa^5-Maa^6-Asn^7-Pro^8-Ala^9-Maa^{10}-Thr^{11}-Gly^{12}-Maa^{13}	97
Formula XVII	1:6, 2:10, 5:13	Xaa$_{n3}$-Maa^1-Maa^2-Xaa^3-Maa^4-Maa^5-Xaa^6-Maa^7-Xaa^8-Xaa^9-Maa^{10}-Xaa^{11}-Maa^{12}-Xaa^{13}-Maa^{13}-Xaa$_{n2}$	98

Table 3.GCRA Peptides

Name	Position of Disulfide bonds	Structure	SEQIDNO:
SP-363	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu-AMIDE^{16}	99
SP-364	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer^{16}	100
SP-365	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer-AMIDE^{16}	101
SP-366	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dTyr^{16}	102
SP-367	C4:C12,C7:C15	dAsn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dTyr-AMIDE^{16}	103
SP-373	C4:C12,C7:C15	Pyglu^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu-AMIDE^{16}	104
/	C4:C12,C7:C15	Pyglu^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	251
SP-304diPEG	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}-PEG3	105
SP-304N-PEG	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	106
SP-304C-PEG	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}-PEG3	107

Table 4. SP-304 Analogs, Uroguanylin, and Uroguanylin Analogs

Name	Position of Disulfide bonds	Structure	SEQID NO
Formula XVIII	C4:C12, C7:C15	Xaa^1-Xaa^2-Xaa^3-Maa^4-Xaa^5-Xaa^6-Maa^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Maa^{12}-Xaa^{13}-Xaa^{14}-Maa^{15}-Xaa^{16}	108
Uroguanylin	C4:C12, C7:C15	Asn^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	109
N32	C4:C12,C7:C15	Glu^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	110
N33	C4:C12,C7:C15	Glu^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	111
N34	C4:C12,C7:C15	Glu^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	112
N35	C4:C12,C7:C15	Glu^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	113
N36	C4:C12,C7:C15	Asp^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	114
N37	C4:C12,C7:C15	Asp^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	115
N38	C4:C12,C7:C15	Asp^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	116
N39	C4:C12,C7:C15	Asp^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	117
N40	C4:C12,C7:C15	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	118
N41	C4:C12,C7:C15	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	119
N42	C4:C12,C7:C15	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	120
N43	C4:C12,C7:C15	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	121
N44	C4:C12,C7:C15	Lys^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	122
N45	C4:C12,C7:C15	Lys^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	123
N46	C4:C12,C7:C15	Lys^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	124
N47	C4:C12,C7:C15	Lys^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	125
N48	C4:C12,C7:C15	Glu^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	126
N49	C4:C12,C7:C15	Glu^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	127

N50	C4:C12,C7:C15	Glu^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	128
N51	C4:C12,C7:C15	Glu^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	129
N52	C4:C12,C7:C15	Asp^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	130
N53	C4:C12,C7:C15	Asp^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	131
N54	C4:C12,C7:C15	Asp^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	132
N55	C4:C12,C7:C15	Asp^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	133
N56	C4:C12,C7:C15	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	134
N57	C4:C12,C7:C15	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	135
N58	C4:C12,C7:C15	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	136
N59	C4:C12,C7:C15	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	137
N60	C4:C12,C7:C15	Lys^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	138
N61	C4:C12,C7:C15	Lys^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	139
N62	C4:C12,C7:C15	Lys^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	140
N63	C4:C12,C7:C15	Lys^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	141
N65	C4:C12,C7:C15	Glu^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	142
N66	C4:C12,C7:C15	Glu^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	143
N67	C4:C12,C7:C15	Glu^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	144
N68	C4:C12,C7:C15	Glu^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	145
N69	C4:C12,C7:C15	Asp^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	146
N70	C4:C12,C7:C15	Asp^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	147
N71	C4:C12,C7:C15	Asp^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	148
N72	C4:C12,C7:C15	Asp^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	149
N73	C4:C12,C7:C15	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	150
N74	C4:C12,C7:C15	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	151

N75	C4:C12,C7:C15	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	152
N76	C4:C12,C7:C15	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	153
N77	C4:C12,C7:C15	Lys^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	154
N78	C4:C12,C7:C15	Lys^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	155
N79	C4:C12,C7:C15	Lys^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	156
N80	C4:C12,C7:C15	Lys^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	157
N81	C4:C12,C7:C15	Glu^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	158
N82	C4:C12,C7:C15	Glu^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	159
N83	C4:C12,C7:C15	Glu^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	160
N84	C4:C12,C7:C15	Glu^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	161
N85	C4:C12,C7:C15	Asp^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	162
N86	C4:C12,C7:C15	Asp^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	163
N87	C4:C12,C7:C15	Asp^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	164
N88	C4:C12,C7:C15	Asp^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	165
N89	C4:C12,C7:C15	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	166
N90	C4:C12,C7:C15	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	167
N91	C4:C12,C7:C15	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	168
N92	C4:C12,C7:C15	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	169
N93	C4:C12,C7:C15	Lys^1-Asp^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	170
N94	C4:C12,C7:C15	Lys^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	171
N95	C4:C12,C7:C15	Lys^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	172
N96	C4:C12,C7:C15	Lys^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	173

Table 5. Guanylin and Analogs

Name	Position of Disulfide bonds	Structure	SEQIDNO
Formula XIX	4:12,7:15	Xaa¹-Xaa²-Xaa³-Maa⁴-Xaa⁵-Xaa⁶-Maa⁷-Xaa⁸-Xaa⁹-Xaa¹⁰-Xaa¹¹-Maa¹²-Xaa¹³-Xaa¹⁴-Maa¹⁵	174
Guanylin	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Phe⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	175
Guanylin	C4:C12,C7:C15	Pro¹-Gly²-Thr³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Tyr⁹-Ala¹⁰-Ala¹¹-Cys¹²-Thr¹³-Gly¹⁴-Cys¹⁵	252
Human Guanylin	C4:C12, C7:C15	Pro¹-Gly²-Thr³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Tyr⁹-Ala¹⁰-Ala¹¹-Cys¹²-Thr¹³-Gly¹⁴-Cys¹⁵	
N97	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	176
N98	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Leu⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	177
N99	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Val⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	178
N100	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Tyr⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	179
N101	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	180
N102	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Leu⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	181
N103	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Val⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	182
N104	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Tyr⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	183
N105	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	184
N106	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Leu⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	185
N107	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Val⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	186
N108	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Tyr⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	187
N109	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	188
N110	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Leu⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	189
N111	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Val⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	190
N112	C4:C12,C7:C15	Ser¹-His²-Thr³-Cys⁴-Glu⁵-Tyr⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	191
N113	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	192
N114	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Leu⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	193
N115	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Val⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	194
N116	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Tyr⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	195
N117	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	196
N118	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Leu⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	197
N119	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Val⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	198
N120	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Tyr⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	199
N121	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Ile⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	200
N122	C4:C12,C7:C15	Asn¹-Asp²-Glu³-Cys⁴-Glu⁵-Leu⁶-Cys⁷-Ala⁸-Asn⁹-Ala¹⁰-Ala¹¹-Cys¹²-Ala¹³-Gly¹⁴-Cys¹⁵	201

Name	Position of Disulfide bonds	Structure	SEQ ID NO
N123	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Val^6-Cys^7-Ala^8-Asn^9-Ala^{10}-Ala^{11}-Cys^{12}-Ala^{13}-Gly^{14}-Cys^{15}	202
N124	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ala^8-Asn^9-Ala^{10}-Ala^{11}-Cys^{12}-Ala^{13}-Gly^{14}-Cys^{15}	203
N125	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Ile^6-Cys^7-Ala^8-Asn^9-Ala^{10}-Ala^{11}-Cys^{12}-Ala^{13}-Gly^{14}-Cys^{15}	204
N126	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ala^8-Asn^9-Ala^{10}-Ala^{11}-Cys^{12}-Ala^{13}-Gly^{14}-Cys^{15}	205
N127	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Val^6-Cys^7-Ala^8-Asn^9-Ala^{10}-Ala^{11}-Cys^{12}-Ala^{13}-Gly^{14}-Cys^{15}	206
N128	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ala^8-Asn^9-Ala^{10}-Ala^{11}-Cys^{12}-Ala^{13}-Gly^{14}-Cys^{15}	207

Table 6. Lymphoguanylin and Analogs

Name	Position of Disulfide bonds	Structure	SEQ ID NO
FormulaXX	4:12	Xaa^1-Xaa^2-Xaa^3-Maa^4-Xaa^5-Maa^6-Xaa^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Maa^{12}-Xaa^{13}-Xaa^{14}-Xaa$_{n1}^{15}$	208
Lymphoguanylin	C4:C12	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	209
N129	C4:C12	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Thr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	210
N130	C4:C12	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Thr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	211
N131	C4:C12	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Thr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	212
N132	C4:C12	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Thr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	213
N133	C4:C12	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Glu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	214
N134	C4:C12	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Glu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	215
N135	C4:C12	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Glu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	216
N136	C4:C12	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Glu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	217
N137	C4:C12	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	218
N138	C4:C12	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	219
N139	C4:C12	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	220
N140	C4:C12	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	221
N141	C4:C12	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Ile^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	222
N142	C4:C12	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Ile^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	223
N143	C4:C12	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Ile^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	224
N144	C4:C12	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Ile^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Tyr^{15}	225
N145	C4:C12,C7	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Thr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	226

N146	:C15	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Thr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	227
N147	C4:C12,C7:C15	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Thr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	228
N148	C4:C12,C7:C15	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Thr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	229
N149	C4:C12,C7:C15	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Glu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	230
N150	C4:C12,C7:C15	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Glu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser	231
N151	C4:C12,C7:C15	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Glu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	232
N152	C4:C12,C7:C15	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Glu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	233
N153	C4:C12,C7:C15	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	234
N154	C4:C12,C7:C15	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	235
N155	C4:C12,C7:C15	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	236
N156	C4:C12,C7:C15	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Tyr^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	237
N157	C4:C12,C7:C15	Gln^1-Glu^2-Glu^3-Cys^4-Glu^5-Ile^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	238
N158	C4:C12,C7:C15	Gln^1-Asp^2-Glu^3-Cys^4-Glu^5-Ile^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	239
N159	C4:C12,C7:C15	Gln^1-Asp^2-Asp^3-Cys^4-Glu^5-Ile^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	240
N160	C4:C12,C7:C15	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Ile^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	241

Table 7. ST Peptide and Analogues

Name	Position of Disulfide bonds	Structure	SEQIDNO
STPeptide	C9:C14,C10:C18,C13:C21	Asn^1-Ser^2-Ser^3-Asn^4-Ser^5-Ser^6-Asn^7-Tyr^8-Cys^9-Cys^{10}-Glu^{11}-Lys^{12}-Cys^{13}-Cys^{14}-Asn^{15}-Pro^{16}-Ala^{17}-Cys^{18}-Thr^{19}-Gly^{20}-Cys^{21}-Tyr^{22}	242
N161	C3:C8,C4:C12,C7:C15	PEG3-Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Thr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}-PEG3	243
N162	C3:C8,C4:C12,C7:C15	PEG3-Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Thr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	244
N163	C3:C8,C4:C12,C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Thr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}-PEG3	245
N164	C3:C8,C4:C12,C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Tyr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	246
N165	C3:C8,C4:C12,C7:C15	$dAsn^1$-Phe^2-Cys^3-Cys^4-Glu^5-Tyr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dTyr^{16}$	247
N166	C3:C8,C4:C12,C7:C15	Asn^1-Phe^2-Cys^3-Cys^4-Glu^5-Tyr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dTyr^{16}$	248
N167	C3:C8,C4:C12,C7:C15	$dAsn^1$-Phe^2-Cys^3-Cys^4-Glu^5-Tyr^6-Cys^7-Cys^8-Asn^9-Pro^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Tyr^{16}	249

Table 8. Alpha-aminoadipic acid derivatives of GCRA Peptides

Corresponds to:	Position of Disulfide bond	Structure	SEQ ID NO
SP-304	C4:C12, C7:C15	Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	253
SP-326	C3:C11, C6:C14	Asp^1-Aad^2-Cys^3-Glu^4-Leu^5-Cys^6-Val^7-Asn^8-Val^9-Ala^{10}-Cys^{11}-Thr^{12}-Gly^{13}-Cys^{14}-Leu^{15}	254
SP-327	C3:C11, C6:C14	Asp^1-Aad^2-Cys^3-Glu^4-Leu^5-Cys^6-Val^7-Asn^8-Val^9-Ala^{10}-Cys^{11}-Thr^{12}-Gly^{13}-Cys^{14}	255
SP-328	C2:C10, C5:C13	Aad^1-Cys^2-Glu^3-Leu^4-Cys^5-Val^6-Asn^7-Val^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}-Leu^{14}	256

	Disulfide	Sequence	No.
SP-329	C2:C10, C5:C13	Aad^1-Cys^2-Glu^3-Leu^4-Cys^5-Val^6-Asn^7-Val^8-Ala^9-Cys^{10}-Thr^{11}-Gly^{12}-Cys^{13}	257
SP332	C4:C12,C7:C15	Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	258
SP-333	C4:C12,C7:C15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	259
SP-334	C4:C12,C7:C15	$dAsn^1$-$dAsp^2$-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	260
SP-336	C4:C12,C7:C15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	261
SP-337	C4:C12,C7:C15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-$dLeu^6$-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	262
SP-338	C4:C12,C7:C15	Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}	263
SP-342	C4:C12,C7:C15	$PEG3$-Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$-$PEG3$	264
SP-343	C4:C12,C7:C15	$PEG3$-$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$-$PEG3$	265
SP-344	C4:C12,C7:C15	$PEG3$-$dAsn^1$-$dAsp^2$-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{15}$-$PEG3$	266
SP-347	C4:C12,C7:C15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$-$PEG3$	267
SP-348	C4:C12,C7:C15	$PEG3$-Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	268
SP-350	C4:C12,C7:C15	$PEG3$-$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	269
SP-352	C4:C12,C7:C15	Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$-$PEG3$	270
SP-359	C4:C12,C7:C15	$PEG3$-$dAsn^1$-$dAsp^2$-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	271
SP-360	C4:C12,C7:C15	$dAsn^1$-$dAsp^2$-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$-$PEG3$	272
SP-368	C4:C12,C7:C15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dNal^{16}$	273
SP-369	C4:C12,C7:C15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-AIB^8-Asn^9-AIB^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	274
SP-370	C4:C12, 7:15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-$Asp[Lactam]^7$-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Orn^{15}-$dLeu^{16}$	275
SP-371	C4:C12,C7:C15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Tyr^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	276
SP-372	C4:C12,C7:C15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Ser^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	277
N1	C4:C12,C7:C15	$PEG3$-$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Tyr^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$-$PEG3$	278
N2	C4:C12,C7:C15	$PEG3$-$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Tyr^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$	279
N3	C4:C12,C7:C15	$dAsn^1$-Asp^2-Aad^3-Cys^4-Glu^5-Tyr^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-$dLeu^{16}$-$PEG3$	280

N4	C4:C12,C7:C15	PEG3-dAsn^1-Asp^2-Aad^3-Cys^4-Glu^5-Ser^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	281
N5	C4:C12,C7:C15	PEG3-dAsn^1-Asp^2-Aad^3-Cys^4-Glu^5-Ser^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}	282
N6	C4:C12,C7:C15	dAsn^1-Asp^2-Aad^3-Cys^4-Glu^5-Ser^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu^{16}-PEG3	283
N7	C4:C12,C7:C15	Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	284
N8	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}-PEG3	285
N9	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	286
N10	C4:C12,C7:C15	Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}-PEG3	287
N11	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer^{16}-PEG3	288
N12	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer^{16}	289
N13	C4:C12,C7:C15	Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer^{16}-PEG3	290
Formula I (I-Aad)	C4:C12,C7:C15	Asn^1-Asp^2-Aad^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-Xaa^{16}	291
Formula II (II-Aad)	C4:C12,C7:C15	Xaa$_{n1}$-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-Xaa$_{n2}^{16}$	292
Formula III (III-Aad)	4:12,7:15	Xaa$_{n1}$-Maa^4-Glu^5-Xaa^6-Maa^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Maa^{12}-Thr^{13}-Gly^{14}-Maa^{15}-Xaa$_{n2}$	293
Formula IV (IV-Aad)	4:12,7:15	Xaa$_{n1}$-Maa^4-Xaa^5-Xaa^6-Maa^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Maa^{12}-Xaa^{13}-Xaa^{14}-Maa^{15}-Xaa$_{n2}$	294
Formula V (V-Aad)	C4:C12,C7:C15	Asn^1-Asp^2-Aad^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Asn^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-Xaa^{16}	295
Formula VI (VI-Aad)	C4:C12,C7:C15	dAsn^1-Glu^2-Aad^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Asn^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	296
Formula VII-a (VI-a-Aad)	C4:C12,C7:C15	dAsn^1-dGlu^2-Aad^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Asn^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	297

Name	Bonds	Sequence	No.
Formula VII-b (VI-b-Aad)	C4:C12,C7:C15	dAsn^1-dAsp^2-Aad^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Asn^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	298
Formula VIII (VIII-Aad)	C4:C12,C7:C15	dAsn^1-dAsp^2-Aad^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Tyr^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	299
Formula IX (IX-Aad)	C4:C12,C7:C15	dAsn^1-dGlu^2-Aad^3-Cys^4-Xaa^5-Xaa^6-Cys^7-Xaa^8-Tyr^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Cys^{15}-d-Xaa^{16}	300
Formula XXI (XXI-Aad)	C4:C12,C7:C15	Xaa$_{n1}$-Cys^4-Xaa^5-Xaa^6-Xaa^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Cys^{12}-Xaa^{13}-Xaa^{14}-Xaa^{15}-Xaa$_{n2}^{16}$	301
SP-363	C4:C12,C7:C15	dAsn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu-AMIDE^{16}	302
SP-364	C4:C12,C7:C15	dAsn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer^{16}	303
SP-365	C4:C12,C7:C15	dAsn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dSer-AMIDE^{16}	304
SP-366	C4:C12,C7:C15	dAsn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dTyr^{16}	305
SP-367	C4:C12,C7:C15	dAsn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dTyr-AMIDE^{16}	306
SP-373	C4:C12,C7:C15	Pyglu^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-dLeu-AMIDE^{16}	307
/	C4:C12,C7:C15	Pyglu^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	308
SP-304diPEG	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}-PEG3	309
SP-304N-PEG	C4:C12,C7:C15	PEG3-Asn^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	310
SP-304C-PEG	C4:C12,C7:C15	Asn^1-Asp^2-Glu^3-Cys^4-Aad^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}-PEG3	311
Formula XVIII (XVIII-Aad)	C4:C12,C7:C15	Xaa^1-Xaa^2-Aad^3-Maa^4-Xaa^5-Xaa^6-Maa^7-Xaa^8-Xaa^9-Xaa^{10}-Xaa^{11}-Maa^{12}-Xaa^{13}-Xaa^{14}-Maa^{15}-Xaa^{16}	312
N32	C4:C12,C7:C15	Glu^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	313

ID		Sequence	#
N34	C4:C12,C7:C15	Glu^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	314
N36	C4:C12,C7:C15	Asp^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	315
N38	C4:C12,C7:C15	Asp^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	316
N40	C4:C12,C7:C15	Gln^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	317
N42	C4:C12,C7:C15	Gln^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	318
N44	C4:C12,C7:C15	Lys^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	319
N46	C4:C12,C7:C15	Lys^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	320
N48	C4:C12,C7:C15	Glu^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	321
N50	C4:C12,C7:C15	Glu^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	322
N52	C4:C12,C7:C15	Asp^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	323
N54	C4:C12,C7:C15	Asp^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	324
N56	C4:C12,C7:C15	Gln^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	325
N58	C4:C12,C7:C15	Gln^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	326
N60	C4:C12,C7:C15	Lys^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	327
N62	C4:C12,C7:C15	Lys^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Val^8-Asn^9-Val^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	328
N65	C4:C12,C7:C15	Glu^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	329
N67	C4:C12,C7:C15	Glu^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	330
N69	C4:C12,C7:C15	Asp^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	331
N71	C4:C12,C7:C15	Asp^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	332
N73	C4:C12,C7:C15	Gln^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	333
N75	C4:C12,C7:C15	Gln^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	334
N77	C4:C12,C7:C15	Lys^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	335
N79	C4:C12,C7:C15	Lys^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Leu^{16}	336
N81	C4:C12,C7:C15	Glu^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	337

N83	C4:C12,C7:C15	Glu^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	338
N85	C4:C12,C7:C15	Asp^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	339
N87	C4:C12,C7:C15	Asp^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	340
N88	C4:C12,C7:C15	Asp^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	341
N89	C4:C12,C7:C15	Gln^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	342
N91	C4:C12,C7:C15	Gln^1-Glu^2-Asp^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	343
N92	C4:C12,C7:C15	Gln^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	344
N93	C4:C12,C7:C15	Lys^1-Asp^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	345
N95	C4:C12,C7:C15	Lys^1-Glu^2-Aad^3-Cys^4-Glu^5-Leu^6-Cys^7-Ile^8-Asn^9-Met^{10}-Ala^{11}-Cys^{12}-Thr^{13}-Gly^{14}-Cys^{15}-Ser^{16}	346

The GCRA peptides and derivative or analogs thereof described herein bind the guanylate cyclase C (GC-C) and stimulate intracellular production of cyclic guanosine monophosphate (cGMP). In some aspects, the GCRA peptides stimulate intracellular cGMP production at higher levels than naturally occurring GC-C agonists (*e.g.*, uroguanylin, guanylin,

5   lymphoguanylin and ST peptides).

