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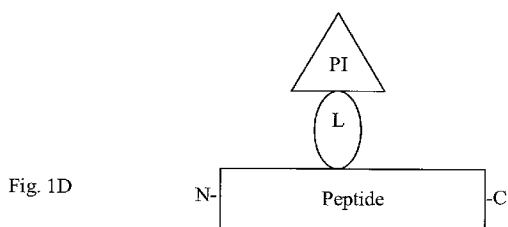
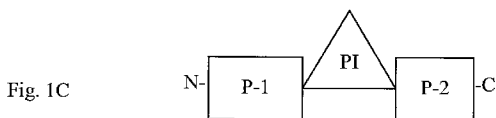
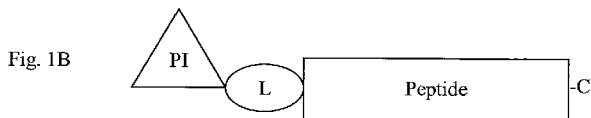
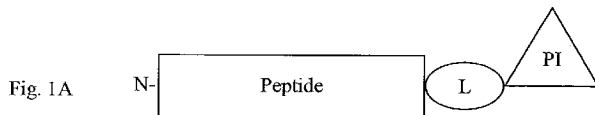
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[Continued on next page]

(54) Title: PEPTIDE-PEPTIDASE INHIBITOR CONJUGATES AND METHODS OF MAKING AND USING SAME



(57) Abstract: Peptide-peptidase inhibitor conjugate molecules and methods of manufacture thereof are disclosed. These conjugate molecules are useful as agents for the treatment and prevention of metabolic and cardiovascular diseases, disorders, and conditions. Such diseases, conditions and disorders include, but are not limited to, hypertension, dyslipidemia, cardiovascular disease, eating disorders, insulin-resistance, obesity, and diabetes mellitus of any kind, and other diabetes-related disorders.

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# PEPTIDE-PEPTIDASE INHIBITOR CONJUGATES AND METHODS OF MAKING AND USING SAME

## TECHNICAL FIELD

[0001] The present disclosure relates to peptide molecules and, more particularly, to peptide-peptidase inhibitor (P-PI) conjugate molecules and methods of synthesis thereof. The disclosure also relates to the medical field, in particular to the fields of metabolic and cardiovascular diseases.

## BACKGROUND

[0002] Many peptides and peptide hormones are involved in the body's regulation of a normal, healthy metabolic state. Central to many metabolic diseases and disorders is the regulation of insulin levels and blood glucose levels. A number of hormones that lower blood glucose levels are released from the gastrointestinal mucosa in response to the presence and adsorption of nutrients in the gut.

[0003] Insulin secretion is modulated in part by secretagogue hormones termed incretins which are produced by enteroendocrine cells. The incretin hormone glucagon-like peptide-1 (GLP-1), a peptide hormone secreted by intestinal cells, has been shown to produce an enhancing effect on insulin secretion. GLP-1 is processed from proglucagon in the gut and enhances nutrient-induced insulin release (Krcymann, *et al.* (1987) *Lancet* **2**:1300-1303). GLP-1 and various truncated forms of GLP-1, such as GLP-1(7-36) amide, and GLP-1(7-37) acid, are known to stimulate insulin secretion (insulinotropic action) and cAMP formation (see, *e.g.*, Mojsov (1992) *Int. J. Pep. Pro. Res.* **40**:333-343, Gutniak *et al.* (1992) *New Eng. J. of Med.* **326**:1316-1322, Nauck *et al.* (1993) *Diabetologia* **36**:741-744; Nauck *et al.* (1993) *J. Clin. Invest.* **91**:301-307, and Thorens *et al.* (1993) *Diabetes* **42**:1219-1225). GLP-1 (7-37) acid can be C-terminally truncated and amidated to form GLP-1 (7-36) NH<sub>2</sub>. The biological effects and metabolic turnover of the free acid GLP-1(7-37) OH, and the amide GLP-1(7-36) NH<sub>2</sub>, are indistinguishable.

[0004] GLP-1(7-36) amide exerts a pronounced antidiabetogenic effect in insulin-dependent diabetics by stimulating insulin sensitivity and by enhancing glucose-induced insulin release at physiological concentrations. When administered to non-insulin dependent diabetics, GLP-1(7-36) amide stimulates insulin release, lowers glucagon secretion, inhibits gastric emptying

and enhances glucose utilization. The use of GLP-1 type molecules for prolonged therapy of diabetes has been complicated because the serum half-life of such peptides is quite short.

[0005] The plasma half-life of active GLP-1 is <5 minutes, and its metabolic clearance rate is about 12-13 minutes. The major protease involved in the metabolism of GLP-1 is dipeptidyl  
5 peptidase IV (DPP-IV), also known in the art for example as CD26, ADABP, ADCP2, TP103 and other surrogate names, which cleaves the N-terminal His-Ala dipeptide, thus producing metabolites, GLP-1 (9-37)OH or GLP-1 (9-36)NH<sub>2</sub>, which are variously described as inactive, weak agonists or antagonists of GLP-1 receptor. The stimulation of GLP-1 receptor by  
10 GLP-1(7-37)OH or GLP-1(7-36)NH<sub>2</sub> results in adenylate cyclase activation, cAMP synthesis, membrane depolarization, rise in intracellular calcium and increase in glucose-induced insulin secretion.

[0006] Other important effects of GLP-1 on glucose homeostasis are suppression of glucagon secretion and inhibition of gastric motility. GLP-1 inhibitory actions on pancreatic alpha cell secretion of glucagon leads to decreases in hepatic glucose production *via* reduction in  
15 gluconeogenesis and glycogenolysis. This antiglucagon effect of GLP-1 is preserved in diabetic patients. Central effects of GLP-1 include increases in satiety, coupled with decreased food intake.

[0007] Native human GIP (gastric inhibitory peptide or glucose-dependent insulinotropic peptide), related to GLP-1, is a single 42 amino acid peptide synthesized in and secreted by  
20 specialized enteroendocrine K-cells. These cells are found throughout the intestine, concentrated primarily in the duodenum and proximal jejunum. The main stimulant for GIP secretion is ingestion of carbohydrate and lipid-rich meals. Following meal ingestion, circulating plasma GIP levels increase 10- to 20-fold. The half-life of intact GIP is estimated to be approximately 7.3 minutes in healthy subjects and 5.2 minutes in diabetic subjects. In  
25 serum, GIP is degraded by DPP-IV. The resulting short biological half-life limits the therapeutic use of GIP.

[0008] GIP stimulates insulin secretion in the presence of elevated glucose concentrations. Thus, the effect of endogenously released GIP appears to be an important mechanism of postprandial insulin secretion and does not appear to play a role in the fasting state. GIP  
30 stimulates beta-cell proliferation and cell survival in INS-1 islet cell line studies. Further, unlike GLP-1, GIP appears to act by accelerating emptying of the stomach rather than by inhibiting gastrointestinal motility.

[0009] Another family of peptide hormones implicated in metabolic diseases and disorders is the amylin family of peptide hormones, including amylin, calcitonin, calcitonin gene related peptide, adrenomedullin, and intermedin (also referred to as AFP-6). See, for example, Wimalawansa (1997) *Crit Rev Neurobiol.* **11**:167-239. Amylin regulates the rate of glucose appearance in circulation through a slowing of gastrointestinal motility and gastric emptying and through suppression of postprandial glucagon secretion and food intake. Amylin has been shown to reduce weight or weight gain. Amylin may also be used to treat pain, bone disorders, gastritis, to modulate lipids, in particular triglycerides, or to affect body composition such as the preferential loss of fat and sparing of lean tissue. Calcitonin (CT) was named for its secretion in response to induced hypercalcemia and its rapid hypocalcemic effect. CT has an effect on plasma calcium levels and inhibits osteoclast function and is widely used for the treatment of osteoporosis. Therapeutically, salmon CT (sCT) appears to increase bone density and decrease fracture rates with minimal adverse effects.

[0010] Calcitonin gene related peptide (CGRP) is a neuropeptide whose receptors are widely distributed in the body, including the nervous system and the cardiovascular system. This peptide seems to modulate sensory neurotransmission and is a potent endogenous vasodilatory peptide. Reported biological effects for CGRP include as follows: modulation of substance P in inflammation, nicotinic receptor activity at the neuromuscular junction, stimulation of pancreatic enzyme secretion, a reduction of gastric acid secretion, peripheral vasodilation, cardiac acceleration, neuro-modulation, regulation of calcium metabolism, osteogenic stimulation, insulin secretion, an increase in body temperature, and a decrease in food intake. An important role of CGRP is to control blood flow to various organs by its potent vasodilatory actions. Prolonged infusion of CGRP into patients with congestive cardiac failure has shown a sustained beneficial effect on hemodynamic functions without adverse effects, suggesting a use in heart failure. Other indications of CGRP use include renal failure, acute and chronic coronary artery ischemia, treatment of cardiac arrhythmia, other peripheral vascular disease such as Raynaud's phenomenon, subarachnoid hemorrhage, hypertension, and pulmonary hypertension.

[0011] Adrenomedullin (ADM) has effects on the cardiovascular system, cellular growth, the central nervous system and the endocrine system, with a range of biological actions including vasodilation, cell growth, regulation of hormone secretion, and natriuresis. Hinson *et al.* (2000) *Endocrine Reviews* **21**:138-167. ADM affects such endocrine organs as the pituitary, the adrenal gland, reproductive organs and the pancreas. The peptide appears to have a role in

inhibiting ACTH release from the pituitary. In the adrenal gland, it appears to affect the secretory activity of the adrenal cortex and it increases adrenal blood flow, acting as a vasodilator in the adrenal vascular bed. ADM has been shown to be present throughout the female reproductive tract and plasma levels are elevated in normal pregnancy. In the pancreas, ADM most likely plays an inhibitory role since it attenuated and delayed insulin response to an oral glucose challenge, resulting in initial elevated glucose levels. ADM can also affect renal function. A bolus administered peripherally can significantly lower mean arterial pressure and raise renal blood flow, glomerular filtration rate and urine flow. In some cases, there is also an increase in Na<sup>+</sup> excretion.

10 [0012] Studies have also demonstrated that ADM acts on fetal and adult rodent osteoblasts to increase cell growth comparable to those of known osteoblast growth factors such as transforming growth factor- $\beta$ . In the lung, ADM not only causes pulmonary vasodilation, but also inhibits bronchoconstriction induced by histamine or acetylcholine. In healthy volunteers, i.v. infusion of ADM has been shown to reduce arterial pressure and to stimulate heart rate, cardiac output, plasma levels of cAMP, prolactin, norepinephrine and rennin. In these patients, there was little or no increase in urine volume or sodium excretion observed. In patients with heart failure or chronic renal failure, i.v. ADM had similar effects to those seen in normal subjects, and also induced diuresis and natriuresis, depending on the dose administered (Nicholls *et al.* (2001) *Peptides* **22**:1745-1752). Experimental ADM treatment has also been shown to be beneficial in arterial and pulmonary hypertension, septic shock and ischemia/reperfusion injury (Beltowski (2004) *Pol. J. Pharmacol.* **56**:5-27). Other indications for ADM treatment include as follows: peripheral vascular disease, subarachnoid hemorrhage, hypertension, preeclamptic toxemia of pregnancy and preterm labor, and osteoporosis.

25 [0013] Expression of AFP-6 (*i.e.*, intermedin) is primarily in the pituitary and gastrointestinal tract. In *in vivo* studies, AFP-6 administration led to blood pressure reduction in both normal and spontaneously hypertensive rats. *In vivo* administration in mice led to a suppression of gastric emptying and food intake (Roh *et al.* (2004) *J. Biol. Chem.* **279**:7264-7274.)

[0014] Yet another peptide hormone family implicated in metabolic diseases and disorders is the leptin family. Leptin is an afferent signal in a negative feedback loop regulating food intake and body weight and the mature form of circulating leptin is a 146-amino acid protein.

30 [0015] Another peptide hormone implicated in metabolic diseases and disorders is cholecystokinin (CCK). Reported biological actions of CCK include stimulation of pancreatic

secretion and pancreatic growth, stimulation of gallbladder contraction, delayed gastric emptying, inhibition of gastric acid secretion, stimulation of intestinal motility, stimulation of insulin secretion, and vasodilation. The actions of CCK also reportedly include effects on cardiovascular function, respiratory function, neurotoxicity and seizures, cancer cell proliferation, analgesia, sleep, sexual and reproductive behaviors, memory, anxiety and dopamine-mediated behaviors. It has also been reported that CCK in physiological plasma concentrations inhibits increases satiety and inhibits food intake in both lean and obese humans. See, for example, Lieverse *et al.* (1994) *Ann. N.Y. Acad. Sci.* **713**:268-272, Crawley *et al.* (1994) *Peptides* **15**:731-755, Walsh, "Gastrointestinal Hormones," In *Physiology of the Gastrointestinal Tract* (3d ed. 1994; Raven Press, New York).

[0016] Another family of peptide hormones implicated in metabolic diseases and disorders is the pancreatic polypeptide family (PPF). The PPF includes pancreatic polypeptide (PP), Peptide YY (PYY), and Neuropeptide Y (NPY). These three related peptides have been reported to exert various biological effects. Effects of PP include inhibition of pancreatic secretion and relaxation of the gallbladder, and centrally administered PP produces modest increases in feeding that may be mediated by receptors localized to the hypothalamus and brainstem (reviewed in Gehlert, *Proc. Soc. Exp. Biol. Med.* **218**: 7-22 (1998)). Peripheral administration of PYY reportedly reduces gastric acid secretion, gastric motility, exocrine pancreatic secretion, gallbladder contraction, and intestinal motility (Yoshinaga *et al.* (1992) *Am. J. Physiol.* **263**:G695-701, Guan *et al.* (1991) *Endocrinology* **128**: 911-916, Pappas *et al.* (1986) *Gastroenterology* **91**:1386-1389, Savage *et al.* (1987) *Gut* **28**:166-170). The effects of central administration (injection in or around the hindbrain/brainstem) of PYY on gastric emptying, gastric motility and gastric acid secretion may differ from those effects observed after peripheral injection (Chen *et al.* (1995) *Am. J. Physiol.* **269**: R787-792, Chen *et al.* (1986) *Regul. Pept.* **61**:95-98 (1996) Yang *et al.* (1995) *Am. J. Physiol.* **268**: G943-948, Chen *et al.* (1997) *Neurogastroenterol. Motil.* **9**:109-116). PYY has been shown to stimulate food and water intake after central administration (Morley *et al.* (1985) *Brain Res.* **341**:200-203, Corp *et al.* (1990) *Am. J. Physiol.* **259**: R317-323).

[0017] Metabolic diseases and disorders take on many forms, including obesity, diabetes, dyslipidemia, and insulin resistance. Obesity and its associated disorders are common and very serious public health problems in the United States and throughout the world. Upper body obesity is the strongest risk factor known for type 2 diabetes mellitus and is a strong risk factor for cardiovascular disease. Obesity is a recognized risk factor for hypertension,

atherosclerosis, congestive heart failure, stroke, gallbladder disease, osteoarthritis, sleep apnea, reproductive disorders such as polycystic ovarian syndrome, cancers of the breast, prostate, and colon, and increased incidence of complications of general anesthesia (*see, e.g.*, Kopelman (2000) *Nature* **404**:635-643).

5 **[0018]** Obesity reduces life-span and carries a serious risk of the co-morbidities listed above, as well disorders such as infections, varicose veins, acanthosis nigricans, eczema, exercise intolerance, insulin resistance, hypertension hypercholesterolemia, cholelithiasis, orthopedic injury, and thromboembolic disease (Rissanen *et al.* (1990) *Br. Med. J.* **301**:835-837). Obesity is also a risk factor for the group of conditions called insulin resistance syndrome, or  
10 “Syndrome X” and metabolic syndrome. The worldwide medical cost of obesity and associated disorders is enormous. The pathogenesis of obesity appears to be multifactorial but the basic problem is that in obese subjects nutrient availability and energy expenditure do not come into balance until there is excess adipose tissue. Obesity is currently a poorly treatable, chronic, essentially intractable metabolic disorder. A therapeutic drug useful in weight  
15 reduction of obese persons could have a profound beneficial effect on their health.

**[0019]** Diabetes is a disorder of carbohydrate metabolism characterized by hyperglycemia and glucosuria resulting from insufficient production or utilization of insulin. Diabetes severely affects the quality of life of large parts of the populations in developed countries. Insufficient production of insulin is characterized as type 1 diabetes and insufficient utilization  
20 of insulin is type 2 diabetes. However, it is now widely recognized that there are many distinct diabetes related diseases which have their onset long before patients are diagnosed as having overt diabetes. Also, the effects from the suboptimal control of glucose metabolism in diabetes give rise to a wide spectrum of related lipid and cardiovascular disorders.

**[0020]** Dyslipidemia, or abnormal levels of lipoproteins in blood plasma, is a frequent  
25 occurrence among diabetics. Dyslipidemia is typically characterized by elevated plasma triglycerides, low HDL (high density lipoprotein) cholesterol, normal to elevated levels of LDL (low density lipoprotein) cholesterol and increased levels of small dense, LDL particles in the blood. Dyslipidemia is one of the main contributors to the increased incidence of coronary events and deaths among diabetic subjects. Epidemiological studies have confirmed this by  
30 showing a several-fold increase in coronary deaths among diabetic subjects when compared with non-diabetic subjects. Several lipoprotein abnormalities have been described among diabetic subjects.

[0021] Insulin resistance is the diminished ability of insulin to exert its biologically action across a broad range of concentrations. In insulin resistance, the body secretes abnormally high amounts of insulin to compensate for this defect and a state of impaired glucose tolerance develops. Failing to compensate for the defective insulin action, the plasma glucose concentration inevitably rises, resulting in the clinical state of diabetes. It is being recognized that insulin resistance and relative hyperinsulinemia have a contributory role in obesity, hypertension, atherosclerosis and type 2 diabetes. The association of insulin resistance with obesity, hypertension and angina has been described as a syndrome, Syndrome X, having insulin resistance as the common pathogenic link.

[0022] Hypertension, or high blood pressure, may or may not be associated with a metabolic disease or disorder in a patient. Hypertension is the most common disease affecting the heart and blood vessels and statistics indicate that it occurs in more than 50 million Americans. The prevalence of hypertension increases with age. Hypertension is of considerable concern because of the harm it can do to the heart, brain and kidneys if it remains uncontrolled.

[0023] There remains a need for effective methods of producing bioactive peptides in forms that are effective for the treatment for diseases, conditions, and disorders, including metabolic and cardiovascular diseases and related disorders.

[0024] All patents, patent applications, and publications cited herein are hereby incorporated by reference in their entirety and for all purposes.

## SUMMARY

[0025] In a first aspect, a method is provided for synthesizing a peptide-peptidase inhibitor (P-PI) conjugate having peptide, linker and peptidase inhibitor components with structure

### Peptide-linker-peptidase inhibitor

wherein the linker is optional, the method including the steps: a) coupling a peptidase inhibitor to a resin under conditions suitable to form a resin-bound peptidase inhibitor, the peptidase inhibitor including a peptidase inhibitor core and an initial linker covalently bound thereto, the peptidase inhibitor including a first amine and a second amine, and the peptidase inhibitor coupled to the resin through the first amine; b) optionally coupling at the second amine an extended linker to form the optional linker, the extended linker including an amine which replaces the second amine; c) coupling the peptide of the P-PI conjugate, one or more amino acids, or one or more fragments of the peptide of the P-PI conjugate at the second amine under

conditions suitable to form the P-PI conjugate; and d) cleaving the P-PI conjugate from the resin, thereby providing the peptide-peptidase inhibitor (P-PI) conjugate. "Peptidase inhibitor core" and like terms refer to chemical groups as described herein which impart peptidase inhibiting activity directed at specific peptidases as described herein. "Initial linker" and like terms refer to a linker as described herein, which initial linker includes at least three coupling sites, e.g., 3, 4, 5 or even 6 coupling sites. "Coupling site" and like terms refer to points of attachment, optionally protectable, to which coupling can occur by methods well known in the art and/or described herein. In some embodiments, the initial linker includes two amine groups and one carboxylic acid group. In some embodiments, the first amine is proximal to the peptidase inhibitor core. In some embodiments, the first amine is distal to the peptidase inhibitor core. "Extended linker" and like terms, as described herein, refer to linkers connecting an initial linker to a peptide of the peptide-peptidase inhibitor (P-PI) conjugate. The term "fragments of the peptide of the P-PI conjugate" refers to any contiguous sequence of amino acid residues within the peptide of the P-PI conjugate, having any length from one amino acid up to the length of the peptide of the P-PI conjugate. In certain embodiments, the method of synthesis is not the method described in Scheme 8 herein.

**[0026]** In another aspect, a method is provided for synthesizing a peptide-peptidase inhibitor (P-PI) conjugate with structure

Peptide-linker-DPP-IV inhibitor

the method including the steps: a) coupling a DPP-IV inhibitor to a resin under conditions suitable to form a resin-bound DPP-IV inhibitor, the DPP-IV inhibitor including a first amine and a second amine, and the DPP-IV inhibitor coupled to the resin through the first amine; b) coupling at the second amine an extended linker to form a linker, the extended linker including an amine which replaces the second amine; c) coupling the peptide of the P-PI conjugate, one or more amino acids, or one or more fragments of the peptide of the P-PI conjugate at the second amine under conditions suitable to form the P-PI conjugate; and d) cleaving the P-PI conjugate from the resin, thereby providing the peptide-peptidase inhibitor (P-PI) conjugate.

**[0027]** In certain embodiments, step b) is repeated such that more than 1, e.g., 2, 3, 4, 5 or even more extended linkers are added to the extended linker coupled to the initial linker. In certain embodiments, extended linkers are attached in series to create a single extended backbone coupled to the initial linker. In certain embodiments, an extended linker is a macromolecule, for example without limitation an immunoglobulin or fragment such as an Fc

fragment, an albumin, a PEG polymer such as PEG 5000, and the like, which embodiments are within the scope of the present disclosure. It is understood that the function of the linker is to link the peptide with the peptidase inhibitor.

5 [0028] In certain embodiments, the peptidase inhibitor is formed by coupling the peptidase inhibitor core with the initial linker under conditions suitable to form the peptidase inhibitor, which conditions are known in the art and/or described herein. In certain further embodiments, the initial linker is coupled to an extended linker prior to coupling with the peptidase inhibitor core, the extended linker comprising an amine which replaces the second amine of the peptidase inhibitor, thereby providing the optional linker. In certain further embodiments, the  
10 initial linker is coupled to an extended linker after coupling with the peptidase inhibitor core, the extended linker comprising an amine which replaces the second amine of the peptidase inhibitor, thereby providing the optional linker. In certain embodiments of this aspect, the step of coupling at the second amine an extended linker to form the optional linker, the extended linker including an amine which replaces the second amine, is conducted.

15 [0029] In certain embodiments of any of the aspects or embodiments described above, the peptidase inhibitor is selected from the group consisting of inhibitors of angiotensin converting enzyme (ACE), vasopeptidase, neuraminadase, plasma peptidase, endothelial converting enzyme, human neutral endopeptidase, dipeptidyl peptidase IV (DPP-IV), aminopeptidase, cysteine proteases, serine proteases, and carboxypeptidases.

20 [0030] In certain embodiments, the peptidase inhibitor is a DPP-IV inhibitor. In certain embodiments, the DPP-IV inhibitor includes a moiety selected from the group consisting of cyanopyrrolidine, thiazoline, pyrrolidine-3-sulfoxide, and derivatives thereof. In certain embodiments, the DPP-IV inhibitor includes a moiety selected from the group consisting of thiazolidine, cyanopyrrolidine and pyrrolidine-3-sulfoxide. In certain embodiments, the DPP-  
25 IV inhibitor includes thiazolidine. In certain embodiments, the DPP-IV inhibitor includes cyanopyrrolidine. In certain embodiments, the DPP-IV inhibitor includes pyrrolidine-3-sulfoxide. In certain embodiments, the DPP-IV inhibitor is selected from the group consisting of N-(substituted glycy)-2-cyanopyrrolidine, tetrahydroisoquinoline 3-carboxamide derivatives, fluorinated cyclic amides, adamantylglycine-based inhibitors, glycinenitrile-based  
30 inhibitors, and boropyrrolidine inhibitors, as known in the art and described herein.

[0031] Further in any of the aspects and embodiments described above, the initial linker includes a diamino acid. In certain embodiments, the initial linker is a diamino acid.

[0032] Further in any of the aspects and embodiments described above, the initial linker includes 3-20 carbon atoms, e.g., 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 or even 20 carbon atoms.

[0033] Further in any of the aspects and embodiments described above which include a  
5 diamino acid as an initial linker, the diamino acid is lysine or a homolog of lysine. In some  
embodiments, the diamino acid is selected from the group consisting of homohomolysine (C<sub>8</sub>),  
homolysine (C<sub>7</sub>), lysine (C<sub>6</sub>), ornithine (C<sub>5</sub>), diaminobutyric acid (C<sub>4</sub>) and diamino propionic  
acid (C<sub>3</sub>). In some embodiments, the diamino acid is orthogonally protected by protecting  
10 groups known in the art. "Orthogonally protected" and like terms refer to the presence of  
different protecting groups on a protected molecule, which protecting groups can be  
differentially deprotected, as known in the art. In some embodiments, the initial linker is  
formed by reaction of the peptidase inhibitor core with Boc-Lys-Fmoc-OH.

[0034] Further in any of the aspects and embodiments described above, the initial linker is  
15 attached to an amine group of said peptidase inhibitor core. In some embodiments, the  
peptidase inhibitor is attached to a carboxylic acid group of the peptide. In some  
embodiments, the carboxylic acid group of the peptide is the C-terminal carboxylic acid. In  
some embodiments, the carboxylic acid group of said peptide is an internal carboxylic acid.  
"Internal carboxylic acid group" and like terms refer to carboxylic acids on the side chains of  
20 amino acids forming a peptide. "Internal amine" and like terms refer to amine groups on the  
side chains of amino acids forming a peptide.

[0035] Further in any of the aspects and embodiments described above, the linker, if present,  
includes 3-100, 5-59, 5-49, 5-39, 5-29, 5-24, or 9-19 backbone atoms.

[0036] Further in any of the aspects and embodiments described above, the linker, if present,  
includes a diamino acid. In some embodiments, the linker, if present, includes one or more,  
25 e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9 or even 10, polyethylene oxide monomers. In some embodiments,  
the linker, if present, includes 1 or 2 polyethylene oxide monomers. In some embodiments, the  
linker, if present, includes 2 polyethylene oxide monomers.

[0037] Further in any of the aspects and embodiments described above, the linker, if present,  
is as described herein. Exemplary linking groups include, but are not limited to, the following:  
30 alkyl; PEG; 8-amino-3,6-dioxo octanoic acid; amino acid, e.g., Lys, Glu,  $\beta$ -Ala; polyamino  
acid, e.g., poly-gly, poly-his, poly-arg, poly-lys, poly-ala, Gly-Lys-Arg (GKR), and the like;  
bifunctional linkers, e.g., those sold by Pierce Biotechnology, Inc., Rockford, IL; aminocaproyl

(“Aca”) and homolog thereof;  $\beta$ -ala; poly- $\beta$ -ala; 8-amino-3,6-dioxaoctanoyl;  $\gamma$ -Abu; poly- $\gamma$ -Abu; and other cleavable and non-cleavable linkers known in the art. Exemplary polyamino acids include, without limitation,  $[\beta\text{-ala}]_x$  wherein  $x$  is 1 to 5, e.g., 1, 2, 3, 4 or 5,  $[\text{gly}]_x$  where  $x$  is 1 to 5, e.g., 1, 2, 3, 4 or 5,  $[[\text{Gly}]_x\text{-Xaa}]_y$  where  $x$  is 1 to 5, e.g., 1, 2, 3, 4 or 5,  $y$  is 1 to 5, e.g., 1, 2, 3, 4 or 5, and where Xaa is any naturally-occurring amino acid (e.g., Ser, Ala and the like), polymers of  $\beta$ -ala and gly, and  $[\gamma\text{-Abu}]_x$  where  $x$  is 1 to 5, e.g., 1, 2, 3, 4 or 5.

**[0038]** Further in any of the aspects and embodiments described above, the resin contains a chemical group that couples with a chemical group of the peptidase inhibitor while retaining the ability to allow cleavage of the P-PI from said resin. In some embodiments, the resin is a *p*-nitrophenyl carbonate Wang resin.

**[0039]** Further in any of the aspects and embodiments described above, the peptide is a therapeutic peptide susceptible to cleavage by a peptidase. In some embodiments, the peptide is a therapeutic peptide susceptible to cleavage by a peptidase, which peptidase is susceptible to inactivation by a peptidase inhibitor of the P-PI conjugate. In some embodiments, the therapeutic peptide is selected from the group consisting of incretins, amylinomimetics, glucose-dependent insulinotropes, leptins, cholecystokinins, pancreatic polypeptides, and analogs thereof, which therapeutic peptides are known in the art and/or described herein. In some embodiments, the peptide is a native peptide hormone. In some embodiments, the peptide is selected from the group consisting of GLP-1, GLP-2, GIP, exendin-3, exendin-4, PYY, amylin, calcitonin, leptin, and analogs thereof. In some embodiments, the peptide is an analog, derivative or hybrid of a native peptide hormone as described herein. In some embodiments, the hybrid of a native peptide hormone includes one or more hormone portions selected from the group consisting of GLP-1, GLP-2, GIP, exendin-3, exendin-4, PYY, amylin, calcitonin, leptin, e.g., metreleptin, A100, A200, and analogs thereof. In some embodiments, the hybrid of a native peptide hormone includes portions selected from both exendin-4 and GLP-1. In some embodiments, the hybrid of a native peptide hormone is  $[\text{}^{14}\text{Leu}, \text{}^{28}\text{Gln}]\text{Exendin-4}(1\text{-}32)\text{-fGLP-1-(}33\text{-}37)$  (SEQ ID NO:269). In some embodiments, the peptidase is DPP-IV, and the peptide is selected from the group consisting of GLP-1, GIP, PYY, NPY and exendin-4, or an analog or derivative thereof. In some embodiments, the peptidase is DPP-IV, and the peptide comprises hormone portions selected from the group consisting of fragments of GLP-1, GIP, PYY, NPY and exendin-4, or an analog or derivative thereof.

[0040] In another aspect, provided are resin-bound peptidase inhibitor compositions, wherein the peptidase inhibitor includes a peptidase inhibitor core and an initial linker covalently bound thereto, wherein the peptidase inhibitor includes a first amine and a second amine, wherein the peptidase inhibitor is coupled to the resin through the first amine, wherein the peptidase inhibitor is optionally coupled to a linker, which linker includes an extended linker coupled to the second amine, and the extended linker includes an amine which replaces the second amine.

[0041] In certain embodiments the peptidase inhibitor is a DPP-IV inhibitor. In certain embodiments, the DPP-IV inhibitor is selected from the group consisting of pyrrolidine, cyanopyrrolidine, thiazoline, and derivatives thereof. In certain embodiments, the resin is a *p*-nitrophenyl carbonate Wang resin. In certain embodiments, the extended linker is an amino carboxylic acid. In certain embodiments, the extended linker is selected from the group consisting of 8-amino-3,6-dioxo octanoic acid and  $\gamma$ -Abu. In certain embodiments of this aspect, the composition further comprises one or more amino acids coupled to the second amine.

[0042] In certain embodiments, the P-PI conjugate comprises a peptide analog, a peptide derivative, or a peptide hybrid of a native peptide hormone. "Hybrid peptide," "hybrid polypeptide," "hybrid peptide hormone" and like terms refer to a polypeptide comprising at least two peptide hormone portions linked together, wherein the at least two peptide hormones are not the same peptide hormone. "Peptide hormone portion," "hormone portion" and like terms refer to segments of a peptide hormone or analog or derivative thereof having a length less than the length of the native peptide hormone. In some embodiments, the segments are contiguous amino acid sequences. The peptide-peptidase inhibitor conjugate has a plasma half-life greater than the plasma half-life of the peptide when not conjugated to the peptidase inhibitor. The peptidase inhibitor of the peptide-peptidase inhibitor conjugate reduces the activity of a regulatory peptidase. The peptidase inhibitor of the peptide-peptidase inhibitor conjugate reduces the activity of a peptidase which inactivates the peptide of the conjugate. The peptidase inhibitor of the peptide-peptidase inhibitor conjugate reduces the activity of a peptidase which does not act upon the peptide of the conjugate. The peptidase inhibitor is selected from a group consisting of an angiotensin converting enzyme inhibitor, a vaso-peptidase inhibitor, endothelial converting enzyme inhibitor, human neutral endopeptidase inhibitor, DPP-IV inhibitor, aminopeptidase inhibitor, cysteine protease inhibitor, serine protease inhibitor, and carboxypeptidase inhibitor.

[0043] In some embodiments, the peptide is a hybrid peptide hormone. In some embodiments, the peptide is selected from a group consisting of a GLP-1, a GLP-2, a GIP, an exendin, a PYY, an amylin, a calcitonin, a leptin, and analogs thereof. In some embodiments, the peptide is a hormone agonist. In some embodiments, the peptide is a hormone antagonist.

5 [0044] The conjugates made by the embodiments disclosed herein can be formulated as pharmaceutical compositions. In some embodiments, the peptide-peptidase inhibitor conjugates are of use in the preparation of pharmaceutical compositions.

[0045] The peptide-peptidase inhibitor conjugates made as described herein can be used in effective amounts for decreasing degradation of a peptidase-sensitive peptide in plasma. In  
10 addition, the peptide-peptidase inhibitor conjugates can be used in effective amounts for increasing the plasma half-life of a peptidase-sensitive peptide.

[0046] Further, the peptide-peptidase inhibitor conjugates made by the methods described herein can be used in therapeutically effective amounts for the treatment of a metabolic disorder. The metabolic disorder can be obesity, diabetes (*e.g.*, type 2 or non-insulin  
15 dependent diabetes, type 1 diabetes, and gestational diabetes), eating disorders, insulin-resistance syndrome, and/or cardiovascular disease. The conjugates also find use to reduce nutrient availability through the administration of peptide-peptidase inhibitor conjugates, and find use in therapeutically effective amounts for the treatment of conditions, diseases, and disorders that would benefit from a reduction in nutrient availability.

20

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0047] Fig. 1 depicts exemplary designs of peptide-peptidase inhibitor conjugated compounds (Peptide rectangle, peptide; PI triangle, peptidase inhibitor; P-1 and P-2 rectangles, two portions of a single peptide; oval, linker).

[0048] Fig. 2 depicts exemplary designs of a peptide-peptidase inhibitor conjugate compound  
25 with the ACE inhibitor lisinopril joined at the C-terminus of the peptide through a variety of depicted linkers.

[0049] Fig. 3A and Fig. 3B graphically depict peptide stability in hKBBM assays in the absence (Fig. 3A) and presence (Fig. 3B) of valinepyrrolidide.

[0050] Fig. 4A, 4B, 4C and 4D graphically depict mass spectrometer results of DPP-IV  
30 resistance assays of GLP-1 (Fig. 4A), GLP-1 + DPP-IV (Fig. 4B), GLP-1 conjugate compound 4844 + DPP-IV (Fig. 4C), and GLP-1 conjugate compound 4845 + DPP-IV Fig. 4D).

[0051] Fig. 5 is a graph depicting changes in blood glucose levels after administration of control compounds and conjugate compounds 4844 and 4845.

[0052] Fig. 6 is a graph depicting changes in blood glucose levels after administration of control compounds and conjugate compounds 4983 and 4984.

5 [0053] Fig. 7 is a graph depicting peptide stability of conjugate compounds in a KMP assay.

[0054] Fig. 8 is a graph depicting changes in the amount of PYY(3-36) (SEQ ID NO:3) and its metabolite PYY(3-35) (SEQ ID NO:245) over time when PYY(3-36) is incubated in human plasma.

10 [0055] Fig. 9 is a graph depicting the formation of PYY(3-35) (SEQ ID NO:245) during incubation of PYY(3-36) (SEQ ID NO:3) in plasma in the absence or presence of <sup>36</sup>N-methyl-Tyr-amide-PYY(3-36).

[0056] Fig. 10 is a graph depicting the formation of PYY(3-35) (SEQ ID NO:245) during incubation of PYY(3-36) (SEQ ID NO:3) in plasma in the absence or presence of <sup>36</sup>N-methyl-Tyr-amide-PYY(22-36).

15 [0057] Fig. 11 is a graph depicting the formation of PYY(3-35) (SEQ ID NO:245) during incubation of PYY(3-36) (SEQ ID NO:3) in plasma in the absence or presence of <sup>36</sup>N-methyl-Tyr-amide-PYY(34-36).

20 [0058] Fig. 12 is a graph depicting the formation of PYY(3-35) (SEQ ID NO:245) during incubation of PYY(3-36) (SEQ ID NO:3) in plasma in the absence or presence of N-methyl-Tyr-NH<sub>2</sub>.

[0059] Fig. 13A-and Fig. 13B are graphs depicting mean diastolic (Fig. 13A) and systolic (Fig. 13B) blood pressure determined at week 5 of an *in vivo* CHF assay.

25 [0060] Fig. 14 depicts the transient effects of P-PI conjugates Cmpds 5933 and 5954 and exendin-4 on glucose and body weight in NIH/Swiss female mice.. After subcutaneous injection of P-PI conjugate or exendin-4, blood glucose (Fig. 14A) and body weight (Fig. 14B) were measured over a 96-hr period. Mean pre-treatment glucose was 130 mg/dL. Mean pre-treatment body weight was 29 g. The symbol "\*" refers to p<0.05 vs. vehicle control (ANOVA, Dunnett's test). Legend: (filled box): vehicle; (diamond): exendin-4; (triangle): Cmpd 5933; (open box): Cmpd 5954.

30 [0061] Fig. 15 depicts the transient effects of P-PI conjugates Cmpds 5932 and 5955 and exendin-4 on glucose and body weight in NIH/Swiss female mice.. After subcutaneous

injection of P-PI conjugate or exendin-4, blood glucose (Fig. 15A) and body weight (Fig. 15B) were measured over a 96-hr period. Mean pre-treatment glucose was 125 mg/dL. Mean pre-treatment body weight was 28 g. The symbol "\*" refers to  $p < 0.05$  vs. vehicle control (ANOVA, Dunnett's test). Legend: (filled box): vehicle; (filled diamond): exendin-4; (open diamond): Cmpd 5955; (triangle): Cmpd 5932.

## DETAILED DESCRIPTION

[0062] Proteolytic cleavage of peptide bonds by regulatory peptidases, as well non-specific peptidases, is a principal mechanism of inactivation and clearance of bioactive peptides and peptide drugs *in vivo*. We have discovered a new approach to peptide drug design, and methods of synthesis of compounds thereof, in which peptidase-inhibiting motifs are strategically and covalently linked to bioactive peptides to render the peptides peptidase resistant. Such peptide-peptidase inhibitor conjugates can thus have a prolonged serum half-life relative to the unconjugated peptide. In some cases, a prolonged half-life can allow administration of less of the peptide without compromising effectiveness of the treatment. In some cases, the peptide in such conjugates can serve to specifically and effectively deliver the peptidase inhibitor to a site rich in peptide receptor. In some cases, such delivery will allow the peptidase inhibitor to also inhibit peptidase activity on endogenous peptide molecules at the site of action, *e.g.*, the receptor.

[0063] In addition, in cases where the peptidases themselves are therapeutic drug targets in a disease indication or in a comorbidity, the peptide-peptidase inhibitor conjugates as described herein provide a dual mechanism of action in treating the disease or comorbidity. In these cases, the peptide-peptidase inhibitor conjugates target both a peptide receptor and a peptidase and may improve the overall therapeutic outcome with a single chemical entity.

[0064] Component peptides for use in the P-PI conjugates disclosed herein include those that are subject to degradation by specific or non-specific peptidases. "Component peptide," "peptide of the P-PI conjugate" and like terms refer to a peptide forming part of a P-PI conjugate. Exemplary component peptides for use in the P-PI conjugates disclosed herein are subject to degradation by regulatory peptidases. In some embodiments, the peptide components are peptide hormones, peptide fragments with hormonal activity, or structural motifs of peptide hormones that impart chemical, metabolic, and/or other pharmacokinetic stability. The peptide hormones may include native peptide hormones, as well as peptide hormone agonists, analogs, derivatives, and hybrids, as known in the art and described herein.

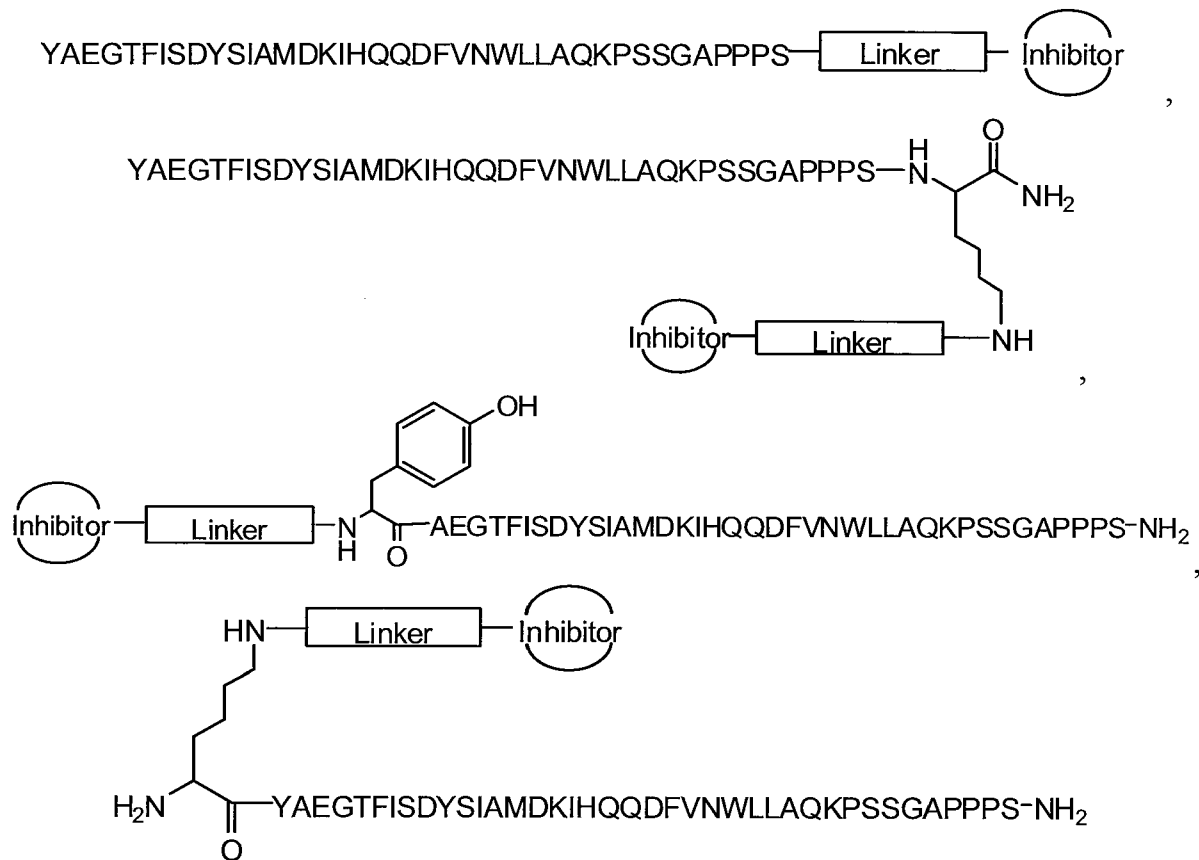
In some embodiments, the peptide components are peptide hormone antagonists, peptide fragments with hormonal antagonist activity, or structural motifs of peptide hormone antagonists that impart chemical, metabolic, and/or other pharmacokinetic stability. The peptide hormone antagonists may include peptide hormone receptor antagonists, as well as  
5 other hormone antagonists, analogs, derivatives, and hybrids thereof, as known in the art and described herein.

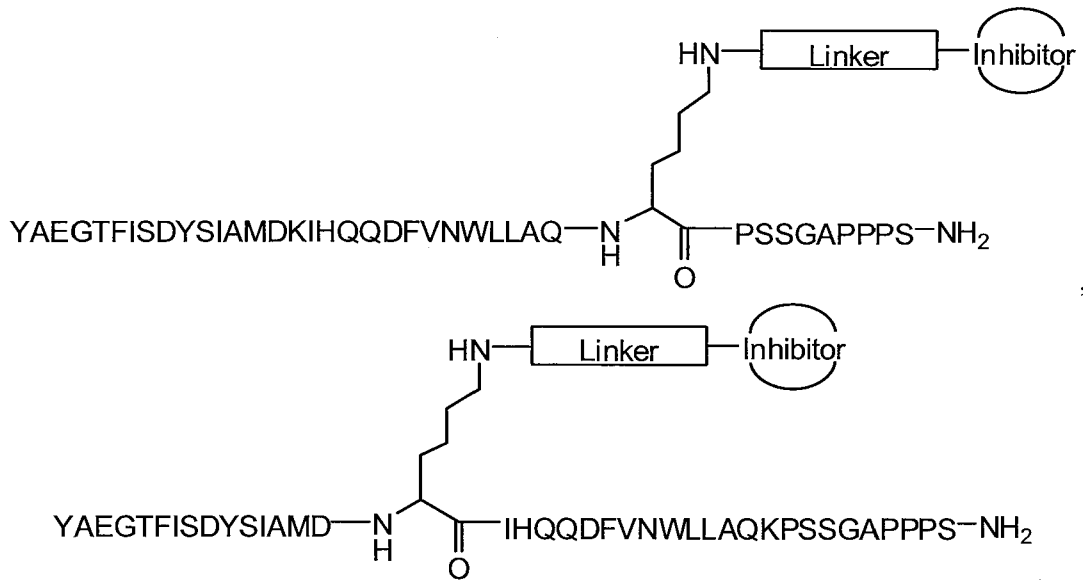
**[0065]** Component peptidase inhibitors for use in the P-PI conjugates disclosed herein include those that inhibit or reduce the activity of specific peptidases, non-specific peptidases, or both. "Component peptidase inhibitor" and like terms refer to a peptidase inhibitor within a  
10 P-PI conjugate. A component peptidase inhibitor for use in the P-PI conjugates disclosed herein has such inhibitory activity whether or not it is in a P-PI conjugate complex. Exemplary component peptidase inhibitors for use in the P-PI conjugates disclosed herein are inhibitors of regulatory peptidases. The peptidase inhibitors include competitive inhibitors, non-competitive inhibitors, uncompetitive inhibitors, and irreversible active site inhibitors. The  
15 peptidase inhibitors include, but are not limited to, small chemical molecules and peptides. As described herein, component peptidase inhibitors include, but are not limited to, angiotensin converting enzyme (ACE) inhibitors, vaso-peptidase inhibitors, neuraminidase inhibitors, plasma peptidase inhibitors, endothelial converting enzyme inhibitors, human neutral endopeptidase inhibitors, DPP-IV inhibitors, aminopeptidase inhibitors, cysteine protease  
20 inhibitors, serine protease inhibitors, and carboxypeptidase inhibitors.

**[0066]** The terms "peptide-peptidase inhibitor conjugate," "P-PI conjugate" and like terms refer to a complex in which at least one peptide and at least one peptidase inhibitor are linked. Such conjugate linkages include covalent and/or non-covalent linkages. Non-covalent linkages may be mediated by any non-covalent bonding force, including by hydrophobic interaction,  
25 ionic (electrostatic) bonding, metal complexation, hydrogen bonds, van der Waals attractions, or a combination of two or more different interactions. The component peptide and component peptidase inhibitor may be covalently linked together in any manner described herein or known in the art, including but not limited to, direct amide bonds or chemical linker groups.

**[0067]** Peptide-peptidase inhibitor conjugates include those in which the peptidase inhibitor  
30 is covalently linked to the backbone of the peptide and those in which the peptidase inhibitor is covalently linked to a side-chain of the peptide. The peptide and the peptidase inhibitor may be directly conjugated or may be conjugated through a linker molecule. In some embodiments, the peptidase inhibitor is directly conjugated through a linker molecule. As can be observed in

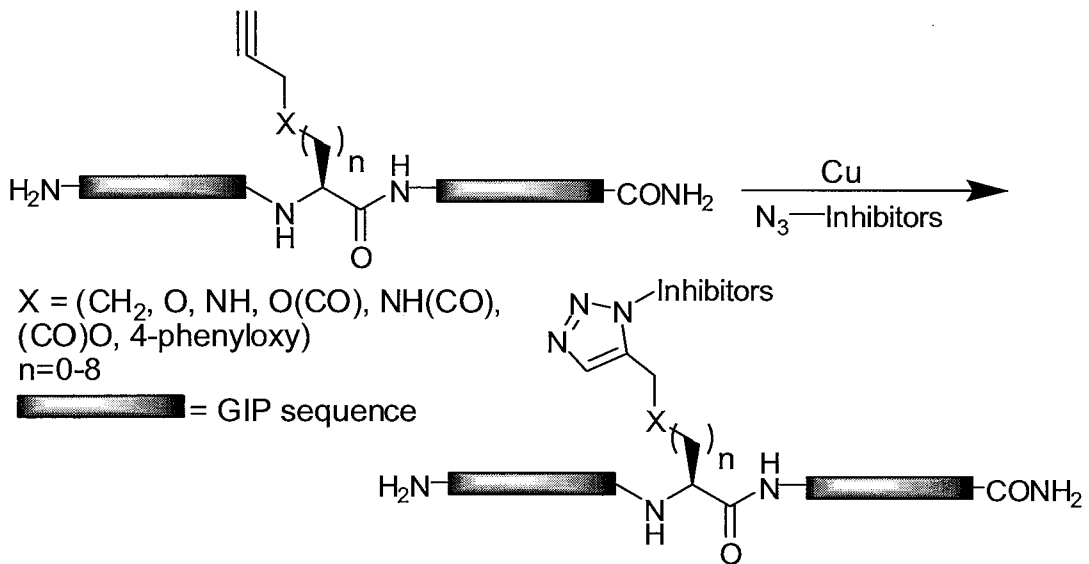
exemplified compounds, in some embodiments the site of attachment can be a free amine group, for example without limitation a peptide terminal amine or the distal amine of a lysine side chain. Lysine residues can be inserted or substituted into the peptide as needed. In other embodiments, a free sulfhydryl group is the site of attachment, and cysteine may be inserted as needed. In some embodiments, the peptide or analog thereof contains a lysine or free terminal amine. In other embodiments, the peptide or analog thereof contains a free cysteine. Designs of peptide-peptidase inhibitor conjugate compounds include, but are not limited to, those are depicted in Fig. 1. As shown in Fig. 1, the peptide may be conjugated to a peptidase inhibitor (PI) (a) at the carboxy-terminus of the peptide, (b) at the amino-terminus of the peptide, (c) through insertion of PI into the polypeptide chain of the peptide, or (d) at an amino acid side chain of the peptide. In peptide-peptidase inhibitor conjugates with an <sup>2</sup>Ala in the peptide, the <sup>2</sup>Ala may be either the L or D isomer. As described herein, any of the linkages between the peptide and the peptidase inhibitor may be through a direct bond or through a linker molecule. For example, P-PI conjugates including the GIP analog GIP(1-30)-exendin-4(31-39) (SEQ ID NO:1) include, but are not limited to, the following:





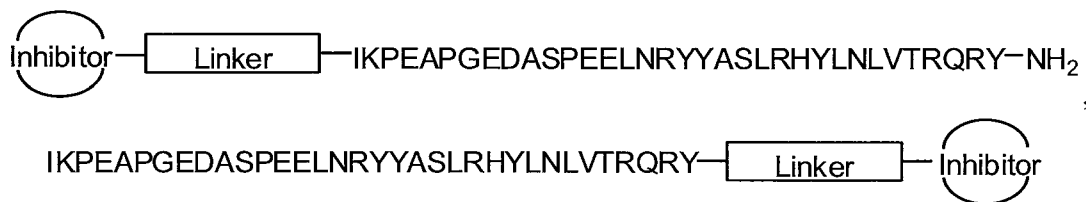
and compounds resulting from the reaction described by Scheme 1.

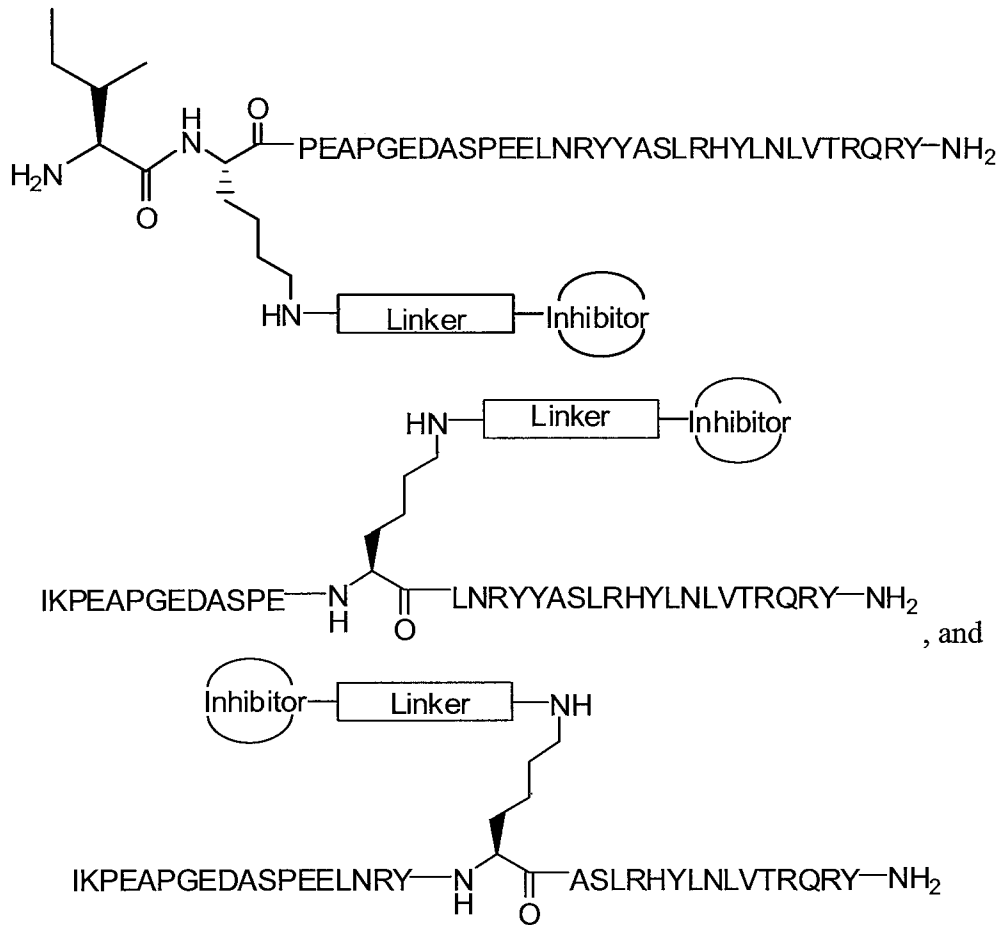
**Scheme 1:**



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**[0068]** Exemplary P-PI conjugates containing all or part of the PYY analog PYY(3-36) (SEQ ID NO:3) include, but are not limited to, the following:





, and

[0069] Component peptides useful in the conjugate molecules and methods described herein  
 5 also include PPF peptide hormones, including PP and PYY. By “PP” is meant human  
 pancreatic peptide polypeptide or species variants thereof, in any physiological form. Thus,  
 the term “PP” includes both the human full length, 36 amino acid peptide, and species  
 variations of PP, including, *e.g.*, murine, hamster, chicken, bovine, rat, and dog PP. In this  
 sense, “PP,” “wild-type PP,” and “native PP,” *i.e.*, unmodified PP, are used interchangeably.  
 10 By “PYY” is meant human peptide YY polypeptide or species variants thereof, in any  
 physiological form. Thus, the term “PYY” includes both the human full-length 36 amino acid  
 peptide, and species variations of PYY, including *e.g.*, murine, hamster, chicken, bovine, rat,  
 and dog PYY. In this sense, “PYY” and “wild-type PYY” and “native PYY,” *i.e.*, unmodified  
 PYY, are used interchangeably. Unless otherwise indicated, modifications discussed herein  
 15 with reference to PYY analog peptides are based on the 36 amino acid sequence of native  
 human PYY.

[0070] Native PPF peptide hormones are known in art, as are functional PPF peptide  
 agonists, analogs, derivatives, and hybrids. Certain PPF native peptides and peptide agonists,  
 analogs, derivatives, and hybrids are described herein, however, it should be recognized that

any PPF peptide or PPF agonist, PPF analog, PPF derivative, or PPF hybrid known in the art may be used in conjunction with the compositions and methods disclosed herein. Exemplary PYY component peptides include

human PYY (hPYY) YPIKPEAPGEDASPEELNRYYYASLRHYLNLVTRQRY

5 (SEQ ID NO:2) and hPYY(3-36) IKPEAPGEDASPEELNRYYYASLRHYLNLVTRQRY

(SEQ ID NO:3). In some embodiments, the peptidase inhibitor is not linked to the Lys at position 2 of PYY(3-36) nor to an analogous Lys of a PYY(3-36) analog. Other exemplary native PPF peptide hormones include, without limitation,

human NPY (hNPY) YPSKPDNPGEDAPAEDMARYYSALRHYINLITRQRY

10 (SEQ ID NO:246), and

pancreatic polypeptide (PP) APLEPVYPGDNATPEQMAQYAADLRRYINMLTRPRY  
(SEQ ID NO:275).

**[0071]** In some embodiments, the PPF agonists, analogs, derivatives, and hybrids have at least one biological activity of a native PPF peptide. In certain embodiments, the PPF analogs,  
15 derivatives, and hybrids are agonists of a receptor which native PPF peptide is capable of specifically binding. In some embodiments, PPF analogs and derivatives generally comprise at least two PYY motifs including a polyproline motif and C-terminal tail motif. Such analogs are generally described in U.S. Pat. Application Publication No. 2006/0094653, which is herein incorporated by reference and for all purposes. In some embodiments, a PPF analog,  
20 derivative, or hybrid has an amino acid sequence that has about 20 or less, 15 or less, 10 or less, 5 or less, 4 or less, 3 or less, 2 or less, or 1 or less substitutions, additions, or deletions as compared to a naturally occurring PPF, such as PYY.

**[0072]** A "PYY motif" is generally a structural component, primary, secondary, or tertiary, of a native PPF peptide that is critical to biological activity, *i.e.*, biological activity is  
25 substantially decreased in the absence or disturbance of the motif. PYY motifs include the N-terminal polyproline type II motif of a native PPF peptide, the type II  $\beta$ -turn motif of native PPF peptide, the  $\alpha$ -helical motif at the C-terminal end of native PPF peptide, and the C-terminal tail motif of native PPF peptide. In some embodiments of PPF peptide, in the N-terminal polyproline region, amino acids corresponding to residues 5 and 8 of a native PPF  
30 peptide are generally conserved as a proline. The type II  $\beta$ -turn motif will generally include amino acids corresponding to residues 12-14 of a native PPF peptide. The  $\alpha$ -helical motif can generally extend from amino acids corresponding to approximately residue 14 of a native PPF peptide to any point up to and including the C-terminal end, so long as the  $\alpha$ -helical motif

includes a sufficient number of amino acid residues such that an  $\alpha$ -helical turn is formed in solution. The  $\alpha$ -helical motif can also include amino acid substitutions, insertions and deletions to the native PPF family sequence, so long as the  $\alpha$ -helical turn is still formed in solution. The C-terminal tail motif generally includes amino acids corresponding to

5 approximately the last 10 residues of a native PPF peptide. In some embodiments, the C-terminal tail motif includes amino acids corresponding to the last 7, 6, or 5 residues of a native PPF peptide, or to amino acid residues 32-35.

[0073] Exemplary PYY analogs include those with internal deletions, insertions, and substitutions in areas of the PYY molecule not corresponding to the polyproline motif and/or  
10 the C-terminal tail motif. For instance, internal deletions at positions 4, 6, 7, 9, or 10 are contemplated.