For example, the GCRA peptides of the invention stimulate 5, 10%, 20%, 30%, 40%, 50% , 75%, 90% or more intracellular cGMP compared to naturally occurring GC-C agonists. The terms induced and stimulated are used interchangeably throughout the specification. The GCRA peptides described herein are more stable than naturally occurring GC-C agonists. By

10   more stable it is meant that the peptide degrades less and/or more slowly in simulated gastrointestinal fluid and/or simulated intestinal fluid compared to naturally occurring GC-C agonists. For example, the GCRA peptide of the invention degrade 2%, 3%, 5%, 10%, 15%, 20%, 30%, 40%, 50% , 75%, 90% or less compared to naturally occurring GC-C agonists.

As used herein, the term "guanylate cyclase receptor (GCR)" refers to the class of

15   guanylate cyclase C receptor on any cell type to which the inventive agonist peptides or natural agonists described herein bind. As used herein, "intestinal guanylate cyclase receptor" is found exclusively on epithelial cells lining the GI mucosa. Uroguanylin, guanylin, and ST peptides are expected to bind to these receptors and may induce apoptosis. The possibility that there may be different receptors for each agonist peptide is not excluded. Hence, the term refers to the class of

20   guanylate cyclase receptors on epithelial cells.

As used herein, the term "GCC agonist" is meant to refer to peptides and/or other compounds that bind to an intestinal guanylate cyclase receptor and stimulate fluid and electrolyte transport. This term also covers fragments and pro-peptides that bind to GCR and stimulate fluid and water secretion.

25   As used herein, the term "substantially equivalent" is meant to refer to a peptide that has an amino acid sequence equivalent to that of the binding domain where certain residues may be deleted or replaced with other amino acids without impairing the peptide's ability to bind to an intestinal guanylate cyclase receptor and stimulate fluid and electrolyte transport.

Addition of carriers (*e.g.*, phosphate-buffered saline or PBS) and other components to the

30   composition of the present invention is well within the level of skill in this art. In addition to the compound, such compositions may contain pharmaceutically acceptable carriers and other

ingredients known to facilitate administration and/or enhance uptake. Other formulations, such as microspheres, nanoparticles, liposomes, and immunologically-based systems may also be used in accordance with the present invention. Other examples include formulations with polymers (*e.g.*, 20% w/v polyethylene glycol) or cellulose, or enteric formulations.

5

GCRA PEPTIDES

In one aspect, the invention provides a GCRA peptide. The GCRA peptides are analogues uroguanylin, guanylin, lymphoguanylin and ST peptides. No particular length is implied by the term "peptide". In some embodiments, the GCRA peptide is less than 25 amino

10   acids in length, *e.g.*, less than or equal to 20, 15, 14, 13, 12, 11, 10, or 5 amino acid in length.

The GCRA peptides can be polymers of L-amino acids, D-amino acids, or a combination of both. For example, in various embodiments, the peptides are D retro-inverso peptides. The term "retro-inverso isomer" refers to an isomer of a linear peptide in which the direction of the sequence is reversed and the chirality of each amino acid residue is inverted. *See, e.g.*, Jameson

15   *et al.*, *Nature*, 368, 744-746 (1994); Brady *et al.*, Nature, 368, 692-693 (1994). The net result of combining D-enantiomers and reverse synthesis is that the positions of carbonyl and amino groups in each amide bond are exchanged, while the position of the side-chain groups at each alpha carbon is preserved. Unless specifically stated otherwise, it is presumed that any given L-amino acid sequence of the invention may be made into a D retro-inverso peptide by

20   synthesizing a reverse of the sequence for the corresponding native L-amino acid sequence. For example a GCRA peptide includes the sequence defined by Formulae I-XXI, their corresponding α-aminoadipic acid (Aad) derivatives (e.g., Formula I-Aad, II-Aad, III-Aad, IV-Aad, V-Aad, VI-Aad, VII-a-Aad, VII-b-Aad, VIII-Aad, IX-Aad, XVIII-Aad or XXI-Aad), as well as those amino acid sequence summarized below in Tables 1-8.

25   By inducing cGMP production is meant that the GCRA peptide induces the production of intracellular cGMP. Intracellular cGMP is measured by methods known in the art. For example, the GCRA peptide of the invention stimulate 5%, 10%, 20%, 30%, 40%, 50% , 75%, 90% or more intracellular cGMP compared to naturally occurring GC-C agonists. In some embodiments the GCRA peptides described herein are more stable than naturally occurring GC-

30   C agonists. By more stable it is meant that the peptide degrade less and/or more slowly in simulated gastric fluid and/or simulated intestinal fluid compared to naturally occurring GC-C

agonists. For example, the GCRA peptide of the invention degrade 2%, 3%, 5%, 10%, 15%, 20%, 30%, 40%, 50%, 75%, 90% or less compared to naturally occurring GC-C agonists.

As used herein PEG3, 3 PEG, is meant to denote polyethylene glycol such as include aminoethyloxy-ethyloxy-acetic acid (AeeA).

5   As used herein, the term "AMIDE" is meant to denote that the terminal carboxylic acid is replaced with an amide group, i.e., the terminal COOH is replaced with $CONH_2$.

As used herein (e.g., in Formulae I- XXI, their corresponding α-aminoadipic acid (Aad) derivatives represented by Formulae I-Aad, II-Aad, III-Aad, IV-Aad, V-Aad, VI-Aad, VII-a-Aad, VII-b-Aad, VIII-Aad, IX-Aad, XVIII-Aad or XXI-Aad), X_{aa} is any natural, unnatural

10   amino acid or amino acid analogue; M_{aa} is a Cysteine (Cys), Penicillamine (Pen), homocysteine, or 3-mercaptoproline. Xaa_{n1} is meant to denote an amino acid sequence of any natural, unnatural amino acid or amino acid analogue that is one, two or three residues in length; Xaa_{n2} is meant to denote an amino acid sequence of any natural, unnatural amino acid or amino acid analogue that is zero or one residue in length; and Xaa_{n3} is meant to denote an amino acid

15   sequence of any natural, unnatural amino acid or amino acid analogue that is zero, one, two, three, four, five or six residues in length. Additionally, any amino acid represented by Xaa, may be an L-amino acid, a D-amino acid, a methylated amino acid, a fluorinated amino acid or any combination of thereof. Preferably the amino acid at the N- terminus, C-terminus or both is a D-amino acid. Optionally, any GCRA peptide represented by Formulae I-XXI and their

20   corresponding α-aminoadipic acid (Aad) derivatives represented by Formulae I-Aad, II-Aad, III-Aad, IV-Aad, V-Aad, VI-Aad, VII-a-Aad, VII-b-Aad, VIII-Aad, IX-Aad, XVIII-Aad or XXI-Aad may contain on or more polyethylene glycol residues at the N- terminus, C-terminus or both. An exemplary polyethylene glycol includes aminoethyloxy-ethyloxy-acetic acid and polymers thereof. In some embodiments, any GCRA peptide represented by Formulae I-XXI

25   and their corresponding α-aminoadipic acid (Aad) derivatives represented by Formulae I-Aad, II-Aad, III-Aad, IV-Aad, V-Aad, VI-Aad, VII-a-Aad, VII-b-Aad, VIII-Aad, IX-Aad, XVIII-Aad or XXI-Aad may contain AMIDE at the c-terminus.

Specific examples of GCRA peptides that can be used in the methods and formulations of the invention include a peptide selected from the group designated by SEQ ID NOs: 1-346.

30   In some embodiments, GCRA peptides include peptides having the amino acid sequence of Formula I. In some embodiments, at least one amino acid of Formula I is a D-amino acid or a

27

methylated amino acid and/or the amino acid at position 16 is a serine. Preferably, the amino acid at position 16 of Formula I is a D-amino acid or a methylated amino acid. For example, the amino acid at position 16 of Formula I is a d-leucine or a d-serine. Optionally, one or more of the amino acids at positions 1-3 of Formula I are D-amino acids or methylated amino acids or a

5   combination of D-amino acids or methylated amino acids. For example, Asn^1, Asp^2 or Glu^3 (or a combination thereof) of Formula I is a D-amino acid or a methylated amino acid. Preferably, the amino acid at position Xaa^6 of Formula I is a leucine, serine or tyrosine.

In alternative embodiments, GCRA peptides include peptides having the amino acid sequence of Formula II. In some embodiments, at least one amino acid of Formula II is a D-

10 amino acid or a methylated amino acid. Preferably, the amino acid denoted by Xaa_{n2} of Formula II is a D-amino acid or a methylated amino acid. In some embodiments, the amino acid denoted by Xaa_{n2} of Formula II is a leucine, a d-leucine, a serine, or a d-serine. Preferably, the one or more amino acids denoted by Xaa_{n1} of Formula II are D-amino acids or methylated amino acids. Preferably, the amino acid at position Xaa^6 of Formula II is a leucine, a serine, or a tyrosine. In

15 some embodiments, Xaa^1 is a pyroglutamic acid. In some embodiments, Xaa^2 is glutamic acid or d-glutamic acid. In some embodiments, Xaa^3 is an aspartic acid or d-aspartic acid. In some embodiments, Xaa^8 and Xaa^{10} are AIB. In some embodiments, Xaa^9 is tyrosine. In some embodiments, Xaa^{16} is dNal.

In some embodiments, GCRA peptides include peptides having the amino acid sequence

20 of Formula III. In some embodiments, at least one amino acid of Formula III is a D-amino acid or a methylated amino acid and/or Maa is not a cysteine. Preferably, the amino acid denoted by Xaa_{n2} of Formula III is a D-amino acid or a methylated amino acid. In some embodiments the amino acid denoted by Xaa_{n2} of Formula III is a leucine, a d-leucine, a serine, or a d-serine. Preferably, the one or more amino acids denoted by Xaa_{n1} of Formula III are D-amino acids or

25 methylated amino acids. Preferably, the amino acid at position Xaa^6 of Formula III is a leucine, a serine, or a tyrosine. In some embodiments, Xaa^1 is a pyroglutamic acid. In some embodiments, Xaa^2 is glutamic acid or d-glutamic acid. In some embodiments, Xaa^3 is an aspartic acid or d-aspartic acid. In some embodiments, Xaa^{16} is dNal.

In other embodiments, GCRA peptides include peptides having the amino acid sequence

30 of Formula IV. In some embodiments, at least one amino acid of Formula IV is a D-amino acid or a methylated amino acid, and/or Maa is not a cysteine. Preferably, the Xaa_{n2} of Formula IV is

a D-amino acid or a methylated amino acid. In some embodiments, the amino acid denoted by Xaa_{n2} of Formula IV is a leucine, a d-leucine, a serine, or a d-serine. Preferably, the one or more of the amino acids denoted by Xaa_{n1} of Formula IV is a D-amino acid or a methylated amino acid. Preferably, the amino acid denoted Xaa^6 of Formula IV is a leucine, a serine, or a tyrosine.

In some embodiments, Xaa^1 is a pyroglutamic acid. In some embodiments, Xaa^2 is glutamic acid or d-glutamic acid. In some embodiments, Xaa^3 is an aspartic acid or d-aspartic acid. In some embodiments, Xaa^8 and Xaa^{10} are AIB. In some embodiments, Xaa^9 is tyrosine. In some embodiments, Xaa^{16} is dNal.

In further embodiments, GCRA peptides include peptides having the amino acid sequence of Formula V. In some embodiments, at least one amino acid of Formula V is a D-amino acid or a methylated amino acid. Preferably, the amino acid at position 16 of Formula V is a D-amino acid or a methylated amino acid. For example, the amino acid at position 16 (i.e., Xaa^{16}) of Formula V is a d-leucine or a d-serine. Optionally, one or more of the amino acids at position 1-3 of Formula V are D-amino acids or methylated amino acids or a combination of D-amino acids or methylated amino acids. For example, Asn^1, Asp^2 or Glu^3 (or a combination thereof) of Formula V is a D-amino acids or a methylated amino acid. Preferably, the amino acid denoted at Xaa^6 of Formula V is a leucine, a serine, or a tyrosine.

In additional embodiments, GCRA peptides include peptides having the amino acid sequence of Formula VI, VII, VIII, or IX. Preferably, the amino acid at position 6 of Formula VI, VII, VIII, or IX is a leucine, a serine, or a tyrosine. In some aspects the amino acid at position 16 of Formula VI, VII, VIII, or IX is a leucine or a serine. Preferably, the amino acid at position 16 of Formula V is a D-amino acid or a methylated amino acid.

In additional embodiments, GCRA peptides include peptides having the amino acid sequence of Formula X, XI, XII, XIII, XIV, XV, XVI or XVII. Optionally, one or more amino acids of Formulae X, XI, XII, XIII, XIV, XV, XVI or XVII are D-amino acids or methylated amino acids. Preferably, the amino acid at the carboxyl terminus of the peptides according to Formulae X, XI, XII, XIII, XIV, XV, XVI or XVII is a D-amino acid or a methylated amino acid. For example the amino acid at the carboxyl terminus of the peptides according to Formulae X, XI, XII, XIII, XIV, XV, XVI or XVII is a D-tyrosine.

Preferably, the amino acid denoted by Xaa^6 of Formula XIV is a tyrosine, phenylalanine or a serine. Most preferably the amino acid denoted by Xaa^6 of Formula XIV is a phenylalanine

or a serine. Preferably, the amino acid denoted by Xaa^4 of Formula XV, XVI or XVII is a tyrosine, a phenylalanine, or a serine. Most preferably, the amino acid position Xaa^4 of Formula V, XVI or XVII is a phenylalanine or a serine.

In some embodiments, GCRA peptides include peptides containing the amino acid sequence of Formula XVIII. Preferably, the amino acid at position 1 of Formula XVIII is a glutamic acid, aspartic acid, glutamine or lysine. Preferably, the amino acid at position 2 and 3 of Formula XVIII is a glutamic acid, or an aspartic acid. Preferably, the amino acid at position 5 is a glutamic acid. Preferably, the amino acid at position 6 of Formula XVIII is an isoleucine, valine, serine, threonine or tyrosine. Preferably, the amino acid at position 8 of Formula XVIII is a valine or isoleucine. Preferably, the amino acid at position 9 of Formula XVIII is an asparagine. Preferably, the amino acid at position 10 of Formula XVIII is a valine or a methionine. Preferably, the amino acid at position 11 of Formula XVIII is an alanine. Preferably, the amino acid at position 13 of Formula XVIII is a threonine. Preferably, the amino acid at position 14 of Formula XVIII is a glycine. Preferably, the amino acid at position 16 of Formula XVIII is a leucine, serine or threonine

In alternative embodiments, GCRA peptides include peptides containing the amino acid sequence of Formula XIX. Preferably, the amino acid at position 1 of Formula XIX is a serine or asparagine. Preferably, the amino acid at position 2 of Formula XIX is a histidine or an aspartic acid. Preferably, the amino acid at position 3 of Formula XIX is a threonine or a glutamic acid. Preferably, the amino acid at position 5 of Formula XIX is a glutamic acid. Preferably, the amino acid at position 6 of Formula XIX is an isoleucine, leucine, valine or tyrosine. Preferably, the amino acid at position 8, 10, 11, or 13 of Formula XIX is an alanine. Preferably, the amino acid at position 9 of Formula XIX is an asparagine or a phenylalanine. Preferably, the amino acid at position 14 of Formula XIX is a glycine.

In further embodiments, GCRA peptides include peptides containing the amino acid sequence of Formula XX. Preferably, the amino acid at position 1 of Formula XX is a glutamine. Preferably, the amino acid at position 2 or 3 of Formula XX is a glutamic acid or an aspartic acid. Preferably, the amino acid at position 5 of Formula XX is a glutamic acid. Preferably, the amino acid at position 6 of Formula XX is threonine, glutamine, tyrosine, isoleucine, or leucine. Preferably, the amino acid at position 8 of Formula XX is isoleucine or valine. Preferably, the amino acid at position 9 of Formula XX is asparagine. Preferably, the

30

amino acid at position 10 of Formula XX is methionine or valine. Preferably, the amino acid at position 11 of Formula XX is alanine. Preferably, the amino acid at position 13 of Formula XX is a threonine. Preferably, the amino acid at position 1 of Formula XX is a glycine. Preferably, the amino acid at position 15 of Formula XX is a tyrosine. Optionally, the amino acid at position 5 15 of Formula XX is two-amino acid in length and is Cysteine (Cys), Penicillamine (Pen) homocysteine, or 3-mercaptoproline and serine, leucine or threonine.

In some embodiments, GCRA peptides include peptides having the amino acid sequence of Formula XXI. In some embodiments, at least one amino acid of Formula XXI is a D-amino acid or a methylated amino acid. Preferably, the amino acid denoted by Xaa_{n2} of Formula XXI is 10 a D-amino acid or a methylated amino acid. In some embodiments, the amino acid denoted by Xaa_{n2} of Formula XXI is a leucine, a d-leucine, a serine, or a d-serine. Preferably, the one or more amino acids denoted by Xaa_{n1} of Formula XXI are D-amino acids or methylated amino acids. Preferably, the amino acid at position Xaa^6 of Formula XXI is a leucine, a serine, or a tyrosine. In some embodiments, Xaa^1 is a pyroglutamic acid. In some embodiments, Xaa^2 is 15 glutamic acid or d-glutamic acid. In some embodiments, Xaa^3 is an aspartic acid or d-aspartic acid. In some embodiments, Xaa^7 is an aspartic acid and forms a lactam bridge with Xaa^{15}. In some embodiments, Xaa^8 and Xaa^{10} are AIB. In some embodiments, Xaa^9 is tyrosine. In some embodiments, Xaa^{15} is an Orn. In some embodiments, Xaa^{16} is dNal.