[0074] Exemplary PPF peptides of use in P-PI conjugates disclosed herein include, but are not limited to, PYY(1-36) (SEQ ID NO:2), PYY(3-36) (SEQ ID NO:3),  
[<sup>3</sup>Leu]PYY (SEQ ID NO:4), [<sup>3</sup>Val]PYY (SEQ ID NO:5), [<sup>4</sup>Arg]PYY (SEQ ID NO:6),  
15 [<sup>4</sup>Gln]PYY (SEQ ID NO:7), [<sup>4</sup>Asn]PYY (SEQ ID NO:8), [<sup>25</sup>Lys]PYY (SEQ ID NO:9),  
[<sup>34</sup>Pro]PYY (SEQ ID NO:10), [<sup>34</sup>His]PYY (SEQ ID NO:11),  
[<sup>13</sup>Pro,<sup>14</sup>Ala]PYY (SEQ ID NO:13), [<sup>31</sup>Leu,<sup>34</sup>Pro]PYY (SEQ ID NO:14),  
[<sup>4</sup>des]PYY (SEQ ID NO:15), PYY(1-35) (SEQ ID NO:16), PYY(1-30) (SEQ ID NO:17),  
PYY(1-25) (SEQ ID NO:18), PYY(1-15) (SEQ ID NO:19), PYY(1-10) (SEQ ID NO:20),  
20 PYY(2-36) (SEQ ID NO:21), PYY(4-36) (SEQ ID NO:22), and PYY(5-36) (SEQ ID NO:23).

[0075] Other exemplary PPF peptides include, but are not limited to,  
isocapPKPEAPGEDASPEELARYYASLRAYINLITRQRY (SEQ ID NO:24),  
isocapYPIKPEAPGEDASPEELAQYAADLRRYINMLTRQRY (SEQ ID NO:25),  
IKPEAPGEDAPAEELARYYASLRAYINLITRQRY (SEQ ID NO:26),  
25 YPIKPEAPGEDASPEELARYYSALRHYINLITRQRY (SEQ ID NO:27),  
IKPEAPGEDASPEELARYYSALRHYINLITRQRY (SEQ ID NO:28),  
isocapIKPEAPGEDASPEELARYYSALRHYINLITRQRY (SEQ ID NO:29),  
PKPEAPGEDASPEELNRYASLRHYLNLVTRQRY (SEQ ID NO:30),  
isocapPKPEHPGEDASAEELARYYASLRAYINLITRQRY (SEQ ID NO:31),  
30 PKPEHPGEDASPEELARYYASLRAYINLITRQRY (SEQ ID NO:32),  
PKPEHPGEDASAEELARYYASLRAYINLITRQRY (SEQ ID NO:33),  
PKPEAPGEDASPEELAKYYASLRAYINLITRQRY (SEQ ID NO:34),

isocapPKPEAPGEDASPEELAKYYASLRAYINLITRQRY (SEQ ID NO:35),  
 PKPEHPGEDAPAEELAKYYASLRAYINLITRQRY (SEQ ID NO:36),  
 PKPEHPGEDAPAEELARYYASLRAYINLITRQRY (SEQ ID NO:37),  
 octanoic acid IAPEAPGEDASPEELARYYASLRHYLNLVTRQRY (SEQ ID NO:38),

5 Octylgly-IKPEAPGEDASPEELARYYSALRHYINLITRQRY (SEQ ID NO:39), and  
 YPIRPEAPGEDASPEELARYYASLRHYINLITRQRY (SEQ ID NO:40). The term "isocap"  
 refers to isocaproic acid. The term "octylgly" refers to octylglycine as known in the art.

[0076] Exemplary PPF analogs and derivatives useful in the P-PI conjugates are disclosed in  
 U.S. Pat. Application Publication Nos. 2006/0094653, 2006/0135747, and 2002/0141985, the  
 10 contents of each is hereby incorporated by reference and for all purposes. Other exemplary  
 PPF analogs and derivatives include those described in PCT Publication Nos. WO 03/026591,  
 WO 03/057235, and WO 2005/ 077094, each are herein incorporated by reference in their  
 entirety and for all purposes.

[0077] Component peptide hormones useful in the compositions and methods disclosed  
 15 herein include the family of incretin hormones and incretin mimetics including, but not limited  
 to GLP-1, GLP-2, oxyntomodulins, and exendins. Component peptide hormones useful in the  
 compositions and methods disclosed herein include GLP-1 peptide hormones. As used herein,  
 "GLP-1" means human glucagon like peptide-1 or species variants thereof, in any  
 physiological form. The term "GLP-1" includes human GLP-1(1-37) (SEQ ID NO:41), GLP-  
 20 1(7-37) (SEQ ID NO:42) and GLP-1(7-36) amide (SEQ ID NO:43), with reference to the full  
 length human GLP-1(1-37), and species variations of GLP-1, including, *e.g.*, murine, hamster,  
 chicken, bovine, rat, and dog GLP-1. In this sense, "GLP-1," "wild-type GLP-1," and "native  
 GLP-1," *i.e.*, unmodified GLP-1, are used interchangeably.

[0078] Native GLP-1 peptide hormones, including  
 25 hGLP-1(1-37) HDEFERHAEGTFTSDVSSYLEGQAAKEFIAWLVKGRG (SEQ ID NO:41),  
 hGLP-1(7-37) HAEGTFTSDVSSYLEGQAAKEFIAWLVKGRG (SEQ ID NO:42),  
 hGLP-1(7-36)amide HAEGTFTSDVSSYLEGQAAKEFIAWLVKGR-NH<sub>2</sub> (SEQ ID NO:43),  
 frog GLP-1B (fGLP-1B) HAEGTYTNDVTEYLEEKAAKEFIEWLIKPKKIRYS-OH  
 (SEQ ID NO:44) and  
 30 frog GLP-1A (fGLP-1A) HAEGTFTSDVTQQLDEKAAKEFIDWLINGGPSKEIIS-OH  
 (SEQ ID NO:45), are known in art, as are functional peptide analogs and derivatives. Unless  
 indicated to the contrary, as used herein the term "fGLP" refers to frog GLP-1A (SEQ ID  
 NO:45). As used herein, GLP-1 refers to all native forms of GLP-1 peptide hormones.

Although certain GLP-1 native peptides, peptide analogs, derivatives, and hybrids are described herein, it should be recognized that any known GLP-1 peptide, GLP-1 analog, GLP-1 derivative, or GLP-1 hybrid that exhibits biological activity known in the art may be used in conjunction with the compositions and methods disclosed herein.

5 **[0079]** In some embodiments, the GLP-1 peptide analogs, derivatives, and hybrids have at least one hormonal activity of a native GLP-1 peptide. In certain embodiments, the GLP-1 peptide analogs, derivatives, and hybrids are agonists of a receptor to which a native GLP-1 peptide is capable of specifically binding. Such GLP-1 analogs may be amidated as known in the art or may be in the acid form unless otherwise specified.

10 **[0080]** In some embodiments, a GLP-1 peptide analog, derivative, or hybrid can have one or more amino acid substitutions, deletions, inversion, or additions compared to a native or naturally occurring GLP-1. Thus, GLP-1 peptide analogs, derivatives, and hybrids can have an amino acid sequence that has one or more amino acid substitutions, additions or deletions as compared with a naturally occurring GLP-1. In some embodiments, a GLP-1 peptide analog,  
15 derivative, or hybrid has an amino acid sequence that has about 25 or less, 20 or less, 15 or less, 10 or less, 5 or less, 4 or less, 3 or less, 2 or less, or 1 or less substitutions, additions, or deletions as compared to a naturally occurring GLP-1, such as GLP-1(7-37) (SEQ ID NO:42).

**[0081]** Exemplary GLP-1 peptide analogs and derivatives include those described herein and known in the art. Exemplary GLP-1 analogs include, but are not limited to,  
20 GLP-1(7-35) (SEQ ID NO:46); [<sup>9</sup>Gln]GLP-1(7-37) (SEQ ID NO:47); [<sup>9</sup>D-Gln]GLP-1(7-37); [<sup>16</sup>Thr,<sup>18</sup>Lys]GLP-1(7-37) (SEQ ID NO:49); [<sup>18</sup>Lys]GLP-1(7-37) (SEQ ID NO:50); [<sup>8</sup>Gly]GLP-1(7-36) (SEQ ID NO:51); [<sup>8</sup>Aib]GLP-1 (7-36) (SEQ ID NO:48); [acetyl-<sup>9</sup>Lys]GLP-1(7-37) (SEQ ID NO:52); [<sup>9</sup>Thr]GLP-1(7-37) (SEQ ID NO:53); [<sup>9</sup>D-Thr]GLP-1 (7-37); [<sup>8</sup>Gly,<sup>9</sup>Thr]GLP-1 (7-37) (SEQ ID NO:54); [<sup>9</sup>Asn]GLP-1-(7-37)  
25 (SEQ ID NO:55); [<sup>8</sup>GLy,<sup>9</sup>Asn]GLP-1-(7-37) (SEQ ID NO:56); [<sup>9</sup>D-Asn]GLP-1(7-37); [<sup>22</sup>Ser,<sup>23</sup>Arg,<sup>24</sup>Arg,<sup>26</sup>Gln]GLP-1(7-37) (SEQ ID NO:57); [<sup>23</sup>Arg]GLP-1(7-37) (SEQ ID NO:58); and [<sup>24</sup>Arg]GLP-1(7-37) (SEQ ID NO:59). Exemplary GLP-1 analogs and derivatives useful in the P-PI conjugates are disclosed in U.S. Pat. Nos. 5,188,666, 5,512,549, 5,545,618, and 6,747,006, and in PCT publication Nos. WO 91/11457 and WO 99/64061, each  
30 of which is incorporated herein by reference in its entirety and for all purposes.

**[0082]** Component peptide hormones useful in the compositions and methods disclosed herein also include GLP-2 peptide hormones. As used herein, "GLP-2" means human

glucagon like peptide-2 or species variants thereof, in any physiological form. GLP-2 is a 33 amino acid peptide, co-secreted along with GLP-1 from intestinal endocrine cells in the small and large intestine. Native GLP-2 peptide hormones, *e.g.*, rat GLP-2 and its homologous including ox GLP-2, porcine GLP-2, dog GLP-2, bovine GLP-2, guinea pig GLP-2, hamster  
5 GLP-2, human GLP-2, rainbow trout GLP-2, and chicken GLP-2, are known in art, as are functional peptide analogs and derivatives. The amino acid sequence of human GLP-2 is HADGSFSDEMNTILDNLAARDFINWLIETKITD (SEQ ID NO:60) and the amino acid sequence of frog GLP-2 is HAEGTFTNDMTNYLEEKAAKEFVGWLIKGRP (SEQ ID NO:61). Although certain GLP-2 native peptides, peptide analogs, derivatives, and  
10 hybrids are described herein, it should be recognized that any known GLP-2 peptides, GLP-2 analogs, GLP-2 derivatives, and GLP-2 hybrids that exhibit biological activity known in the art may be used in conjunction with the compositions and methods disclosed herein.

**[0083]** In some embodiments, the GLP-2 peptide analogs, derivatives, and hybrids have at least one hormonal activity of a native GLP-2 peptide. In certain embodiments, the GLP-2  
15 peptide analogs, derivatives, and hybrids are agonists of a receptor to which a native GLP-2 peptide is capable of specifically binding. In some embodiments, GLP-2 analogs, derivatives, and hybrids include rat or human GLP-2 altered at position 2 to confer DPP-IV resistance by substituting a Gly for an Ala. Exemplary GLP-2 peptide analogs and derivatives useful in the P-PI conjugates include those described in U.S. Pat. Nos. 5,789,379 and 5,990,077, both of  
20 which are hereby incorporated by reference in its entirety and for all purposes.

**[0084]** In some embodiments, a GLP-2 peptide analog, derivative, or hybrid can have one or more amino acid substitutions, deletions, inversion, or additions compared to a native or naturally occurring exendin. Thus, GLP-2 peptide analogs, derivatives, and hybrids can have an amino acid sequence that has one or more amino acid substitutions, additions or deletions as  
25 compared with a naturally occurring GLP-2. In some embodiments, a GLP-2 peptide analog, derivative, or hybrid has an amino acid sequence that has about 25 or less, 20 or less, 15 or less, 10 or less, 5 or less, 4 or less, 3 or less, 2 or less, or 1 or less substitutions, additions, or deletions as compared to a naturally occurring GLP-2.

**[0085]** Component peptide hormones useful in the compositions and methods disclosed  
30 herein also include oxyntomodulin (OXM) peptide hormones. As used herein, "OXM" means human oxyntomodulin or species variants thereof in any physiological form. OXM is a 37 amino acid peptide that contains the 29 amino acid sequence of glucagon followed by an 8 amino acid carboxy terminal extension. For example, the amino acid sequence of human

OXM is HSQGTFTSDYSKYLDSRRAQDFVQWLMNTRNRNNIA (SEQ ID NO:62).

Native OXM peptide hormones are known in art, as are functional peptide analogs and derivatives. Although certain native OXM peptides, peptide analogs, derivatives, and hybrids are described herein, it should be recognized that any known OXM peptides, OXM analogs, OXM derivatives, and OXM hybrids that exhibit biological activity known in the art may be used in conjunction with the compositions and methods disclosed herein. In some embodiments, the OXM peptide analogs, derivatives, and hybrids have at least one hormonal activity of a native OXM peptide. In certain embodiments, the OXM peptide analogs, derivatives, and hybrids are agonists of a receptor to which a native OXM peptide is capable of specifically binding.

[0086] In some embodiments, an OXM peptide analog, derivative, or hybrid can have one or more amino acid substitutions, deletions, inversion, or additions compared to a native or naturally occurring OXM. Thus, OXM peptide analogs, derivatives, and hybrids can have an amino acid sequence that has one or more amino acid substitutions, additions or deletions as compared with a naturally occurring OXM. In some embodiments, an OXM peptide analog, derivative, or hybrid has an amino acid sequence that has about 30 or less, 25 or less, 20 or less, 15 or less, 10 or less, 5 or less, 4 or less, 3 or less, 2 or less, or 1 or less substitutions, additions, or deletions as compared to a naturally occurring OXM.

[0087] Component peptide hormones useful in the compositions and methods disclosed herein also include exendin peptide hormones. By "exendin" is meant a peptide hormone found in the saliva of the Gila-monster, a lizard endogenous to Arizona, and the Mexican Beaded Lizard, as well as species variants thereof. Exendin-3 is present in the saliva of *Heloderma horridum*, and exendin-4 is present in the saliva of *Heloderma suspectum* (Eng *et al.* (1990) *J. Biol. Chem.* **265**:20259-20262; Eng. *et al.* (1992) *J. Biol. Chem.* **267**:7402-7405). The exendins have some sequence similarity to several members of the glucagon-like peptide family, with the highest identity, 53%, being to GLP-1 (Goke *et al.* (1993) *J. Biol. Chem.* **268**:19650-19555). In this sense, "exendin," "wild-type exendin," and "native exendin," *i.e.*, unmodified exendin, are used interchangeably.

[0088] Native exendin peptide hormones are known in art, as are functional exendin peptide analogs, derivatives, and hybrids. Amino acid sequences of exendin-3 and exendin-4 follow: exendin-3 (HSDGTFTSDLSKQMEEEEAVRLFIEWLKNGGPSSGAPPPS) (SEQ ID NO:63); exendin-4 (HGEFTFTSDLSKQMEEEEAVRLFIEWLKNGGPSSGAPPPS) (SEQ ID NO:64). Although certain native exendin peptides, peptide analogs, derivatives and hybrids are

described herein, it should be recognized that any known exendin peptides, exendin analogs, exendin derivatives, and exendin hybrids that exhibit biological activity known in the art may be used in conjunction with the compositions and methods disclosed herein.

**[0089]** In some embodiments, the exendin peptide analogs, derivatives, and hybrids have at least one hormonal activity of a native exendin peptide. In certain embodiments, the exendin peptide analogs, derivatives, and hybrids are agonists of a receptor to which a native exendin peptide is capable of specifically binding. Exendin analogs, derivatives, and hybrids may be amidated as known in the art or may be in the acid form unless otherwise specified. In some embodiments, an exendin analog, derivative, or hybrid can have one or more amino acid substitutions, deletions, inversion, or additions compared to a native or naturally occurring exendin. Thus, exendin analogs, derivatives, and hybrids can have an amino acid sequence that has one or more amino acid substitutions, additions or deletions as compared with a naturally occurring exendin, for example, exendin-4. In some embodiments, an exendin analog, derivative, or hybrid has an amino acid sequence that has about 30 or less, 25 or less, 20 or less, 15 or less, 10 or less, 5 or less, 4 or less, 3 or less, 2 or less, or 1 or less substitutions, additions, or deletions as compared to a naturally occurring exendin, such as exendin-4.

**[0090]** Exemplary exendin analogs include, but are not limited to, exendin-4(1-30) (SEQ ID NO:65), exendin-4(1-28) (SEQ ID NO:66), [<sup>14</sup>Leu,<sup>25</sup>Phe]exendin-4 (SEQ ID NO:67), [<sup>5</sup>Ala,<sup>14</sup>Leu,<sup>25</sup>Phe]exendin-4 (SEQ ID NO:68), [<sup>14</sup>Leu,<sup>22</sup>Ala,<sup>25</sup>Phe]exendin-4 (SEQ ID NO:69), [<sup>14</sup>Leu]exendin-4(1-28) (SEQ ID NO:70), [<sup>14</sup>Leu,<sup>25</sup>Phe] exendin-4(1-28) (SEQ ID NO:71), [<sup>5</sup>Ala,<sup>14</sup>Leu,<sup>25</sup>Phe] exendin-4(1-28) (SEQ ID NO:72), and [<sup>14</sup>Leu,<sup>22</sup>Ala,<sup>25</sup>Phe] exendin-4 (1-28) (SEQ ID NO:73). Other exemplary exendin analogs and derivatives are disclosed in U.S. Pat. Nos. 6,858,576, 6,956,026 and 6,989,366, each of which is incorporated herein by reference in its entirety and for all purposes.

**[0091]** Additional exemplary exendin agonists are described in U.S. Pat. No. 7,157,555 and PCT Publication No. WO 99/07404, which are herein incorporated by reference and for all purposes and including, for example, compounds of formula (I), formula (II) and formula (III) of these applications.

**[0092]** Other exendin agonists are described in U.S. Pat. No. 7,223,725 and PCT Publication No. WO 99/25727, which are herein incorporated by reference and for all purposes. Still other exendin agonists are described in U.S. Pat. No. 7,220,721 and PCT Publication No. WO

99/25728, both of which are herein incorporated by reference and for all purposes. Still other extendin agonists are described in U.S. Pat. Application Publication Nos. 2004/0209803, 2004/0266692, 2005/0043238, and 2005/0215469, each of which is hereby incorporated by reference in its entirety and for all purposes.

5 [0093] Component peptide hormones useful in the compositions and methods disclosed herein also include GIP peptide hormones. By "GIP" is meant a gastric inhibitory peptide or glucose-dependent insulinotropic peptide hormone obtained or derived from any species. The term "GIP", with reference to the full length human GIP(1-42) (SEQ ID NO:74), includes hGIP(1-42) acid, hGIP(1-42) amide, GIP(1-30) acid, GIP(1-30) amide, GIP(1-14), GIP(19-30),  
10 GIP(1-11) and species variations of GIP, including, *e.g.*, murine, hamster, chicken, bovine, rat, and dog. The amino acid sequences of human GIP (hGIP), rat GIP, mouse GIP, pig GIP and bovine GIP are, respectively:

YAEGTFISDYSIAMDKIHQQDFVNWLLAQKGKKNDWKHNITQ (SEQ ID NO:74),

YAEGTFISDYSIAMDKIRQQDFVNWLLAQKGKKNDWKHNLTQ (SEQ ID NO:75),

15 YAEGTFISDYSIAMDKIRQQDFVNWLLAQRGKKSDWKHNITQ (SEQ ID NO:76),

YAEGTFISDYSIAMDKIRQQDFVNWLLAQKGKKSDWKHNITQ (SEQ ID NO:77),

YAEGTFISDYSIAMDKIRQQDFVNWLLAQKGKKSDWIHNITQ (SEQ ID NO:78). In this sense, "GIP," "wild-type GIP," and "native GIP," *i.e.*, unmodified GIP, are used interchangeably.

20 [0094] Native GIP peptide hormones are known in art, as are functional peptide analogs, derivatives, and hybrids. Although certain native GIP peptides, GIP peptide analogs, derivatives, and hybrids are described herein, it should be recognized that any known GIP peptides, GIP analogs, GIP derivatives, and GIP hybrids that exhibit biological activity known in the art may be used in the compositions and methods disclosed herein. In some  
25 embodiments, the GIP peptide analogs, derivatives, and hybrids have at least one hormonal activity of a native GIP peptide. In certain embodiments, the GIP peptide analogs, derivatives, and hybrids are agonists of a receptor to which a native GIP peptide is capable of specifically binding.

[0095] In some embodiments, GIP analogs, derivatives, of hybrids of use include those that  
30 correspond to at least about 65% of human GIP(1-42) or hGIP(1-30) and have GIP activity. Exemplary GIP analogs having at least 50% sequence identity to native GIP(1-30), GIP(1-26), GIP(1-39), GIP(1-14), GIP(19-30) GIP(19-26), GIP(19-39) or GIP(1-42) over the entire length of each of the above molecules are further embodiments for use in the compositions and

methods described herein. In some embodiments, GIP analogs, derivatives, or hybrids of use include those that comprise at least 15 amino acid residues from the N-terminal end of GIP(1-42), have at least one amino acid substitution or modification at position 1-3, and are biologically active. This includes modification by fatty acid addition at an epsilon amino group of at least one lysine residue, either present in or introduced into the molecule. Such modifications include Tyr1-glucitol of a GIP, for example Tyr1-glucitol GIP(1-42) or Tyr1-glucitol GIP(1-30). GIP analogs of interest include those comprising a substitution or modification selected from the group comprising D-amino acid substitutions in 1, 2 and/or 3 positions and/or N-terminal glycation, alkylation, acetylation or acylation, or other N-terminal modifications described herein. Of further interest are analogs wherein the amino acid in the 2 or 3 position is substituted by lysine, serine, 4-amino butyric amino acid, Aib, D-alanine, sarcosine or proline.

**[0096]** In some embodiments, a GIP analog, derivative, or hybrid can have one or more amino acid substitutions, deletions, inversion, or additions compared to a native or naturally occurring GIP. Thus, GIP analogs, derivatives, and hybrids can have an amino acid sequence that has one or more amino acid substitutions, additions or deletions as compared with a naturally occurring GIP. In some embodiments, a GIP analog, derivative, or hybrid has an amino acid sequence that has about 30 or less, 25 or less, 20 or less, 15 or less, 10 or less, 5 or less, 4 or less, 3 or less, 2 or less, or 1 or less substitutions, additions, or deletions as compared to a naturally occurring GIP.

**[0097]** Exemplary GIP analogs include, but are not limited to, hGIP(1-30) (GIP(1-30)) YAEGTFISDYSIAMDKIHQQDFVNWLLAQK (SEQ ID NO:79); GIP(1-26) YAEGTFISDYSIAMDKIHQQDFVNWL (SEQ ID NO:80); GIP(1-14) YAEGTFISDYSIAM (SEQ ID NO:81); GIP(1-11) YAEGTFISDYS (SEQ ID NO:82); GIP(19-30) QQDFVNWLLAQK (SEQ ID NO:83); GIP(19-26) QQDFVNWL (SEQ ID NO:84); GIP(1-39) YAEGTFISDYSIAMDKIHQQDFVNWLLAQKGGKNDWKHN (SEQ ID NO:85); GIP(19-39) QQDFVNWLLAQKGGKNDWKHN (SEQ ID NO:86); GIP(1-42) YAEGTFISDYSIAMDKIHQQDFVNWLLAQKGGKNDWKHNITQ (SEQ ID NO:74); [<sup>2</sup>D-Ala]GIP(1-42); [<sup>2</sup>D-Ala]GIP(1-30); [<sup>2</sup>D-Ala, <sup>14</sup>Leu]GIP(1-30); [<sup>14</sup>Leu]GIP(1-30) (SEQ ID NO:87) and [<sup>14</sup>Leu]GIP(1-26) (SEQ ID NO:88). Other exemplary

GIP peptide analogs are disclosed in U.S. Pat. Nos. 6,410,508 and 6,921,748, and in U.S. Pat. Application Publication Nos. 2003/0232761, 2005/0272652, and 2005/0277590, each of which is incorporated herein by reference in its entirety and for all purposes.

[0098] Component peptide hormones useful in the compositions and methods disclosed  
5 herein include amylin family peptide hormones including amylin, adrenomedullin (“ADM”), calcitonin (“CT”), calcitonin gene related peptide (“CGRP”), intermedin (also known as “AFP-6”) and related peptides. Native amylin family peptide hormones are known in art, as are functional amylin family peptide analogs, derivatives, and hybrids. Although certain native amylin family peptides, analogs, derivatives, and hybrids are described herein, it should be  
10 recognized that any known amylin family peptides, amylin family peptide analogs, amylin family peptide derivatives and amylin family peptide hybrids that exhibit hormonal activity known in the art may be used in the compositions and methods disclosed herein.

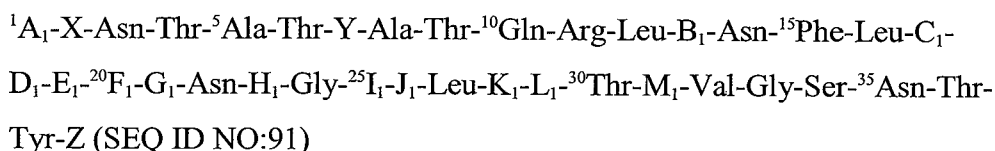
[0099] Component peptide hormones useful in the compositions and methods disclosed herein also include amylin peptide hormones. By “amylin” is meant the human peptide  
15 hormone referred to as amylin and species variations thereof. Amylin is a 37-amino acid polypeptide hormone normally co-secreted with insulin by pancreatic beta cells in response to nutrient intake (Koda *et al.* (1992) *Lancet* 339:1179-1180). In this sense, “amylin,” “wild-type amylin,” and “native amylin,” *i.e.*, unmodified amylin, are used interchangeably.

[0100] Native amylin peptides are known in the art, as are functional amylin peptide analogs,  
20 derivatives, and hybrids. The amino acid sequence of human amylin (h-amylin) is KCNTATCATQRLANFLVHSSNCFGAILSSSTNVGSNTY (SEQ ID NO:89) and the amino acid sequence of rat amylin (r-amylin) is KCNTATCATQRLANFLVRSSNNLGPVLPPTNVGSNTY (SEQ ID NO:90). Although certain native amylin peptides, peptide analogs, derivatives, and hybrids are described herein, it  
25 should be recognized that any known amylin peptides, amylin peptide analogs, amylin peptide derivatives and amylin peptide hybrids that exhibit hormonal activity known in the art may be used in the compositions and methods disclosed herein.

[0101] In some embodiments, the amylin peptide analogs, derivatives, and hybrids have at least one hormonal activity of native amylin peptide. In certain embodiments, the amylin  
30 peptide analogs, derivatives, and hybrids are agonists of a receptor which native amylin is capable of specifically binding. Amylin peptide analogs, derivatives, and hybrids may be amidated as known in the art or may be in the acid form.

[0102] In some embodiments, an amylin analog, derivative, or hybrid can have one or more amino acid substitutions, deletions, inversion, or additions compared to a native or naturally occurring amylin. Thus, amylin analogs, derivatives, and hybrids can have an amino acid sequence that has one or more amino acid substitutions, additions or deletions as compared with a naturally occurring amylin. In some embodiments, an amylin analog, derivative, or hybrid has an amino acid sequence that has about 30 or less, 25 or less, 20 or less, 15 or less, 10 or less, 5 or less, 4 or less, 3 or less, 2 or less, or 1 or less substitutions, additions, or deletions as compared to a naturally occurring amylin.

[0103] Amylin analogs contemplated for use in the compositions and methods disclosed herein include those described in U.S. Pat. Nos. 5,686,411, 6,114,304, and 6,410,511, which are herein incorporated by reference in their entirety and for all purposes. Exemplary such compounds include those having the formula:



wherein  $A_1$  is Lys, Ala, Ser or absent;  $B_1$  is Ala, Ser or Thr;  $C_1$  is Val, Leu or Ile;  $D_1$  is His or Arg;  $E_1$  is Ser or Thr;  $F_1$  is Ser, Thr, Gln or Asn;  $G_1$  is Asn, Gln or His;  $H_1$  is Phe, Leu or Tyr;  $I_1$  is Ala or Pro;  $J_1$  is Ile, Val, Ala or Leu;  $K_1$  is Ser, Pro, Leu, Ile or Thr;  $L_1$  is Ser, Pro or Thr;  $M_1$  is Asn, Asp, or Gln; X and Y are Cys or independently selected amino acid residues having side chains which are chemically bonded to each other to form an intramolecular linkage; and Z, if present, is a bond, hydroxy, amino, alkylamino, dialkylamino, cycloalkylamino, arylamino, aralkylamino, alkyloxy, aryloxy or aralkyloxy. Exemplary amylin analogs include but are not limited to,

[des-<sup>1</sup>Lys]h-amylin (SEQ ID NO:92), [<sup>28</sup>Pro]h-amylin (SEQ ID NO:93),

[<sup>25,28,29</sup>Pro]h-amylin (SEQ ID NO:94), [<sup>18</sup>Arg,<sup>25,28</sup>Pro]h-amylin (SEQ ID NO:95),

[des-<sup>1</sup>Lys,<sup>18</sup>Arg,<sup>25,28</sup>Pro]h-amylin (SEQ ID NO:96),

[<sup>25</sup>Pro,<sup>26</sup>Val,<sup>28,29</sup>Pro]h-amylin (SEQ ID NO:97),

[<sup>18</sup>Arg,<sup>25,28,29</sup>Pro]h-amylin (SEQ ID NO:98),

[des-<sup>1</sup>Lys,<sup>18</sup>Arg,<sup>25,28,29</sup>Pro]h-amylin (SEQ ID NO:99),

[des-<sup>1</sup>Lys,<sup>25,28,29</sup>Pro]h-amylin (SEQ ID NO:100),

[<sup>23</sup>Leu,<sup>25</sup>Pro,<sup>26</sup>Val,<sup>28,29</sup>Pro]h-amylin (SEQ ID NO:101),

[<sup>23</sup>Leu<sup>25</sup>Pro<sup>26</sup>Val<sup>28</sup>Pro]h-amylin (SEQ ID NO:102),

[des-<sup>1</sup>Lys<sup>23</sup>Leu<sup>25</sup>Pro<sup>26</sup>Val<sup>28</sup>Pro]h-amylin (SEQ ID NO:103),

- [<sup>18</sup>Arg,<sup>23</sup>Leu,<sup>25</sup>Pro,<sup>26</sup>Val,<sup>28</sup>Pro]h-amylin (SEQ ID NO:104),  
 [<sup>18</sup>Arg,<sup>23</sup>Leu,<sup>25,28,29</sup>Pro]h-amylin (SEQ ID NO:105),  
 [<sup>18</sup>Arg,<sup>23</sup>Leu,<sup>25,28</sup>Pro]h-amylin (SEQ ID NO:106),  
 [<sup>17</sup>Ile,<sup>23</sup>Leu,<sup>25,28,29</sup>Pro]h-amylin (SEQ ID NO:107),  
 5 [<sup>17</sup>Ile,<sup>25,28,29</sup>Pro]h-amylin (SEQ ID NO:108),  
 [des-<sup>1</sup>Lys,<sup>17</sup>Ile,<sup>23</sup>Leu,<sup>25,28,29</sup>Pro]h-amylin (SEQ ID NO:109),  
 [<sup>17</sup>Ile,<sup>18</sup>Arg,<sup>23</sup>Leu]h-amylin (SEQ ID NO:110),  
 [<sup>17</sup>Ile,<sup>18</sup>Arg,<sup>23</sup>Leu,<sup>26</sup>Val,<sup>29</sup>Pro]h-amylin (SEQ ID NO:111),  
 [<sup>17</sup>Ile,<sup>18</sup>Arg,<sup>23</sup>Leu,<sup>25</sup>Pro,<sup>26</sup>Val,<sup>28,29</sup>Pro]h-amylin (SEQ ID NO:112),  
 10 [<sup>13</sup>Thr,<sup>21</sup>His,<sup>23</sup>Leu,<sup>26</sup>Ala,<sup>28</sup>Leu,<sup>29</sup>Pro,<sup>31</sup>Asp]h-amylin (SEQ ID NO:113),  
 [<sup>13</sup>Thr,<sup>21</sup>His,<sup>23</sup>Leu,<sup>26</sup>Ala,<sup>29</sup>Pro,<sup>31</sup>Asp]h-amylin (SEQ ID NO:114),  
 [des-<sup>1</sup>Lys,<sup>13</sup>Thr,<sup>21</sup>His,<sup>23</sup>Leu,<sup>26</sup>Ala,<sup>28</sup>Pro,<sup>31</sup>Asp]h-amylin (SEQ ID NO:115),  
 [<sup>13</sup>Thr,<sup>18</sup>Arg,<sup>21</sup>His,<sup>23</sup>Leu,<sup>26</sup>Ala,<sup>29</sup>Pro,<sup>31</sup>Asp]h-amylin (SEQ ID NO:116),  
 [<sup>13</sup>Thr,<sup>18</sup>Arg,<sup>21</sup>His,<sup>23</sup>Leu,<sup>28,29</sup>Pro,<sup>31</sup>Asp]h-amylin (SEQ ID NO:117), and  
 15 [<sup>13</sup>Thr,<sup>18</sup>Arg,<sup>21</sup>His,<sup>23</sup>Leu,<sup>25</sup>Pro,<sup>26</sup>Ala,<sup>28,29</sup>Pro<sup>31</sup>Asp]h-amylin (SEQ ID NO:118).

**[0104]** In some embodiments, amylin analogs and derivatives contemplated for use in the compositions and methods disclosed herein include those described in PCT Publication No. WO2006/083254, each of which is incorporated herein by reference in its entirety and for all purposes. Such amylin analogs and derivatives have at least a loop region of amylin or  
 20 calcitonin and analogs thereof, an  $\alpha$  helix region of at least a portion of an  $\alpha$  helix region of calcitonin or analogs thereof or an  $\alpha$  helix region having a portion of an amylin  $\alpha$  helix region and a calcitonin  $\alpha$  helix region or their respective analogs, and a C-terminal tail of amylin or calcitonin or analogs thereof, with the proviso that the C-terminal tail of calcitonin or a calcitonin analog is not proline, hydroxyproline (Hyp), homoserine (Hse) or derivatives of Hse.  
 25 Accordingly, such peptides are referred to herein as LHC (loop helix C-terminus) peptides, examples of which include, but are not limited to,  
 KCNTATCVLGRLSQELHRLQTYPRTNTGSNTY (SEQ ID NO:119),  
 Isocap-CNTATCVLGRLSQELHRLQTYPRTNTGSNTY (SEQ ID NO:120),  
 CSNLSTCATQRLANELVRLQTYPRTNVGSNTY (SEQ ID NO:121),  
 30 KCNTATCATQRLANELVRLQTYPRTNVGSNTY (SEQ ID NO:122), and  
 CSNLSTCVLGRLSQELHRLQTYPRTNTGSNTY (SEQ ID NO:123). Other exemplary amylin analogs and derivatives are disclosed in U.S. Pat. Nos. 6,087,334 and 6,936,584, both of which are incorporated herein by reference in their entireties and for all purposes.

[0105] Component peptides useful in the compositions and methods disclosed herein also include amylin antagonist peptides, including for example, those described in U.S. Pat. Nos. 5,625,032 and 5,580,953, which are incorporated herein by reference in their entireties and for all purposes. Amylin antagonists may be acetylated or non-acetylated at the N-terminus and  
5 include acid as well as amide forms of the molecule. Examples of amylin antagonists include, but are not limited to,

acetyl-ATQRLANELVRLQTYPRTNVGSNTY (SEQ ID NO:124);

ATQQLANQLVRLQTYPRTNVGSNTY (SEQ ID NO:125);

ATQLLANQLVRLQTYPRTNVGSNTY (SEQ ID NO:126);

10 ATQRLANQLVRLQTYPRTNVGSNTY (SEQ ID NO:127);

ATQLLANELVRLQTYPRTNVGSNTY (SEQ ID NO:128); and

ATQQLANELVRLQTYPRTNVGSNTY (SEQ ID NO:129).

[0106] Component peptide hormones useful in the compositions and methods disclosed herein also include ADM peptides. By “adrenomedullin” or “ADM” is meant the human  
15 peptide hormone and species variants thereof. ADM is generated from a 185 amino acid preprohormone through consecutive enzymatic cleavage and amidation. This process culminates in the liberation of a 52 amino acid bioactive peptide. Any known ADM peptide, analog, derivative, or hybrid that exhibits biological activity known in the art may be used in conjunction with the compositions and methods disclosed herein. In some embodiments, the  
20 ADM peptides, analogs, derivatives, and hybrids have at least one hormonal activity of native ADM peptide. In certain embodiments, the ADM peptides, analogs, derivatives, and hybrids are agonists of a receptor which native ADM is capable of specifically binding.

[0107] Component peptide hormones useful in the compositions and methods disclosed herein also include calcitonin (CT) peptides. By “calcitonin” or “CT” is meant the human  
25 peptide hormone and species variants thereof, including salmon calcitonin (sCT). CT is a 32 amino acid peptide cleaved from a larger prohormone. It contains a single disulfide bond, which causes the amino terminus to assume the shape of a ring. Native CT peptides are known in the art, as are functional CT peptide analogs, derivatives, and hybrids. The amino acid sequence of human CT (hCT) is CGNLSTCMLGTYTQDFNKFHTFPQTAIGVGAP

30 (SEQ ID NO:130) and the amino acid sequence of sCT is

CSNLSTCVLGKLSQELHKLQTYPRTNTGSGTP (SEQ ID NO:131). Any CT peptide analog, derivative, or hybrid known in the art that exhibits biological activity known in the art may be used in conjunction with the compositions and methods disclosed herein. In some

embodiments, the CT peptides, analogs, derivatives, and hybrids have at least one hormonal activity of native CT peptide. In certain embodiments, the CT peptides, analogs, derivatives, and hybrids are agonists of a receptor which native CT is capable of specifically binding. CT peptide analogs, derivatives, and hybrids may be amidated as known in the art or may be in the acid form.

**[0108]** In some embodiments, a CT analog, derivative, or hybrid can have one or more amino acid substitutions, deletions, inversion, or additions compared to a native or naturally occurring CT. Thus, CT analogs, derivatives, and hybrids can have an amino acid sequence that has one or more amino acid substitutions, additions or deletions as compared with a naturally occurring CT, for example, sCT. In some embodiments, an CT analog, derivative, or hybrid has an amino acid sequence that has about 25 or less, 20 or less, 15 or less, 10 or less, 5 or less, 4 or less, 3 or less, 2 or less, or 1 or less substitutions, additions, or deletions as compared to a naturally occurring CT, such as sCT.

**[0109]** Exemplary CT analogs include, but are not limited to, [<sup>8</sup>Gly]CT (SEQ ID NO:132), [<sup>22</sup>Leu]CT (SEQ ID NO:133), [<sup>2</sup>Gly,<sup>3</sup>Ser,<sup>8</sup>Gly,des-<sup>22</sup>Phe]CT (SEQ ID NO:134), [<sup>8</sup>Gly,des-<sup>22</sup>Phe]CT (SEQ ID NO:135), [<sup>18</sup>Arg]sCT (SEQ ID NO:136) and [<sup>11,18</sup>Arg]sCT (SEQ ID NO:137). Other exemplary CT analogs and derivatives are disclosed in U.S. Pat. Nos. 4,652,627, 4,606,856, 4,604,238, 4,597,900, 4,537,716, 4,497,731, 4,495,097, 4,444,981, 4,414,149, 4,401,593, and 4,397,780, which are hereby incorporated by reference in their entireties and for all purposes.

**[0110]** Component peptide hormones useful in the compositions and methods disclosed herein also include calcitonin gene related peptide (CGRP). By "calcitonin gene related peptide" or "CGRP" is meant the human peptide hormone and species variants thereof, in any physiological form. CGRP is a 37 amino acid peptide and is encoded and expressed from alternative splicing of calcitonin pre-mRNA. Representative CGRP peptides include CGRP alpha (ACDTATCVTHRLAGLLSRSGGVVKNNFVPTNVGSKAF) (SEQ ID NO:138) and CGRP beta (ACNTATCVTHRLAGLLSRSGGMVKSNNFVPTNVGSKAF) (SEQ ID NO:139). Unless indicated to the contrary, the term "CGRP" as used herein refers to CGRP alpha. Any CGRP, CGRP analog, derivative, or hybrid known in the art that exhibits biological activity known in the art may be used in conjunction with the compositions and methods disclosed herein. In some embodiments, the CGRP peptides, analogs, derivatives, and hybrids have at least one hormonal activity of native CGRP. In certain embodiments, the CGRP peptides, analogs, derivatives, and hybrids are agonists of a receptor which native

CGRP is capable of specifically binding. CGRP peptide analogs, derivatives, and hybrids may be amidated as known in the art or may be in the acid form.

5 [0111] In some embodiments, a CGRP analog, derivative, or hybrid can have one or more amino acid substitutions, deletions, inversion, or additions compared to a native or naturally occurring CGRP. Thus, CGRP analogs, derivatives, and hybrids can have an amino acid sequence that has one or more amino acid substitutions, additions or deletions as compared with a naturally occurring CGRP. In some embodiments, a CGRP analog, derivative, or hybrid has an amino acid sequence that has about 30 or less, 25 or less, 20 or less, 15 or less, 10 or less, 5 or less, 4 or less, 3 or less, 2 or less, or 1 or less substitutions, additions, or deletions as compared to a naturally occurring CGRP.

10 [0112] Exemplary CGRP analogs include, but are not limited to, [D-<sup>36</sup>Ser]CGRP, [D-<sup>36</sup>Thr]CGRP, [D-<sup>36</sup>Asp]CGRP, [D-<sup>36</sup>Asn]CGRP, [<sup>36</sup>Ser]CGRP (SEQ ID NO:144), [<sup>36</sup>Hse]CGRP (SEQ ID NO:145), [<sup>36</sup>Asp]CGRP (SEQ ID NO:146), [<sup>36</sup>Thr]CGRP (SEQ ID NO:147), and [<sup>36</sup>Asn]CGRP (SEQ ID NO:148). Other exemplary CGRP analogs and derivatives are disclosed in U.S. Pat. Nos. 4,697,002; and 4,687,839, which are hereby incorporated by reference in their entireties and for all purposes. Other exemplary CGRP analogs include, but are not limited to, [<sup>36</sup>Ser]CGRP beta (SEQ ID NO:140), [<sup>36</sup>Asp]CGRP beta (SEQ ID NO:141), [<sup>36</sup>Thr]CGRP beta (SEQ ID NO:142), and [<sup>36</sup>Asn]CGRP beta (SEQ ID NO:143).

20 [0113] Component peptide hormones useful in the compositions and methods disclosed herein also include intermedin or AFP-6 peptides. By “intermedin” or “AFP-6” is meant the human peptide hormone and species variants thereof, in any physiological form. Native AFP-6 peptides are known in the art, as are functional AFP-6 peptide analogs, derivatives, and hybrids. The amino acid sequence of human AFP-6 (or intermedin) is

25 TQAQLLRVGCVLGTCQVQNLSHRLWQLMGPAQRQDSAPVDPSSPHSY (SEQ ID NO:149). Any AFP-6 peptide, analog, derivative, or hybrid known in the art that exhibits biological activity known in the art may be used in conjunction with the compositions and methods disclosed herein. In some embodiments, the AFP-6 peptides, analogs, derivatives, and hybrids have at least one hormonal activity of native AFP-6. In certain

30 embodiments, the AFP-6 peptides, analogs, derivatives, and hybrids are agonists of a receptor which native AFP-6 is capable of specifically binding. AFP-6 peptide analogs, derivatives, and hybrids may be amidated as known in the art or may be in the acid form.

[0114] Exemplary AFP-6 analogs include, but are not limited to, VGCVLGTCQVQNLSHRLWQLMGPAGRQDSAPVDPSSPHSY (SEQ ID NO:150), RVGCVLGTCQVQNLSHRLWQLMGPAGRQDSAPVDPSSPHSY (SEQ ID NO:151), GCVLGTTCQVQNLSHRLWQLMGPAGRQDSAPVDPSSPHSY (SEQ ID NO:152),  
5 CVLGTTCQVQNLSHRLWQLMGPAGRQDSAPVDPSSPHSY (SEQ ID NO:153), TQAQLLRVGCVLGTCQVQNLSHRLWQLRQDSAPVDPSSPHSY (SEQ ID NO:154), and TQAQLLRVGCVLGTCQVQNLSHRLWQLDSAPVDPSSPHSY (SEQ ID NO:155). Other exemplary AFP-6 analogs and derivatives are disclosed in U.S. Pat. No. 6,965,013 and PCT Publication Nos. WO 2004/048547 and WO 2006/042242, each of which is herein  
10 incorporated by reference in its entirety and for all purposes.

[0115] Component peptide hormones useful in the compositions and methods disclosed herein also include members of the cholecystokinin (CCK) hormones, including CCK agonists. By "CCK" is meant the human peptide hormone and species variants thereof. More particularly, CCK is a 33-amino acid sequence first identified in humans, and includes an 8-  
15 amino acid *in vivo* C-terminal fragment ("CCK-8") that has been reportedly demonstrated in pig, rat, chicken, chinchilla, dog and humans. Other species variants include a 39-amino acid sequence found in pig, dog and guinea pig, and a 58-amino acid found in cat, dog and humans, and a 47-amino acid sequences homologous to both CCK and gastrin. The C-terminal sulfated octapeptide sequence (CCK-8) is relatively conserved across species, and may be the minimum  
20 sequence for biological activity in the periphery of rodents. Thus, the term CCK-33 will generally refer to human CCK(1-33) KAPSGRMSIVKLNQLDPSHRISDRDYMGMWDF (SEQ ID NO:156), while CCK-8 (CCK(26-33) (SEQ ID NO:160), will refer to the C-terminal octapeptide generically in both the sulfated and unsulfated unless otherwise specified. Sulfated CCK-8 has the amino acid sequence DY(SO<sub>3</sub>)MGWMD (SEQ ID NO:157). The terms  
25 "Y(SO<sub>3</sub>)" "Y(SO<sub>3</sub>H)" refer to sulfotyrosine, as known in the art. The terms "Phe(CH<sub>2</sub>SO<sub>3</sub>)" and "Phe(CH<sub>2</sub>SO<sub>3</sub>H)" refer to sulfomethylphenylalanine, as known in the art. Further, pentagastrin or CCK-5 refer to the C-terminal peptide CCK(29-33) GWMD (SEQ ID NO:158), and the CCK-4 will refer to the C-terminal tetrapeptide CCK(30-33) WMDF. However, as used herein, CCK generally refers to all naturally occurring variations of  
30 the hormone, including CCK-33, CCK-8, CCK-5, and CCK-4, in the sulfated and unsulfated form unless otherwise specified. CCKs and various analogs thereof are known in the art.

[0116] Various *in vivo* and *in vitro* screening methods for CCK analogs are known in the art. Examples include *in vivo* assays involving the contraction of the dog or guinea pig gallbladder

after rapid intravenous injection of the compound to be tested for CCK-like activity, and *in vitro* assays measuring using strips of rabbit gallbladder. See. E.g., Walsh, "Gastrointestinal Hormones", In Physiology of the Gastrointestinal Tract (3d ed. 1994; Raven Press, New York).

[0117] Exemplary CCKs and CCK analogs include, but are not limited to,

5 DY(SO<sub>3</sub>H)MGWMDF (SEQ ID NO:157), YMGWMDF (SEQ ID NO:159), DYMGWMDF (SEQ ID NO:160), MGWMDF (SEQ ID NO:161), GWMDF (SEQ ID NO:158), WMDF, KDY(SO<sub>3</sub>H)MGWMDF (SEQ ID NO:162), KDYMGWMDF (SEQ ID NO:163), KMGWMDF (SEQ ID NO:164), KGWMDF (SEQ ID NO:165), and KWWMDF (SEQ ID NO:166). As known in the art, such CCK peptides are may be amidated or may  
10 optionally be in the acid form.

[0118] Component peptide hormones useful in the compositions and methods disclosed

herein also include ghrelins. In some embodiments, the peptides are ghrelin antagonists such as those described in PCT Publication Nos. WO 01/87335 and WO 02/08250. Ghrelin antagonists are also known as GHS (growth hormone secretagogue receptor) antagonists. The  
15 compositions and methods provided therefore contemplate the use GHS antagonists in place of ghrelin antagonists.

[0119] Component peptide hormones useful in the compositions and methods disclosed

herein also include leptin family peptide hormones. By "leptin" is meant the naturally occurring leptin from any species, as well as biologically active D-isoforms, or fragments of  
20 naturally occurring leptin and variants thereof, and combinations of the preceding. Leptin is the polypeptide product of the ob gene as described in U.S. Pat. No. 6,001,968. Native leptin family peptide hormones are known in art, as are functional peptide analogs, derivatives, and hybrids. Although certain leptin native peptides, analogs, derivatives and hybrids are described herein, it should be recognized that any known leptin peptides, analogs, derivatives,  
25 or hybrids that exhibit hormonal activity known in the art may be used in the compositions and methods disclosed herein. In some embodiments, the leptin analogs, derivatives, and hybrids have at least one hormonal activity of native leptin. In certain embodiments, the leptin analogs, derivatives and hybrids are agonists of a receptor which native leptin is capable of specifically binding. Means for testing for leptin agonism or antagonism are described, for  
30 example, in U.S. Pat. Nos. 6,007,998 and 5,856,098.

[0120] Human leptin is 167 amino acids in length:

MHWGTLGFLWLWPYLFYVQAVPIQKVQDDTKTLIKTIVTRINDISHTQSVSSKQKVT

GLDFIPGLHPILTLISKMDQTLAVYQQILTSMP SRNVIQISNDLENLRDLLHVLA FSKSCH  
LPWASGLETLD SLGGVLEASGYSTEVVALSRLQGSLQDMLWQLDLSPGC

(SEQ ID NO:167). This leptin polypeptide contains a signal sequence cleavage site located after amino acid 21 (Ala). Consequently, the mature human leptin protein extends from amino acid 22 (Val) to amino acid 167 (Cys) and is 146 amino acids in length:

VPIQKVQDDTKTLIKTIVTRINDISHTQSVSSKQKVTGLDFIPGLHPILTLISKMDQTLAV  
YQQILTSMP SRNVIQISNDLENLRDLLHVLA FSKSCHLPWASGLETLD SLGGVLEASGY  
STEVVALSRLQGSLQDMLWQLDLSPGC (SEQ ID NO:168). In some embodiments, the

leptin component peptide is recombinant and has a methionyl residue at the N-terminus. Other  
exemplary leptins for use in the methods and compositions described herein include, but are  
not limited to, the amino acid sequence for mature, recombinant methionyl human leptin  
(herein called rmetHu-Leptin 1-146 or Metreleptin) having the amino acid sequence:

MVPIQKVQDDTKTLIKTIVTRINDISHTQSVSSKQKVTGLDFIPGLHPILTLISKMDQTLA  
VYQQILTSMP SRNVIQISNDLENLRDLLHVLA FSKSCHLPWASGLETLD SLGGVLEASG  
YSTEVVALSRLQGSLQDMLWQLDLSPGC (SEQ ID NO:274).

**[0121]** Another exemplary leptin analog is a natural variant of human leptin which has a Gln absent from position 28 of mature leptin and is 145 amino acids in length:

VPIQKVQDDTKTLIKTIVTRINDISHTSVSSKQKVTGLDFIPGLHPILTLISKMDQTLAVY  
QQILTSMP SRNVIQISNDLENLRDLLHVLA FSKSCHLPWASGLETLD SLGGVLEASGYS  
TEVVALSRLQGSLQDMLWQLDLSPGC (SEQ ID NO:169).

**[0122]** Exemplary leptin analogs include those where the amino acid at position 43 of  
SEQ ID NO:167 is substituted with Asp or Glu; position 48 is substituted Ala; position 49 is  
substituted with Glu, or absent; position 75 is substituted with Ala; position 89 is substituted  
with Leu; position 93 is substituted with Asp or Glu; position 98 is substituted with Ala;  
position 117 is substituted with Ser, position 139 is substituted with Leu, position 167 is  
substituted with Ser, and any combination thereof. Exemplary leptin analogs include, but are  
not limited to, [<sup>43</sup>Asp]leptin (SEQ ID NO:170), [<sup>43</sup>Glu]leptin (SEQ ID NO:171),

[<sup>48</sup>Ala]leptin (SEQ ID NO:172), [<sup>49</sup>Glu]leptin (SEQ ID NO:173),

[des-<sup>49</sup>AA-leptin (SEQ ID NO:174), [<sup>75</sup>Ala]leptin (SEQ ID NO:175),

[<sup>89</sup>Leu]leptin (SEQ ID NO:176), [<sup>93</sup>Asp]leptin (SEQ ID NO:177),

[<sup>93</sup>Glu]leptin (SEQ ID NO:178), [<sup>98</sup>Ala]leptin (SEQ ID NO:179),

[<sup>117</sup>Ser]leptin (SEQ ID NO:180), [<sup>139</sup>Leu]leptin (SEQ ID NO:181),

[<sup>167</sup>Ser]leptin (SEQ ID NO:182), [<sup>43</sup>Asp, <sup>49</sup>Glu]leptin (SEQ ID NO:183),

[<sup>43</sup>Asp, <sup>75</sup>Ala]leptin (SEQ ID NO:184), [<sup>89</sup>Leu, <sup>117</sup>Ser]leptin (SEQ ID NO:185), and [<sup>93</sup>Glu<sup>167</sup>Ser]leptin (SEQ ID NO:186).

[0123] Other exemplary leptin peptides, analogs, and derivatives are disclosed in U.S. Pat. Nos. 5,935,810, 6,001,968, 6,429,290, 6,309,853, 5,521,283, 5,532,336, 6,777,388 and  
5 6,936,439, each of which is incorporated herein by reference in its entirety and for all purposes. Other exemplary leptin peptides, analogs, and derivatives are disclosed in PCT Publication Nos. WO 2004/039832, WO 97/02004, WO 97/06816, WO 97/18833, WO 97/38014, and WO 98/28427, and in U.S. Pat. Publication Nos. 2004/0072219, 2003/049693, 2003/0166847, 2003/0092126, all of which are hereby incorporated by reference in their  
10 entireties and for all purposes.

[0124] Component peptides useful in the compositions and methods disclosed herein also include hybrid polypeptides. In some embodiments, the hybrid polypeptides comprise portions of at least two peptide hormones covalently linked together. In some embodiments, the peptide hormones portions are directly linked together and, in other embodiments, the peptide  
15 hormones portions are indirectly linked together, *e.g.*, through a linker group. In some embodiments, the hybrid polypeptide exhibits at least one biological activity of a component peptide. Exemplary hybrid polypeptides include those comprising one or more of the following component peptides: an amylin, an ADM, a CT, a leptin, a PYY, an NPY, a GLP-1, an AFP-6, a CCK, a CGRP, a GLP-2, an OXM, an exendin, and a GIP.

[0125] For example, reference sequences for some hybrid polypeptides include human GIP, truncated GIP, human GLP-1 and exendin-4, an exemplary Trp-cage (FIEWLKNGGPSSGAPPPS (SEQ ID NO:187)), an exemplary short exendin tail (PSSGAPPPS (SEQ ID NO:188)), and an exemplary long exendin tail (KNGGPSSGAPPPS (SEQ ID NO:189)). The exendin tail and/or Trp cage sequences, and analogs and derivatives  
25 disclosed herein and in the incorporated documents, exemplify, without limitation, peptidic enhancers.

[0126] Exemplary GIP hybrid molecules include, for example, [<sup>14</sup>Leu]GIP(1-30)-exendin-4(31-39) (SEQ ID NO:266), [<sup>2</sup>D-Ala]GIP(1-30)-exendin-4(31-39), and GIP(1-30)-exendin-4(31-39) (SEQ ID NO:1). Exemplary exendin hybrid molecules  
30 include, for example without limitation, [<sup>14</sup>Leu, <sup>28</sup>Gln]exendin-4(1-31)-fGLP-1(33-37) (SEQ ID NO:268) and [<sup>14</sup>Leu, <sup>28</sup>Gln]exendin-4(1-32)-fGLP-1(33-37) (SEQ ID NO:269).

[0127] GIP hybrids can comprise a peptidic enhancer: a C-terminal Trp-cage motif sequence. In one such embodiment are GIP hybrids of formula D-L-C-S, where the "D" region comprises optionally-modified N-terminal GIP sequences. Region "S" in the formulas can be a C-terminal sequence of a Trp-cage sequence that when adjacent to an N-terminal portion of a Trp-cage sequence is capable of forming a Trp-cage. Such peptidic enhancer sequences are believed to shield the novel GIP analog from protease digestion and enhance stability. The S region typically comprises at least one proline or proline-like residue capable of interacting with a tryptophan or tryptophan-like residue in an adjoining sequence to form a Trp-cage. Region C comprises a C-terminal sequence of a GIP. In some embodiments of these molecules, the tryptophan or tryptophan-like residue that is capable of interacting with the at least one proline or proline-like residue in region S is located in region "C". In alternative embodiments, when region C is absent, the Trp or Trp-like residue can be provided in a linker region "L".

[0128] In exemplary GIP hybrid embodiments, the GIP portion comprises a GIP N-terminal region modified or substituted to provide DPP-IV resistance superior to that of native GIP. Compounds or fragments thereof suitable to comprise hybrid molecules with GIP include incretins (e.g., GLP-1, exendin), amylin family peptides (e.g., amylin, calcitonin, calcitonin related gene peptide, adrenomedullin, intermedin), cholecystokinins (CCK), gastrin, PPFs (e.g., PP, PYY), secretin, natriuretic peptides, neuromedins, and urocortin.

[0129] In certain embodiments, a peptide hormone amidated at the C-terminal end is a component of the P-PI conjugate. In other embodiments, the peptide hormone component may not be amidated. In some embodiments, P-PI conjugates with amidated peptide hormones include, but are not limited to, those with amylin family peptide hormones, CCK, PYY, hGLP-1(7-36), and hGLP-2. In other embodiments, P-PI conjugates with peptide hormones without amidated C-terminal ends include, but are not limited to, those with exendin-4, exendin-4(1-28), GIP, GLP-1(7-37) (SEQ ID NO:42), frog GLP-1(7-36), and frog GLP-2. However, in other embodiments, these component peptide hormones may be amidated at the C-terminal end.