The GCRA peptides of the invention also include analogs that contain an α-aminoadipic 20 acid (Aad), preferably at the 3rd position from the N-terminus of each peptide or at the position to the N-terminal side next to the first cysteine ("Cys") residue. In some embodiments, the GCRA peptide Aad derivatives include peptides having the amino acid sequences of Formula I-Aad, II-Aad, III-Aad, IV-Aad, V-Aad, VI-Aad, VII-a-Aad, VII-b-Aad, VIII-Aad, IX-Aad, XVIII-Aad or XXI-Aad (Table 8). Except the Aad replacement described herein, variations of 25 amino acid at each position of each Formula are the same as those described above in its corresponding Formula sequence without Aad. In some embodiments, when Xaa_{n1} represents one amino acid, Xaa_{n1} is an α-aminoadipic acid (Aad). In some embodiments, when Xaa_{n1} represents two amino acids, the second residue from the N-terminus is an α-aminoadipic acid (Aad). In some embodiments, when Xaa_{n1} represents three amino acids, the third residue from 30 the N-terminus is an α-aminoadipic acid (Aad). Exemplary Ad analogs are listed in Table 8.

In certain embodiments, one or more amino acids of the GCRA peptides can be replaced by a non-naturally occurring amino acid or a naturally or non-naturally occurring amino acid analog. There are many amino acids beyond the standard 20 (Ala, Arg, Asn, Asp, Cys, Gln, Glu, Gly, His, Ile, Leu, Lys, Met, Phe, Pro, Ser, Thr, Trp, Tyr, and Val). Some are naturally-

5   occurring others are not. (*See*, for example, Hunt, The Non-Protein Amino Acids: In Chemistry and Biochemistry of the Amino Acids, Barrett, Chapman and Hall, 1985). For example, an aromatic amino acid can be replaced by 3,4-dihydroxy-L-phenylalanine, 3-iodo-L-tyrosine, triiodothyronine, L-thyroxine, phenylglycine (Phg) or nor-tyrosine (norTyr). Phg and norTyr and other amino acids including Phe and Tyr can be substituted by, *e.g.*, a halogen, -CH3, -OH, -

10   CH2NH3, -C(O)H, -CH2CH3, - CN, -CH2CH2CH3, -SH, or another group. Any amino acid can be substituted by the D-form of the amino acid.

With regard to non-naturally occurring amino acids or naturally and non-naturally occurring amino acid analogs, a number of substitutions in the polypeptide and agonists described herein are possible alone or in combination.

15   For example, glutamine residues can be substituted with gamma-Hydroxy-Glu or gamma- Carboxy-Glu. Tyrosine residues can be substituted with an alpha substituted amino acid such as L-alpha-methylphenylalanine or by analogues such as: 3-Amino-Tyr; Tyr(CH3); Tyr(PO3(CH3)2); Tyr(SO3H); beta-Cyclohexyl-Ala; beta-(1-Cyclopentenyl)-Ala; beta-Cyclopentyl-Ala; beta-Cyclopropyl-Ala; beta-Quinolyl-Ala; beta-(2-Thiazolyl)-Ala; beta-

20   (Triazole-1-yl)-Ala; beta-(2-Pyridyl)-Ala; beta-(3-Pyridyl)-Ala; Amino-Phe; Fluoro-Phe; Cyclohexyl-Gly; tBu-Gly; beta-(3-benzothienyl)-Ala; beta-(2-thienyl)-Ala; 5-Methyl-Trp; and A- Methyl-Trp. Proline residues can be substituted with homopro (L-pipecolic acid); hydroxy-Pro; 3,4-Dehydro-Pro; 4-fluoro-Pro; or alpha-methyl-Pro or an N(alpha)-C(alpha) cyclized amino acid analogues with the structure: n = 0, 1, 2, 3 Alanine residues can be substituted with

25   alpha-substituted or N-methylated amino acid such as alpha-amino isobutyric acid (aib), L/D-alpha-ethylalanine (L/D-isovaline), L/D-methylvaline, or L/D-alpha-methylleucine or a non-natural amino acid such as beta-fluoro-Ala. Alanine can also be substituted with: n = 0, 1, 2, 3 Glycine residues can be substituted with alpha-amino isobutyric acid (aib) or L/D-alpha-ethylalanine (L/D-isovaline).

30   Further examples of unnatural amino acids include: an unnatural analog of tyrosine; an unnatural analogue of glutamine; an unnatural analogue of phenylalanine; an unnatural analogue

of serine; an unnatural analogue of threonine; an alkyl, aryl, acyl, azido, cyano, halo, hydrazine, hydrazide, hydroxyl, alkenyl, alkynl, ether, thiol, sulfonyl, seleno, ester, thioacid, borate, boronate, phospho, phosphono, phosphine, heterocyclic, enone, imine, aldehyde, hydroxylamine, keto, or amino substituted amino acid, or any combination thereof; an amino acid with a

5   photoactivatable cross-linker; a spin-labeled amino acid; a fluorescent amino acid; an amino acid with a novel functional group; an amino acid that covalently or noncovalently interacts with another molecule; a metal binding amino acid; an amino acid that is amidated at a site that is not naturally amidated, a metal-containing amino acid; a radioactive amino acid; a photocaged and/or photoisomerizable amino acid; a biotin or biotin-analogue containing amino acid; a

10   glycosylated or carbohydrate modified amino acid; a keto containing amino acid; amino acids comprising polyethylene glycol or polyether; a heavy atom substituted amino acid (*e.g.*, an amino acid containing deuterium, tritium, ^{13}C, ^{15}N, or ^{18}O); a chemically cleavable or photocleavable amino acid; an amino acid with an elongated side chain; an amino acid containing a toxic group; a sugar substituted amino acid, *e.g.*, a sugar substituted serine or the

15   like; a carbon-linked sugar-containing amino acid; a redox-active amino acid; an α-hydroxy containing acid; an amino thio acid containing amino acid; an α, α disubstituted amino acid; a β-amino acid; a cyclic amino acid other than proline; an O-methyl-L-tyrosine; an L-3-(2-naphthyl)alanine; a 3-methyl-phenylalanine; a ρ-acetyl-L-phenylalanine; an O-4-allyl-L-tyrosine; a 4-propyl-L-tyrosine; a tri-O-acetyl-GlcNAc β -serine; an L-Dopa; a fluorinated phenylalanine;

20   an isopropyl-L-phenylalanine; a p-azido-L-phenylalanine; a p-acyl-L-phenylalanine; a p-benzoyl-L-phenylalanine; an L-phosphoserine; a phosphonoserine; a phosphonotyrosine; a p-iodo-phenylalanine; a 4-fluorophenylglycine; a p-bromophenylalanine; a p-amino-L-phenylalanine; an isopropyl-L-phenylalanine; L-3-(2-naphthyl)alanine; D- 3-(2-naphthyl)alanine (dNal); an amino-, isopropyl-, or O-allyl-containing phenylalanine analogue; a dopa, 0-methyl-

25   L-tyrosine; a glycosylated amino acid; a p-(propargyloxy)phenylalanine; dimethyl-Lysine; hydroxy-proline; mercaptopropionic acid; methyl-lysine; 3-nitro-tyrosine; norleucine; pyro-glutamic acid; Z (Carbobenzoxyl); ε- Acetyl-Lysine; β -alanine; aminobenzoyl derivative; aminobutyric acid (Abu); citrulline; aminohexanoic acid; aminoisobutyric acid (AIB); cyclohexylalanine; d-cyclohexylalanine; hydroxyproline; nitro-arginine; nitro-phenylalanine;

30   nitro-tyrosine; norvaline; octahydroindole carboxylate; ornithine (Orn); penicillamine (PEN); tetrahydroisoquinoline; acetamidomethyl protected amino acids and pegylated amino acids.

Further examples of unnatural amino acids and amino acid analogs can be found in U.S. 20030108885, U.S. 20030082575, US20060019347 (paragraphs 410-418) and the references cited therein. The polypeptides of the invention can include further modifications including those described in US20060019347, paragraph 589.

5   In some embodiments, an amino acid can be replaced by a naturally-occurring, non-essential amino acid, *e.g.*, taurine.

Alternatively, the GCRA peptides are cyclic peptides. GCRA cyclic peptides are prepared by methods known in the art. For example, macrocyclization is often accomplished by forming an amide bond between the peptide N- and C-termini, between a side chain and the N-

10   or C-terminus [*e.g.*, with $K_3Fe(CN)_6$ at pH 8.5] (Samson *et al.*, *Endocrinology*, 137: 5182-5185 (1996)), or between two amino acid side chains, such as cysteine. See, *e.g.*, DeGrado, *Adv Protein Chem, 39*: 51-124 (1988). In various aspects the GCRA peptides are [4,12; 7,15] bicycles.

In some GCRA peptides one or both members of one or both pairs of Cys residues which

15   normally form a disulfide bond can be replaced by homocysteine, penicillamine, 3-mercaptoproline (Kolodziej et al. 1996 Int J Pept Protein Res 48:274); β, β dimethylcysteine (Hunt et al. 1993 Int JPept Protein Res 42:249) or diaminopropionic acid (Smith et al. 1978 J Med Chem 2 1:117) to form alternative internal cross-links at the positions of the normal disulfide bonds.

20   In addition, one or more disulfide bonds can be replaced by alternative covalent cross-links, *e.g.*, an amide linkage (-CH2CH(O)NHCH 2- or -CH2NHCH(O)CH 2-), an ester linkage, a thioester linkage, a lactam bridge , a carbamoyl linkage, a urea linkage, a thiourea linkage, a phosphonate ester linkage, an alkyl linkage (-CH2CH2CH2CH2-), an alkenyl linkage(-CH 2CH=CHCH 2-), an ether linkage (-CH2CH2OCH2- or -CH2OCH2CH2-), a thioether linkage (-

25   CH2CH2SCH2- or - CH2SCH2CH2-), an amine linkage (-CH2CH2NHCH2- or -CH2NHCH 2CH2-) or a thioamide linkage (-CH2CH(S)HNHCH 2- or -CH2NHCH(S)CH 2-). For example, Ledu et al. (Proc Nat'l Acad. Sci. 100:11263-78, 2003) describe methods for preparing lactam and amide cross-links. Exemplary GCRA peptides which include a lactam bridge include for example SP-370.

30   The GCRA peptides can have one or more conventional polypeptide bonds replaced by an alternative bond. Such replacements can increase the stability of the polypeptide. For

example, replacement of the polypeptide bond between a residue amino terminal to an aromatic residue (*e.g.* Tyr, Phe, Trp) with an alternative bond can reduce cleavage by carboxy peptidases and may increase half-life in the digestive tract. Bonds that can replace polypeptide bonds include: a retro-inverso bond (C(O)-NH instead of NH-C(O)); a reduced amide bond (NH-CH2);

5   a thiomethylene bond (S-CH2 or CH2-S); an oxomethylene bond (0-CH 2 or CH2-O); an ethylene bond (CH2-CH2); a thioamide bond (C(S)-NH); a trans-olefine bond (CH=CH); a fluoro substituted trans-olefme bond (CF=CH); a ketomethylene bond (C(O)-CHR or CHR-C(O) wherein R is H or CH3; and a fluoro-ketomethylene bond (C(O)-CFR or CFR-C(O) wherein R is H or F or CH3.

10   The GCRA peptides can be modified using standard modifications. Modifications may occur at the amino (N-), carboxyl (C-) terminus, internally or a combination of any of the preceding. In one aspect described herein, there may be more than one type of modification on the polypeptide. Modifications include but are not limited to: acetylation, amidation, biotinylation, cinnamoylation, farnesylation, formylation, myristoylation, palmitoylation,

15   phosphorylation (Ser, Tyr or Thr), stearoylation, succinylation, sulfurylation and cyclisation (via disulfide bridges or amide cyclisation), and modification by Cys3 or Cys5. The GCRA peptides described herein may also be modified by 2, 4-dinitrophenyl (DNP), DNP-lysine, modification by 7-Amino-4-methyl- coumarin (AMC), flourescein, NBD (7-Nitrobenz-2-Oxa-l,3-Diazole), p-nitro-anilide, rhodamine B, EDANS (5-((2-aminoethyl)amino)naphthalene-l- sulfonic acid),

20   dabcyl, dabsyl, dansyl, texas red, FMOC, and Tamra (Tetramethylrhodamine). The GCRA peptides described herein may also be conjugated to, for example, polyethylene glycol (PEG); alkyl groups (*e.g.*, C1-C20 straight or branched alkyl groups); fatty acid radicals; combinations of PEG, alkyl groups and fatty acid radicals (*See*, U.S. Patent 6,309,633; Soltero et al., 2001 Innovations in Pharmaceutical Technology 106-110); BSA and KLH (Keyhole Limpet

25   Hemocyanin). The addition of PEG and other polymers which can be used to modify polypeptides of the invention is described in US2006019347 section IX.

Also included in the invention are peptides that biologically or functional equivalent to the peptides described herein. The term "biologically equivalent" or functional equivalent" is intended to mean that the compositions of the present invention are capable of demonstrating

30   some or all of the cGMP production modulatory effects.

GCRA peptides can also include derivatives of GCRA peptides which are intended to include hybrid and modified forms of GCRA peptides in which certain amino acids have been deleted or replaced and modifications such as where one or more amino acids have been changed to a modified amino acid or unusual amino acid and modifications such as glycosylation so long

5   the modified form retains the biological activity of GCRA peptides. By retaining the biological activity, it is meant that cGMP and or apoptosis is induced by the GCRA peptide, although not necessarily at the same level of potency as that of a naturally-occurring GCRA peptide identified.

Preferred variants are those that have conservative amino acid substitutions made at one

10 or more predicted non-essential amino acid residues. A "conservative amino acid substitution" is one in which the amino acid residue is replaced with an amino acid residue having a similar side chain. Families of amino acid residues having similar side chains have been defined in the art. These families include amino acids with basic side chains (*e.g.*, lysine, arginine, histidine), acidic side chains (*e.g.*, aspartic acid, glutamic acid), uncharged polar side chains (*e.g.*, glycine,

15 asparagine, glutamine, serine, threonine, tyrosine, cysteine), nonpolar side chains (*e.g.*, alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan), beta-branched side chains (*e.g.*, threonine, valine, isoleucine) and aromatic side chains (*e.g.*, tyrosine, phenylalanine, tryptophan, histidine). Thus, a predicted nonessential amino acid residue in a GCRA polypeptide is replaced with another amino acid residue from the same side chain family. Alternatively, in

20 another embodiment, mutations can be introduced randomly along all or part of a GCRA coding sequence, such as by saturation mutagenesis, and the resultant mutants can be screened to identify mutants that retain activity.

Also included within the meaning of substantially homologous is any GCRA peptide which may be isolated by virtue of cross-reactivity with antibodies to the GCRA peptide.

25

PREPARATION OF GCRA PEPTIDES

GCRA peptides are easily prepared using modern cloning techniques, or may be synthesized by solid state methods or by site-directed mutagenesis. A GCRA peptide may include dominant negative forms of a polypeptide.

30 Chemical synthesis may generally be performed using standard solution phase or solid phase peptide synthesis techniques, in which a peptide linkage occurs through the direct

condensation of the amino group of one amino acid with the carboxyl group of the other amino acid with the elimination of a water molecule. Peptide bond synthesis by direct condensation, as formulated above, requires suppression of the reactive character of the amino group of the first and of the carboxyl group of the second amino acid. The masking substituents must permit their

5   ready removal, without inducing breakdown of the labile peptide molecule.

In solution phase synthesis, a wide variety of coupling methods and protecting groups may be used (*See*, Gross and Meienhofer, eds., "The Peptides: Analysis, Synthesis, Biology," Vol. 1-4 (Academic Press, 1979); Bodansky and Bodansky, "The Practice of Peptide Synthesis," 2d ed. (Springer Verlag, 1994)). In addition, intermediate purification and linear scale up are

10   possible. Those of ordinary skill in the art will appreciate that solution synthesis requires consideration of main chain and side chain protecting groups and activation method. In addition, careful segment selection is necessary to minimize racemization during segment condensation. Solubility considerations are also a factor. Solid phase peptide synthesis uses an insoluble polymer for support during organic synthesis. The polymer-supported peptide chain permits the

15   use of simple washing and filtration steps instead of laborious purifications at intermediate steps. Solid-phase peptide synthesis may generally be performed according to the method of Merrifield et al., J. Am. Chem. Soc., 1963, 85:2149, which involves assembling a linear peptide chain on a resin support using protected amino acids. Solid phase peptide synthesis typically utilizes either the Boc or Fmoc strategy, which is well known in the art.

20   Those of ordinary skill in the art will recognize that, in solid phase synthesis, deprotection and coupling reactions must go to completion and the side-chain blocking groups must be stable throughout the synthesis. In addition, solid phase synthesis is generally most suitable when peptides are to be made on a small scale.

Acetylation of the N-terminal can be accomplished by reacting the final peptide with

25   acetic anhydride before cleavage from the resin. C-amidation is accomplished using an appropriate resin such as methylbenzhydrylamine resin using the Boc technology.

Alternatively the GCRA peptides are produced by modern cloning techniques. For example, the GCRA peptides are produced either in bacteria including, without limitation, E. coli, or in other existing systems for polypeptide or protein production (*e.g.*, Bacillus subtilis,

30   baculovirus expression systems using Drosophila Sf9 cells, yeast or filamentous fungal expression systems, mammalian cell expression systems), or they can be chemically synthesized.

If the GCRA peptide or variant peptide is to be produced in bacteria, *e.g.*, E. coli, the nucleic acid molecule encoding the polypeptide may also encode a leader sequence that permits the secretion of the mature polypeptide from the cell. Thus, the sequence encoding the polypeptide can include the pre sequence and the pro sequence of, for example, a naturally-occurring

5   bacterial ST polypeptide. The secreted, mature polypeptide can be purified from the culture medium.

The sequence encoding a GCRA peptide described herein can be inserted into a vector capable of delivering and maintaining the nucleic acid molecule in a bacterial cell. The DNA molecule may be inserted into an autonomously replicating vector (suitable vectors include, for

10   example, pGEM3Z and pcDNA3, and derivatives thereof). The vector nucleic acid may be a bacterial or bacteriophage DNA such as bacteriophage lambda or M13 and derivatives thereof. Construction of a vector containing a nucleic acid described herein can be followed by transformation of a host cell such as a bacterium. Suitable bacterial hosts include but are not limited to, E. coli, B subtilis, Pseudomonas, Salmonella. The genetic construct also includes, in

15   addition to the encoding nucleic acid molecule, elements that allow expression, such as a promoter and regulatory sequences. The expression vectors may contain transcriptional control sequences that control transcriptional initiation, such as promoter, enhancer, operator, and repressor sequences.

A variety of transcriptional control sequences are well known to those in the art. The

20   expression vector can also include a translation regulatory sequence (*e.g.*, an untranslated 5' sequence, an untranslated 3' sequence, or an internal ribosome entry site). The vector can be capable of autonomous replication or it can integrate into host DNA to ensure stability during polypeptide production.

The protein coding sequence that includes a GCRA peptide described herein can also be

25   fused to a nucleic acid encoding a polypeptide affinity tag, *e.g.*, glutathione S-transferase (GST), maltose E binding protein, protein A, FLAG tag, hexa-histidine, myc tag or the influenza HA tag, in order to facilitate purification. The affinity tag or reporter fusion joins the reading frame of the polypeptide of interest to the reading frame of the gene encoding the affinity tag such that a translational fusion is generated. Expression of the fusion gene results in translation of a single

30   polypeptide that includes both the polypeptide of interest and the affinity tag. In some instances

where affinity tags are utilized, DNA sequence encoding a protease recognition site will be fused between the reading frames for the affinity tag and the polypeptide of interest.

Genetic constructs and methods suitable for production of immature and mature forms of the GCRA peptides and variants described herein in protein expression systems other than

5   bacteria, and well known to those skilled in the art, can also be used to produce polypeptides in a biological system.

The peptides disclosed herein may be modified by attachment of a second molecule that confers a desired property upon the peptide, such as increased half-life in the body, for example, pegylation. Such modifications also fall within the scope of the term "variant" as used herein.