[0130] Additional exemplary hybrid polypeptides for use in the compositions and methods described herein include, but are not limited to, exendin-4-PYY(22-36) (SEQ ID NO:190), exendin-4-PYY(25-36) (SEQ ID NO:191), exendin-4-PYY(18-36) (SEQ ID NO:192), exendin-4- $\beta$ Ala- $\beta$ Ala-PYY(22-36) (SEQ ID NO:193), exendin-4- $\beta$ Ala- $\beta$ Ala-PYY(25-36) (SEQ ID NO:194), exendin-4- $\beta$ Ala- $\beta$ Ala-PYY(31-36) (SEQ ID NO:195), exendin-4(1-28)-

PYY(22-36) (SEQ ID NO:196), exendin-4(1-28)-PYY(25-36) (SEQ ID NO:197), exendin-4(1-28)-PYY(18-36) (SEQ ID NO:198), exendin-4(1-28)- $\beta$ Ala- $\beta$ Ala-PYY(22-36) (SEQ ID NO:199), exendin-4(1-28)- $\beta$ Ala- $\beta$ Ala-PYY(25-36) (SEQ ID NO:200), exendin-4(1-28)- $\beta$ Ala- $\beta$ Ala-PYY(31-36) (SEQ ID NO:201), [<sup>5</sup>Ala, <sup>14</sup>Leu, <sup>25</sup>Phe]exendin-4(1-28)-PYY(18-36) (SEQ ID NO:202), [<sup>5</sup>Ala, <sup>14</sup>Leu, <sup>25</sup>Phe]exendin-4(1-28)-PYY(22-36) (SEQ ID NO:203), [<sup>5</sup>Ala, <sup>14</sup>Leu, <sup>25</sup>Phe]exendin-4(1-28)-PYY(25-36) (SEQ ID NO:204), [<sup>5</sup>Ala, <sup>14</sup>Leu, <sup>25</sup>Phe]exendin-4(1-27)-PYY(18-36) (SEQ ID NO:205), [<sup>5</sup>Ala, <sup>14</sup>Leu, <sup>25</sup>Phe]exendin-4(1-28)- $\beta$ Ala- $\beta$ Ala -PYY(22-36) (SEQ ID NO:206), [<sup>5</sup>Ala, <sup>14</sup>Leu, <sup>25</sup>Phe]exendin-4(1-28)- $\beta$ Ala- $\beta$ Ala -PYY(25-36) (SEQ ID NO:207), [<sup>5</sup>Ala, <sup>14</sup>Leu, <sup>25</sup>Phe]exendin-4(1-28)- $\beta$ Ala- $\beta$ Ala -PYY(31-36) (SEQ ID NO:208), exendin-4-CCK-8 (SEQ ID NO:209), exendin-4(1-28)-CCK-8 (SEQ ID NO:210), exendin-4(1-28)-[<sup>8</sup>Phe(CH<sub>2</sub>SO<sub>3</sub>)]CCK-8 (SEQ ID NO:211), exendin-4(1-28)-(8-amino-3,6-dioxactanoyl)-CCK-8 (SEQ ID NO:212), exendin-4(1-28)-(8-amino-3,6-dioxactanoyl)-[<sup>8</sup>Phe(CH<sub>2</sub>SO<sub>3</sub>)]CCK-8 (SEQ ID NO:213), exendin-4(1-27)-h-amylin(1-7)-[<sup>14</sup>Gln, <sup>11,18</sup>Arg]sCT(8-27)-Amylin(33-37) (SEQ ID NO:214), exendin-4(1-27)-[<sup>2,7</sup>Ala]hAmylin(1-7)-sCT(8-10) (SEQ ID NO:215), [<sup>29</sup>12-Ado]exendin(1-28)-hAmylin(1-7)-[<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:216), [<sup>29</sup>12-Ado]exendin(1-28)-[des-<sup>1</sup>Lys]hAmylin(1-7)-[<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:217), [<sup>29</sup>3,6-dioxaoctanoyl]exendin(1-28)-hAmylin(1-7)-[<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:218), [<sup>29</sup>3,6-dioxaoctanoyl]exendin(1-28)-[des-<sup>1</sup>Lys]hAmylin(1-7)- [<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:219), [<sup>29</sup>5-Apa]exendin(1-28)-hAmylin(1-7)-[<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:220), [<sup>29</sup>5-Apa]exendin(1-28)-[des-<sup>1</sup>Lys]hAmylin(1-7)-[<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:221), [<sup>29</sup> $\beta$ Ala- $\beta$ Ala]exendin(1-28)-hAmylin(1-7)-[<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:222), [<sup>29</sup> $\beta$ Ala- $\beta$ Ala]-exendin(1-28)-[des-<sup>1</sup>Lys]hAmylin(1-7)-[<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:223), [<sup>29</sup>4,7,10-trioxa-13-tridecanamine succinimidyl]exendin(1-28)-hAmylin(1-7)-[<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:224), [<sup>29</sup>4,7,10-trioxa-13-tridecanamine succinimidyl]exendin(1-28)-[des-<sup>1</sup>Lys]hAmylin(1-7)-[<sup>11,18</sup>Arg]sCT(8-32)-hAmylin(33-37) (SEQ ID NO:225), CCK-8-GKR-[<sup>15</sup>Glu]h-amylin(1-17)-[<sup>18</sup>Arg]sCT(18-26)-amylin(32-37) (SEQ ID NO:226), amylin(1-18)-PYY(19-36) (SEQ ID NO:227), isocap-STAVL-(Aib)-K(formyl)-LSQEL-(Aib)-K(formyl)-LQT-PYY(18-36) (SEQ ID NO:228), isocap-STAVL-

(Aib)-K(formyl)-LSQEL-(Aib)-K(formyl)-L-PYY(16-36) (SEQ ID NO:229), CCK-8-[Succinoyl-Cys]PYY(3-36) (SEQ ID NO:230), CCK-8-[Bis-Cys(N-Acetyl)]PYY(3-36) (SEQ ID NO:231), and CCK-8-[Gly-Aminoxymethylcarbonyl]PYY(3-36) (SEQ ID NO:232).

[0131] Other exemplary hybrid polypeptides for use in the compositions and methods described herein include, but are not limited to, GIP(1-30)-(12-Ado)-hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:233), GIP(1-30)-(12-Ado)-[des-<sup>1</sup>Lys]hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:234), GIP(1-30)-(3,6-dioxaoctanoyl)-hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:235), GIP(1-30)-(3,6-dioxaoctanoyl)-[des-<sup>1</sup>Lys]hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:236), GIP(1-30)-(5-Apa)-hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:237), GIP(1-30)-(5-Apa)-[des-<sup>1</sup>Lys]hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:238), GIP(1-30)-(βAla-βAla)-hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:239), GIP(1-30)-(βAla-βAla)-[des-<sup>1</sup>Lys]hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(27)-hAmylin(33-37) (SEQ ID NO:240), GIP(1-30)-(4,7,10-trioxa-13-tridecanamine succinimidyl)-hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:241), GIP(1-30)-(4,7,10-trioxa-13-tridecanamine succinimidyl)-[des-<sup>1</sup>Lys]hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:242), GIP(1-30)-(Gly-Gly-Gly)-hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(8-27)-hAmylin(33-37) (SEQ ID NO:243), and GIP(1-30)-(Gly-Gly-Gly)-[des-<sup>1</sup>Lys]hAmylin(1-7)-<sup>11,18</sup>Arg]sCT(27)-hAmylin(33-37) (SEQ ID NO:244).

[0132] Exemplary hybrid polypeptides for use in the compositions and methods described herein include those described in U.S. Provisional Application Nos. 60/653,433, 60/651,647, 60/707,244, 60/707,369, 60/709,316 and 60/709,320, each of which is incorporated by reference herein for those molecules. Exemplary hybrid polypeptides for use in the compositions and methods described herein also include those described in U.S. Application Publication Nos. 2006/0094652 and 2006/0293232, and PCT Publication No. WO 2005/077072, each of which is incorporated by reference herein for those molecules.

[0133] Component peptidase inhibitors useful in the conjugate molecules and methods described herein can be in the active drug form or the pro-drug form that is converted to an active form *in vivo*. As demonstrated herein, P-PI conjugates with lisinopril ester are inactive in *in vitro* ACE inhibitor assays but P-PI conjugates with de-esterified lisinopril demonstrate ACE inhibitor activity. Exemplary component peptidase inhibitors are listed herein as either

the active drug form or as the pro-drug form of the inhibitor, and either form may be of use in the conjugate molecules and methods disclosed herein.

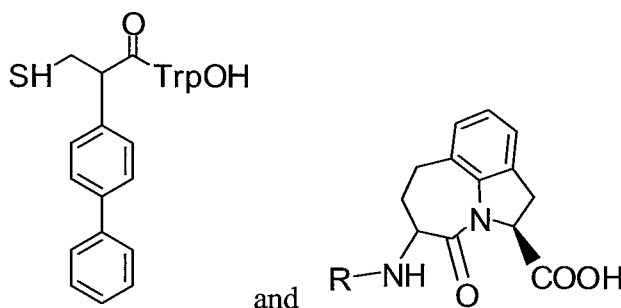
**[0134]** Component peptidase inhibitors useful in the conjugate molecules and methods described herein include, but are not limited to, vaso-peptidase inhibitors, such as angiotensin-converting enzyme (ACE) inhibitors, neutral endopeptidase (NEP) inhibitors, endothelin-converting enzyme (ECE) inhibitors, ACE/NEP inhibitors, NEP/ECE inhibitors, and ACE/NEP/ECE inhibitors. Angiotensin I-converting enzyme is a dipeptidyl carboxypeptidase that plays an important role in blood pressure regulation and electrolyte balance by hydrolyzing angiotensin I into angiotensin II, a potent vasopressor, and aldosterone-stimulating peptide. ACE is also able to hydrolyze other biologically active polypeptides, such as kinins, e.g., bradykinin. Bradykinin is a vasodilator, which acts at least in part by inducing release of vasodilator prostaglandins, and which is inactivated upon hydrolysis by ACE. Thus, ACE increases blood pressure at least in part by producing angiotensin II, a vasoconstrictor, and by inactivating bradykinin, a vasodilator. ACE, also referred to as peptidyl dipeptidase A (EC 3.4.15.1) and kininase II, is a metallopeptidase, more particularly a zinc peptidase.

**[0135]** Exemplary ACE inhibitors for use in the conjugate molecules and methods described herein include, but are not limited to, benazepril, captopril (1-[(2S)-3-mercapto-2-methylpropionyl]-L-proline), ceronapril, enalapril (N-(1-ethoxycarbonyl-3-phenylpropyl)-L-alanyl-L-proline), enalaprilat, fentiapril, fosinopril, imidapril, lisinopril (Merck, Astra-Zeneca), moexipril, perindopril (Servier), quinapril (Warner-Lambert), ramipril, andtrandolapril. Other nonlimiting examples of ACE inhibitors that may be employed herein include cetapril, cilazapril, delapril, indolapril (Schering), spirapril (Schering), and zofenopril. In some embodiments, the ACE inhibitor is a peptide, for example, pGluWPRPQIPP (SEQ ID NO:270) or pGluKWAP (SEQ ID NO:273), wherein "pGlu" refers to pyroglutamic acid. Exemplary ACE inhibitors include those disclosed in, for example, U.S. Pat. Nos. 4,046,889, 4,316,906, 4,374,829, 4,452,790, 4,168,267, 4,337,201, 4,385,051, and 4,344,949.

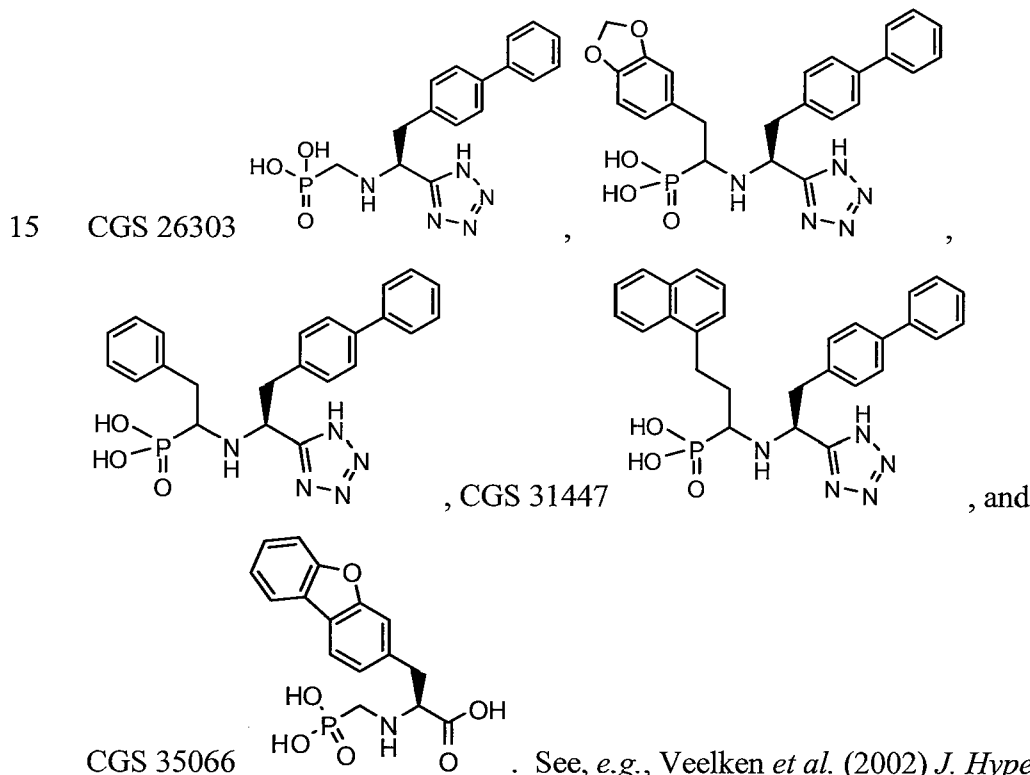
**[0136]** As discussed herein, component peptidase inhibitors useful in the conjugate molecules and methods described herein also include NEP inhibitors. Similar to ACE, NEP is an endothelial cell surface metalloproteinase, which is involved in the degradation of several regulatory peptides including the natriuretic peptides and thus augments vasodilatation and natriuresis through increased levels of atrial natriuretic peptide. Examples of NEP inhibitors include, but are not limited to, phosphoramidon, thiophan, retrothiorphan, candoxatril, and acetorphan. Also, component peptidase inhibitors useful in the conjugate molecules and

methods described herein include ECE inhibitors. ECE is the main enzyme responsible for the formation of the biologically active endothelin peptides, potent vasoconstrictors.

[0137] Vasopeptidase inhibitors also include NEP/ACE inhibitors that possess NEP and ACE inhibitory activity. Examples of NEP/ACE inhibitors include, but are not limited to, tricyclic benzazepinone thiols, omapatrilat, gemopatrilat, mixanpril, racecadotril, fasidotril, sampatrilat, MDL 100.240, Z13752A, BMS189921, BMS182657, and CGS 30008. Examples of NEP/ACE inhibitors suitable for use herein include those disclosed in U.S. Pat. Nos. 5,362,727, 5,366,973, 5,225,401, 4,722,810, 5,223,516, 4,749,688, 5,552,397, 5,504,080, 5,612,359, and 5,525,723. Exemplary NEP/ACE inhibitors include without limitation compounds with structure following:

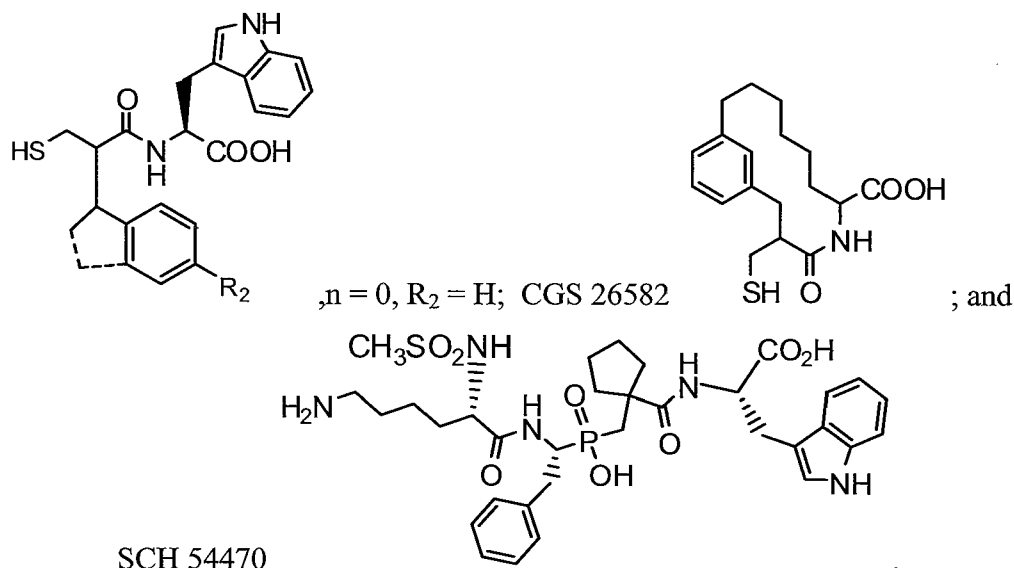


[0138] Vasopeptidase inhibitors also include NEP/ECE inhibitors that possess NEP and ECE inhibitory activity. Examples of NEP/ECE inhibitors include, but are not limited to, phosphoramidon and compounds with structure following:



[0139] Vasopeptidase inhibitors also include NEP/ACE/ECE inhibitors that possess ACE, NEP and ACE inhibitory activity. Examples of NEP/ACE/ECE inhibitors include, but are not limited to, CGS 26582 and N-[2-(Indan-1-yl)-3-mercapto-propionyl] amino acid analogs (Inguibert *et al.* (2002) *Bioorg. Med. Chem. Lett.* **12**:2001-2005). Exemplary

5 NEP/ACE/ECE inhibitors include the following:



[0140] Component peptidase inhibitors useful in the conjugate molecules and methods described herein include, inhibitors of angiotensin-converting enzyme-related

10 carboxypeptidase (ACE2). ACE2 is a zinc metallopeptidase and a homolog of ACE but ACE2 has different substrate specificities than ACE (Vickers *et al.* (2002) *J. Biol. Chem.* **277**:14838-14843). ACE2 cleaves and inactivates des-Arg bradykinin, a local vasodilator functioning through binding to the bradykinin B1 receptor expressed when inflammation or tissue damage occurs. Exemplary ACE2 inhibitors for use in the conjugate molecules and methods described

15 herein include, but are not limited to, MLN-4760 ((*S,S*)-2-{1-carboxy-2-[3-(3,5-dichlorobenzyl)-3*H*-imidazol-4-yl]-ethylamino}-4-methylpentanoic acid; Towler *et al.* (2004) *J. Biol. Chem.* **279**:17996-18007), N-(2-aminoethyl)-1 aziridine-ethanamine (Huentelman *et al.* (2004) *Hypertension* **44**:903-906, and peptide inhibitors of ACE2 such as Ac-GDYSHCSPLRYYYPWWKCTYPDPEGGG-NH<sub>2</sub> (SEQ ID NO:247) and others described in

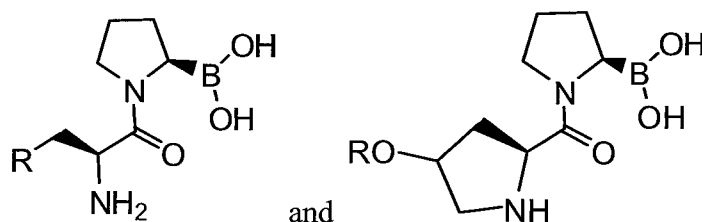
20 Huang *et al.* (2003) *J. Biol. Chem.* **278**:15532-15540.

[0141] Dipeptidyl peptidase-IV (DPP-IV) (EC 3.4.14.5) is a serine protease that preferentially hydrolyzes an N-terminal dipeptide from peptide substrates having proline or alanine in the 2 position. DPP-IV has been implicated in the control of glucose homeostasis because its substrates include GLP-1 and GIP. Members of the PPF members, such as PYY

25 and NPY, are also substrates of DPP-IV. Cleavage of the N-terminal amino acids from these

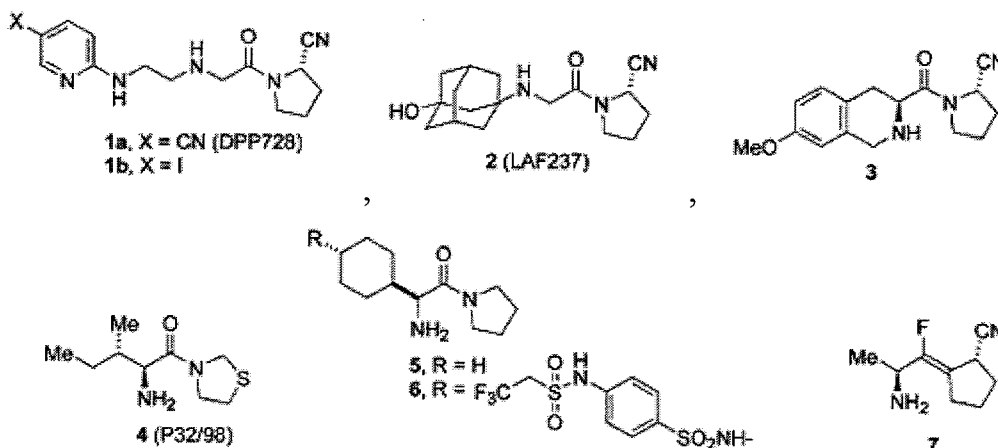
peptides renders them functionally inactive. Accordingly, DPP-IV may have a physiological role in diabetes, glucose tolerance, obesity, appetite regulation, cardiovascular diseases, and other conditions or disorders described herein. Administration of DPP-IV inhibitors *in vivo* prevents N-terminal degradation of GLP-1 and GIP and resulting in higher circulating concentrations of these peptides. In addition, treatment with DPP-IV inhibitors prevents degradation of PYY and NPY.

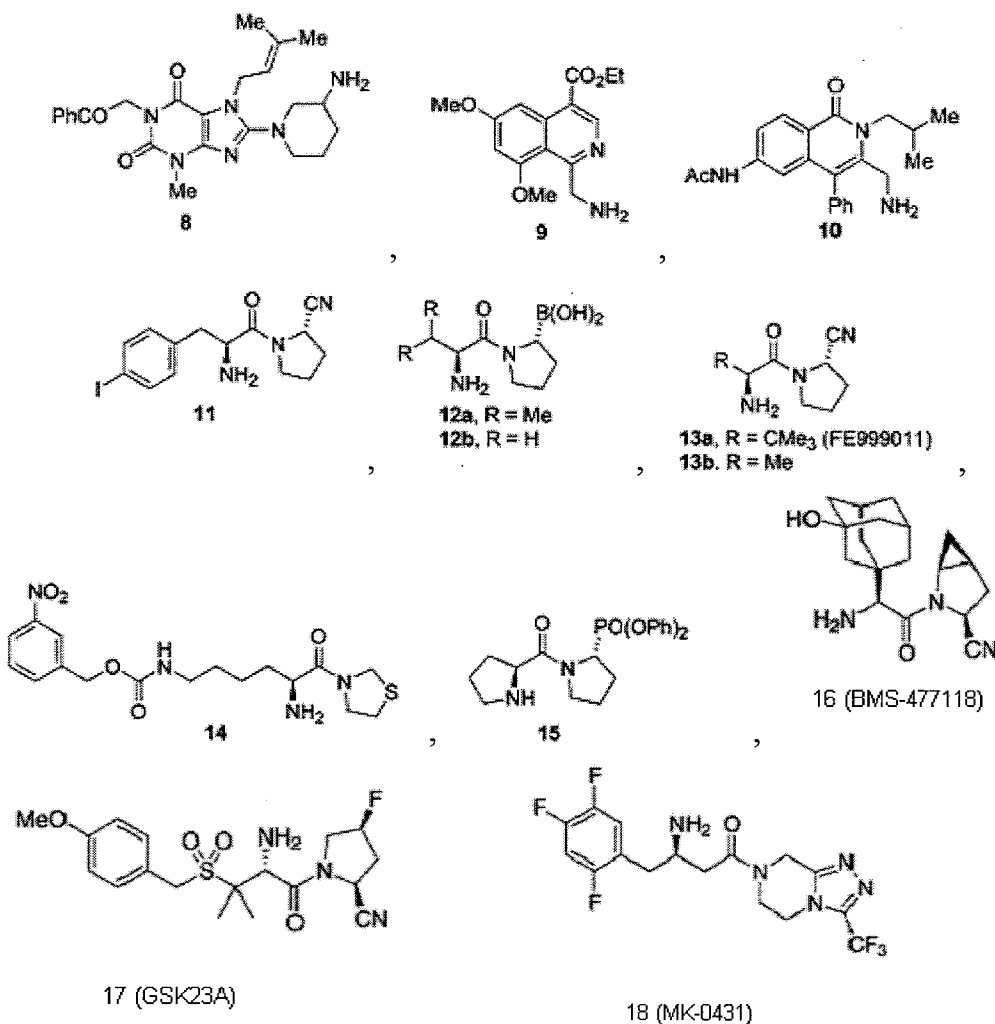
[0142] Accordingly, component peptidase inhibitors useful in the conjugate molecules and methods described herein also include DPP-IV inhibitors. Examples of DPP-IV inhibitors include, but are not limited to, N-(substituted glyceryl)-2-cyanopyrrolidine, tetrahydroisoquinoline 3-carboxamide derivatives, fluorinated cyclic amides, adamantylglycine-based inhibitors, glycinenitrile-based inhibitors, and boropyrrolidine inhibitors. Boropyrrolidine inhibitors include, but are not limited to, reversible inhibitors such as the following slow reversible inhibitors:



wherein R = covalent or non-covalent linker for peptide modification. Examples of DPP-IV inhibitors suitable for use herein include those disclosed in U.S. Pat. Nos. 6,011,155, 6,124,305, 6,166,063, 6,432,969, 6,172,081, 6,710,040, 6,869,947, 6,995,183 and 6,995,180, each of which is incorporated herein in its entirety and for all purposes.

[0143] Examples of DPP-IV inhibitors include, but are not limited to, compounds with structure following:





, and . Exemplary

5 DPP-IV inhibitors useful for the methods described herein further include without limitation compounds described in U.S. Patent Nos. 6,699,871 and 7,326,708, European Patent No. EP19112938, and PCT Publication No. WO/2007/120936, the contents of all of which are incorporated by reference herein and for all purposes.

10 [0144] DPP-IV inhibitors suitable for use herein include boro- and cyano-based maleimido DPP-IV inhibitors. See, for example, Kelly *et al.* (1993) *Tetrahedron* **49**:1009-1016; Snow *et al.* (1994) *J. Am. Chem. Soc.* **116**:10860-10869; Coutts *et al.* (1996) *J. Med. Chem.* **39**:2087-2094; and Jeanfavre *et al.* (1996) *Biochem. Pharmacol.* **52**:1757-1765. Examples of boro-based (compound 19 below) and cyano-based (compound 20 below) maleimido DPP-IV inhibitors include, but are not limited to:



[0147] Component peptidase inhibitors useful in the conjugate molecules and methods described herein also include serine protease inhibitors. Serine protease inhibitors are well-known in the art. Examples of serine protease inhibitors of use include, but are not limited to, 4-(2-aminoethyl)-benzenesulfonylfluoride (AEBSF), aprotinin, elastinal, Glu-Gly-Arg-chloromethylketone (GGACK), leupeptin, phenylmethylsulphonylfluoride (PMSF), chymostatin, anti-thrombin III, 3,4-dichloroisocoumarin, tosyl-L-lysine chloromethyl ketone (TLCK), tosyl-L-phenylalanine chloromethyl ketone (TPCK), diphenyliodonium hexafluorophosphate (DIFP), antipain, and  $\alpha$ 2-macroglobulin. In some embodiments, the P-PI conjugate includes AEBSF as the component peptidase inhibitor.

10 [0148] Component peptidase inhibitors useful in the conjugate molecules and methods described herein also include carboxypeptidase inhibitors. In some embodiments, the carboxypeptidase inhibitor for use in the P-PI conjugate is a peptide. In some embodiments, the carboxypeptidase inhibitor is a peptide which inhibits the activity of a carboxypeptidase that acts on a substrate peptide having a carboxy-terminal amino acid motif of RQRY or RQRW to remove the C-terminal amino acid from the substrate peptide. In some 15 embodiments, the substrate peptide of the carboxypeptidase is PYY(1-36), PYY(3-36), and NPY, for example amidated PYY(1-36)NH<sub>2</sub>, PYY(3-36)NH<sub>2</sub>, and NPY-NH<sub>2</sub>.

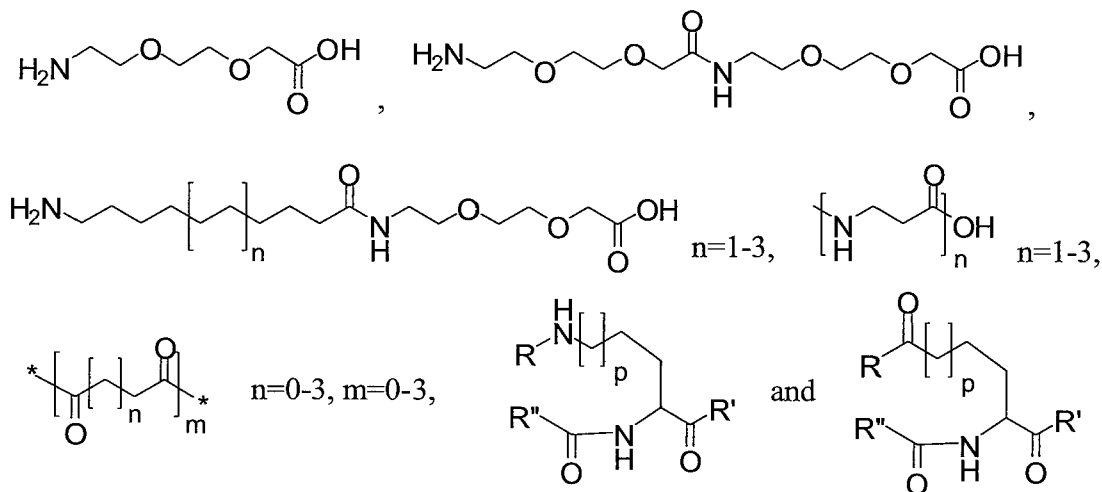
[0149] In some embodiments, the carboxypeptidase inhibitor is a modified PYY peptide or a modified NPY peptide, for example, a PYY or NPY peptide modified at position 36.

20 Exemplary carboxypeptidase inhibitors include, but are not limited to, PYY or NPY peptides with a methyl group at the  $\alpha$ -amino nitrogen of Tyr<sup>36</sup>, for example, [<sup>36</sup>N-methyl-Tyr]PYY(1-36) (SEQ ID NO:248), [<sup>36</sup>N-methyl-Tyr]PYY(3-36) (SEQ ID NO:249), [<sup>36</sup>N-methyl-Tyr]PYY(12-36) (SEQ ID NO:250), [<sup>36</sup>N-methyl-Tyr]PYY(18-36) (SEQ ID NO:251), [<sup>36</sup>N-methyl-Tyr]PYY(22-36) (SEQ ID NO:252), [<sup>36</sup>N-methyl-D-Tyr]PYY(1-36), [<sup>36</sup>N-methyl-D-Tyr]PYY(3-36), [<sup>36</sup>N-methyl-D-Tyr]PYY(12-36), [<sup>36</sup>N-methyl-D-Tyr]PYY(18-36), [<sup>36</sup>N-methyl-D-Tyr]PYY(22-36), [<sup>36</sup>N-methyl-Tyr]NPY (SEQ ID NO:253), [<sup>36</sup>N-methyl-Tyr]NPY(12-36) (SEQ ID NO:254), [<sup>36</sup>N-methyl-Tyr]NPY(18-36) (SEQ ID NO:255), [<sup>36</sup>N-methyl-Tyr]NPY(22-36) (SEQ ID NO:256), [<sup>36</sup>N-methyl-D-Tyr]NPY, [<sup>36</sup>N-methyl-D-Tyr]NPY(12-36), [<sup>36</sup>N-methyl-D-Tyr]NPY(18-36), and [<sup>36</sup>N-methyl-D-Tyr]NPY(22-36). Other exemplary carboxypeptidase inhibitors include, but are not limited to, PYY or NPY peptides with a D-Tyr at position 36, a chiral  $\beta$ -Tyr at position 36, a hydroxy-Pro at position 36, Phe at position 36, Phe-CH<sub>2</sub>SO<sub>3</sub>H at position 36, or Trp at 30

position 36. Exemplary carboxypeptidase inhibitors include PYY(1-36), PYY(3-36), PYY(12-36), PYY(18-36), PYY(22-36), NPY, NPY(12-36), NPY(18-36), and NPY(22-36) with such modifications at position 36. The carboxy-terminus of these carboxypeptidase inhibitors may be -NH<sub>2</sub>, -NH-OH, -NH-CH<sub>3</sub>, or -NH-CH<sub>2</sub>CH<sub>3</sub>.