10

COMPOSITIONS

The present invention also provides compositions comprising at least one GCRA peptide (*i.e.*, GCC agonist peptide) described herein, at least one enteric coating which releases the peptide at a specific pH (*e.g.*, about pH 4.0, pH 5.0, pH 6.0 or pH 7.0) and an inert carrier.

15   A composition may comprise an enteric coating which releases the peptide at pH5 and an inert carrier coated with GCRA peptides.

A composition may comprise an enteric coating which releases the peptide at pH6 and an inert carrier coated with GCRA peptides.

A composition may comprise an enteric coating which releases the peptide at pH7 and an

20   inert carrier coated with GCRA peptides.

The present invention further provides a formulation comprising a mixture of compositions that contain different peptides and/or that release the peptides at different pH levels. The mixture may comprise at least 2, 3, 4 or more compositions that release the peptides at different pH levels. The mixture may comprise at least 2, 3, 4 or more compositions that

25   contain different GCRA peptides. A skilled artisan can determine the ratio of these compositions within the mixture, for example, according to the activity of each peptide, solubility of each peptide, and/or the targeting region of the GI tract.

In some embodiments, a formulation comprises a mixture of (1) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at

30   pH5.0 ("pH5.0 composition") and (2) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at pH6.0 ("pH6.0 composition").

The ratio of pH5.0 composition to pH6.0 composition can be any value between 100:1 (v/v) and 1: 100 (v/v) and can be determined, for example, by the activity of each peptide, solubility of each peptide, and/or the targeting region of the GI tract. In some embodiments, the ratio of pH5.0 composition to pH6.0 composition is 10:1, 9:1, 8:1, 7:1, 6:1, 5:1, 4:1, 3:1, 2: 1, 1:

5   1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7, 1:8, 1:9, or 1:10.

In some embodiments, a formulation comprises a mixture of (1) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at pH5.0 ("pH5.0 composition") and (2) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at pH7.0 ("pH7.0 composition").

10   The ratio of pH5.0 composition to pH7.0 composition can be any value between 100:1 (v/v) and 1: 100 (v/v) and can be determined, for example, by the activity of each peptide, solubility of each peptide, and/or the targeting region of the GI tract. In some embodiments, the ratio of pH5.0 composition to pH7.0 composition is 10:1, 9:1, 8:1, 7:1, 6:1, 5:1, 4:1, 3:1, 2: 1, 1: 1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7, 1:8, 1:9, or 1:10.

15   In some embodiments, a formulation comprises a mixture of (1) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at pH6.0 ("pH6.0 composition") and (2) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at pH7.0 ("pH7.0 composition").

The ratio of pH6.0 composition to pH7.0 composition can be any value between 100:1

20   (v/v) and 1: 100 (v/v) and can be determined, for example, by the activity of each peptide, solubility of each peptide, and/or the targeting region of the GI tract. In some embodiments, the ratio of pH6.0 composition to pH7.0 composition is 10:1, 9:1, 8:1, 7:1, 6:1, 5:1, 4:1, 3:1, 2: 1, 1: 1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7, 1:8, 1:9, or 1:10.

In some embodiments, a formulation comprises a mixture of (1) a composition having an

25   inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at pH5.0 ("pH5.0 composition"); (2) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at pH6.0 ("pH6.0 composition") and (3) a composition having an inert carrier coated with GCRA and an enteric coating that releases the peptides at pH7.0 ("pH7.0 composition").

The ratio of pH5.0 composition to pH6.0 composition to pH7.0 composition can be determined, for example, by the activity of each peptide, solubility of each peptide, and/or the targeting region of the GI tract.

In some embodiments, a formulation comprises a mixture of (1) a composition having an
5   inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at duodenum or jejunum ("duodenum composition") and (2) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides at ileum, terminal ileum, or ascending colon ("ileum composition").

In some embodiments, a formulation comprises a mixture of (1) a composition having an
10 inert carrier coated with GCRA peptides and an enteric coating that releases the peptides in a pH range of 4.5 to 5.5 or in a pH range of 5.5 to 6.5 at duodenum or jejunum ("duodenum composition"); and (2) a composition having an inert carrier coated with GCRA peptides and an enteric coating that releases the peptides in a pH range of 5.5 to 6.5 or in a pH range of 6.5 to 7.5 at ileum, terminal ileum, or ascending colon ("ileum composition").

15 The ratio of duodenum composition to ileum composition can be any value between 100:1 (v/v) and 1: 100 (v/v) and can be determined, for example, by the activity of each peptide, solubility of each peptide, and/or the targeting region of the GI tract. In some embodiments, the ratio of duodenum composition to ileum composition is 10:1, 9:1, 8:1, 7:1, 6:1, 5:1, 4:1, 3:1, 2: 1, 1: 1, 1:2, 1:3, 1:4, 1:5, 1:6, 1:7, 1:8, 1:9, or 1:10.

20 The targeting region of the GI tract includes, but is not limited to, duodenum, jejunum, ileum, terminal ileum, and ascending colon.

The GCRA peptides that can be used in the methods and formulations of the invention include a peptide selected from the group designated by SEQ ID NOs: 1-346. Preferably, the GCRA peptide is SEQ ID NO: 1, 9, 55 or 56. In some embodiments, the inert carrier is selected
25 from the group consisting of sorbitol, mannitol, EMDEX, and starch. In some embodiments, the carrier is mannitol (*e.g.*, MANNOGEM) or microcrystalline cellulose (*e.g.*, PROSOLV, CELPHERE®, CELPHERE® beads). In a preferred embodiment, the carrier is microcrystalline cellulose spheres or spherical microcrystalline cellulose, such as Celphere® SCP-100.

The enteric coating material is chosen to target the release of the composition of the
30 present invention to a specific region of the gastrointestinal tract. The enteric coating material

preferably comprises one of the following: (1) a pH dependent polymer; (2) a swellable polymer; or (3) a degradable composition.

In some embodiments, the enteric coating material is an enteric coating which releases the peptides at pH5.

In some embodiments, the enteric coating material is an enteric coating which releases the peptides at pH6.

In some embodiments, the enteric coating material is an enteric coating which releases the peptides at pH 7.

In accordance with the invention, the enteric coating chosen for the formulation is any coating which will achieve the targeting objective of the formulation. Examples of suitable enteric coatings include, but are not limited to, the following: (1) acrylic polymers (anionic polymers of methacrylic acid and methacrylates polymers with methacrylic acid as a functional group) such as the EUDRAGIT® (Degussa) polymers, *e.g.*, for release in the duodenum (dissolution above pH 5.5), EUDRAGIT® L 100-55 and EUDRAGIT® L 30 D-55; for release in the jejunum (dissolution above pH 6.0), EUDRAGIT® L 100; for release in the ileum (dissolution above pH 7), EUDRAGIT® S 100 and EUDRAGIT® FS 30, and COLORCON ACRYL-EZE®; (2) polyvinyl Acetate Phthalate (PVAP) including the COLORCON SURETERIC® Aqueous Enteric Coating System, and the COLORCON OPADRY® Enteric Coating System; (3) hypromellose Phthalate, NF (Hydroxy Propyl Methyl Cellulose Phthtalate; HPMCP; HP-55 Shin-Etsu); (4) cellulose acetate phthalate (CAP), such as AQUACOAT® CPD; and (5) cellulose acetate trimellitate (CAT). Further examples of suitable enteric coatings include, without limitation, sustained release blends such as EUDRACOL, EUDRAPULSE, and EUDRAMODE, as well as sustained release polymers such as the EUDRAGIT® RL, RS, and NE polymers.

In certain embodiments, the formulations of the invention comprise a pH-dependent targeting material that is pharmacologically inactive, meaning that it is excreted without being absorbed or metabolized. In some embodiments, the GCRA peptide-loaded composition is coated with a pH-dependent material. In some embodiments, the GCRA peptide-loaded composition is formed as a matrix with a pH-dependent material. Preferably, the pH-dependent material comprises a pH-dependent polymer.

Preferably, the pH-dependent polymer is stable in the low pH environment of the stomach (*i.e.*, at pH 1-2) and begins to disintegrate at the higher pH of the small intestine (pH 6-7) or distal ileum (pH 7-8). In certain embodiments, the polymer begins to disintegrate at pH 4.5-4.8, pH 4.8-5.0, pH 5.0-5.2, pH 5.2-5.4, pH 5.4-5.8, pH 5.8-6.0, pH 6.0-6.2, pH 6.2-6.4, pH 6.4-6.6, pH 6.6-6.8, pH 6.8-7.0, pH 7.0-7.2, or pH 7.2-7.4. In certain embodiments, the polymer begins to disintegrate at pH 4.5-5.5, pH 5.5-6.5, or pH 6.5-7.5. The pH at which a pH-sensitive polymer begins to disintegrate is also referred to herein as the "threshold pH" of the polymer.

In certain embodiments, the pH-dependent polymer is a methacrylic acid copolymer, a polyvinyl acetate phthalate, a hydroxypropylmethylcellulose phthalate, a cellulose acetate trimelliate, a cellulose acetate phthalate, or a hydroxypropyl methyl cellulose acetate succinate.

In a preferred embodiment, the pH-dependent polymer is a methacrylic acid copolymer selected from among the EUDRAGIT® polymers. EUDRAGIT® polymers are available in a wide range of different concentrations and physical forms, including aqueous solutions, aqueous dispersion, organic solutions, and solid substances. The pharmaceutical properties of the polymers are determined by the chemical properties of their functional groups. For example, EUDRAGIT® L, S, FS and E polymers have acidic or alkaline groups that are pH-dependent. Enteric EUDRAGIT® coatings provide protection against release of the GCRA peptide in the stomach and enable controlled release in the intestine. In certain embodiments, anionic EUDRAGIT® grades containing carboxyl groups are mixed with each other to provide pH-dependent release of the GCRA peptide. In certain embodiments, EUDRAGIT® L and S grades are used for enteric coatings. In one embodiment, EUDRAGIT® FS 30D is used for controlled release in the colon. The various EUDRAGIT® polymers are further described in international pharmacopeias such as Ph.Eur., USP/NF, DMF and JPE.

In specific embodiments, the pH-dependent polymer is a methacrylic acid copolymer selected from EUDRAGIT® L100, having a threshold pH of 6.0; EUDRAGIT® S100, having a threshold pH of 7.0; EUDRAGIT® L-30D, having a threshold pH of 5.6; EUDRAGIT® FS 30D, having a threshold pH of 6.8; or EUDRAGIT® L100-55, having a threshold pH of 5.5, or a combination thereof.

In one embodiment, the GCRA peptide formulation comprises a targeting material which provides a controlled (time-dependent) release of the GCRA peptide. Controlled release in this

context includes delayed sustained release, delayed controlled release, delayed slow release, delayed prolonged release, delayed extended release, and a sudden release or "burst."

Preferably, the controlled release formulation comprises a slowly disintegrating composition comprising the GCRA peptide surrounded by the targeting material. The targeting material preferably comprises at least one swellable polymer. Non-limiting examples of swellable polymers for use in a controlled release formulation of the invention include acrylic copolymers, e.g., EUDRAGIT® RL, EUDRAGIT® RS, or EUDRAGIT® NE; polyvinylacetate, e.g., KOLLICOAT® SR 30D; and cellulose derivatives such as ethylcellulose or cellulose acetate, e.g., SURELEASE® and AQUACOAT® ECD. In a preferred embodiment, the targeting material comprises one or more of EUDRAGIT® RL, EUDRAGIT® RS, or EUDRAGIT® NE to provide controlled time release of the GCRA peptide by pH-independent swelling. In a particular embodiment, the targeting material comprises EUDRAGIT® RL:RS (2:8) and an outing coating comprising EUDRAGIT® FS.

Further non-limiting examples of swellable polymers that can be used in the sustained release formulations of the invention include poly(hydroxalkyl methacrylate) having a molecular weight of from 30,000 to 5,000.000; kappa-carrageenan; polyvinylpyrrolidone having a molecular weight of from 10,000 to 360,000; anionic and cationic hydrogels; polyelectrolyte complexes; poly(vinyl alcohol) having low amounts of acetate, cross-linked with glyoxal, formaldehyde, or glutaraldehyde and having a degree of polymerization from 200 to 30,000; a mixture comprising methyl cellulose, cross-linked agar and carboxymethyl cellulose; a water-insoluble, water-swellable copolymer produced by forming a dispersion of finely divided maleic anhydride with styrene, ethylene, propylene, butylene or isobutylene; water-swellable polymers of N-vinyl lactams; polysaccharide, water swellable gums, high viscosity hydroxylpropylmethyl cellulose and/or mixtures thereof. In certain embodiments, the swellable polymer is selected from the group consisting of calcium pectinate, cross-linked polysaccharide, water insoluble starch, microcrystalline cellulose, water insoluble cross-linked peptide, water insoluble cross-linked protein, water insoluble cross-linked gelatin, water insoluble cross-linked hydrolyzed gelatin, water insoluble cross-linked collagen, modified cellulose, and cross-linked polyacrylic acid. Non-limiting examples of a cross-linked polysaccharide include insoluble metal salts or cross-linked derivatives of alginate, pectin, xantham gum, guar gum, tragacanth gum, and locust bean gum, carrageenan, metal salts thereof, and covalently cross-linked derivatives thereof.

Non-limiting examples of modified cellulose include cross-linked derivatives of hydroxypropylcellulose, hydroxypropylmethylcellulose, hydroxyethylcellulose, methylcellulose, carboxymethylcellulose, and metal salts of carboxymethylcellulose.

In certain embodiments, the swellable composition also comprises a wicking agent such as silicon dioxide. The wicking agent may also be selected from a disintegrant such as microcrystalline cellulose to enhance the speed of water uptake. Other suitable wicking agents include, but are not limited to, kaolin, titanium dioxide, fumed silicon dioxide, alumina, niacinamide, sodium lauryl sulfate, low molecular weight polyvinyl pyrrolidone, m-pyrol, bentonite, magnesium aluminum silicate, polyester, polyethylene, and mixtures thereof.

In certain embodiments, the targeting material, which may comprise part of the composition and/or form one or more layers coating the composition, optionally further comprises at least one of a lubricant, a flow promoting agent, a plasticizer, an anti-sticking agent, surfactant, wetting agent, suspending agent and dispersing agent.

In certain embodiments, the targeting material comprises a water insoluble polymer and a pore-forming agent. Non-limiting examples of pore forming agents include saccharose, sodium chloride, potassium chloride, polyvinylpyrrolidone, and/or polyethyleneglycol, water soluble organic acids, sugars and sugar alcohol. In certain embodiments, the pore forming agent forms part of an outer layer or coating. In other embodiments, the pore forming agent is distributed uniformly throughout the water insoluble polymer.

In one embodiment, the targeting material comprises a compression coating. Non-limiting examples of materials that can be used as a compression coating include a gum selected from the group consisting of xanthan gum, locust bean gum, galactans, mannans, alginates, gum karaya, pectin, agar, tragacanth, accacia, carrageenan, tragacanth, chitosan, agar, alginic acid, hydrocolloids acacia catechu, salai guggal, indian bodellum, copaiba gum, asafetida, cambi gum, Enterolobium cyclocarpum, mastic gum, benzoin gum, sandarac, gambier gum, butea frondosa (Flame of Forest Gum), myrrh, konjak mannan, guar gum, welan gum, gellan gum, tara gum, locust bean gum, carageenan gum, glucomannan, galactan gum, sodium alginate, tragacanth, chitosan, xanthan gum, deacetylated xanthan gum, pectin, sodium polypectate, gluten, karaya gum, tamarind gum, ghatti gum, Accaroid/Yacca/Red gum, dammar gum, juniper gum, ester gum, ipil-ipil seed gum, gum talha (acacia seyal), and cultured plant cell gums including those of the plants of the genera: acacia, actinidia, aptenia, carbobrotus, chickorium, cucumis, glycine,

hibiscus, hordeum, letuca, lycopersicon, malus, medicago, mesembryanthemum, oryza, panicum, phalaris, phleum, poliathus, polycarbophil, sida, solanum, trifolium, trigonella, Afzelia africana seed gum, Treculia africana gum, detarium gum, cassia gum, carob gum, Prosopis africana gum, Colocassia esulenta gum, Hakea gibbosa gum, khaya gum, scleroglucan, and zea, as well as

5   mixtures of any of the foregoing.

In some embodiments, the targeting material further comprises a plasticizer, a stiffening agent, a wetting agent, a suspending agent, or a dispersing agent, or a combination thereof. Non-limiting examples of a plasticizer include dibutyl sebacate, polyethylene glycol and polypropylene glycol, dibutyl phthalate, diethyl phthalate, triethyl citrate, tributyl citrate,

10   acetylated monoglyceride, acetyl tributyl citrate, triacetin, dimethyl phthalate, benzyl benzoate, butyl and/or glycol esters of fatty acids, refined mineral oils, oleic acid, castor oil, corn oil, camphor, glycerol and sorbitol or a combination thereof. In one embodiment, the stiffening agent comprises cetyl alcohol. Non-limiting examples of wetting agents include a poloxamer, polyoxyethylene ethers, polyoxyethylene sorbitan fatty acid esters, polyoxymethylene stearate,

15   sodium lauryl sulfate, sorbitan fatty acid esters, benzalkonium chloride, polyethoxylated castor oil, and docusate sodium. Non-limiting examples of suspending agents include alginic acid, bentonite, carbomer, carboxymethylcellulose, carboxymethylcellulose calcium, hydroxyethylcellulose, hydroxypropylcellulose, microcrystalline cellulose, colloidal silicon dioxide, dextrin, gelatin, guar gum, xanthan gum, kaolin, magnesium aluminum silicate, maltitol,

20   medium chain triglycerides, methylcellulose, polyoxyethylene sorbitan fatty acid esters, polyvinylpyrrolidinone, propylene glycol alginate, sodium alginate, sorbitan fatty acid esters, and tragacanth. Non-limiting examples of dispersing agents include poloxamer, polyoxyethylene sorbitan fatty acid esters and sorbitan fatty acid esters.

In certain embodiments, the targeted release formulation further comprises an outer

25   enteric coating over the targeted release material. Preferably, the outer enteric coating is selected from the group consisting of cellulose acetate phthalate, hydroxy propyl methyl cellulose acetate succinate, EUDRAGIT® L100 and EUDRAGIT® L30D-55.

In one embodiment, the GCRA peptide formulation is a time-delayed formulation designed to release the GCRA peptide in a fast burst in the colon or small intestine ("burst

30   formulation"). The formulation comprises a core and an outer layer. The composition comprises at least one GCRA peptide and at least one burst controlling agent. In certain embodiments, the

composition further comprises at least one disintegrant selected from the group consisting of croscarmellose sodium, crospovidone (cross-linked PVP), sodium carboxymethyl starch (sodium starch glycolate), cross-linked sodium carboxymethyl cellulose (Croscarmellose), pregelatinized starch (starch 1500), microcrystalline starch, water insoluble starch, calcium carboxymethyl

5   cellulose, and magnesium aluminum silicate, or a combination thereof. In other embodiments, the composition further comprises at least one of an absorption enhancer, a binder, a hardness enhancing agent, a buffering agent, a filler, a flow regulating agent, a lubricant, a synergistic agent, a chelator, an antioxidant, a stabilizer and a preservative. Optionally, the composition also comprises one or more other excipients.