- 5 [0150] Exemplary carboxypeptidase inhibitors also include PYY or NPY peptides with the position 36 modifications, as described, and with modifications at other sites within the peptide. For example, the PYY or NPY peptides with the position 36 modifications described herein may also have an internal deletion of amino acids, an internal insertion of a linker group, or a combination of an internal amino acid deletion and an internal linker group
- 10 insertion. Exemplary carboxypeptidase inhibitors of this type include, but are not limited to, [<sup>36</sup>N-methyl-Tyr]PYY(3-10, 22-36) IKPEAPGEASLRHYLNLVTRQRY(N-Me) (SEQ ID NO:257), [<sup>36</sup>N-methyl-Tyr]PYY(3-10-linker-22-36) IKPEAPGE(linker)ASLRHYLNLVTRQRY(N-Me) (SEQ ID NO:267, SEQ ID NO:252), and
- 15 [<sup>36</sup>N-methyl-Tyr]PYY(3-10-linker-18-36) IKPEAPGE(linker)NRYASLRHYLNLVTRQRY(N-Me) (SEQ ID NO:267, SEQ ID NO:251). The carboxy-terminus of these carboxypeptidase inhibitors may be -NH<sub>2</sub>, -NH-OH, -NH-CH<sub>3</sub>, or -NH-CH<sub>2</sub>CH<sub>3</sub>.

- [0151] Linker groups and extended linkers useful in the methods and compounds described
- 20 herein include, for example without limitation,



- where p=0-3; R = peptide; R' = OH or NH<sub>2</sub>; R'' = peptide. In some embodiments, the linker is attached at a coupling site on the peptidase inhibitor that will not inactivate the peptidase inhibitor nor create a steric hindrance that would substantially decrease peptidase inhibitor
- 25 activity. Nor should the linker be such that it would interact with the peptide portion in a way

that would inactivate the peptide or sterically hinder the peptide activity. By way of example, see the inhibitors and their sites of conjugation as disclosed herein. Suitable linker locations can be readily assessed by synthesis of peptidase inhibitors comprising peptidase inhibitor core, initial linker, and extended linker, followed by assay for peptidase activity by methods known in the art. As used herein, "Aun" refers to 11-amino undecanoic acid, "Ado" refers to 8-amino 3,6-dioxaoctanoic acid, "12-Ado" refers to 12-amino dodecanoyl, and "5-Apa" refers to 5-amino-pentanoyl.

**[0152]** Linkers may also be selected to add or change the charge of the P-PI conjugate. For example, a glutamic acid may be used as a linker to, e.g., a lysine, whereby the formal positive charge on the lysine amine is neutralized upon formation of the resultant amide linkage.

**[0153]** Exemplary carboxypeptidase inhibitors also include PYY or NPY peptides with modifications at other sites within the peptide with or without the position 36 modifications described herein. For example, the PYY or NPY peptides may have internal D-amino acids, an internal amino acid with a methyl group at the  $\alpha$ -amino nitrogen, or a combination of such amino acid residues. Exemplary carboxypeptidase inhibitors of this type include, but are not limited to, [<sup>35</sup>N-methyl-Arg]PYY(3-36) (SEQ ID NO:258), [<sup>35</sup>D-Arg<sup>36</sup>N-methyl-Tyr]PYY(3-36), [<sup>35</sup>N-methyl-D-Arg]PYY(3-36), [<sup>34</sup>N-methyl-Gln]PYY(3-36) (SEQ ID NO:259), [<sup>34</sup>D-Gln<sup>36</sup>N-methyl-Tyr]PYY(3-36), [<sup>34</sup>N-methyl-D-Gln]PYY(3-36), [<sup>33</sup>N-methyl-Arg]PYY(3-36) (SEQ ID NO:260), [<sup>33</sup>D-Arg<sup>36</sup>N-methyl-Tyr]PYY(3-36), [<sup>33</sup>N-methyl-D-Arg]PYY(3-36), [<sup>19</sup>N-methyl-Ala]PYY(3-36) (SEQ ID NO:261), [<sup>19</sup>D-Ala<sup>36</sup>N-methyl-Tyr]PYY(3-36), [<sup>19</sup>N-methyl-D-Ala]PYY(3-36), [<sup>35</sup>N-methyl-Arg]NPY (SEQ ID NO:262), [<sup>35</sup>D-Arg<sup>36</sup>N-methyl-Tyr]NPY, [<sup>35</sup>N-methyl-D-Arg]NPY, [<sup>34</sup>N-methyl-Gln]NPY (SEQ ID NO:263), [<sup>34</sup>D-Gln<sup>36</sup>N-methyl-Tyr]NPY, [<sup>34</sup>N-methyl-D-Gln]NPY, [<sup>33</sup>N-methyl-Arg]NPY (SEQ ID NO:264), [<sup>33</sup>D-Arg<sup>36</sup>N-methyl-Tyr]NPY, [<sup>33</sup>N-methyl-D-Arg]NPY, [<sup>19</sup>N-methyl-Ala]NPY (SEQ ID NO:265), [<sup>19</sup>D-Ala<sup>36</sup>N-methyl-Tyr]NPY, and [<sup>19</sup>N-methyl-D-Ala]NPY. The carboxy-terminus of these carboxypeptidase inhibitors may be -NH<sub>2</sub>, -NH-OH, -NH-CH<sub>3</sub>, or -NH-CH<sub>2</sub>CH<sub>3</sub>.

**[0154]** The peptide and peptidase inhibitor of the conjugates may be linked in any manner described herein or known in the art. Such conjugate linkages include covalent linkages, non-covalent linkages, or both. A stable linkage may be used or a cleavable linkage may be used. Non-covalent linkages may be mediated by any non-covalent bonding force, including by

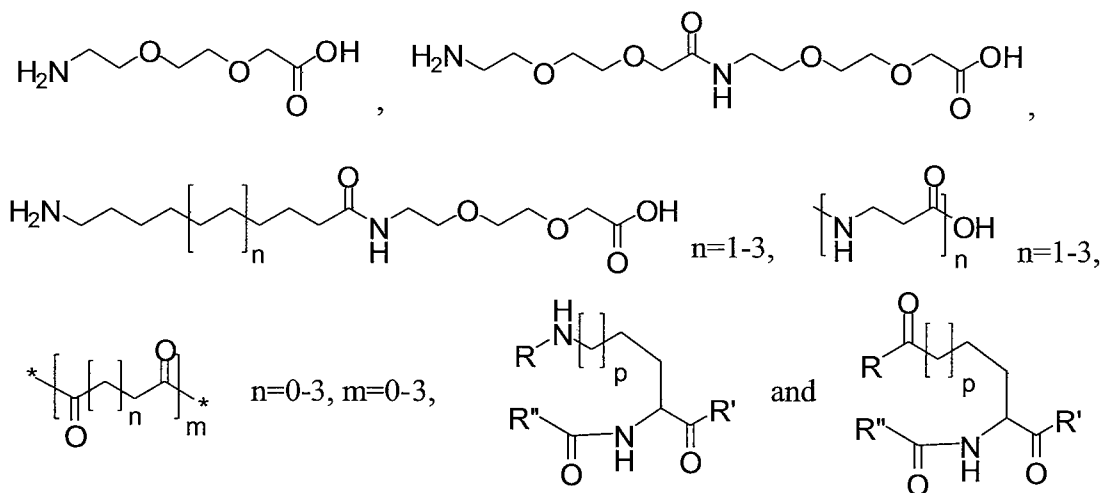
hydrophobic interaction, ionic (electrostatic) bonding, metal complexation, hydrogen bonds, van der Waals attractions, or a combination of two or more different interactions.

[0155] As described herein, the component peptide and component peptidase inhibitor may be covalently linked together through direct amide bonds or chemical linker groups. The conjugate peptide and peptidase inhibitor components may be indirectly linked through chemical or peptide linker groups or turn inducers. Examples of useful linking means and linkages are shown in the P-PI conjugates presented herein.

[0156] In some embodiments, the component peptide and component peptidase inhibitor may be directly linked to a functionality of the other component. In another embodiment, linking groups may be used to attach component peptide and component peptidase inhibitor.

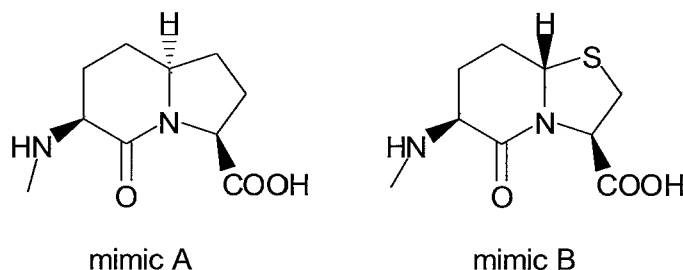
Exemplary linking groups include, but are not limited to, an alkyl; PEG; amino acid, *e.g.*, Lys, Glu,  $\beta$ -Ala; polyamino acids, *e.g.*, poly-his, poly-arg, poly-lys, poly-ala, Gly-Lys-Arg (GKR); bifunctional linkers, *e.g.*, those sold by Pierce Biotechnology, Inc., Rockford, IL; aminocaproyl ("Aca"),  $\beta$ -alanyl, 8-amino-3,6-dioxaoctanoyl, and other cleavable and non-cleavable linkers known in the art.

[0157] In some embodiments, a peptide is linked to the peptidase inhibitor by a linker or turn inducer. The linker or turn inducer may be non-peptidic or peptidic in nature. Linkers may be attached, for example, to the amino-terminus of the peptide, to the carboxy-terminus of the peptide, or to an internal amino acid side chain of the peptide, and are covalently linked to the peptide and the peptidase inhibitor. The linker may be any linker capable of joining the peptidase inhibitor to the peptide, for example without limitation, succinic acid, any orthogonally linkable amino acid (*e.g.*, Glu or Lys), and polyamino acids (*e.g.*, polylysine, polyarginine, polyglycine). In some embodiments, a linker is selected from the group consisting of those shown in Fig. 2. In some embodiments, a linker is selected from a group consisting of:



where  $p=0-3$ ;  $R$  = peptide;  $R'$  = OH or  $\text{NH}_2$ ;  $R''$  = peptide or inhibitor.

[0158] In some embodiments, linking groups may include peptide mimetics. The use of such mimetics may induce or stabilize the peptide conformation. By way of example,  $\beta$ -turn mimetics include Ala-Aib and Ala-Pro dipeptides, as well as, mimic A and mimic B illustrated as follows,



wherein mimic A is *N*-(3S,6S,9S)-2-oxo-3-amino-1-azabicyclo[4.3.0]-nonane-9-carboxylic acid, and mimic B is *N*-(3S,6S,9R)-2-oxo-3-amino-7-thia-1-azabicyclo[4.3.0]-nonane-9-carboxylic acid.

[0159] In some embodiments, the linker is 1 to 30 amino acid residues in length, in another embodiment, the linker is 2 to 30 amino acid residues in length, and in yet another embodiment, the linker is 3 to 30 amino acid residues in length. In another embodiment, the linker is of any integer length from 2 to 30 amino acid residues inclusive; each integer unit is contemplated, e.g., 2, 3, 4, 5, 6, 7, and so on. In some embodiments, a Gly linker is used. In some embodiments, a three residue Gly linker (Gly-Gly-Gly) is used. In some embodiments, a  $\beta$ -Ala linker, e.g.,  $\beta$ -Ala- $\beta$ -Ala, is used. In some embodiments, a  $\gamma$ -Abu ( $\gamma$ -aminobutyric acid) linker is used. In some embodiments, multiple a  $\gamma$ -Abu linkers are used in series. In some embodiments, different linkers are used in series, for example without limitation,  $\beta$ -Ala- $\gamma$ -Abu.

[0160] In some embodiments, the P-PI conjugate exhibits at least biological activity of the component peptide. In some embodiments, the P-PI conjugate exhibits at least inhibitor activity of the component peptidase inhibitor. In other embodiments, the P-PI conjugate exhibits at least biological activity of the peptide and inhibitor activity of the peptidase inhibitor. In some embodiments, the P-PI conjugate has at least increased metabolic stability, chemical stability, receptor interaction, or conformational stability as compared to either the component peptide or the component protease inhibitor not in a conjugate complex.

[0161] As described herein, the P-PI conjugates comprise at least one peptide linked (covalently or non-covalently) to at least one peptidase inhibitor. In some embodiments, the P-PI conjugates include two or more peptides linked to a peptidase inhibitor molecule. In some embodiments, the P-PI conjugate includes two peptidase inhibitor molecules linked to a peptide. In some embodiments, the P-PI conjugate includes two different peptidase inhibitors linked to a peptide. In some embodiments, the P-PI conjugate includes three peptidase inhibitor molecules linked to a peptide. In conjugates with three inhibitor molecules, all three inhibitors may be the same, all three inhibitors may be different, or two inhibitors may be the same while the third is different from the other two.

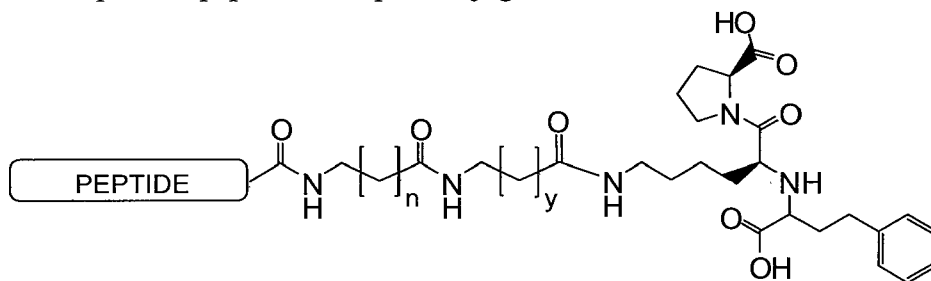
[0162] As described herein, a single peptidase inhibitor molecule can inhibit more than one type of peptidase. For example, an NEP/ACE inhibitor has the dual activities of an NEP inhibitor and an ACE inhibitor. Accordingly, a P-PI conjugate molecule comprising one peptidase inhibitor molecule may possess more than one peptidase inhibitor activities. In some embodiments, the P-PI conjugate has two or more peptidase inhibitor activities. In some embodiments, the P-PI conjugate has three or more peptidase inhibitor activities. In some embodiments, linking one or more peptidase inhibitors to a peptide generates a P-PI conjugate with more than one peptidase inhibitor activity. For example, a P-PI comprising a peptide linked with an NEP/ACE inhibitor possesses two inhibitor activities through the linkage of a single peptidase inhibitor molecule. As another example, a P-PI comprising a peptide linked with an NEP/ECE inhibitor and an ACE inhibitor possesses three inhibitor activities through the linkage of a two different peptidase inhibitor molecules.

[0163] With regard to any of the P-PI conjugates described herein, the component peptide may be of any length. In some embodiments, the component peptide is less than 200 amino acids in length. In some embodiments, the component peptide is less than 150 amino acids in length, for example, less than 100, less than 50, less than 40, less than 30, or less than 20 amino acids in length. In some embodiments, the component peptide is between about 30 and

about 40 amino acid residues in length. In some embodiments, the component peptide is between about 15 and about 25 amino acids in length, between about 20 and about 30 amino acids in length, or between about 25 and about 35 amino acids in length. In some  
 5 embodiments, the component peptide is about 15, about 17, about 19, about 21, about 23, about 25, about 27, about 29, about 30, about 31, about 32, about 33, about 34, about 35, or about 36 amino acids in length.

**[0164]** Exemplary P-PI conjugates include, but are not limited to, those in which the peptidase inhibitor is covalently linked to a side-chain of the peptide.

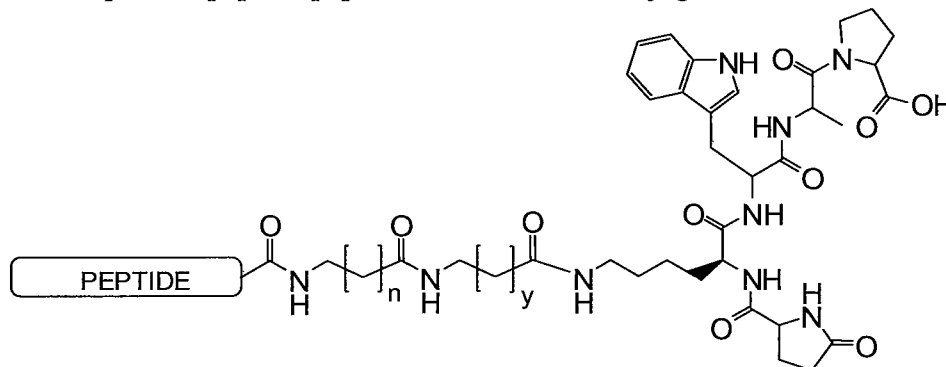
**[0165]** An example of a peptide-lisinopril conjugate is:



10

where  $n = 0, 1, \text{ or } 2$ ;  $y = 0, 1 \text{ or } 2$ ; and peptide = GLP-1(7-37) (SEQ ID NO:42), exendin-4, other active analog of GLP-1(7-37) or exendin-4, or other bioactive peptide described herein.

**[0166]** An example of a peptide-peptide/ACE inhibitor conjugate is:

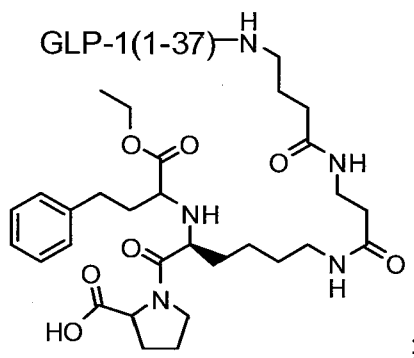


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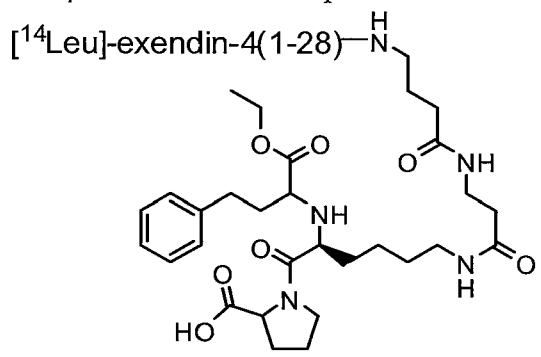
where  $n = 0, 1, \text{ or } 2$ ;  $y = 0, 1, \text{ or } 2$ ; peptide = GLP-1(7-37) (SEQ ID NO:42), exendin-4, other active analogs of GLP-1(7-37) or exendin-4, or other bioactive peptide described herein.

**[0167]** In certain embodiments, the P-PI conjugate comprises a peptidase inhibitor, such as lisinopril or pGluKWAP-OH (SEQ ID NO:273) (ACE inhibitors), conjugated to a GLP-1, such as GLP-1(7-37) (SEQ ID NO:42) or an exendin analog, such as [<sup>14</sup>Leu]exendin-4(1-28)  
 20 (SEQ ID NO:70). In these conjugates, the peptidase inhibitor may be linked, by various linkers, at the carboxy-terminus of the peptide analog, at the amino-terminus of the peptide analog, or at an amino acid residue within the peptide analog. Such P-PI conjugates include, but are not limited to, the following:

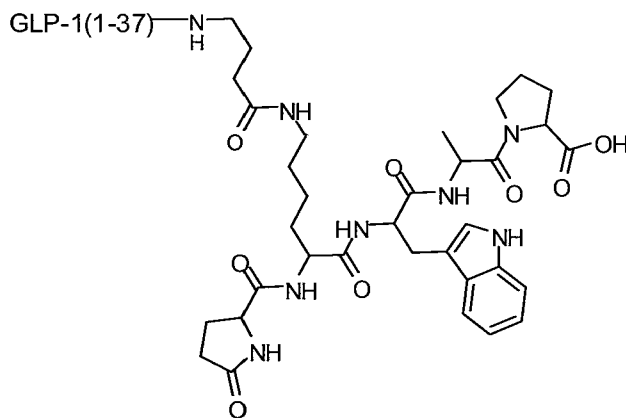
GLP-1(7-37)- $\gamma$ -Abu- $\beta$ -Ala-CONH-lisinopril monoester:



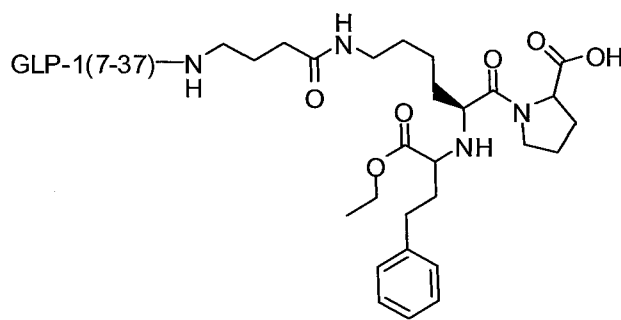
[<sup>14</sup>Leu]exendin-4(1-28)- $\gamma$ -Abu- $\beta$ -Ala-CONH-lisinopril monoester:



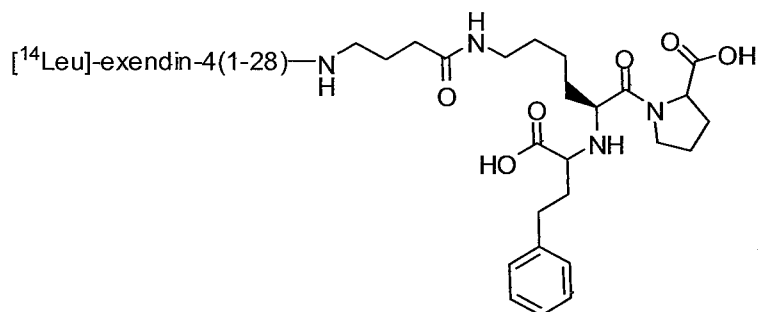
5 GLP-1(7-37)- $\gamma$ -Abu- Lys(pGlu)WAP-OH:



GLP-1(7-37)- $\gamma$ -Abu-CONH-lisinopril monoester:

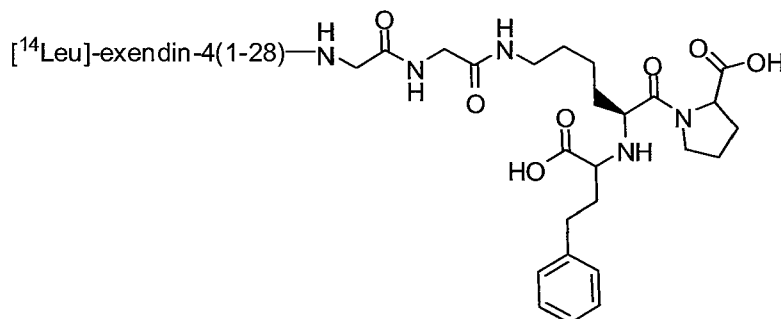


[<sup>14</sup>Leu]exendin-4(1-28)-γ-Abu-CONH-lisinopril:



; and

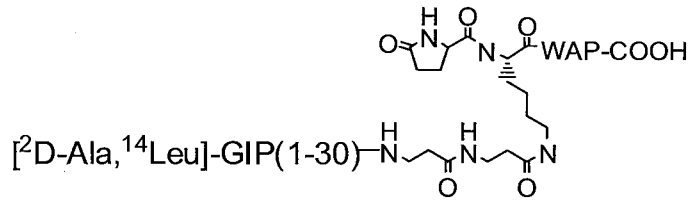
[<sup>14</sup>Leu]exendin-4(1-28)-Gly-Gly-CONH-lisinopril:



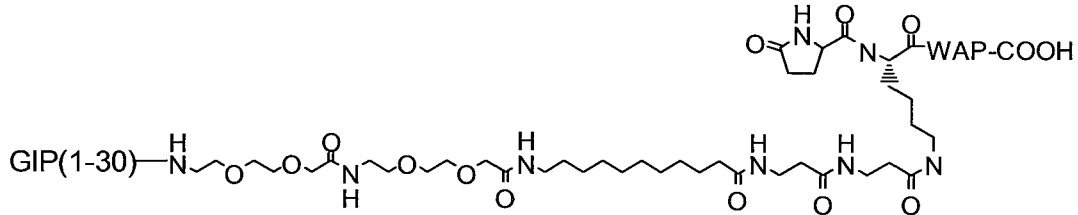
5 **[0168]** In some embodiments, the P-PI conjugate comprises a peptidase inhibitor and a peptide other than a GLP-1 or an exendin peptide. Accordingly, in some embodiments, the P-PI conjugate comprises at least one peptidase inhibitor linked to a peptide wherein the peptide is not a GLP-1 or a GLP-1 analog. In other embodiments, the P-PI conjugate comprises at least one peptidase inhibitor linked to a peptide wherein the peptide is not an exendin or an  
10 exendin analog.

**[0169]** In certain embodiments, the P-PI conjugate comprises a peptidase inhibitor, such as lisinopril or pGluKWAP-OH (SEQ ID NO:273) (ACE inhibitors) conjugated to a GIP analog or a GIP hybrid molecule, such as GIP(1-30) (SEQ ID NO:79), [<sup>14</sup>Leu]GIP(1-30) (SEQ ID NO:87), [<sup>14</sup>Leu]GIP(1-30)-exendin-4(31-39) (SEQ ID NO:266), [<sup>2</sup>D-Ala]GIP(1-30)-exendin-4(31-39), [<sup>2</sup>D-Ala]GIP(1-30) and GIP(1-30)-exendin-4(31-39) (SEQ ID NO:1). In peptide-peptidase inhibitor conjugates with an <sup>2</sup>Ala in the peptide, the <sup>2</sup>Ala may be either the L or D isomer. In these conjugates, the peptidase inhibitor may be linked, by various linkers, at the carboxy-terminus of the GIP analog, at the amino-terminus of the GIP analog, or at an amino acid residue within the GIP analog, for example, at the ε-amino position of <sup>30</sup>Lys.  
15  
20 Exemplary P-PI conjugates include, but are not limited to, the following:

[<sup>2</sup>D-Ala,<sup>14</sup>Leu] GIP-(1-30)-β-Ala-β-Ala-Lys(α-NH-Pyroglutamoyl)-Trp-Ala-Pro-COOH:

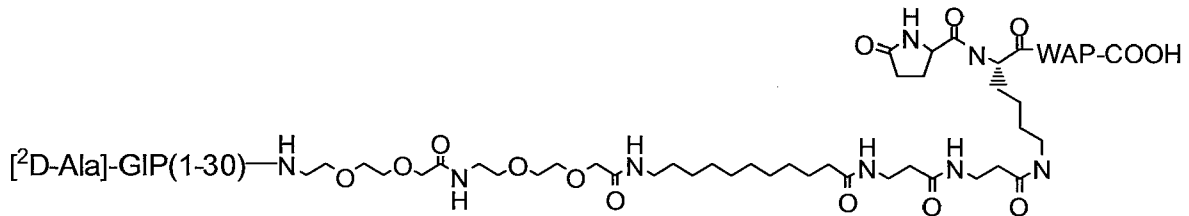


GIP-(1-30)-Ado-Ado-Aun-βAla-βAla-ε-NH-Lys(α-NH-Pyroglutamoyl)-Trp-Ala-Pro:



; and

5 [<sup>2</sup>D-Ala]GIP-(1-30)-Ado-Ado-Aun-βAla-βAla-ε-NH-Lys(α-NH-Pyroglutamoyl)-Trp-Ala-Pro:



[0170] In certain embodiments, the P-PI conjugate comprises a peptidase inhibitor

conjugated to a GIP analog or a GIP hybrid molecule, such as GIP(1-30) (SEQ ID NO:79),

[<sup>14</sup>Leu]GIP(1-30) (SEQ ID NO:87), [<sup>14</sup>Leu]GIP(1-30)-exendin-4(31-39) (SEQ ID NO:266),

10 [<sup>2</sup>D-Ala]GIP(1-30)-exendin-4(31-39), [<sup>2</sup>D-Ala]GIP(1-30) and GIP(1-30)-exendin-4(31-39)

(SEQ ID NO:1). In certain embodiments, the peptidase inhibitor is a DPP-IV inhibitor. In

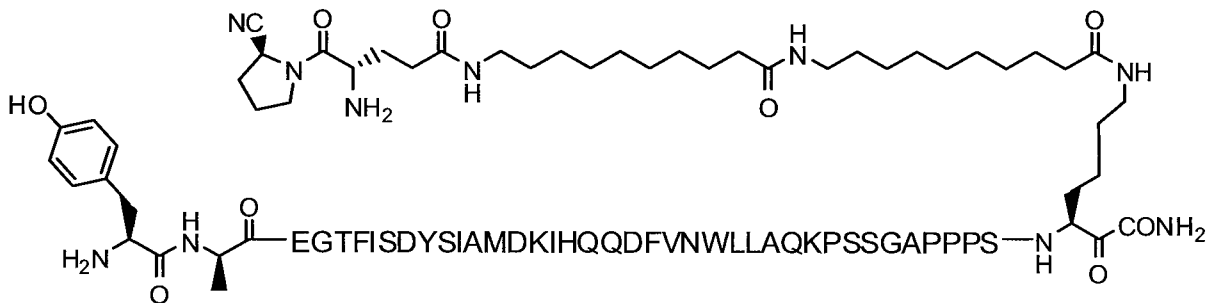
these conjugates, the DPP-IV inhibitor may be linked, by various linkers, at the carboxy-

terminus of the GIP analog, at the amino-terminus of the GIP analog, or at an amino acid

residue within the GIP analog, for example, at the ε-amino position of <sup>30</sup>Lys. Exemplary P-PI

15 conjugates include, but are not limited to, the following:

[<sup>2</sup>D-Ala]GIP(1-30)-exendin-4(31-39)-(Lys(ε-NH-(Aun-Aun-(γ-L-Glu-(2-(S)-cyano  
pyrrolidyl))))):