10   The burst controlling agent in the composition preferably comprises a water insoluble polymer for controlling the rate of penetration of water into the composition and raising the internal pressure (osmotic pressure) inside the composition. Such a burst controlling agent is preferably able to swell upon contact with liquid. Non-limiting examples of suitable water insoluble polymers include cross-linked polysaccharide, water insoluble starch, microcrystalline

15   cellulose, water insoluble cross-linked peptide, water insoluble cross-linked protein, water insoluble cross-linked gelatin, water insoluble cross-linked hydrolyzed gelatin, water insoluble cross-linked collagen modified cellulose, and cross-linked polyacrylic acid. In one embodiment, the water insoluble polymer is a cross-linked polysaccharide selected from the group consisting of insoluble metal salts or cross-linked derivatives of alginate, pectin, xanthan gum, guar gum,

20   tragacanth gum, and locust bean gum, carrageenan, metal salts thereof, and covalently cross-linked derivatives thereof. In one embodiment, the water insoluble polymer is modified cellulose selected from the group consisting of cross-linked derivatives of hydroxypropylcellulose, hydroxypropylmethylcellulose, hydroxyethylcellulose, methylcellulose, carboxymethylcellulose, and metal salts of carboxymethylcellulose. In another embodiment, the

25   water insoluble polymer is selected from calcium pectinate, microcrystalline cellulose, or a combination thereof.

The outer layer comprises a water insoluble hydrophobic carrier and a pore forming agent comprised of a water insoluble hydrophilic particular matter. The pore forming agent is a water permeable agent which allows entry of liquid into the core. Optionally, the outer layer further

30   comprises at least one of a wetting agent, a suspending agent, a dispersing agent, a stiffening age and a plasticizer.

In certain embodiments, the water insoluble hydrophobic carrier is selected from the group consisting of a dimethylaminoethylacrylate/ethylmethacrylate copolymer, the copolymer being based on acrylic and methacrylic acid esters with a low content of quaternary ammonium groups, wherein the molar ratio of the ammonium groups to the remaining neutral (meth)acrylic acid esters is approximately 1:20, the polymer corresponding to USP/NF "Ammonio Methacrylate Copolymer Type A", an ethylmethacrylate/chlorotrimethylammoniumethyl methacrylate copolymer, the copolymer based on acrylic and methacrylic acid esters with a low content of quaternary ammonium groups wherein the molar ratio of the ammonium groups to the remaining neutral (meth)acrylic acid esters is 1:40, the polymer corresponding to USP/NF "Ammonio Methacrylate Copolymer Type B", a dimethylaminoethylmethacrylate /methylmethacrylate and butylmethacrylate copolymer, a copolymer based on neutral methacrylic acid esters and dimethylaminoethyl methacrylate esters wherein the polymer is cationic in the presence of acids, an ethylacrylate and methylacrylate/ethylmethacrylate and methyl methylacrylate copolymer, the copolymer being a neutral copolymer based on neutral methacrylic acid and acrylic acid esters, ethylcellulose, shellac, zein, and waxes.

In certain embodiments, the water insoluble particulate matter is a hydrophilic yet water insoluble polymer, preferably selected from the group consisting of a water insoluble cross-linked polysaccharide, a water insoluble cross-linked protein, a water insoluble cross-linked peptide, water insoluble cross-linked gelatin, water insoluble cross-linked hydrolyzed gelatin, water insoluble cross-linked collagen, water insoluble cross linked polyacrylic acid, water insoluble cross-linked cellulose derivatives, water insoluble cross-linked polyvinyl pyrrolidone, micro crystalline cellulose, insoluble starch, micro crystalline starch and a combination thereof. Most preferably, the water insoluble particulate matter is microcrystalline cellulose.

In another embodiment, the GCRA peptide containing composition comprises a GCRA peptide covalently conjugated to a carrier molecule such that the covalent bond between the GCRA peptide and the carrier is stable in the stomach and small intestine but labile in the lower gastrointestinal tract, especially the colon. The GCRA peptide covalently linked to a carrier molecule is referred to as the "GCC prodrug." In certain embodiments, the GCC prodrug comprises a GCRA peptide covalently conjugated to a carrier molecule via an azo bond or a glycosidic bond. In other embodiments, the GCC prodrug comprises a glucuronide, a cyclodextrin, a dextran ester, or a polar amino acid. In certain embodiments, the GCC prodrug is

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a polymeric prodrug. In one embodiment, the polymeric prodrug comprises polyamides containing azo groups.

FORMULATIONS

The formulations of the invention contain one or more GCRA peptides described herein, in combination with one or more pharmaceutically acceptable carriers (also referred to as diluents) and/or excipients. In a preferred embodiment, the formulations of the invention include an inert carrier. The inert carrier is preferably non-hygroscopic. In one embodiment, the carrier in the formulation contains few or no reducing sugars and is substantially free of contaminants including, but not limited to, iron, peroxide, and formaldehyde. In one embodiment, the carrier is selected from the group consisting of sorbitol, mannitol, EMDEX, and starch. In one embodiment, the carrier is mannitol (*e.g.*, MANNOGEM) or microcrystalline cellulose (*e.g.* PROSOLV, CELPHERE®, CELPHERE® beads).

The formulations of the invention comprise a mixture of the compositions described herein and one or more pharmaceutically acceptable carriers (also referred to as diluents) and/or excipients.

The remainder of the formulation is comprised of the carrier and one or more optional excipients. In one embodiment, the amount of carrier is at least 90% of the total weight of the formulation. In another embodiment, the amount of carrier is at least 95% or at least 98% of the total weight of the formulation. In one embodiment, the amount of carrier is between 90 and 99.9% of the total weight of the formulation. In one embodiment, the one or more optional excipients comprise a disintegrant which is present at 1 to 5% of the total weight of the formulation. In one embodiment, the one or more optional excipients comprise a lubricant which is present at 0.02 to 5% of the total weight of the formulation. In one embodiment, the one or more optional excipients comprise an amino acid such as leucine, isoleucine, valine, histidine, phenylalanine, alanine, glutamic acid, aspartic acid, glutamine, methionine, asparagine, tyrosine, threonine, tryptophan, or glycine, which is present at 0.1 to 4% (*e.g.*, 0.1-1%) of the total weight of the formulation. In one embodiment, the molar ratio between the amino acid and the GCRA peptide is from about 2:1 to about 20:1 (*e.g.*, 5:1). In one embodiment, the one or more optional excipients comprise a stabilizer such as a divalent cation salt, more specifically, a water-soluble divalent cation salt *(e.g.,* calcium chloride, magnesium chloride, zinc chloride, manganese

chloride), which is present at 0.1 to 12% (*e.g.*, 0.1-4%) of the total weight of the formulation. In one embodiment, the molar ratio between the salt and the GCRA peptide is from about 5:1 to about 20:1 (*e.g.*, 10:1).

The formulations may contain other additives as needed, including for example lactose, glucose, fructose, galactose, trehalose, sucrose, maltose, raffnose, maltitol, melezitose, stachyose, lactitol, palatinite, starch, xylitol, mannitol, myoinositol, and the like, and hydrates thereof, and amino acids, for example alanine, glycine and betaine, and polypeptides and proteins, for example albumen.

Further examples of pharmaceutically acceptable carriers and excipients include, but are not limited to binders, fillers, disintegrants, lubricants, anti-microbial agents, and coating agents such as: BINDERS: corn starch, potato starch, other starches, gelatin, natural and synthetic gums such as acacia, xanthan, sodium alginate, alginic acid, other alginates, powdered tragacanth, guar gum, cellulose and its derivatives (*e.g.*, ethyl cellulose, cellulose acetate, carboxymethyl cellulose calcium, sodium carboxymethyl cellulose), polyvinyl pyrrolidone (*e.g.*, povidone, crospovidone, copovidone, etc), methyl cellulose, Methocel, pre-gelatinized starch (*e.g.*, STARCH 1500® and STARCH 1500 LM®, sold by Colorcon, Ltd.), hydroxypropyl methyl cellulose, microcrystalline cellulose (FMC Corporation, Marcus Hook, PA, USA), or mixtures thereof, FILLERS: talc, calcium carbonate (*e.g.*, granules or powder), dibasic calcium phosphate, tribasic calcium phosphate, calcium sulfate (*e.g.*, granules or powder), microcrystalline cellulose, powdered cellulose, dextrates, kaolin, mannitol, silicic acid, sorbitol, starch, pre-gelatinized starch, dextrose, fructose, honey, lactose anhydrate, lactose monohydrate, lactose and aspartame, lactose and cellulose, lactose and microcrystalline cellulose, maltodextrin, maltose, mannitol, microcrystalline cellulose & guar gum, molasses, sucrose,or mixtures thereof, DISINTEGRANTS: agar-agar, alginic acid, calcium carbonate, microcrystalline cellulose, croscarmellose sodium, crospovidone, polacrilin potassium, sodium starch glycolate, potato or tapioca starch, other starches, pre-gelatinized starch, clays, other algins, other celluloses, gums (like gellan), low-substituted hydroxypropyl cellulose, or mixtures thereof, LUBRICANTS: calcium stearate, magnesium stearate, mineral oil, light mineral oil, glycerin, sorbitol, mannitol, polyethylene glycol, other glycols, stearic acid, sodium lauryl sulfate, sodium stearyl fumarate, vegetable based fatty acids lubricant, talc, hydrogenated vegetable oil (*e.g.*, peanut oil, cottonseed oil, sunflower oil, sesame oil, olive oil, corn oil and soybean oil), zinc stearate, ethyl

oleate, ethyl laurate, agar, syloid silica gel (AEROSIL 200, W.R. Grace Co., Baltimore, MD USA), a coagulated aerosol of synthetic silica (Deaussa Co., Piano, TX USA), a pyrogenic silicon dioxide (CAB-O-SIL, Cabot Co., Boston, MA USA), or mixtures thereof, ANTI-CAKING AGENTS: calcium silicate, magnesium silicate, silicon dioxide, colloidal silicon dioxide, talc, or mixtures thereof, ANTIMICROBIAL AGENTS: benzalkonium chloride, benzethonium chloride, benzoic acid, benzyl alcohol, butyl paraben, cetylpyridinium chloride, cresol, chlorobutanol, dehydroacetic acid, ethylparaben, methylparaben, phenol, phenylethyl alcohol, phenoxyethanol, phenylmercuric acetate, phenylmercuric nitrate, potassium sorbate, propylparaben, sodium benzoate, sodium dehydroacetate, sodium propionate, sorbic acid, thimersol, thymo, or mixtures thereof, and COATING AGENTS: sodium carboxymethyl cellulose, cellulose acetate phthalate, ethylcellulose, gelatin, pharmaceutical glaze, hydroxypropyl cellulose, hydroxypropyl methylcellulose (hypromellose), hydroxypropyl methyl cellulose phthalate, methylcellulose, polyethylene glycol, polyvinyl acetate phthalate, shellac, sucrose, titanium dioxide, carnauba wax, microcrystalline wax, gellan gum, maltodextrin, methacrylates, microcrystalline cellulose and carrageenan or mixtures thereof.

The formulation can also include other excipients and categories thereof including but not limited to Pluronic®, Poloxamers (such as Lutrol® and Poloxamer 188), ascorbic acid, glutathione, protease inhibitors (*e.g.* soybean trypsin inhibitor, organic acids), pH lowering agents, creams and lotions (like maltodextrin and carrageenans); materials for chewable tablets (like dextrose, fructose, lactose monohydrate, lactose and aspartame, lactose and cellulose, maltodextrin, maltose, mannitol, microcrystalline cellulose and guar gum, sorbitol crystalline); parenterals (like mannitol and povidone); plasticizers (like dibutyl sebacate, plasticizers for coatings, polyvinylacetate phthalate); powder lubricants (like glyceryl behenate); soft gelatin capsules (like sorbitol special solution); spheres for coating (like sugar spheres); spheronization agents (like glyceryl behenate and microcrystalline cellulose); suspending/gelling agents (like carrageenan, gellan gum, mannitol, microcrystalline cellulose, povidone, sodium starch glycolate, xanthan gum); sweeteners (like aspartame, aspartame and lactose, dextrose, fructose, honey, maltodextrin, maltose, mannitol, molasses, sorbitol crystalline, sorbitol special solution, sucrose); wet granulation agents (like calcium carbonate, lactose anhydrous, lactose monohydrate, maltodextrin, mannitol, microcrystalline cellulose, povidone, starch), caramel, carboxymethylcellulose sodium, cherry cream flavor and cherry flavor, citric acid anhydrous,

citric acid, confectioner's sugar, D&C Red No. 33, D&C Yellow #10 Aluminum Lake, disodium edetate, ethyl alcohol 15%, FD&C Yellow No. 6 aluminum lake, FD&C Blue # 1 Aluminum Lake, FD&C Blue No. 1, FD&C blue no. 2 aluminum lake, FD&C Green No.3, FD&C Red No. 40, FD&C Yellow No. 6 Aluminum Lake, FD&C Yellow No. 6, FD&C Yellow No.10, glycerol palmitostearate, glyceryl monostearate, indigo carmine, lecithin, manitol, methyl and propyl parabens, mono ammonium glycyrrhizinate, natural and artificial orange flavor, pharmaceutical glaze, poloxamer 188, Polydextrose, polysorbate 20, polysorbate 80, polyvidone, pregelatinized corn starch, pregelatinized starch, red iron oxide, saccharin sodium, sodium carboxymethyl ether, sodium chloride, sodium citrate, sodium phosphate, strawberry flavor, synthetic black iron oxide, synthetic red iron oxide, titanium dioxide, and white wax.

Solid oral dosage forms may optionally be treated with coating systems (*e.g.* Opadry® fx film coating system, for example Opadry® blue (OY-LS-20921), Opadry® white (YS-2-7063), Opadry® white (YS- 1-7040), and black ink (S- 1-8 106).

The agents either in their free form or as a salt can be combined with a polymer such as polylactic-glycoloic acid (PLGA), poly-(I)-lactic-glycolic-tartaric acid (P(I)LGT) (WO 01/12233), polyglycolic acid (U.S. 3,773,919), polylactic acid (U.S. 4,767,628), poly(ε-caprolactone) and poly(alkylene oxide) (U.S. 20030068384) to create a sustained release formulation. Other sustained release formulations and polymers for use in the compositions and methods of the invention are described in EP 0 467 389 A2, WO 93/24150, U.S. 5,612,052, WO 97/40085, WO 03/075887, WO 01/01964A2, U.S. 5,922,356, WO 94/155587, WO 02/074247A2, WO 98/25642, U.S. 5,968,895, U.S. 6,180,608, U.S. 20030171296, U.S. 20020176841, U.S. 5,672,659, U.S. 5,893,985, U.S. 5,134,122, U.S. 5,192,741, U.S. 5,192,741, U.S. 4,668,506, U.S. 4,713,244, U.S. 5,445,832 U.S. 4,931,279, U.S. 5,980,945, WO 02/058672, WO 97/26015, WO 97/04744, and US20020019446. In such sustained release formulations microparticles (Delie and Blanco-Prieto 2005 Molecule 10:65-80) of polypeptide are combined with microparticles of polymer. U.S. 6,011,0 1 and WO 94/06452 describe a sustained release formulation providing either polyethylene glycols (i.e. PEG 300 and PEG 400) or triacetin. WO 03/053401 describes a formulation which may both enhance bioavailability and provide controlled releaseof the agent within the GI tract. Additional controlled release formulations are described in WO 02/38129, EP 326151, U.S. 5,236,704, WO 02/30398, WO 98/13029; U.S. 20030064105, U.S. 20030138488A1, U.S. 20030216307A1, U.S. 6,667,060, WO 01/49249, WO

01/49311, WO 01/49249, WO 01/49311, and U.S. 5,877,224 materials which may include those described in WO04041195 (including the seal and enteric coating described therein) and pH-sensitive coatings that achieve delivery in the colon including those described in US4,910,021 and WO9001329. US4910021 describes using a pH-sensitive material to coat a capsule. WO9001329 describes using pH-sensitive coatings on beads containing acid, where the acid in the bead core prolongs dissolution of the pH-sensitive coating. U. S. Patent No. 5,175,003 discloses a dual mechanism polymer mixture composed of pH-sensitive enteric materials and film-forming plasticizers capable of conferring permeability to the enteric material, for use in drug-delivery systems; a matrix pellet composed of a dual mechanism polymer mixture permeated with a drug and sometimes covering a pharmaceutically neutral nucleus; a membrane-coated pellet comprising a matrix pellet coated with a dual mechanism polymer mixture envelope of the same or different composition; and a pharmaceutical dosage form containing matrix pellets. The matrix pellet releases acid-soluble drugs by diffusion in acid pH and by disintegration at pH levels of nominally about 5.0 or higher.

The GCC peptides described herein may be formulated in the pH triggered targeted control release systems described in WO04052339. The agents described herein may be formulated according to the methodology described in any of WO03105812 (extruded hyrdratable polymers); WO0243767 (enzyme cleavable membrane translocators); WO03007913 and WO03086297 (mucoadhesive systems); WO02072075 (bilayer laminated formulation comprising pH lowering agent and absorption enhancer); WO04064769 (amidated polypeptides); WO05063156 (solid lipid suspension with pseudotropic and/or thixotropic properties upon melting); WO03035029 and WO03035041 (erodible, gastric retentive dosage forms); US5007790 and US5972389 (sustained release dosage forms); WO041 1271 1 (oral extended release compositions); WO05027878, WO02072033, and WO02072034 (delayed release compositions with natural or synthetic gum); WO05030182 (controlled release formulations with an ascending rate of release); WO05048998 (microencapsulation system); US Patent 5,952,314 (biopolymer); US5,108,758 (glassy amylose matrix delivery); US 5,840,860 (modified starch based delivery). JP10324642 (delivery system comprising chitosan and gastric resistant material such as wheat gliadin or zein); US 5,866,619 and US 6,368,629 (saccharide containing polymer); US 6,531,152 (describes a drug delivery system containing a water soluble core (Ca pectinate or other water-insoluble polymers) and outer coat which bursts (*e.g.* hydrophobic polymer-

Eudragrit)); US 6,234,464; US 6,403,130 (coating with polymer containing casein and high methoxy pectin; WO0174 175 (Maillard reaction product); WO05063206 (solubility increasing formulation); WO040 19872 (transferring fusion proteins).

The GCC peptides described herein may be formulated using gastrointestinal retention system technology (GIRES; Merrion Pharmaceuticals). GIRES comprises a controlled-release dosage form inside an inflatable pouch, which is placed in a drug capsule for oral administration. Upon dissolution of the capsule, a gas-generating system inflates the pouch in the stomach where it is retained for 16-24 hours, all the time releasing agents described herein.

The GCC peptides described herein can also be formulated using the multi matrix system technology (MMX).

The GCC peptides described herein can be formulated in an osmotic device including the ones disclosed in US 4,503,030, US 5,609,590 and US 5,358,502. US 4,503,030 describing an osmotic device for dispensing a drug to certain pH regions of the gastrointestinal tract. More particularly, the invention relates to an osmotic device comprising a wall formed of a semi-

5   permeable pH sensitive composition that surrounds a compartment containing a drug, with a passageway through the wall connecting the exterior of the device with the compartment. The device delivers the drug at a controlled rate in the region of the gastrointestinal tract having a pH of less than 3.5, and the device self- destructs and releases all its drug in the region of the gastrointestinal tract having a pH greater than 3.5, thereby providing total availability for drug

10   absorption. U.S. Patent Nos. 5,609,590 and 5, 358,502 disclose an osmotic bursting device for dispensing a beneficial agent to an aqueous environment. The device comprises a beneficial agent and osmagent surrounded at least in part by a semi-permeable membrane. The beneficial agent may also function as the osmagent. The semi-permeable membrane is permeable to water and substantially impermeable to the beneficial agent and osmagent. A trigger means is attached

15   to the semi-permeable membrane (*e.g.*, joins two capsule halves). The trigger means is activated by a pH of from 3 to 9 and triggers the eventual, but sudden, delivery of the beneficial agent. These devices enable the pH-triggered release of the beneficial agent core as a bolus by osmotic bursting.

The composition of the present invention can be formulated in the form of a tablet, a

20   capsule, granules, pellets, or crystals. In certain embodiments, the composition comprises microparticles or microspheres. In one embodiment, the composition comprises a cellulose

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acetate butyrate microsphere. In some embodiments, the composition comprises one or more layers of targeting materials. In other embodiments, the composition is formulated in a matrix with a targeting material. In certain embodiments, the matrix is coated with at least one additional targeting material.

5   The GCC-agonist containing composition of the present formulations is formed according to art-recognized methods. In one embodiment, the composition is formed with a pellet-forming agent such as microcrystalline cellulose, low-substituted hydroxypropylcellulose, chitin, chitosan, or any combination or mixture thereof. Generally, an amount of pellet-forming agent that is less than 20% by weight results in poor sphericity and broad particle size

10   distribution. Accordingly, the pellet-forming agent of the present formulations is preferably at least 20% by weight. In certain embodiments, the pellet-forming agent is present at 20% to 95% or 50% to 90% by weight.

The formulation may further comprise one or more pharmaceutically acceptable excipients. Preferably, the excipients are present in an amount of 2 to 70% or 5 to 50% by

15   weight. The term excipient broadly refers to a biologically inactive substance used in combination with the active agents of the formulation. An excipient can be used, for example, as a solubilizing agent, a stabilizing agent, a diluent, an inert carrier, a preservative, a binder, a disintegrant, a coating agent, a flavoring agent, or a coloring agent. Preferably, at least one excipient is chosen to provide one or more beneficial physical properties to the formulation, such

20   as increased stability and/or solubility of the active agent(s).

A "pharmaceutically acceptable" excipient is one that has been approved by a state or federal regulatory agency for use in animals, and preferably for use in humans, or is listed in the U.S. Pharmacopia, the European Pharmacopia or another generally recognized pharmacopia for use in animals, and preferably for use in humans. Examples of excipients include certain inert

25   proteins such as albumins; hydrophilic polymers such as polyvinylpyrrolidone; amino acids such as aspartic acid (which may alternatively be referred to as aspartate), glutamic acid (which may alternatively be referred to as glutamate), lysine, arginine, glycine, and histidine; fatty acids and phospholipids such as alkyl sulfonates and caprylate; surfactants such as sodium dodecyl sulphate and polysorbate; nonionic surfactants such as such as TWEEN®, PLURONICS®, or

30   polyethylene glycol (PEG); carbohydrates such as glucose, sucrose, mannose, maltose, trehalose, and dextrins, including cyclodextrins; polyols such as sorbitol; chelating agents such as EDTA;

and salt-forming counter-ions such as sodium. Particularly preferred are hydrophilic excipients which reduce the protein binding activity and aggregation of GCRA peptides.

In some embodiments, the GCRA peptide formulation further comprises one or more excipients selected from among an absorption enhancer, a binder, a disintegrant, and a hardness enhancing agent. In other embodiments, the formulation further comprises one or more excipients selected from among a wicking agent, a stabilizer, a flow regulating agent, a lubricant, an antioxidant, a chelating agent, or a sequestrate.

Non-limiting examples of suitable binders include starch, polyvinylpyrrolidone (POVIDONE), low molecular weight hydroxypropylcellulose, low molecular weight hydroxypropylmethylcellulose, low molecular weight carboxymethylcellulose, ethylcellulose, gelatin, polyethylene oxide, acacia, dextrin, magnesium aluminum silicate, and polymethacrylates. Non-limiting examples of a disintegrant include croscarmellose sodium crospovidone (cross-linked PVP), sodium carboxymethyl starch (sodium starch glycolate), pregelatinized starch (starch 1500), microcrystalline starch, water insoluble starch, calcium carboxymethyl cellulose, and magnesium aluminum silicate (Veegum). In certain embodiments, a binder is selected from polyvinylpyrrolidone and sodium carboxymethylcellulose.

Non-limiting examples of a wicking agent include colloidal silicon dioxide, kaolin, titanium oxide, fumed silicon dioxide, alumina, niacinamide, sodium lauryl sulfate, low molecular weight polyvinyl pyrrolidone, m-pyrol, bentonite, magnesium aluminum silicate, polyester, polyethylene, and mixtures thereof. In certain embodiments, a wicking agent is selected from sodium lauryl sulfate, colloidal silicon dioxide, and low molecular weight polyvinyl pyrrolidone.

Non-limiting examples of a stabilizer include butyl hydroxyanisole, ascorbic acid, citric acid, and mixtures thereof. Preferably, the stabilizer is a basic substance which can elevate the pH of an aqueous solution or dispersion of the formulation to at least about pH 6.8. Examples of such basic substances include, for example, antacids such as magnesium aluminometasilicate, magnesium aluminosilicate, magnesium aluminate, dried aluminum hydroxide, synthetic hydrotalcite, synthetic aluminum silicate, magnesium carbonate, precipitated calcium carbonate, magnesium oxide, aluminum hydroxide, and sodium hydrogencarbonate. Other examples incldue pH-regulating agents such as L-arginine, sodium phosphate, disodium hydrogen phosphate, sodium dihydrogenphosphate, potassium phosphate, dipotassium hydrogenphosphate,

potassium dihydrogenphosphate, disodium citrate, sodium succinate, ammonium chloride, and sodium benzoate. In certain embodiments, a stabilizer is selected from ascorbic acid and magnesium aluminometasilicate.

In an embodiment where the stabilizer is a basic substance, the basic substance can be an inorganic water-soluble compound or an inorganic water-insoluble compound. Non-limiting examples of an inorganic water-soluble compounds for use as a stabilizer include carbonate salts such as sodium carbonate, potassium carbonate, sodium bicarbonate, or potassium hydrogen carbonate; phosphate salts such as anhydrous sodium phosphate, potassium phosphate, calcium dibasic phosphate, or trisodium phosphate; and alkali metal hydroxides, such as sodium, potassium, or lithium hydroxide. Non-limiting examples of inorganic water-insoluble compounds for use as a stabilizer include suitable alkaline compounds capable of imparting the requisite basicity, such as those commonly employed in antiacid compositions, for example, magnesium oxide, magnesium hydroxide, magnesium carbonate, magnesium hydrogen carbonate, aluminum hydroxide, calcium hydroxide, or calcium carbonate; composite aluminum-magnesium compounds, such as magnesium aluminum hydroxide; silicate compounds such as magnesium aluminum silicate (Veegum F), magnesium aluminometasilicate (Nesulin FH2), magnesium aluminosilicate (Nisulin A); and pharmaceutically acceptable salts of phosphoric acid such as tribasic calcium phosphate.

Non-limiting examples of a flow regulating agents include a colloidal silicon dioxide and aluminum silicate.

Non-limiting examples of a lubricant include stearate salts, such as magnesium stearate, calcium stearate, and sodium stearate, stearic acid, talc, sodium stearyl fumarate, sodium lauryl sulfate, sodium benzoate, polyethylene glycol, polyvinyl alcohol, glycerol behenate compritol (glycerol behenate), corola oil, glyceryl palmitostearate, hydrogenated vegetable oil, magnesium oxide, mineral oil, poloxamer, and combinations thereof. In certain embodiments, a lubricant is selected from talc and magnesium stearate.

Non-limiting examples of antioxidants include 4,4 (2,3 dimethyl tetramethylene dipyrochatechol), tocopherol-rich extract (natural vitamin E), α-tocopherol, β-tocopherol, γ-tocopherol, δ-tocopherol, butylhydroxinon, butyl hydroxyanisole (BHA), butyl hydroxytoluene (BHT), propyl gallate, octyl gallate, dodecyl gallate, tertiary butylhydroquinone (TBHQ), fumaric acid, malic acid, ascorbic acid (Vitamin C), sodium ascorbate, calcium ascorbate,

potassium ascorbate, ascorbyl palmitate, ascorbyl stearate,citric acid, sodium lactate, potassium lactate, calcium lactate, magnesium lactate, anoxomer, erythorbic acid, sodium erythorbate, erythorbin acid, sodium erythorbin, ethoxyquin, glycine, gum guaiac, sodium citrates (monosodium citrate, disodium citrate, trisodium citrate), potassium citrates (monopotassium

5   citrate, tripotassium citrate), lecithin, polyphosphate, tartaric acid, sodium tartrates (monosodium tartrate, disodium tartrate), potassium tartrates (monopotassium tartrate, dipotassium tartrate), sodium potassium tartrate, phosphoric acid, sodium phosphates (monosodium phosphate, disodium phosphate, trisodium phosphate), potassium phosphates (monopotassium phosphate, dipotassium phosphate, tripotassium phosphate), calcium disodium ethylene diamine tetra-

10   acetate (Calcium disodium EDTA), lactic acid, trihydroxy butyrophenone and thiodipropionic acid.

In certain embodiments, the composition of the formulation comprises an antioxidant and both a chelator and a sequestrate. The chelating agent acts to remove trace quantities of metals which might otherwise bind to the GCC agonist and cause loss of activity, for example through

15   oxidation. The sequestrate preferably has several hydroxyl and/or carboxylic acid groups which provide a supply of hydrogen for regeneration of the inactivated antioxidant free radical. Non-limiting examples of chelating agents include antioxidants, dipotassium edentate, disodium edentate, edetate calcium disodium, edetic acid, fumaric acid, malic acid, maltol, sodium edentate, and trisodium edetate. Non-limiting examples of sequestrates include citric acid and

20   ascorbic acid.

In some embodiments, the formulation further comprises a filler. Preferably, the filler is present in an amount of from 10% to 85% by weight. Non-limiting examples of suitable materials for use as a filler include starch, lactitol, lactose, an inorganic calcium salt, microcrystalline cellulose, sucrose, and combinations thereof. In some embodiments, the filler

25   comprises microcrystalline cellulose. Preferably, the microcrystalline cellulose has a particle size of less than about 100 microns, and most preferably the microcrystalline cellulose has a particle size of about 50 microns.

In some embodiments, the composition optionally includes a buffering agent such as an inorganic salt compound and an organic alkaline salt compound. Non-limiting examples of a

30   buffering agent include potassium bicarbonate, potassium citrate, potassium hydroxide, sodium bicarbonate, sodium citrate, sodium hydroxide, calcium carbonate, dibasic sodium phosphate,

monosodium glutamate, tribasic calcium phosphate, monoethanolamine, diethanolamine, triethanolamine, citric acid monohydrate, lactic acid, propionic acid, tartaric acid, fumaric acid, malic acid, and monobasic sodium phosphate.

In some embodiments, the composition described herein further comprises a preservative. Non-limiting examples of a preservative include an antioxidant, dipotassium edentate, disodium edentate, edetate calcium disodium, edetic acid, fumaric acid, malic acid, maltol, sodium edentate, and trisodium edentate.

The formulations of the invention are preferably optimized for oral delivery. However, in some embodiments, the formulations may be prepared in the form of suppositories (*e.g.*, with conventional suppository bases such as cocoa butter and other glycerides) or retention enemas for rectal delivery. Solid oral dosage forms may optionally be treated with coating systems (*e.g.* Opadry® fx film coating system, for example Opadry® blue (OY-LS-20921), Opadry® white (YS-2-7063), Opadry® white (YS- 1-7040), and black ink (S- 1-8 106).

USES

The present invention provides a method of colonic cleansing by administering to a subject in need thereof an effective amount of any compositions of the present invention, for example a GCRA peptide.

The present invention also provides a method of colonic cleansing by administering to a subject in need thereof an effective amount of any formulations of the present invention.

The GCRA peptides that can be used in the methods and formulations of the invention include a peptide selected from the group designated by SEQ ID NOs: 1-346. Preferably, the GCRA peptide is SEQ ID NO: 1, 9, 55 or 56.

This method can be used in cleansing or purging the bowels or colon prior to carrying out a diagnostic, therapeutic or surgical procedure on the colon, rectum or anus or elsewhere in the abdomen. The diagnostic or surgical procedure may, for example, be sigmoidoscopy, colonoscopy, radiographic examination, preparation for patients undergoing bowel surgery, and other medical or diagnostic procedures. It has been believed that profuse, uncontrolled diarrhea was necessary to produce adequate cleansing of the colon. This present invention provides a safe and effective cleansing method for the bowels and colon, without the ingestion of large volumes

of lavage solutions, without the unpleasant, bitter, and dangerous hypertonic salt solutions, thus
providing an improved patients compliance.

"Subject", as used herein, means an individual. In one aspect, the subject is a mammal
such as a primate, and, in another aspect, the subject is a human. The term "subject" also includes
5   domesticated animals (e.g., cats, dogs, etc.), and livestock (e.g., cattle, horses, pigs, sheep, goats,
etc.). The subject may be a human over 50 years old. In some embodiments, the subject is one
who is undergoing colonoscopy for a routinely accepted indication, including, but not limited to
routine screening, polyp or neoplasm history, rectal bleeding, other gastrointestinal bleeding,
abdominal pain, unknown diarrhea or constipation etiology, anemia of unknown etiology,
10   inflammatory bowel disease, abnormal endosonography or evaluation of barium enema results.

The compositions (*e.g.*, GCRA peptides) or the formulations described herein can be
administered with one or more other agents, for example, L-glucose, cholera toxin, osmotic
colonic evacuants, cathartic, laxatives and agents for treating chronic constipation. In some
embodiments, the compositions (*e.g.*, GCRA peptides) or the formulations described herein can
15   be administered with L-glucose. The compositions or the formulations described herein can be
administered prior to, concurrently, or after the administration of one or more such agents.

Preferably, the GCRA peptide or its derivative or analog of the present invention or any
composition/formulation described herein is used in combination with L-glucose, cholera toxin,
osmotic colonic evacuants, cathartic, laxatives, agents for treating chronic constipation and/or an
20   osmotic liquid prep. For example, an osmotic liquid prep is SUPREP® Bowel Prep Kit (sodium
sulfate potassium sulfate, magnesium sulfate).

The term "cathartic", as used herein, refers to any composition that acts as a colonic
evacuant for cleansing or purging the bowels or colon prior to sigmoidoscopy, colonoscopy,
radiographic examination, preparation for patients undergoing bowel surgery, and other medical
25   or diagnostic procedures.

The phrase "osmotic colonic evacuant", as used herein, refers to any composition that
induces water infusion and retention into the intestinal lumen when the composition is
administered to a subject. Compositions of an osmotic colonic evacuant include solids, powders,
gels, or liquids. A liquid composition of an osmotic colonic evacuant may be constituted from a
30   solid, powder, or gel composition using a physiologically acceptable carrier (*e.g.*, water). A
liquid composition of an osmotic colonic evacuant suitable for administration also may be

constituted from liquid concentrate form using a physiologically acceptable carrier (*e.g.*, water) as diluent.

An osmotic colonic evacuant may be a phosphate-based cathartic, for example, sodium dihydrogen phosphate, disodium hydrogen phosphate, sodium biphosphate, sodium acid pyrophosphate, or mixtures thereof; or a sulfate-based cathartic, for example, sodium picosulfate and sodium sulfate, or mixtures thereof; or magnesium-based cathartic, for example, magnesium citrate, magnesium hydroxide, magnesium sulfate, magnesium oxide, or mixtures thereof; or magnesium sulfate (Epsom salts).

A stimulant laxative can cause rhythmic muscle contractions in the large intestines. Exemplary stimulant laxatives and their effective doses include: Aloe, 250-1000 mg.; bisacodyl, about 5-80 mg.; casanthranol, 30 to 360 mg.; cascara aromatic fluid extract, 2-24 ml.; cascara sagrada bark, 300-4000 mg.; cascada sagrada extract, 300 to 2000 mg.; cascara sagrada fliuid extract, 0.5 to 5 ml.; castor oil, 15-240 ml.; danthron, 75-300 mg.; dehydrocholic acid, 250-2000 mg; phenolphthalein, 30-1000 mg.; sennosides A and B, 12-200 mg.; and picosulfate, 1-100 mg.

Other laxatives may include glycerin suppositories, sorbitol, lactulose, and polyethylene glycol (PEG).

Exemplary agents for treating chronic constipation include, but are not limited to lubiprostone (Amitiza), prucalopride, SENNA, MIRALAX, LACTULOSE, PEG, or calcium polycarbophil), stool softeners (such as mineral oil or COLACE), bulking agents (such as METAMUCIL or bran), agents such as ZELNORM (also called tegaserod), and anticholinergic medications such as BENTYL and LEVSIN.

The compositions (e.g., GCRA peptides) or the formulations described herein can be used in combination with a phosphodiesterase inhibitor. PDE inhibitors are those compounds which slow the degradation of cyclic AMP (cAMP) and/or cyclic GMP (cGMP) by inhibition of the phosphodiesterases, which can lead to a relative increase in the intracellular concentration of c AMP and/or cGMP. Possible PDE inhibitors are primarily those substances which are to be numbered among the class consisting of the PDE3 inhibitors, the class consisting of the PDE4 inhibitors and/or the class consisting of the PDE5 inhibitors, in particular those substances which can be designated as mixed types of PDE3/4 inhibitors or as mixed types of PDE3/4/5 inhibitors. By way of example, those PDE inhibitors may be mentioned such as are described and/or claimed in the following patent applications and patents: DE1470341, DE2108438, DE2123328,

DE2305339, DE2305575, DE2315801, DE2402908, DE2413935, DE2451417, DE2459090, DE2646469, DE2727481, DE2825048, DE2837161, DE2845220, DE2847621, DE2934747, DE3021792, DE3038166, DE3044568, EP000718, EP0008408, EP0010759, EP0059948, EP0075436, EP0096517, EPO1 12987, EPO1 16948, EP0150937, EP0158380, EP0161632,

5   EP0161918, EP0167121, EP0199127, EP0220044, EP0247725, EP0258191, EP0272910, EP0272914, EP0294647, EP0300726, EP0335386, EP0357788, EP0389282, EP0406958, EP0426180, EP0428302, EP0435811, EP0470805, EP0482208, EP0490823, EP0506194, EP0511865, EP0527117, EP0626939, EP0664289, EP0671389, EP0685474, EP0685475, EP0685479, JP92234389, JP94329652, JP95010875, U.S. Pat. Nos. 4,963,561, 5,141,931,

10   WO9117991, WO9200968, WO9212961, WO9307146, WO9315044, WO9315045, WO9318024, WO9319068, WO9319720, WO9319747, WO9319749, WO9319751, WO9325517, WO9402465, WO9406423, WO9412461, WO9420455, WO9422852, WO9425437, WO9427947, WO9500516, WO9501980, WO9503794, WO9504045, WO9504046, WO9505386, WO9508534, WO9509623, WO9509624, WO9509627,

15   WO9509836, WO9514667, WO9514680, WO9514681, WO9517392, WO9517399, WO9519362, WO9522520, WO9524381, WO9527692, WO9528926, WO9535281, WO9535282, WO9600218, WO9601825, WO9602541, WO9611917, DE3142982, DE1 116676, DE2162096, EP0293063, EP0463756, EP0482208, EP0579496, EP0667345 US6,331,543, US20050004222 (including those disclosed in formulae I-XIII and paragraphs 37-39, 85-0545

20   and 557-577) and WO9307124, EP0163965, EP0393500, EP0510562, EP0553174, WO9501338 and WO9603399. PDE5 inhibitors which may be mentioned by way of example are RX-RA-69, SCH-51866, KT- 734, vesnarinone, zaprinast, SKF-96231, ER-21355, BF/GP-385, NM-702 and sildenafil (Viagra®). PDE4 inhibitors which may be mentioned by way of example are RO-20-1724, MEM 1414 (R1533/R1500; Pharmacia Roche), DENBUFYLLINE, ROLIPRAM,

25   OXAGRELATE, NITRAQUAZONE, Y-590, DH-6471, SKF-94120, MOTAPIZONE, LIXAZINONE, INDOLIDAN, OLPRINONE, ATIZORAM, KS-506-G, DIPAMFYLLINE, BMY-43351, ATIZORAM, AROFYLLINE, FILAMINAST, PDB-093, UCB-29646, CDP-840, SKF- 107806, PICLAMILAST, RS- 17597, RS-25344-000, SB-207499, TIBENELAST, SB-210667, SB-211572, SB-211600, SB-212066, SB-212179, GW-3600, CDP-840, MOPIDAMOL,

30   ANAGRELIDE, IBUDILAST, AMRINONE, PIMOBENDAN, CILOSTAZOL, QUAZINONE and N-(3,5-dichloropyrid-4-yl)-3-cyclopropylmethoxy4-difluoromethoxybenzamide. PDE3

inhibitors which may be mentioned by way of example are SULMAZOLE, AMPIZONE, CILOSTAMIDE, CARBAZERAN, PIROXIMONE, IMAZODAN, CI-930, SIGUAZODAN, ADIBENDAN, SATERINONE, SKF-95654, SDZ-MKS-492, 349-U-85, EMORADAN, EMD-53998, EMD-57033, NSP-306, NSP-307, REVIZINONE, NM-702, WIN-62582 and WIN-63291, ENOXIMONE and MILRINONE. PDE3/4 inhibitors which may be mentioned by way of example are BENAFENTRINE, TREQUINSIN, ORG-30029, ZARDAVERINE, L-686398, SDZ-ISQ-844, ORG-20241, EMD-54622, and TOLAFENTRINE. Other PDE inhibitors include: cilomilast, pentoxifylline, roflumilast, tadalafil(Cialis®), theophylline, and vardenafil(Levitra®), zaprinast (PDE5 specific). Preferably, the cGMP-specific phosphodiesterase inhibitor is selected from the group consisting of sulindac sulfone, zaprinast, motapizone, vardenafil, and sildenafil.