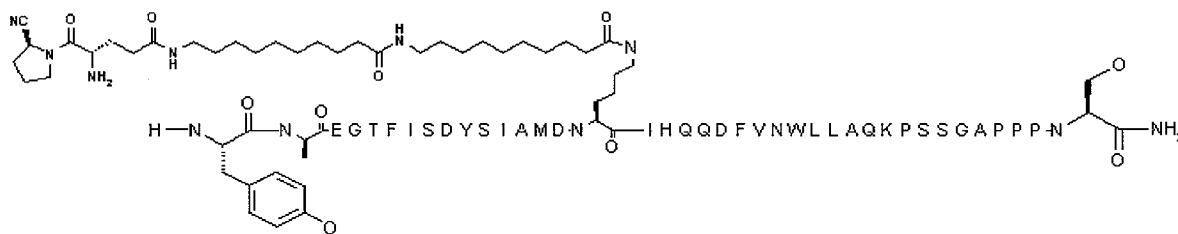




Lys<sup>30</sup> N-ε-(Ado-(γ-L-Glu-2-(S)-cyano pyrrolidyl)) GIP(1-30)-exendin-4(31-39):



[D-Ala<sup>2</sup>,Lys<sup>16</sup>(ε-NH-(Aun-Aun-(γ-L-Glu-2-(S)-cyano pyrrolidyl)))] GIP(1-30)-exendin-4(31-39):

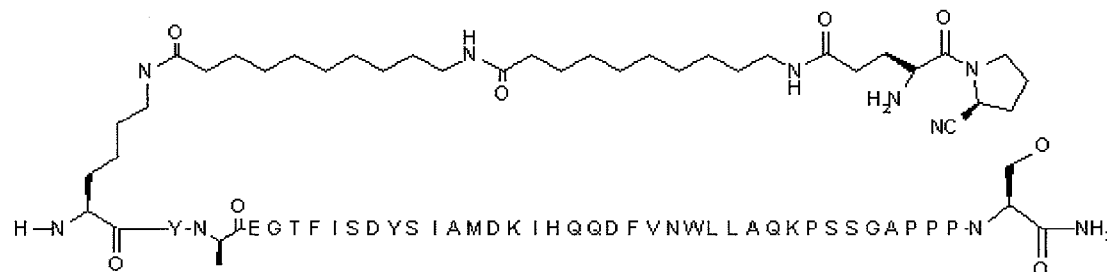


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N-(γ-L-Glu-2-(S)-cyano pyrrolidyl)-Ado-Ado GIP(1-30)-exendin-4(31-39):

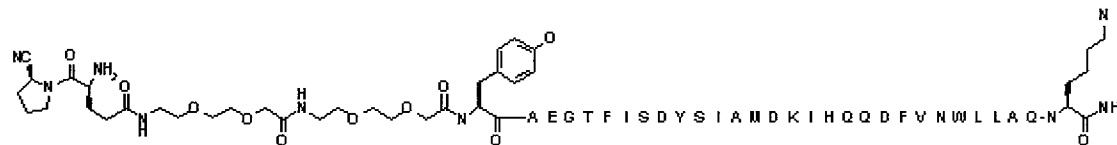


[D-Ala<sup>2</sup>, Lys(ε-NH-(Aun-Aun-(γ-L-Glu-2-(S)-cyano pyrrolidyl)))]GIP(1-30)-exendin-4(31-39):



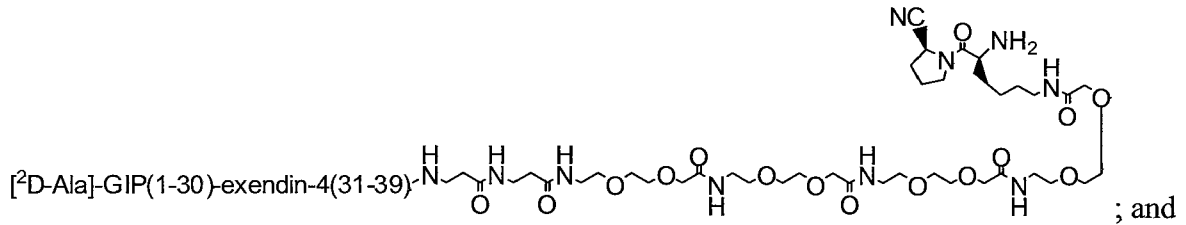
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N-(γ-L-Glu-2-(S)-cyano pyrrolidyl)-Ado-Ado GIP(1-30):

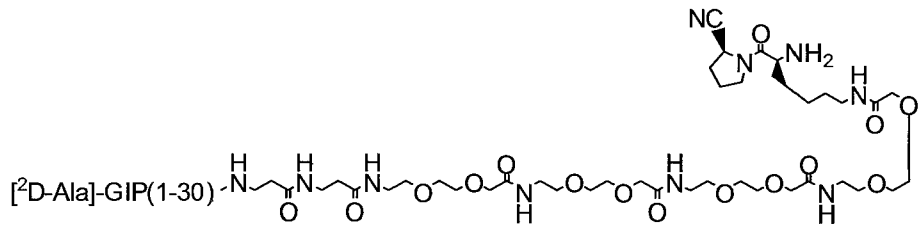


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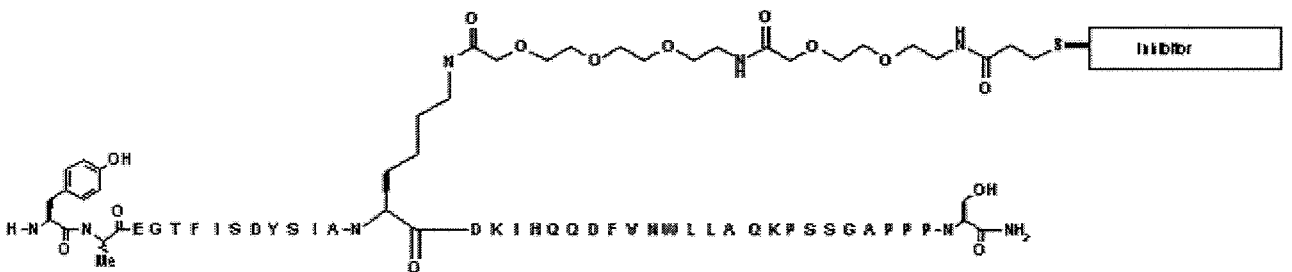
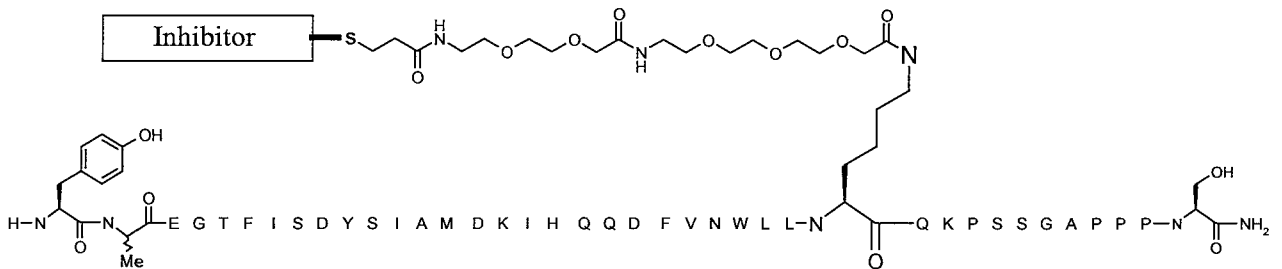
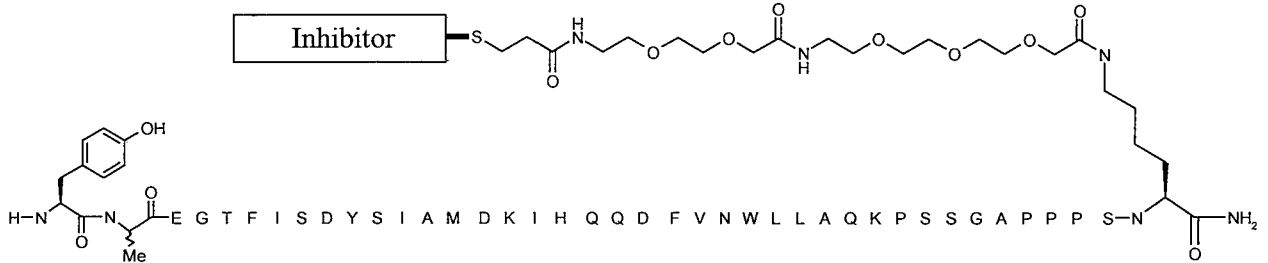
[<sup>2</sup>D-Ala] GIP(1-30)-exendin-4(31-39)-β-Ala-β-Ala-Ado-Ado-Ado-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl):



5 [<sup>2</sup>D-Ala] GIP(1-30)-β-Ala-β-Ala-Ado-Ado-Ado-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl):

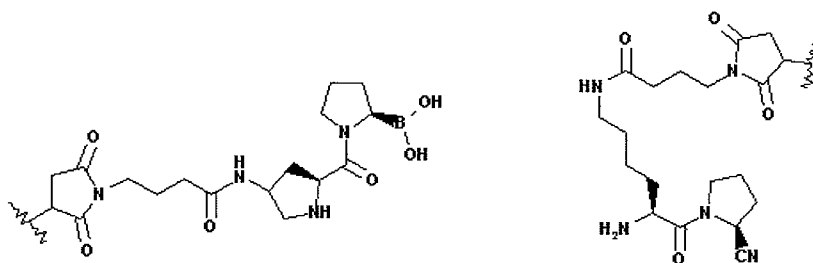


[0171] In certain embodiments, P-PI conjugates contemplated herein comprises a DPP-IV inhibitor conjugated to a GIP analog or a GIP hybrid molecule by various linkers at the carboxy-terminus of the GIP analog, at the amino-terminus of the GIP analog or at an amino acid residue within the GIP analog. Examples of such conjugates include the following:



15

where inhibitors have structure, for example without limitation,



or

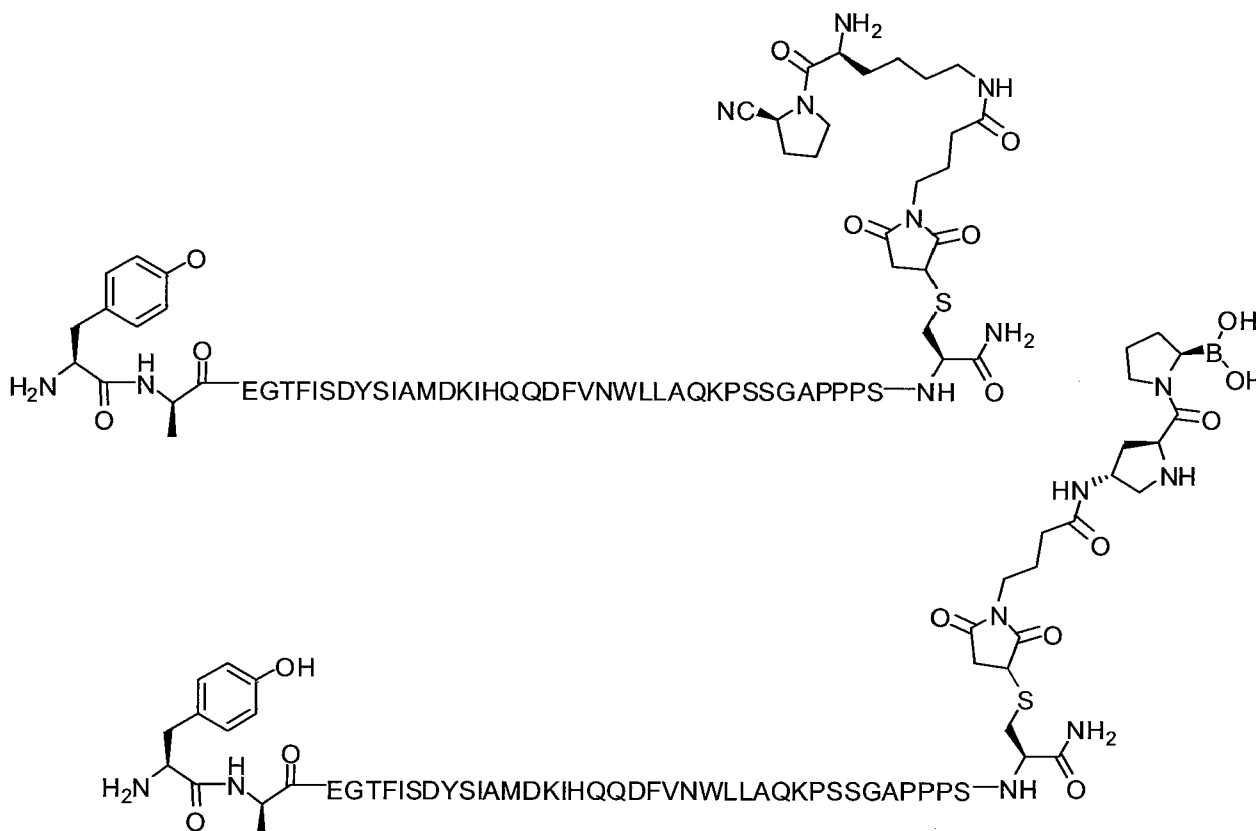
. Examples of such P-PI

conjugates include, but are not limited to, [D-<sup>2</sup>Ala]GIP(1-30)-exendin-4(31-39)-Cys-((S-

5 4(31-39)-Cys-((S-maleimido propanoyl)-Lys-N-ε-(2-(S)-cyano pyrrolidyl)) and [<sup>2</sup>D-Ala]GIP(1-30)-exendin-

4(31-39)-Cys-((S-maleimido propanoyl)-(2-(S)-4(s)amino)Pro-(2-(S)-boro pyrrolidyl)), with

structure as follows, respectively:



[0172] In other embodiments, the P-PI conjugate comprises a serine protease inhibitor

10 conjugated to a PYY analog, an NPY analog, or hybrid molecule, such as PYY(3-36). In other

embodiments, the P-PI conjugate comprises a carboxypeptidase inhibitor conjugated to a PYY

analog, an NPY analog, or hybrid molecule, such as PYY(3-36).

[0173] As used herein, the singular form “a”, “an”, and “the” includes plural references unless otherwise indicated or clear from context. For example, as will be apparent from context, “a” peptide hormone can include one or more peptide hormones.

[0174] As used herein, an “analog” refers to a peptide whose sequence was derived from that of a base reference or native peptide, *e.g.*, amylin, PYY, and includes insertions, substitutions, extensions, and/or deletions of the reference amino acid sequence, for example having at least 50%, 55%, 60%, 65% amino acid sequence identity with the base peptide, in other cases, for example, having at least 70%, 80%, 90%, 95%, 95%, 97%, 98%, or even 99% amino acid sequence identity with the base peptide. Such analogs may comprise conservative or non-conservative amino acid substitutions (including non-natural amino acids and L and D forms).  
Analogues include compounds having agonist and compounds having antagonist activity. Analogues may also include compounds having an activity not present in the reference peptide, for example, a peptidase inhibitor activity. Analogues, as herein defined, also include derivatives.

[0175] A “derivative” is defined as a reference peptide or analog, described above, having a chemical modification of one or more of its amino acid side groups,  $\alpha$ -carbon atoms, terminal amino group, or terminal carboxylic acid group. A chemical modification includes, but is not limited to, adding chemical moieties, creating new bonds, and removing chemical moieties. Modifications at amino acid side groups include, without limitation, acylation of lysine  $\epsilon$ -amino groups, N-alkylation of arginine, histidine, or lysine, alkylation of glutamic or aspartic carboxylic acid groups, and deamidation of glutamine or asparagine. Modifications of the terminal amino group include, without limitation, the desamino, N-lower alkyl, N-di-lower alkyl, constrained alkyls (*e.g.* branched, cyclic, fused, adamantyl) and N-acyl modifications, such as alkyl acyls, branched alkylacyls, alkylaryl-acyls. Modifications of the terminal carboxy group include, without limitation, the amide, lower alkyl amide, constrained alkyls (*e.g.* branched, cyclic, fused, adamantyl), dialkyl amide, arylamide, alkylarylamide and lower alkyl ester modifications. Lower alkyl is C1-C4 alkyl. Furthermore, one or more side groups, or terminal groups, may be protected by protective groups known to the ordinarily-skilled synthetic chemist. The  $\alpha$ -carbon of an amino acid may be mono- or dimethylated.

[0176] In general, with respect to an amino acid sequence, the term “modification” includes substitutions, insertions, elongations, deletions, and derivatizations alone or in combination. In some embodiments, the peptides may include one or more modifications of a “non-essential”

amino acid residue. In this context, a “non-essential” amino acid residue is a residue that can be altered, *e.g.*, deleted or substituted, in the novel amino acid sequence without abolishing or substantially reducing the activity (*e.g.*, the agonist activity) of the peptide (*e.g.*, the analog peptide). In some embodiments, the peptides may include one or more modifications of an  
5 “essential” amino acid residue. In this context, an “essential” amino acid residue is a residue that when altered, *e.g.*, deleted or substituted, in the novel amino acid sequence the activity of the reference peptide is substantially reduced or abolished. In such embodiments where an essential amino acid residue is altered, the modified peptide may possess an activity of use in the P-PI conjugate, for example, a peptidase inhibitor activity. The peptides of use in the P-PI  
10 conjugates may include deletions of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more amino acid residues. The peptides of use in the P-PI conjugates may include additions of at least of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more amino acids. The peptides of use in the P-PI conjugates may include substitutions of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more amino acid residues.

[0177] Substitutions include conservative amino acid substitutions. A “conservative amino  
15 acid substitution” is one in which the amino acid residue is replaced with an amino acid residue having a similar side chain, or physicochemical characteristics (*e.g.*, electrostatic, hydrogen bonding, isosteric, hydrophobic features). The amino acids may be naturally occurring or nonnatural (unnatural). Families of amino acid residues having similar side chains are known in the art. These families include amino acids with basic side chains (*e.g.*, lysine, arginine,  
20 histidine), acidic side chains (*e.g.*, aspartic acid, glutamic acid), uncharged polar side chains (*e.g.*, glycine, asparagine, glutamine, serine, threonine, tyrosine, methionine, cysteine), nonpolar side chains (*e.g.*, alanine, valine, leucine, isoleucine, proline, phenylalanine, tryptophan),  $\beta$ -branched side chains (*e.g.*, threonine, valine, isoleucine) and aromatic side chains (*e.g.*, tyrosine, phenylalanine, tryptophan, histidine). Substitutions may also include  
25 non-conservative changes.

[0178] By “amino acid” or “amino acid residue” is meant natural amino acids, unnatural amino acids, and modified amino acid. Unless stated to the contrary, any reference to an amino acid, generally or specifically by name, includes reference to both the D and the L stereoisomers if their structure allow such stereoisomeric forms. Natural amino acids include  
30 alanine (Ala), arginine (Arg), asparagine (Asn), aspartic acid (Asp), cysteine (Cys), glutamine (Gln), glutamic acid (Glu), glycine (Gly), histidine (His), isoleucine (Ile), leucine (Leu), Lysine (Lys), methionine (Met), phenylalanine (Phe), proline (Pro), serine (Ser), threonine (Thr), tryptophan (Trp), tyrosine (Tyr) and valine (Val). Unnatural amino acids include, but are not

limited to, homolysine, homoarginine, homoserine, azetidinecarboxylic acid, 2-aminoadipic acid, 3-aminoadipic acid, beta-alanine, aminopropionic acid, 2-aminobutyric acid, 4-aminobutyric acid, 6-aminocaproic acid, 2-aminoheptanoic acid, 2-aminoisobutyric acid, 3-aminoisobutyric acid, 2-aminopimelic acid, tertiary-butylglycine, 2,4-diaminoisobutyric acid, 5 desmosine, 2,2'-diaminopimelic acid, 2,3-diaminopropionic acid, N-ethylglycine, N-ethylasparagine, homoproline, hydroxylysine, allo-hydroxylysine, 3-hydroxyproline, 4-hydroxyproline, isodesmosine, allo-isoleucine, N-methylalanine, N-methylglycine, N-methylisoleucine, N-methylpentylglycine, N-methylvaline, naphthalanine, norvaline, norleucine, ornithine, pentylglycine, pipercolic acid, pyroglutamate, and thioproline.

10 Additional unnatural amino acids include modified amino acid residues which are chemically blocked, reversibly or irreversibly, or chemically modified on their N-terminal amino group or their side chain groups, as for example, N-methylated D and L amino acids or residues wherein the side chain functional groups are chemically modified to another functional group. For example, modified amino acids include methionine sulfoxide; methionine sulfone; aspartic acid- (beta-methyl ester), a modified amino acid of aspartic acid; N-ethylglycine, a modified 15 amino acid of glycine; or alanine carboxamide, a modified amino acid of alanine. Additional residues that can be incorporated are described in Sandberg *et al.* (1998) *J. Med. Chem.* 41:2481-2491.

[0179] It should be noted that alternatives are written throughout in Markush groups, for 20 example, each amino acid position that contains more than one possible amino acid. It is specifically contemplated that each member of the Markush group should be considered separately, thereby comprising another embodiment, and the Markush group is not to be read as a single unit.

[0180] "Sequence identity", as is well understood in the art, is a relationship between two or 25 more polypeptide sequences or two or more polynucleotide sequences, as determined by comparing the sequences. In the art, "identity" can also mean the degree of sequence relatedness between polypeptide or polynucleotide sequences, as determined by the match between strings of such sequences. Identity can be readily calculated by known methods including, but not limited to, those described in *Computational Molecular Biology*, Lesk, 30 A.M., ed., Oxford University Press, New York (1988); *Biocomputing: Informatics and Genome Projects*, Smith, D.W., ed., Academic Press, New York, 1993; *Computer Analysis of Sequence Data, Part I*, Griffin, A.M. and Griffin, H.G., eds., Humana Press, New Jersey (1994); *Sequence Analysis in Molecular Biology*, von Heinje, G., Academic Press (1987);

Sequence *Analysis Primer*, Gribskov, M. and Devereux, J., eds., Stockton Press, New York (1991); and Carillo, H., and Lipman, D., *SIAM J Applied Math*, **48**:1073 (1988). Methods to determine identity are designed to give the largest match between the sequences tested.

Moreover, methods to determine identity are codified in publicly available programs.

- 5 Computer programs which can be used to determine identity between two sequences include, but are not limited to, GCG (Devereux *et al.* (1984) *Nucleic Acids Research* **12**:387; suite of five BLAST programs, three designed for nucleotide sequences queries (BLASTN, BLASTX, and TBLASTX) and two designed for protein sequence queries (BLASTP and TBLASTN) (Coulson (1994) *Trends in Biotechnology* **12**:76-80; Birren *et al.* (1997) *Genome Analysis*
- 10 **1**:543-559). The BLAST X program is publicly available from NCBI and other sources (*BLAST Manual*, Altschul, S., *et al.*, NCBI NLM NIH, Bethesda, MD 20894; Altschul *et al.* (1990) *J. Mol. Biol.* **215**:403-410). The well known Smith Waterman algorithm can also be used to determine identity.

[0181] Parameters for polypeptide sequence comparison typically include the following:

- 15 Algorithm: Needleman and Wunsch (1970) *J. Mol. Biol.* **48**:443-453; Comparison matrix: BLOSSUM62 from Hentikoff and Hentikoff (1992) *Proc. Natl. Acad. Sci. USA* **89**:10915-10919; Gap Penalty: 12; Gap Length Penalty: 4. A program that can be used with these parameters is publicly available as the “gap” program from Genetics Computer Group (“GCG”), Madison, WI. The above parameters along with no penalty for end gap are the
- 20 default parameters for peptide comparisons. In some embodiments, the BLASTP program of NCBI is used with the default parameters of no compositional adjustment, expect value of 10, word size of 3, BLOSUM62 matrix, gap extension cost of 11, end gap extension cost of 1, dropoff (X) for blast extension (in bits) 7, X dropoff value for gapped alignment (in bits) 15, and final X dropoff value for gapped alignment (in bits) 25.

- 25 [0182] Parameters for nucleic acid molecule sequence comparison include the following: Algorithm: Needleman and Wunsch (1970) *J. Mol. Bio.* **48**:443-453; Comparison matrix: matches - +10; mismatches = 0; Gap Penalty: 50; Gap Length Penalty: 3. As used herein, “% identity” is determined using the above parameters as the default parameters for nucleic acid molecule sequence comparisons and the “gap” program from GCG, version 10.2.

- 30 [0183] In one aspect, use of a P-PI conjugate compound disclosed herein provides a method of increasing the plasma half-life of a peptide hormone in plasma. Administration of a P-PI conjugate increases plasma half-life of the peptide of the conjugate as compared to administration of an unconjugated peptide. The peptidase inhibitor of the P-PI conjugate may

also increase plasma half-life of the endogenous component peptide. An increase in plasma half-life of the peptide may lead to a prolonged or an increase in the effective plasma concentration of the peptide.

5 [0184] As used herein, “increasing plasma half-life” means an increase in the half-life of the peptide in plasma compared to a suitable control. For example, the plasma half-life of the peptide in the P-PI conjugate is greater than that of an unconjugated peptide. In some  
embodiments, the P-PI conjugate increases the plasma half-life of the peptide by at least 5% compared to the plasma half-life of an unconjugated component peptide. In some instances, the P-PI conjugate increases the plasma-life of the peptide by at least 10%, at least 15%, at  
10 least 20%, at least 25%, at least 30% compared to the plasma half-life of an unconjugated component peptide. The plasma half-life of a peptide can be measured *in vivo* or *in vitro* and may be determined by any method described herein or known in the art.

[0185] In another aspect, use of a P-PI conjugate compound disclosed herein provides a method for decreasing or delaying peptide degradation of a peptide hormone in plasma.  
15 Administration of a P-PI conjugate decreases or delays degradation of the peptide of the conjugate as compared to administration of an unconjugated peptide. The peptidase inhibitor of the P-PI conjugate may also decrease or delay degradation of the endogenous component peptide in plasma. A decrease or delay in degradation of the peptide in plasma may lead to a prolonged or an increase in the effective plasma concentration of the peptide.

20 [0186] As used herein, “peptide degradation” refers to a process where an endogenous or exogenous peptide is degraded *in vivo* or *in vitro* by a biological process, such as by a peptidase. For example, degradation of the peptide in the P-PI conjugate in plasma is less than that of an unconjugated peptide. In some embodiments, the P-PI conjugate decreases or delays peptide degradation in plasma by at least 5% compared to degradation of an unconjugated  
25 component peptide in plasma. In some instances, the P-PI conjugate decreases plasma degradation of the peptide by at least 10%, at least 15%, at least 20%, at least 25%, at least 30% compared to plasma degradation of an unconjugated component peptide. Degradation of peptides can be measured *in vivo* or *in vitro* and may be determined by any method described herein or known in the art.

30 [0187] In general, the P-PI conjugate compounds disclosed herein are of use in methods where the individual component peptide or peptidase inhibitor would be of use based on their biological activities. In one aspect, certain P-PI conjugates disclosed herein have a prolonged

serum half-life relative to the unconjugated peptide. Accordingly, the conjugate is of use in methods in which a skilled artisan would use the component peptide. In another aspect, the peptide in certain P-PI conjugates can serve to specifically and effectively deliver the peptidase inhibitor to a site rich in peptide receptor. Accordingly, this will allow the peptidase inhibitor to reduce peptidase activity on endogenous peptide molecules at their site of action, *e.g.*, the peptide receptor.

[0188] In a one general aspect, methods are provided for reducing nutrient availability through administration of a P-PI conjugate compound. Thus, disclosed herein are methods for treating diseases, disorders, and/or conditions that would benefit from a reduction in nutrient availability. Conditions, diseases, and disorders that may benefit from a reduction in nutrient availability include, but are not limited to, obesity, obesity-related conditions, eating disorders, hypertension, pulmonary hypertension, dyslipidemia, hyperlipidemia, cardiovascular disease, insulin-resistance, abnormal postprandial hyperglycemia, and diabetes mellitus of any kind, Dumping Syndrome, and Metabolic Syndrome. Given the increase in serum half-life and thus extended effectiveness of the conjugate as compared to the peptide alone, methods disclosed herein may allow for administration of lower or less frequent dosages of therapeutic agent. Exemplary P-PI conjugate compounds for use in methods for reducing nutrient availability include, but are not limited to, those conjugates in which the component peptide is a PYY, an exendin, a GLP-1, an amylin, sCT, an AFP-6, a leptin, or a hybrid, agonist, analog or derivative of any of these. Accordingly, conjugates in which the component peptide is a PYY, an exendin, a GLP-1, amylin, sCT, an AFP-6, a leptin or a hybrid, agonist, analog or derivative of any of these are nonlimiting examples of P-PI conjugates of use in treating or preventing conditions, diseases, and disorders that may benefit from a reduction in nutrient availability, as described herein.

[0189] “Reduced nutrient availability” is meant to include any means by which the body reduces the nutrients available to the body to store as fat. In other words, reducing nutrient availability may be by means that include, but are not limited to, reducing food intake, reducing appetite, increasing satiety, affecting food choice/taste aversion, increasing metabolism, decreasing or inhibiting food absorption, or any combination of the preceding. An exemplary mechanism that may be affected includes delayed gastric emptying.

[0190] In one aspect, methods are provided for treating or preventing obesity in a subject, where the method comprises administering a therapeutically or prophylactically effective amount of a P-PI conjugate to the subject. Methods are also provided for treating or

ameliorating symptoms or effects of obesity in a subject in need thereof, where the method comprises administering a therapeutically effective amount of a P-PI conjugate to the subject. While "obesity" is generally defined as a body mass index (BMI,  $\text{kg/m}^2$ ) over 30, for purposes of this disclosure, any subject, including those with a body mass index of less than 30, who  
5 needs or wishes to reduce body weight or prevent body weight gain is included in the scope of "obese." Thus, subjects with a BMI of between 30 and 25 (considered overweight) or below 25 are also included in the subjects of the methods disclosed herein. Morbid obesity refers to a BMI of 40 or greater.

[0191] In some embodiments, methods are provided to increase the metabolic rate in a  
10 subject, decrease a reduction in the metabolic rate in a subject, or preserve the metabolic rate in a subject. By "metabolic rate" is meant the amount of energy liberated/expended per unit of time. Metabolism per unit time can be estimated by food consumption, energy released as heat, or oxygen used in metabolic processes. It is generally desirable to have a higher  
15 metabolic rate when one wants to loose weight. For example, a person with a high metabolic rate may be able to expend more energy (*e.g.*, the body burns more calories) to perform an activity than a person with a low metabolic rate for that activity.