Prior to consumption, flavorants and/or sweeteners may be added to compositions of the present invention to increase its palatability. Optionally, the flavorant can be present in the mixture or solution that contains the instant compositions. Alternatively, the flavorant and sweetener can be individually packaged apart from the instant compositions. The flavorant may include a citrate-based component. The citrate-based component may include citric acid, salts, such as sodium or potassium citrate, derivatives of citrate, such as a citrate derivatized with ester functionality, and the like. The flavorant also may include natural and/or artificial flavorings, such as natural and/or artificial fruit flavors, to further increase the palatability of the cathartic. Preferred sweeteners include aspartame, sucralose, and acesulfame potassium, among other ingredients. Preferably, the flavorant and sweetener may be combined as a powered mixture. Examples of such combinations include the commercially available aspartame-based drink mixture, such as the CRYSTAL LIGHT®™ powder that is available from Kraft Foods, Northfield, Ill. (USA) or the N&A Pink Lemonade FL System Sugar FAFT523 that is available from WILD Flavors, Inc., Erlanger, Ky. (USA). Both of these powders include aspartame, citric acid, and fruit flavors that result in flavored drinks when the powder is combined with water. Examples of compositions and uses of flavorants and sweeteners in phosphate-based cathartics are described, for example, in ASPARTAME AND CITRATE FLAVORED PHOSPHATE SALT CATHARTIC, U.S. Published Patent Application publication no. US20060051428 to Ayala et al.

The GCRA peptides may be in a pharmaceutical composition in unit dose form, together with one or more pharmaceutically acceptable excipients. The term "unit dose form" refers to a

single drug delivery entity, *e.g.*, a tablet, capsule, solution or inhalation formulation. The amount of peptide present should be sufficient to have a positive effect when administered to a patient (typically, between 10 μg and 3 g). "Positive effect" refers to effective cleansing or purging the bowels or colon prior to carrying out a diagnostic, therapeutic or surgical procedure on the colon,

5   rectum or anus or elsewhere in the abdomen.

The GCRA peptides can be administered alone or in combination with other agents. Combination methods can be achieved by administering two or more agents, *e.g.*, a GCRA peptide described herein and another compound, each of which is formulated and administered separately, or by administering two or more agents in a single formulation. Other combinations

10   are also encompassed by combination therapy. For example, two agents can be formulated together and administered in conjunction with a separate formulation containing a third agent. While the two or more agents in the combination methods can be administered simultaneously, they need not be. For example, administration of a first agent (or combination of agents) can precede administration of a second agent (or combination of agents) by minutes, hours, or days.

15   Thus, the two or more agents can be administered within minutes of each other or within 1, 2, 3, 6, 9, 12, 15, 18, or 24 hours of each other or within 1 or 2 days of each other. In some cases even longer intervals are possible. While in many cases it is desirable that the two or more agents used in a combination therapy be present in within the patient's body at the same time, this need not be so.

20   In some embodiments, a GCRA peptide or its derivative or analog of the present invention is administered 30 minutes before administering an additional colon cleansing agent (*e.g.*, L-glucose, cholera toxin, osmotic colonic evacuants, cathartic, laxatives, agents for treating chronic constipation and/or an osmotic liquid prep).

In some embodiments, a GCRA peptide or its derivative or analog of the present

25   invention is administered the evening prior to the colonoscopy (*e.g.*, at least 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 hours or more before the colonoscopy).

Combination therapy can also include two or more administrations of one or more of the agents used in the combination. For example, if agent X and agent Y are used in a combination, one could administer them sequentially in any combination one or more times, *e.g.*, in the order

30   X-Y- X, X-X-Y, Y-X-Y,Y-Y-X,X-X-Y-Y, etc.

Combination therapy can also include the administration of two or more agents via different routes or locations. For example, (a) one agent is administered orally and another agent is administered intravenously or (b) one agent is administered orally and another is administered locally. In each case, the agents can either simultaneously or sequentially. Approximated

5   dosages for some of the combination therapy agents described herein are found in the "BNF Recommended Dose" column of tables on pages 11-17 of WO01/76632 (the data in the tables being attributed to the March 2000 British National Formulary) and can also be found in other standard formularies and other drug prescribing directories. For some drugs, the customary prescribed dose for an indication will vary somewhat from country to country.

10   In some embodiments, the GCRA peptide or its derivative or analog of the present invention or any composition/formulation described herein and the additional agent (*e.g.*, L-glucose, cholera toxin, osmotic colonic evacuants, cathartic, laxatives, agents for treating chronic constipation and/or an osmotic liquid prep) are administered orally.

The GCRA peptides, alone or in combination, can be combined with any

15   pharmaceutically acceptable carrier or medium. Thus, they can be combined with materials that do not produce an adverse, allergic or otherwise unwanted reaction when administered to a patient. The carriers or mediums used can include solvents, dispersants, coatings, absorption promoting agents, controlled release agents, and one or more inert excipients (which include starches, polyols, granulating agents, microcrystalline cellulose (*e.g.* Celphere®, Celphere®

20   beads), diluents, lubricants, binders, disintegrating agents, and the like), etc. If desired, tablet dosages of the disclosed compositions may be coated by standard aqueous or nonaqueous techniques.

A pharmaceutical composition of the invention is formulated to be compatible with its intended route of administration. Examples of routes of administration include parenteral, *e.g.*,

25   intravenous, intradermal, subcutaneous, oral (*e.g.*, inhalation), transdermal (topical), transmucosal, and rectal administration. Solutions or suspensions used for parenteral, intradermal, or subcutaneous application can include the following components: a sterile diluent such as water for injection, saline solution, fixed oils, polyethylene glycols, glycerine, propylene glycol or other synthetic solvents; antibacterial agents such as benzyl alcohol or methyl

30   parabens; antioxidants such as ascorbic acid or sodium bisulfite; chelating agents such as ethylenediaminetetraacetic acid; buffers such as acetates, citrates or phosphates, and agents for

the adjustment of tonicity such as sodium chloride or dextrose. The pH can be adjusted with acids or bases, such as hydrochloric acid or sodium hydroxide. The parenteral preparation can be enclosed in ampoules, disposable syringes or multiple dose vials made of glass or plastic.

5   Pharmaceutical compositions suitable for injectable use include sterile aqueous solutions (where water soluble) or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersion. For intravenous administration, suitable carriers include physiological saline, bacteriostatic water, Cremophor EL™ (BASF, Parsippany, N.J.) or phosphate buffered saline (PBS). In all cases, the composition must be sterile and should be fluid to the extent that easy syringeability exists. It must be stable under the conditions of

10   manufacture and storage and must be preserved against the contaminating action of microorganisms such as bacteria and fungi. The carrier can be a solvent or dispersion medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyethylene glycol, and the like), and suitable mixtures thereof. The proper fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the

15   required particle size in the case of dispersion and by the use of surfactants. Prevention of the action of microorganisms can be achieved by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, ascorbic acid, thimerosal, and the like. In many cases, it will be preferable to include isotonic agents, for example, sugars, polyalcohols such as manitol, sorbitol, sodium chloride in the composition. Prolonged absorption of the injectable

20   compositions can be brought about by including in the composition an agent which delays absorption, for example, aluminum monostearate and gelatin.

      Sterile injectable solutions can be prepared by incorporating the active compound (*e.g.*, a GCRA agonist) in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by filtered sterilization. Generally,

25   dispersions are prepared by incorporating the active compound into a sterile vehicle that contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, methods of preparation are vacuum drying and freeze-drying that yields a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof.

30   Oral compositions generally include an inert diluent or an edible carrier, such as mannitol, fructooligosaccharides, polyethylene glycol and other excepients. They can be

enclosed in gelatin capsules or compressed into tablets. For the purpose of oral therapeutic administration, the active compound can be incorporated with excipients and used in the form of tablets, troches, or capsules. Oral compositions can also be prepared using a fluid carrier for use as a mouthwash, wherein the compound in the fluid carrier is applied orally and swished and

5   expectorated or swallowed. Pharmaceutically compatible binding agents, and/or adjuvant materials can be included as part of the composition. The tablets, pills, capsules, troches and the like can contain any of the following ingredients, or compounds of a similar nature: a binder such as microcrystalline cellulose, gum tragacanth or gelatin; an excipient such as starch or lactose, a disintegrating agent such as alginic acid, Primogel, or corn starch; a lubricant such as

10   magnesium stearate or Sterotes; a glidant such as colloidal silicon dioxide; a sweetening agent such as sucrose or saccharin; or a flavoring agent such as peppermint, methyl salicylate, or orange flavoring.

Systemic administration can also be by transmucosal or transdermal means. For transmucosal or transdermal administration, penetrants appropriate to the barrier to be permeated

15   are used in the formulation. Such penetrants are generally known in the art, and include, for example, for transmucosal administration, detergents, bile salts, and fusidic acid derivatives. Transmucosal administration can be accomplished through the use of nasal sprays or suppositories. For transdermal administration, the active compounds are formulated into ointments, salves, gels, or creams as generally known in the art.

20   The compositions described herein can also be prepared in the form of suppositories (*e.g.*, with conventional suppository bases such as cocoa butter and other glycerides) or retention enemas for rectal delivery.

In one embodiment, the active compounds are prepared with carriers that will protect the compound against rapid elimination from the body, such as a controlled release formulation,

25   including implants and microencapsulated delivery systems. Biodegradable, biocompatible polymers can be used, such as ethylene vinyl acetate, polyanhydrides, polyglycolic acid, collagen, polyorthoesters, and polylactic acid. Methods for preparation of such formulations will be apparent to those skilled in the art. The materials can also be obtained commercially from Alza Corporation and Nova Pharmaceuticals, Inc. Liposomal suspensions (including liposomes

30   targeted to infected cells with monoclonal antibodies to viral antigens) can also be used as pharmaceutically acceptable carriers. These can be prepared according to methods known to

those skilled in the art, for example, as described in U.S. Pat. No. 4,522,811, incorporated fully herein by reference.

It is especially advantageous to formulate oral or parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form as used herein refers to physically discrete units suited as unitary dosages for the subject to be treated; each unit containing a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the dosage unit forms of the invention are dictated by and directly dependent on the unique characteristics of the active compound and the particular therapeutic effect to be achieved.

The pharmaceutical compositions can be included in a container, pack, or dispenser together with instructions for administration.

Compositions of the present invention may also optionally include other therapeutic ingredients, anti-caking agents, preservatives, sweetening agents, colorants, flavors, desiccants, plasticizers, dyes, glidants, anti-adherents, anti-static agents, surfactants (wetting agents), anti-oxidants, film- coating agents, and the like. Any such optional ingredient must be compatible with the compound described herein to insure the stability of the formulation.

DOSAGE

Dosage levels of active ingredients in a pharmaceutical composition can also be varied so as to achieve a transient or sustained concentration of the compound in a subject, and to result in the desired response. It is well within the skill of the art to start doses of the compound at levels lower than required to achieve the desired effect and to gradually increase the dosage until the desired effect is achieved. It will be understood that the specific dose level for any particular subject will depend on a variety of factors, including body weight, general health, diet, natural history of disease, route and scheduling of administration, combination with one or more other drugs, and severity of disease.

An effective dosage of the composition will typically be between about 1 µg and about 10 mg per kilogram body weight, preferably between about 10 µg to 5 mg of the compound per kilogram body weight. Adjustments in dosage will be made using methods that are routine in the art and will be based upon the particular composition being used and clinical considerations.

The guanylate cyclase receptor agonists used in the methods described above may be administered orally, systemically or locally. Dosage forms include preparations for inhalation or injection, solutions, suspensions, emulsions, tablets, capsules, topical salves and lotions, transdermal compositions, other known peptide formulations and pegylated peptide analogs.

5   Agonists may be administered as either the sole active agent or in combination with other drugs, *e.g.*, L-glucose, lubiprostone (Amitiza), prucalopride, a laxative, an osmotic colonic evacuant and/or an inhibitor of cGMP-dependent phosphodiesterase. In all cases, additional drugs should be administered at a dosage that is therapeutically effective using the existing art as a guide. Drugs may be administered in a single composition or sequentially.

10   Dosage levels of the GCRA peptide for use in methods of this invention typically are from about 0.001 mg to about 10,000 mg daily, preferably from about 0.005 mg to about 1,000 mg daily. For example, an effective amount of the GCRA peptide for use in methods of this invention is 0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 35,

15   40, 45, 50, 55 or 60 mg per unit dose. In some preferred embodiments, an effective amount of the GCRA peptide for use in methods of this invention is 6.0 mg per unit dose. In some embodiments, an effective amount of the GCRA peptide for use in methods of this invention is 1.0 - 60 mg (*e.g.*, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 35, 40, 45, 50, 55 or 60 mg) per unit dose, when

20   the GCRA peptide is SP-304 (SEQ ID NO: 1), SP-333 (SEQ ID NO: 9) or their derivatives or analogs. In some embodiments, an effective amount of the GCRA peptide for use in methods of this invention is 0.3 - 3.0 mg (*e.g.*, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5, 2.0, 2.5, or 3.0 mg) per unit dose, when the GCRA peptide is an E. coli ST peptide, linaclotide (SEQ ID NO: 55) or its derivatives or analogs. In a merely illustrative embodiment, the GCRA peptide is given once or

25   twice one day before the procedure (*e.g.*, colonoscopy, surgery etc.) and once or twice on the day of the procedure but before the procedure. In some embodiments a second agent useful for cleansing or purging the bowels or colon prior to carrying out a diagnostic, therapeutic or surgical procedure on the colon, rectum or anus or elsewhere in the abdomen is administered, prior to, concurrently or after the administration of the GCRA peptide. Suitable second agents

30   are described herein (e.g., an osmotic colonic evacuant; L-glucose, lubiprostone (Amitiza), prucalopride; or a cGMP-specific phosphodiesterase inhibitor). In some aspects the second agent

is administered at less than the standard dose for cleansing and purging the bowels and colon because the GCR agonist acts synergistically with the second agent. The dosage of the second agent can be determined by a physician. For example, the amount of L-glucose is a unit dose of 20g-200g, preferably a unit dose of 24g-48g. On the basis of mg/kg daily dose, either given in

5 single or divided doses, dosages typically range from about 0.001/75 mg/kg to about 10,000/75 mg/kg, preferably from about 0.005/75 mg/kg to about 1,000/75 mg/kg.

In some embodiments, subdoses can be administered two to six times in total before the procedure, preferably two to four times before the procedure, and even more preferably two to three times before the procedure. Doses can be in immediate release form or sustained release

10 form sufficiently effective to obtain the desired control over the medical condition.

The dosage regimen to clean or purge the bowels or colon prior to the procedure with the combinations and compositions of the present invention is selected in accordance with a variety of factors. These factors include, but are not limited to, the type, age, weight, sex, diet, and medical condition of the subject, the route of administration, pharmacological considerations

15 such as the activity, efficacy, pharmacokinetics and toxicology profiles of the particular second agent employed, whether a drug delivery system is utilized. Thus, the dosage regimen actually employed may vary widely and therefore deviate from the preferred dosage regimen set forth above.

20   **EXAMPLES**

Example 1. A Phase 1, Single-Dose, Pilot Clinical Study to Assess the Safety, Tolerability and Efficacy of Oral SP-333 as an Adjunct to SUPREP® Bowel Prep Kit for Cleansing of the Colon Prior to Colonoscopic Examination in Adults

Table 9. PROTOCOL SYNOPSIS	
Study Title	A Phase 1, Single-Dose, Pilot Clinical Study to Assess the Safety, Tolerability and Efficacy of Oral SP-333 as an Adjunct to SUPREP® Bowel Prep Kit for Cleansing of the Colon Prior to Colonoscopic Examination in Adults
Objectives	**Primary Objective:** The primary endpoint of this study is bowel preparation treatment success as determined by the investigator (bowel preparation will be rated by the Investigator as "Excellent", "Good", "Fair" or "Poor"). **Secondary Objectives:** Safety and Tolerability of SP-333 when given as an adjunct to the SUPREP® Bowel Prep

70

	Kit for cleansing of the colon prior to colonoscopy.
Methodology	Open Label, Exploratory Single Dose Study
Number of Patients and Population	Approximately 10 adult male and female patients scheduled to undergo colonoscopy
Study Drug	SP-333 6.0 mg tablets for oral administration.
Treatment	Patients will take one (1) 6 mg tablet of SP-333 the evening before their scheduled colonoscopy.
Study Design	This is a phase 1, exploratory, open-label, single-dose, single-center study.
Criteria for Evaluation: Efficacy and Safety	**Primary efficacy endpoint:** Efficacy will be assessed on the basis of a binary outcome of overall bowel preparation treatment success or failure for the Study Population (defined as those patients who took study drug and for whom the colonoscopy was initiated and who did not have an adverse event preventing initiation of the colonoscopy procedure). Bowel preparation treatment success rate will be described; formal hypothesis testing will not be performed. **Exploratory Endpoints** The exploratory endpoints for this study are: • Volume of intra-procedural water required to improve visualization during the procedure as determined by the Investigator; and, • Proportion of procedures that reach the cecum and allow complete visualization of the right colon and cecum as determined by the Investigator **Safety** will be assessed by descriptive summary of treatment-emergent adverse events (TEAEs), adverse events leading to withdrawal, and serious adverse events (SAEs).
Data Analysis	**Efficacy analysis** Bowel preparation treatment success rate will be described for the study population; formal hypothesis testing will not be performed. **Safety Data** The safety analysis data set will include all randomized subjects who receive at least one dose of study drug. Incidence of treatment emergent adverse events, withdrawals due to adverse events, serious adverse events and concomitant medications will be listed for each patient and summarized by treatment group.

Overall Design of the Study

This clinical study outlined above was designed to assess the effect of a single oral dose of 6 mg SP-333 when given concurrently with a standard pre-colonoscopy bowel prep - the SUPREP® Bowel Prep Kit (Braintree Laboratories, Braintree, MA 02185, USA). The investigator is a highly experienced gastroenterologist and oversaw all study activities and performed all colonoscopies per his usual routine.

SUPREP® Bowel Prep Kit (FDA Approved Split-Dose regimen)

The SUPREP® Bowel Prep Kit is an osmotic laxative approved and indicated for cleansing of the colon as a preparation for colonoscopy in adults. (Note that the Medication Guide that accompanies the SUPREP® Bowel Prep Kit was given to the patient as per standard clinical practice.)

Patient Instructions for SUPREP® Bowel Prep Kit and Study Drug Administration:

Evening before colonoscopy - approximately 6 PM

1. Take Study Drug approximately 30 minutes before the start of the first bottle of the bowel prep kit.

2. Take a 6 ounce bottle of study preparation and pour the entire contents into the mixing cup provided. Fill the cup with cool water to the fill line (16 ounces) and drink the entire cup of solution.

3. Drink two (2) 16 ounce glasses of WATER over the next hour. Fill the mixing cup with water up to the fill line (16 ounces) and drink the entire glass.

Morning of colonoscopy

At least 3 hours prior to colonoscopy:

1. Take the second 6 ounce bottle of study preparation and pour the entire contents into the mixing cup provided. Fill the cup with cool water to the fill line (16 ounces) and drink the entire cup of solution.

2. Drink two (2) 16 ounce glasses of WATER over the next hour. Fill the mixing cup with water up to the fill line (16 ounces) and drink the entire glass.
   Patient must complete the solution and additional water at least 2 hours before colonoscopy.

Introduction

Background

Colonoscopists rate currently available pre-procedure colon cleansing preparations as "excellent" (i.e., low residual solid and liquid volume allowing improved visualization) in only 50% of patients. Increasing the proportion of preps that result in optimal visualization,

especially of the right colon [a segment with traditionally higher miss rates for polyps and flat lesions], will serve to improve the clinical outcome of the colonoscopy.

Orally administered GC-C agonists have been shown to increase bowel movement frequency and improve stool consistency in patients with chronic idiopathic constipation and in patients with

5   irritable bowel syndrome with constipation. The normal physiological response to an orally delivered GC-C receptor agonist is an increase in water transport into the lumen of the proximal small bowel; the increased water content results in more frequent bowel movement with a normalized consistency in these patients.

SP-333 Mechanism of Action

10   SP-333 is a novel investigational medicinal product that has demonstrated potent agonist of the intestinal GC-C receptor in several in vitro and in vivo pharmacology studies and is now in Phase 2 clinical development. It is a synthetic hexadecapeptide designed to mimic the actions of the natriuretic peptide uroguanylin, a member of the guanylin family of enteric peptides. Uroguanylin and guanylin are endogenous agonists for the human GC-C receptor that is

15   expressed on the luminal surface of epithelial cells lining the GI mucosa; this naturally occurring GI hormone stimulates the intracellular production of cyclic guanosine monophosphate (cGMP), resulting in activation of the Cystic Fibrosis Transmembrane Conductance Regulator (CFTR), and thereby generating water transport into the bowel lumen.

20   **Clinical Experience**

Two phase 1 clinical studies with SP-333 have been completed to date and a Phase 2 trial in OIC is in progress. In the Phase I single ascending oral dose study, conducted in 64 healthy subjects, the following doses of SP-333 were tested: 0.1, 0.3, 1, 3, 10, 20, 30, and 60 mg. Overall, SP-333 was safe and well tolerated. Diarrhea was the most common adverse event and

25   was generally dose-related, with 1 mg being the threshold dose. The time to onset of diarrhea was variable but tended to decrease with increasing doses from 4 to 2 hours or less. The number of subjects with watery bowel movement rose from none (< 3 mg) to 2 of 6 (3, 10 and 20 mg) to 4 of 6 (30 mg). The majority of these episodes was mild, occurred once, and was associated with urgency and in some cases mild cramping. There were no SAEs. No clinically meaningful

30   changes in clinical laboratory test results, ECG or vital signs were observed, and no serious adverse events were reported.

In the Phase I multiple ascending dose study, 89 subjects received daily doses of 0.3, 1, 3, 10, & 30 mg SP-333 for 14 days or 60 mg SP-333 for 7 days. The maximum tolerated dose was 30 mg with 60 mg deemed an intolerable dose due to 2 instances of fecal incontinence or soiling in the 7 patients dosed with 60 mg SP-333. SP-333 was generally safe and well-tolerated during this study; there were no clinically meaningful changes in hematology, clinical chemistry, or urinalysis parameters, and no clinically meaningful changes in vital sign or ECG parameters with SP-333 dosing at any dose level. Most commonly reported as TEAEs (treatment-emergent adverse events) were gastrointestinal disorders (primarily diarrhea and defecation urgency) of mild or moderate intensity. No clinically meaningful changes in clinical laboratory test results, ECG or vital signs were observed; no subject experienced a serious adverse event (SAE) and no subject withdrew from the study due to a TEAE.

Phase 1 pharmacokinetic sampling indicated no detectable (limit of quantitation = 1 ng/mL) systemic absorption of SP-333 following oral doses < 10 mg; it is therefore highly unlikely that a single oral dose of 6 mg SP-333 will result in any systemic exposure.

Detailed information concerning the available pharmacology, toxicology, drug metabolism, clinical studies' data and the adverse event profile of SP-333 can be found in the Investigator's Brochure.

Overall, SP-333 is an ideal agent to enhance the effectiveness of current bowel cleansing regimens by physiologically increasing water content in the intestine thereby facilitating better evacuation of bowel contents prior to colonoscopy.

Rationale and Objectives

Colorectal cancer (CRC) is a leading cause of cancer death. The lifetime risk of developing CRC in the US approaches 6%, and almost half of those affected will die of the disease. Despite the usefulness of screening procedures for its detection, CRC is a major cause of morbidity and mortality. In screening procedures for CRC such as sigmoidoscopy, colonoscopy, and radiography, it is important that the colon be thoroughly purged and cleansed. In particular, it is essential that as much fecal matter and fluids as possible be removed from the colon to permit adequate visualization of the intestinal mucosa. Furthermore, should a planned diagnostic procedure become a therapeutic procedure by virtue of an unexpected pathological finding (e.g., an adenomatous polyp requiring removal), the ease of performance and overall

success of the therapeutic intervention is enhanced when minimal residual fecal matter and fluid are present.

Primary Objective:

The primary objective of this study was to assess the bowel preparation treatment success of 6 mg SP-333 plus SUPREP® Bowel Prep Kit compared to previous bowel preparation treatment success experience of the Investigator using the SUPREP® Bowel Prep Kit used alone.

Secondary Objective:

The secondary objective of this study was to assess the overall safety and tolerability of 6 mg SP-333 when used as an adjunct to SUPREP® Bowel Prep Kit for bowel cleansing prior to colonoscopy.

Exploratory Objectives:

The exploratory objectives of this study were to assess the volume of intra-procedural water required to improve visualization and the proportion of procedures that reach the cecum and allow complete visualization of the right colon and cecum using 6 mg SP-333 plus SUPREP® Bowel Prep Kit compared to the previous experience of the Investigator with the SUPREP® Bowel Prep Kit used alone.

Rationale for the Doses Selected

Dose selection for this trial was based on results of the Phase 1 studies where a 6 mg oral daily dose of SP-333 was found to result in self-limited diarrhea (watery stools) with mild urgency in healthy volunteers. No additional AEs of note were observed.

Efficacy Endpoints

Primary Endpoint

The primary endpoint of this study was bowel preparation treatment success as determined by the investigator (bowel preparation will be rated by the Investigator as "Excellent", "Good", "Fair" or "Poor"). A successful bowel preparation treatment is defined as bowel cleansing graded either "Excellent" or "Good" by the investigator (See Table 10).

Table 10. Bowel Preparation Treatment Assessment

Score	Grade	Description
1	Poor	Large amounts of fecal residue, additional cleansing required

2	Fair	Enough feces or fluid to prevent a completely reliable exam
3	Good	Small amounts of feces or fluid not interfering with exam
4	Excellent	No more than small bits of adherent feces/fluid

Secondary Endpoints

The secondary endpoints for this study were:

- Frequency of Treatment Emergent Adverse Events
- Frequency of Serious Adverse Events (SAEs)

Exploratory Endpoints

The exploratory endpoints for this study were:

- Volume of intra-procedural water required to improve visualization during the procedure as determined by the Investigator; and,
- Proportion of procedures that reach the cecum and allow complete visualization of the right colon and cecum as determined by the Investigator

Safety Endpoints

- Frequency of Treatment Emergent Adverse Events
- Frequency of SAEs
- Number of patients who were not able to initiate colonoscopy due to an adverse event

Planned Sample Size and Number of Study Centers

Approximately ten (10) patients requiring routine diagnostic colonoscopy were recruited by the Investigator from his practice.

Duration of Study

Patients were consented for the study at the same time that informed consent was obtained for the colonoscopy procedure. Each successfully consented & recruited patient took a single dose of 6 mg SP-333 in the evening before the colonoscopy - approximately 30 minutes

5   prior to ingestion of the first bottle of the SUPREP® Bowel Prep Kit (See Section entitled "Patient Instructions for SUPREP® Bowel Prep Kit" above).

Study Population

The study population consisted of male and female outpatients who were undergoing

10   colonoscopy for a routinely accepted indication.

Inclusion Criteria

Patients were entered into the study only if they meet all of the following criteria:

1.   Male or female outpatients who are undergoing colonoscopy for a routinely accepted

15   indication, including (but not limited to routine screening, polyp or neoplasm history, rectal bleeding, other gastrointestinal bleeding, abdominal pain, unknown diarrhea or constipation etiology, anemia of unknown etiology, inflammatory bowel disease, abnormal endosonography or evaluation of barium enema results

2.   At least 18 years of age

20   3.   Females, and of child-bearing potential, and males with female partners of child-bearing potential are using an acceptable form of birth control (hormonal birth control, IUD, double-barrier method, depot contraceptive, abstinent, or vasectomized spouse). Subjects practicing abstinence must agree to use an acceptable form of birth control should they become sexually active during the study.

25   Pharmacologic methods of contraception must be stable for at least one month prior to Visit 1.

4.   Females of child bearing potential must have a negative urine pregnancy test within 48 hours of the colonoscopy

5.   In the Investigator's judgment, subject is mentally competent to provide informed consent to

30   participate in the study

Exclusion Criteria

Subjects who meet any of the following criteria were excluded from the study:

1. Subjects with known or suspected ileus, severe ulcerative colitis, gastrointestinal obstruction, gastric retention, bowel perforation, toxic colitis or megacolon
2. Subjects who had previous gastrointestinal surgeries (e.g. colostomy, colectomy, gastric bypass, stomach stapling). Any questions regarding the significance of a previous gastrointestinal surgery should be directed to Synergy Pharmaceuticals Inc.
3. Subjects who, in the opinion of the Principal Investigator, have an uncontrolled clinically significant pre-existing medical condition which might put them at undue medical risk for colonoscopy; examples include, but are not limited to:
   a. Chronic Child-Pugh Grade B or C liver insufficiency
   b. renal insufficiency
   c. Abnormal and clinically significant ECG finding within 3 months prior to scheduled colonoscopy
   d. History of or current New York Heart Association (NYHA) Functional Classification grade III or IV congestive heart failure
4. Subjects with impaired consciousness that predisposes them to pulmonary aspiration.
5. Subjects undergoing colonoscopy for foreign body removal and decompression.
6. Subjects who are pregnant or lactating
7. Subjects of childbearing potential who refuse a pregnancy test.
8. Subjects who, in the opinion of the Investigator, should not be included in the study for any reason, including inability to follow study procedures.
9. Subjects who have participated in an investigational surgical, drug, or device study within the past 30 days.
10. Subjects who withdraw consent before completion of SUPREP® Bowel Prep Kit

Dietary Restrictions

Subjects may have a light breakfast on the day before colonoscopy, followed by clear liquids until the colonoscopy is completed the following day. Examples of acceptable clear liquids are:

- Water

- Strained fruit juices (without pulp) including apple, orange, white grape, or white cranberry
- Limeade or lemonade
- Gatorade/ Powerade
- Ginger ale
- Coffee or tea (do not use any dairy or non-dairy creamer)
- Chicken broth
- Gelatin desserts without added fruit or topping

Note: Purple/Red liquids, Milk and Alcoholic beverages are <u>not</u> permitted.

Variables and Methods of Assessment

Demographics

Demographics were assessed at Screening.

Patient Demography

Patient demography consists of:

- Age at screening (date of birth)
- Ethnicity
- Sex (Gender)

Descriptive summaries of demographic characteristics were provided.

Efficacy Variables

Efficacy were assessed on the basis of a binary outcome of overall bowel preparation treatment success or failure for the Study Population (defined as those patients who took study drug and for whom the colonoscopy was initiated and who did not have an adverse event preventing initiation of the colonoscopy procedure). Bowel preparation treatment success rate was described; formal hypothesis testing was not performed.

The volume of intra-procedural water required to improve visualization, the proximal insertion depth of the colonoscope and whether or not the right colon and cecum were completely visualized were recorded in the Colonoscopy Procedure Record.

Safety Variables

All adverse events were collected from the time of informed consent until the end of the study; the SAE reporting period concluded approximately 30 days after completion of the colonoscopy.

5   Treatment emergent adverse events were descriptively presented by preferred term, severity and relationship to treatment.

Procedures by Visit

Visit 1: Screening

10   1. All pre-colonoscopy procedures were performed per the standard of pre-colonoscopy evaluation as determined important and necessary by the Investigator.

2. Proper use of the SUPREP® Bowel Prep Kit was explained per the routine of Investigator.

3. Informed consent for colonoscopy was obtained.

4. Once informed consent was obtained for the colonoscopy:

15   a. Explained SP-333 study and its objectives; allowed subject to ask any questions he or she may have

b. Obtained informed consent for the study

5. Instructed patient to take study medication in the evening prior to the colonoscopy - approximately 30 minutes before the start of the first bottle of the SUPREP® Bowel Prep

20   Kit.

Visit 2 (Day of Colonoscopy)

Visit 2 (Day of Colonoscopy)

1. When patient arrived for procedure ensured that study drug was take on the proper timing

25   and assessed patient for continued suitability for performance of colonoscopy per standard routine.

2. Ensured that colonoscopy record includes all information as outlined below.

Study Data Recorded in Colonoscopy Procedure Record

The following data were collected and recorded in the colonoscopy procedure record :

30   1) Start time of colonoscopy

2) Completion time of colonoscopy

3) Volume of water used to improve visualization

4) Presence/absence of aphthous ulcerations and characterization

5) Presence/absence of ischemic colitis and characterization

6) Number of polyps identified and post biopsy characterization

7) Number of flat lesions identified and post biopsy characterization

Drug Accountability

The Investigator, or qualified designee, maintained an accurate record of the receipt of the study medication as shipped by the Sponsor (or designee) and the date received. In addition, accurate records of study drug dispensed to patients were kept by the Investigator, or qualified designee, including the amount dispensed to each patient, and the date dispensed.

ASSESSMENT, REPORTING, RECORDING AND FOLLOW UP OF ADVERSE EVENTS

Adverse Event Definition and Reporting

Study patients were monitored and questioned for TEAEs at each study visit. An Adverse Event (AE) is any untoward medical occurrence associated with the use of a drug in humans, whether or not considered drug related. An AE can therefore be any unfavorable and unintended sign (including a clinically significant abnormal laboratory finding), symptom, or disease temporally associated with the use of a medicinal (investigational) product. Subjects were queried for any problems they experienced during and after preparation by site personnel at all visits. Colonoscopy and biopsy findings are not considered adverse events unless considered by the investigator to be related to the preparation or colonoscopy procedure. Adverse event collection commenced at the time the patient provides informed consent to participate in the study and concluded with the completion of the colonoscopy. Subjects were instructed to promptly report adverse events to the Investigator. The Investigator recorded date/time of report, date/time of onset, description of the adverse event, severity of adverse event, action(s) taken regarding treatment of the event, action(s) taken regarding study participation, duration of adverse event, and the Investigator's assessment of relationship of adverse event to study treatment. The Investigator assessed the severity of each adverse event using the following categories:

Grade	Severity	Description

Grade	Severity	Description
1	Mild	Barely noticeable, does not influence functioning causing no limitations of usual activities
2	Moderate	Makes participant uncomfortable, influences functioning causing some limitations of usual activities
3	Severe	Severe discomfort, treatment needed Severe and undesirable, causing inability to carry out usual activities
4	Life threatening	Immediate risk of death, Life threatening or disabling (Must be reported as serious adverse event)
5	Fatal	Causes death of the participant (Must be reported as serious adverse event)

The Investigator assessed the relationship to study drug for each adverse event using the following categories:

Categories of Attribution:	Description
UNRELATED	There is *no* evidence of any causal relationship.
POSSIBLE	There is *some* evidence to suggest a causal relationship (e.g., the event occurred within a reasonable time after administration of the trial medication). However, the influence of *other factors may have contributed* to the event (e.g., the subject's clinical condition, other concomitant events).
PROBABLE	There *is evidence* to suggest a causal relationship, and the influence of other factors is *unlikely*.
DEFINITE	There is *clear* evidence to suggest a causal relationship, and other possible contributing factors can be *ruled out*.

Assessment of Adverse Events

A Serious Adverse Event (SAE) is any untoward medical occurrence that results in at least one of the following outcomes:

- Results in death
- Is life-threatening
- Requires inpatient hospitalization or prolongation of existing hospitalization
- A persistent or significant incapacity or substantial disruption of the ability to conduct normal life functions
- Is a congenital anomaly/birth defect
- Requires medical or surgical intervention to prevent permanent impairment or damage

Statistical Methods

No analyses were carried out other than a descriptive summary of the primary, secondary, safety and exploratory endpoints of this study.

Results

A total of 9 patients received SP-333 according to the study protocol and completed the study. All patients tolerated the combination of SP-333 and the standard colonoscopy preparation very well.

The same gastroenterologist performed all colonoscopy on the 9 patients. The gastroenterologist observed that the addition of SP-333 to the standard colonoscopy cleansing preparation allowed better visualization of the entire colon and ensured a safe and successful procedure. Subjects who had undergone previous colonoscopies concluded that taking the SP-333 along with their colon cleansing preparation made the preparation much easier than their past colon cleansing preparation without SP-333.

We claim:

1.   A composition comprising a guanylate cyclase receptor agonist (GCRA) peptide of SEQ ID NO: 9 for use in colonic cleansing in a subject, wherein the composition comprises a unit dose of 0.01 mg to 60 mg of the GCRA peptide of SEQ ID NO:9.

2.   The composition for the use of claim 1, wherein the peptide is bicyclic.

3.   The composition for the use of any one of claims 1 or 2, wherein the composition further comprisesa unit dose of 20 g to 200 g of an osmotic colonic evacuant.

4.   The composition for the use of claim 3, wherein the osmotic colonic evacuant is magnesium citrate.

5.   The composition for the use of claim 3, wherein the osmotic colonic evacuant is a phosphate salt laxative.

6.   The composition for the use of any one of claims 1 to 5, wherein the composition comprises at least one of L-glucose, lubiprostone (Amitiza), prucalopride, an agent for treating chronic constipation.

7.   The composition for the use of any one of claims 1 to 6, wherein the composition comprises a cGMP-specific phosphodiesterase inhibitor.

8.   The composition for the use of claim 7, wherein the cGMP-specific phosphodiesterase inhibitor is selected from the group consisting of sulindac sulfone, zaprinast, motapizone, vardenafil, and sildenafil.

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9. A formulation comprising a mixture of :

    a. a composition comprising an inert carrier coated with a GCRA peptide consisting of the sequence of SEQ ID NO: 9, wherein the composition comprises an enteric coating that releases the peptide at pH 5.0; and

    b. a composition comprising an inert carrier coated with a GCRA peptide consisting of the sequence of SEQ ID NO: 9, wherein the composition comprises an enteric coating that releases the peptide at pH 6.0 or pH 7.0.

10. The formulation of claim 9, wherein the inert carrier is selected from mannitol, lactose, a microcrystalline cellulose, or starch.

11. The formulation of claim 9, wherein the amount of GCRA peptide per unit dose is from 1 mg to 60 mg.

12. The formulation of any one of claims 9 to 11 for use in colonic cleansing in a subject in need thereof.