[0192] In some embodiments, the metabolic rate may involve the preferential use of the  
20 body's fat as an energy source over lean body tissue. In one aspect, lean body mass is not decreased following administration of the P-PI conjugate. In another aspect, a reduction in the lean body mass is lessened or prevented following administration of the P-PI conjugate. In still  
25 another aspect, lean body mass is increased following administration of the P-PI conjugate. Such preference for fat as the energy source may be determined by comparing the amount of fatty tissue to lean body tissue, ascertained by measuring total body weight and fat content at the beginning and end of the treatment period. An increase in metabolic rate is a higher level  
30 of the use of calories or another energy source by a subject over a period of time compared with the level of use of calories or other energy source by the subject over another period of time under substantially similar or identical conditions without administration of the P-PI conjugate. In some embodiments, the metabolic rate is increased at least about 5% in a subject, in other embodiments, the metabolic rate is increased at least about 10%, 15%, 20%  
35 25%, 30%, or 35% in a subject compared with the level of use of calories or other energy source by the subject over another period of time under substantially similar or identical conditions without administration of the P-PI conjugate. The increase in metabolic rate can be measured using a respiratory calorimeter, for example.

[0193] In another embodiment, a method is provided to reduce a decrease in metabolic rate in a subject. Such a decrease in metabolic rate can be the result of any condition or nutritional or physical regimen that leads to a reduction in metabolic rate, *e.g.*, due to a reduced calorie diet, a restricted diet, or weight loss. A restricted diet includes allowances or prohibitions, or  
5 both on the types of food or the amounts of food or both permitted in a diet, not necessarily based on calories. For example, as in individual diets, the body compensates with a reduced metabolic rate based on the lower caloric intake. In essence, the body down-regulates the requirement for food, thereby subsisting on less food. As dieting continues, the threshold for caloric intake is reduced. When dieting has ended, the individual typically gains weight while  
10 eating a normal diet because of the lowered caloric intake threshold and lower-basal metabolic rate (NIH Technology Assessment Conference Panel (1992) *Ann. Intern. Med.* 116:942-949; Wadden (1993) *Ann. Intern. Med.* 119:688-693). In one aspect, a method is provided to reduce the loss of metabolic rate in a subject, where the loss of metabolic rate is the result of a reduced calorie diet or weight loss. By using such a method, the subject's reduction in metabolic rate is  
15 decreased by at least about 10%, 15%, 20%, 25%, 30%, 35%, 40%, 50%, 60%, 70%, 80%, 90%, or 95% in a subject. For such methods, it may be desirable to administer the P-PI conjugate at the time the condition or nutritional or physical regimen is initiated which leads to a loss or reduction in metabolic rate. However, it is also contemplated that administration of the P-PI conjugate is commenced before the condition or nutritional or physical regimen is  
20 initiated. In one instance, metabolic rate is measured using a respiratory calorimeter.

[0194] In another aspect, methods for reducing metabolic plateaus are provided, where a method comprises administering effective amounts of the P-PI conjugate to a subject. In some embodiments, the subject is losing weight, or has lost weight, for example, due to a reduced calorie diet, increased exercise or a combination thereof. By "metabolic plateau" is meant time  
25 intervals of steady metabolic rate while the body adjusts to changes in caloric or energy input. Changes in caloric input or expenditure can be the result of, for example, reduced calorie diets or increased physical activity. Such plateaus can be observed, for example, during a weight loss regimen when weight loss slows or stops. In some embodiments, a method provided reduces the duration of a metabolic plateau in a subject compared with the duration of  
30 metabolic plateaus in an otherwise identical subject over the same period of time under substantially similar or identical conditions without administration of the P-PI conjugate. In another embodiment, a method provided reduces the frequency of metabolic plateaus compared with the frequency of metabolic plateaus in an otherwise identical subject over the

same period of time under substantially similar or identical conditions without administration of the P-PI conjugate. In still another embodiment, a method provided delays the onset of a metabolic plateau compared with the onset of a metabolic plateau in an otherwise identical subject over the same period of time under substantially similar or identical conditions without administration of the P-PI conjugate. In some embodiments, metabolic plateaus are identified by charting periods of reduced or no weight loss. In some embodiments, at least one metabolic plateau is reduced. In other embodiments, at least two, three, four, five, six, seven, eight, nine, or ten metabolic plateaus are reduced. In another aspect, metabolic plateaus are delayed one day as compared to a subject not administered the P-PI conjugate under identical or similar conditions. In other aspects, metabolic plateaus are delayed 2 days, 3 days, 4 days, 5 days, 6 days, 1 week, 10 days, 2 weeks or 3 weeks in a subject.

**[0195]** In yet another embodiment, a method is provided to preserve the metabolic rate in a subject. In some embodiments, the subject may be at risk of losing metabolic rate, for example, due to the initiation of a reduced calorie diet, restricted diet, or anticipated weight loss. A preservation of metabolic rate is a maintenance of the level of the use of calories or another energy source by a subject over a period of time compared with the level of use of calories or other energy source by an otherwise identical subject over the same period of time under substantially similar or identical conditions without administration of the P-PI conjugate. In one aspect, the metabolic rate is maintained within 15% of the subject's metabolic rate prior to the initiation of the event that results in the decrease in metabolic rate. In other aspects, the metabolic rate is maintained within 10%, within 7%, within 5%, within 3% or less of the subject's metabolic rate. In one aspect, the P-PI conjugate is administered at the initiation of a reduced calorie diet, restricted diet, or exercise regimen.

**[0196]** In another embodiment, methods for reducing fat mass by increasing the metabolic rate in a subject are provided, where the methods comprise administering a P-PI in an amount effective to reduce fat mass by increasing the subject's metabolic rate. Fat mass can be expressed as a percentage of the total body mass. In some instances, the fat mass is reduced by at least 1%, at least 5%, at least 10%, at least 15%, at least 20%, or at least 25% over the course of treatment. In one aspect, the subject's lean mass is not decreased over the course of the treatment. In another aspect, the subject's lean mass is maintained or increased over the course of the treatment. In another aspect, the subject is on a reduced calorie diet or restricted diet. By "reduced calorie diet" is meant that the subject is ingesting fewer calories per day than compared to the same subject's normal diet. In one instance, the subject is consuming at

least 50 fewer calories per day. In other instances, the subject is consuming at least 100, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, or 1000 fewer calories per day.

[0197] As used herein, "lean mass" or "lean body mass" refers to muscle and bone. Lean body mass does not necessarily indicate fat free mass. Lean body mass contains a small  
5 percentage of fat (roughly 3%) within the central nervous system (brain and spinal cord), marrow of bones, and internal organs. Lean body mass is measured in terms of density. In some embodiments, fat mass and lean mass is measured using underwater weighing.

[0198] In some embodiments, a method for altering the fat distribution in a subject is provided where the method comprises administering a P-PI conjugate in an amount effective to  
10 alter fat distribution in the subject. By "fat distribution" is meant the location of fat deposits in the body. Such locations of fat deposition include, for example, subcutaneous, visceral and ectopic fat depots. In one aspect, the alteration results from an increased metabolism of visceral or ectopic fat, or both in the subject. In some embodiments, the method involves the metabolism of visceral or ectopic fat or both at a rate of at least about 5%, 10%, 15%, 20%,  
15 25%, 30%, 40%, or 50% greater than for subcutaneous fat. In one aspect, the methods result in a favorable fat distribution. In some embodiments, favorable fat distribution is an increased ratio of subcutaneous fat to visceral fat, ectopic fat, or both. In one aspect, the method involves an increase in lean body mass, for example, as a result of an increase in muscle cell mass.

[0199] In another embodiment, methods for reducing the amount of subcutaneous fat in a  
20 subject are provided, wherein the method comprises administering, to a subject in need thereof, a P-PI conjugate in an amount effective to reduce the amount of subcutaneous fat in the subject. By "subcutaneous fat" is meant the deposit of lipids just below the skin's surface. The amount of subcutaneous fat in a subject can be measured using any method available for  
25 the measurement of subcutaneous fat. In one instance, the amount of subcutaneous fat is reduced in a subject by at least about 5%. In other instances, the amount of subcutaneous fat is reduced by at least about 10%, 15%, 20%, 25%, 30%, 40%, or 50% compared to the subject prior to administration of the P-PI conjugate.

[0200] The methods described herein can be used to reduce the amount of visceral fat in a  
30 subject. By "visceral fat" is meant the deposit of fat as intra-abdominal adipose tissue. Visceral fat surrounds vital organs and can be metabolized by the liver to produce blood cholesterol. Visceral fat has been associated with increased risks of conditions such as

polycystic ovary syndrome, metabolic syndrome and cardiovascular diseases. Visceral fat can be measured through any means available to determine the amount of visceral fat in a subject. In one instance, the visceral fat is reduced in a subject by at least about 5%. In other instances, the visceral fat is reduced in the subject by at least about 10%, 15%, 20%, 25%, 30% 40%, or 50% compared to the subject prior to administration of the P-PI conjugate.

**[0201]** In some embodiments, a method for preventing the accumulation of ectopic fat or reducing the amount of ectopic fat in a subject is provided, wherein the method comprises administering, to a subject in need thereof, a P-PI conjugate in an amount effective to prevent accumulation of ectopic fat or to reduce the amount of ectopic fat in the subject. By “ectopic fat storage” is meant lipid deposits within and around tissues and organs that constitute the lean body mass (*e.g.*, skeletal muscle, heart, liver, pancreas, kidneys, blood vessels). Generally, ectopic fat storage is an accumulation of lipids outside classical adipose tissue depots in the body. In one instance, the amount of ectopic fat is reduced in a subject by at least about 5% compared to the subject prior to administration of the P-PI conjugate. In other instances, the amount of ectopic fat is reduced in a subject by at least about 10%, or by at least about 15%, 20%, 25%, 30% 40%, or 50%. Alternatively, the amount of ectopic fat is proportionally reduced 5%, 10%, 15%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100% in comparison to subcutaneous fat in a subject. Ectopic fat can be measured in a subject using any method available for measuring ectopic fat.

**[0202]** In another embodiment, methods are provided for producing a more favorable fat distribution in a subject, where the method comprises administering to a subject the P-PI conjugate in an amount effective to produce a favorable fat distribution. In some embodiments, administration of the P-PI conjugate reduces the amount of visceral fat or ectopic fat, or both, in a subject. In some embodiments, the methods preferentially reduce the amount of visceral or ectopic fat, or a combination of both, over the reduction in subcutaneous fat. Such methods result in a higher ratio of subcutaneous fat to visceral fat or ectopic fat. Such improved ratios may result in a reduced risk of the development of cardiovascular diseases, polycystic ovary syndrome, metabolic syndrome, or any combinations thereof. In some embodiments, ectopic or visceral fat is metabolized at a rate 5% greater than subcutaneous fat. In other embodiments, ectopic or visceral fat is metabolized at a rate at least 10% 15%, 20%, 25%, 30% 50%, 60%, 70%, 80%, 90%, or 100% greater than subcutaneous fat.

[0203] In still another aspect, methods provided include the use of a therapeutically effective amount of the P-PI conjugate administered in combination with glucocortico-steroids.

Glucocortico-steroids have the adverse effect of increasing fat mass and decreasing lean mass.

Accordingly, it is contemplated that the P-PI conjugate can be used in conjunction with

5 glucocortico-steroids under conditions where glucocortico steroid use is beneficial.

[0204] Also provided are methods to reduce weight in a morbidly obese subject by first reducing the subject's weight to a level below that of being morbidly obese, then administering to the subject the P-PI conjugate in an amount effective to further reduce the subject's weight.

10 Methods for reducing a subject's weight to below that of morbid obesity include reducing caloric intake, increasing physical activity, drug therapy, bariatric surgery, such as gastric bypass surgery, or any combinations of the preceding methods. In one aspect, administering the combination of anti-obesity agents further reduces the weight of the subject. In another embodiment, methods are provided for reducing the body mass index in a subject having a body mass index of 40 or less by administering the P-PI conjugate in an effective amount to

15 further reduce the subject's weight.

[0205] By reducing weight it is meant that the subject loses a portion of his/her total body weight over the course of treatment, whether the course of treatment be days, weeks, months or years. Alternatively, reducing weight can be defined as a decrease in proportion of fat mass to lean mass (in other words, the subject has lost fat mass, but maintained or gained lean mass,

20 without necessarily a corresponding loss in total body weight). An effective amount of the P-PI conjugate administered in this embodiment is an amount effective to reduce a subject's body weight over the course of the treatment, or alternatively an amount effective to reduce the subject's percentage of fat mass over the course of the treatment. In certain embodiments, the subject's body weight is reduced, over the course of treatment, by at least about 1%, by at least about 5%, by at least about 10%, by at least about 15%, by at least about 20%, by at least about

25 25%, by at least about 30%, by at least about 40%, or by at least about 50%. In certain embodiments, the subject's BMI is reduced, over the course of treatment, to less than about 35, to about 30, to less than 30, to about 25, to less than 25, or to between 25 and 30. Alternatively, the subject's percentage of fat mass is reduced, over the course of treatment, by

30 at least 1%, at least 5%, at least 10%, at least 15%, at least 20%, or at least 25%.

[0206] Also provided are methods of increasing thermogenesis in a subject, the method comprising administering to a subject in need thereof an effective amount of the P-PI conjugate. Thermogenesis is the process of liberating calories as heat by increasing the body's

metabolic rate. Thermogenesis is activated by mechanisms, including supplements, nutrition, exercise, and exposure to cold.

[0207] Also provided are methods of increasing oxidative metabolism in a subject, the method comprising administering to a subject in need thereof an effective amount of the P-PI conjugate. Oxidative metabolism is the process by which oxygen is used to make energy from carbohydrates (sugars).

[0208] In another aspect, a method of inducing a feeling of fullness in a subject is provided, wherein the method comprises administering an effective amount of the P-PI conjugate to the subject. In yet another aspect, a method of controlling hunger in a subject is provided, wherein the method comprises administering an effective amount of the P-PI conjugate to the subject. In yet a further aspect, a method of prolonging a feeling of satiation in a subject is provided, wherein the method comprises administering an effective amount of the P-PI conjugate to the subject.

[0209] In yet a further aspect, a method of reducing caloric intake by reducing the size of a meal eaten by a subject is provided, wherein the method comprises administering an effective amount of the P-PI conjugate to the subject. In another aspect, a method of controlling food intake by a subject is provided, wherein the method comprises administering an effective amount of the P-PI conjugate to the subject.

[0210] In yet another aspect, a method for ensuring or assisting a subject in compliance with a reduced calorie or restrictive diet is provided, wherein the method comprises administering an effective amount of the P-PI conjugate to the subject. In a further aspect, a method of adjusting a subject's set point so that the body's propensity for homeostasis is adjusted to a healthier set point is provided, wherein the method comprises administering an effective amount of the P-PI conjugate to the subject. In yet a further aspect, a method of maintaining weight loss or maintaining the weight lost by a subject is provided, wherein the method comprises administering an effective amount of the P-PI conjugate to the subject. In some embodiments of this aspect, the weight loss is maintained by re-setting the subject's set point.

[0211] In some embodiments, methods are provided that are of use in treating and/or preventing metabolic conditions or disorders that benefit from a reduction in nutrient availability. Accordingly, these methods may be useful in treating and/or preventing of obesity, diabetes (*e.g.*, type 2 or non-insulin dependent diabetes, type 1 diabetes, and gestational diabetes), eating disorders, insulin-resistance syndrome, and cardiovascular disease.

In another embodiment, a method for treating or preventing eating disorders (such as Prader-Willi syndrome), hyperphagia, disorders associated with hypernutrition, or any combination thereof is provided, where the method comprises administering an effective amount of the P-PI conjugate to the subject.

5 [0212] As described herein, methods of use in altering fat distribution, reducing fat mass, or both in a subject are provided. Accordingly, subjects for whom altering body composition is of benefit can also benefit from the present methods. Altered body composition, as intended herein, includes loss or maintenance of body fat, with minimization of loss, maintenance, or gain of lean body mass. In such situations, weight may increase as well as decrease.

10 Accordingly, subjects may be lean, overweight, or obese as these terms are generally used in the art. Methods provided may also include reducing fat in non-adipose tissue while sparing lean mass. Uses for this method include treating diseases such as nonalcoholic steatohepatitis or lipodystrophy.

[0213] As described herein, conjugates in which the component peptide is a PYY, an  
15 exendin, a GLP-1, amylin, sCT, an AFP-6, a leptin, or a hybrid, agonist, analog or derivative of any of these are nonlimiting examples of P-PI conjugates of use in treating or preventing such conditions, diseases, and disorders that may benefit from a reduction in nutrient availability. Accordingly, in another aspect, the P-PI conjugates and compositions described herein are of use in the manufacture of a medicament useful in treating or preventing such conditions,  
20 diseases, and disorders that may benefit from a reduction in nutrient availability.

[0214] Metabolic rates can be assessed using any method available for determining such rates, for example by using a respiratory calorimeter. Such methods and devices for assaying metabolic rates are known in the art and are described, for example, in U.S. Pat. Nos. 4,572,208, 4,856,531, 6,468,222, 6,616,615, 6,013,009, and 6,475,158. Alternatively, the  
25 metabolic rate of an animal can be assessed by measuring the amount of lean tissue versus fatty tissue catabolized by the animal following the diet period. Thus, total body weight and fat content can be measured at the end of the dietary period.

[0215] Methods of measuring fat mass and lean mass include, but are not limited to, underwater weighing, air displacement plethysmograph, x-ray, DEXA scans, MRIs and CT  
30 scans. Methods of measuring subcutaneous fat are known in the art, for example, those described in U.S. Pat. No. 6,530,886. Visceral fat can be measured through any means available to determine the amount of visceral fat in a subject. Such methods include, for

example, abdominal tomography by means of CT scanning and MRI. Other methods for determining visceral fat are described, for example, in U.S. Pat. Nos. 6,864,415, 6,850,797, and 6,487,445. Ectopic fat can be measured in a subject using any method available for measuring ectopic fat. In rats, a frequently used method to determine total body fat is to surgically remove and weigh the retroperitoneal fat pad, a body of fat located in the retroperitoneum, the area between the posterior abdominal wall and the posterior parietal peritoneum. The pad weight is considered to be directly related to percent body fat of the animal. Since the relationship between body weight and body fat in rats is linear, obese animals have a correspondingly higher percent of body fat and retroperitoneal fat pad weight.

5  
10 [0216] In another embodiment, methods are provided for treating, preventing, or ameliorating a symptom or effect of diabetes in a subject, where the method comprises administering a therapeutically or prophylactically effective amount of a P-PI conjugate to the subject. The methods are of use in subjects with any form of diabetes mellitus including type 2 or non-insulin dependent diabetes, type 1 diabetes, and gestational diabetes. As described  
15 herein, P-PI conjugates of use in treating diabetes include, but are not limited to, those that stimulate insulin secretion, stimulate insulin sensitivity, enhance glucose-induced insulin release, lower glucagon secretion, inhibit gastric emptying, and enhance glucose utilization. Accordingly, exemplary P-PI conjugate compounds for use in methods for treating, preventing, or ameliorating a symptom or effect of diabetes include, but are not limited to, those  
20 conjugates in which the component peptide is an exendin, a GLP-1, a GIP, an amylin, a leptin, or a hybrid, agonist, analog or derivative of any of these.

[0217] In another aspect, methods are provided for treating, preventing, or ameliorating a symptom or effect of insulin resistance in a subject, where the method comprises administering a therapeutically or prophylactically effective amount of a P-PI conjugate to the subject.  
25 Insulin resistance is the diminished ability of insulin to exert its biological action across a broad range of concentrations. Exemplary P-PI conjugate compounds for use in methods for treating, preventing, or ameliorating a symptom or effect of insulin resistance include, but are not limited to, those conjugates in which the component peptide is an exendin, a GLP-1, a GIP, a leptin, or a hybrid, agonist, analog or derivative of any of these.

30 [0218] Hypertension, together with insulin resistance and hyperlipidemia, comprise the constellation of symptoms that characterize Metabolic Syndrome, also known as insulin resistance syndrome ("IRS") and syndrome X. In another aspect, methods are provided for treating, preventing, or ameliorating a symptom or effect of Metabolic Syndrome in a subject,

where the method comprises administering a therapeutically or prophylactically effective amount of a P-PI conjugate to the subject. Exemplary P-PI conjugate compounds for use in methods for treating, preventing, or ameliorating a symptom or effect of Metabolic Syndrome include, but are not limited to, those conjugates in which the component peptide is an exendin,  
5 a GLP-1, a GIP, a CGRP, or a hybrid, agonist, analog or derivative of any of these.

[0219] In another general aspect, methods are provided for treating, preventing, or ameliorating a symptom or effect of a cardiovascular disease or condition in a subject, where the method comprises administering a therapeutically or prophylactically effective amount of a P-PI conjugate to the subject. Cardiovascular diseases or conditions include, but are not  
10 limited to, hypertension, pulmonary hypertension, myocardial ischemia, myocardial reperfusion, stroke, cardiac arrhythmias, congestive heart failure, hibernating myocardium, myocardium infarction, cardiomyopathies, and coronary artery disease. In some embodiments, methods are provided for treating, preventing, or ameliorating a symptom or effect of a cardiovascular disease or condition associated with obesity in a subject. In another  
15 embodiment, methods are provided for treating, preventing, or ameliorating a symptom or effect of a cardiovascular disease or condition not associated with obesity in a subject (i.e., wherein the subject is not obese). Exemplary P-PI conjugate compounds for use in methods for treating, preventing, or ameliorating a symptom or effect of a cardiovascular disease or condition include, but are not limited to, those conjugates in which the component peptide is an  
20 exendin, a GLP-1, an amylin, sCT, a CGRP, or a hybrid, agonist, analog or derivative of any of these. Accordingly, in another aspect, the P-PI conjugates and compositions described herein are of use in the manufacture of a medicament useful for treating, preventing, or ameliorating a symptom or effect of a cardiovascular disease or condition in a subject as described herein.

[0220] Hypertension (or high blood pressure) is a condition that can occur in many patients  
25 in whom the causative agent or disorder is unknown. Such "essential" hypertension is often associated with disorders such as obesity, diabetes and hypertriglyceridemia. Hypertension can result in numerous complications including left ventricular failure, atherosclerotic heart disease, myocardial infarction, retinal hemorrhages, exudates, papilledema, and vascular accidents, cerebrovascular insufficiency with or without stroke, and renal failure.  
30 Hypertension can also result in retinal hemorrhages, exudates, papilledema, and vascular accidents. An abnormal blood pressure can also result from specific conditions or diseases, such as heart failure. Heart failure is a chronic or acute state that results when the heart is not capable of providing sufficient cardiac output to satisfy the metabolic needs of the body. Heart

failure is commonly referred to as congestive heart failure (CHF), since symptoms of increased venous pressure (*e.g.*, pulmonary congestion with left heart failure and peripheral edema with right heart failure) are often predominant. Symptoms and signs of CHF include fatigue, peripheral and pulmonary edema, and visceral congestion (*e.g.*, dyspnea). These symptoms are produced by diminished blood flow to the various tissues of the body and by accumulation of excess blood in various organs that results from the heart being incapable of pumping out the blood. Heart failure can result from several underlying diseases, most commonly in industrialized nations from atherosclerotic coronary artery disease with myocardial infarction. Metabolic diseases associated with endocrine disorders may cause cardiomyopathies and some cardiomyopathies may result in heart failure. Exemplary P-PI conjugate compounds for use in methods for treating, preventing, or ameliorating a symptom or effect of hypertension, heart failure, and conditions associated therewith include, but are not limited to, those conjugates in which the component peptide is an exendin, a GLP-1, an amylin, sCT, a CGRP, or a hybrid, agonist, analog or derivative of any of these.

**[0221]** As discussed herein, angiotensin converting enzyme (ACE) inhibitors have major roles as vasodilators in hypertension and treating CHF and are known in the art to be among the most efficient drugs in treating these disorders. Also, the survival benefit for the use of ACE inhibitors in patients with acute and chronic myocardial infarction has been established by a series of internationally conducted, randomized, controlled clinical studies and is well known in the art. For example, ACE inhibitors have been shown to be effective in reducing mortality and the incidence of serious nonfatal cardiovascular events in acute myocardial infarction. Clinical trials indicate that ACE inhibitors prolong survival in a broad spectrum of patients with myocardial infarction and heart failure, ranging from those who are asymptomatic with ventricular dysfunction to those who have symptomatic heart failure but are normotensive and hemodynamically stable. Exemplary P-PI conjugate compounds for use in methods for treating, preventing, or ameliorating a symptom or effect of hypertension, heart failure, myocardial infarction, and conditions associated therewith include, but are not limited to, those conjugates in which the component peptidase inhibitor is an ACE inhibitor or a neutral endopeptidase (NEP)/ACE inhibitor.

**[0222]** In some embodiments, methods are provided for treating or preventing cardiac arrhythmias, or for ameliorating a symptom of cardiac arrhythmias, where the method comprises administering to a subject in need thereof an effective amount of the P-PI conjugate. In some embodiments, P-PI conjugate administration provides an anti-arrhythmic effect in

patients with myocardial ischemia, myocardial reperfusion, or congestive heart failure. For example, GLP-1 administration has been shown to reduce cardiac injury and enhance recovery in patients with these disorders. GLP-1 and exendin effectively enhance peripheral glucose uptake without inducing dangerous hypoglycemia. GLP-1 and exendin also strongly suppress  
5 glucagon secretion and thereby powerfully reduce plasma free fatty acid (FFA) levels substantially more than can be accomplished with insulin. High FFA levels have been implicated as a major toxic mechanism during myocardial ischemia. Accordingly, P-PI conjugates, including those containing a GLP-1 or exendin peptide, are of use in treating or ameliorating a symptom of myocardial ischemia. In another embodiment hybrids are useful  
10 for preventing and treating cardiac arrhythmias that reliably reduce injury associated with reperfusion. In yet a further embodiment, P-PI conjugate treatment after acute stroke or hemorrhage provides a means for optimizing insulin secretion, increasing brain anabolism, enhancing insulin effectiveness by suppressing glucagon, and maintaining euglycemia or mild hypoglycemia with no risk of severe hypoglycemia or other adverse side effects.

15 **[0223]** In other embodiments, methods for improving the lipid profile in a subject are provided, wherein the methods comprise administering to a subject an effective amount of a P-PI conjugate disclosed herein. Improving a lipid profile includes, but is not limited to, reducing LDL cholesterol, reducing triglyceride levels, changing HDL cholesterol levels, or any combination thereof. Exemplary P-PI conjugate compounds for use in methods for a lipid  
20 profile include, but are not limited to, those conjugates in which the component peptide is an exendin, a GLP-1, a PYY, an amylin, sCT, or a hybrid, agonist, analog or derivative of any of these.

**[0224]** In another general aspect, methods for treating or preventing diseases or disorders associated with loss or absence of pancreatic beta cells, where the methods comprise  
25 administering to a subject an effective amount of a P-PI conjugate. GLP-1 may contribute to beta cell neogenesis and increase beta cell mass and GIP stimulates beta-cell proliferation and cell survival. GLP-2 may promote pancreatic islet growth for example by enlargement and proliferation of the islets. Exemplary P-PI conjugate compounds for use in methods for stimulating pancreatic beta cell proliferation or survival include, but are not limited to, those  
30 conjugates in which the component peptide is an exendin, GLP-1, GLP-2, a GIP, or a hybrid, agonist, analog or derivative of any of these.

**[0225]** In another aspect, methods for preventing and treating nephropathy are provided, where the methods comprise administering to a subject an effective amount of a P-PI

conjugate. In some embodiments, methods are provided for ameliorating a symptom of nephropathy comprising administration of a P-PI conjugate in an amount effective to ameliorate a nephropathy symptom. Such nephropathy conditions include, but are not limited to, hypertensive nephropathy, diabetic nephropathy, nephropathy associated with insulin resistance, and nephropathy associated with metabolic syndrome. P-PI conjugates are useful in these conditions by, for example, improving or preventing worsening of hypertension, endothelial function, renal function, glomerulosclerosis, or any combination thereof. P-PI conjugates disclosed herein may also find use for improving endothelial function in a subject having reduced vasodilatory capacity, having glomerulosclerosis, or any other reduction in glomerular flow. In another embodiment, P-PI conjugates disclosed herein are useful in preventing or delaying progression of nephropathy to end-stage renal disease and in preventing, treating, or slowing progression of proteinuria or glomerulosclerosis, or both. Exemplary P-PI conjugate compounds for use in methods for preventing and treating nephropathy include, but are not limited to, those conjugates in which the component peptide is an exendin, a GLP-1, or a hybrid, agonist, analog or derivative of any of these.

[0226] In another aspect, methods for treating polycystic ovary syndrome (PCOS) are provided, where the methods comprise administering to a subject an effective amount of a P-PI conjugate. As used herein, the terms “polycystic ovary syndrome,” “PCOS”, or “polycysticovary disease” refer to a clinical symptom complex. Women diagnosed with PCOS may exhibit one or more of the following symptoms: oligomenorrhea, amenorrhea, anovulation, bilateral polycystic ovaries, hyperandrogenism (elevated serum testosterone and/or androstenedione), abnormal uterine bleeding, enlarged multifollicular ovaries, infertility, excess facial hair growth, hair loss, acne, insulin-resistance, obesity, hyperinsulinemia, hypertension, hyperlipidemia, and type-2 diabetes. Accordingly, administration of the P-PI conjugate to a subject with PCOS may restore regular menses, regular ovulation, or fertility in the subject. In general, P-PI conjugates effective in lowering insulin resistance or in increasing insulin sensitivity are useful in treating PCOS. In some embodiments, methods for reducing or preventing insulin resistance in a subject with PCOS are provided, where the methods comprise administering to a subject an effective amount of a P-PI conjugate. In yet another embodiment, administration of the P-PI conjugate to a subject with PCOS is of use in preventing the onset of type-2 diabetes in the subject. Exemplary P-PI conjugate compounds for use in methods for treating PCOS include, but are not limited to,

those conjugates in which the component peptide is an exendin, a GLP-1, or a hybrid, agonist, analog or derivative of any of these.

[0227] As described herein, the disclosed P-PI conjugate compounds exhibit a broad range of biological activities including some related to the anti-secretory and anti-motility properties of the component peptide. Anti-secretory properties include inhibition of gastric and/or pancreatic secretions. Accordingly, methods are provided for treating or preventing diseases and disorders associated with gastric or pancreatic secretions, where the methods comprise administering to a subject an effective amount of a P-PI conjugate. Diseases and disorders associated with gastric or pancreatic secretions include gastritis, pancreatitis, Barrett's esophagus, and Gastroesophageal Reflux Disease (GERD). Exemplary P-PI conjugate compounds for use in methods for treating or preventing diseases and disorders associated with gastric or pancreatic secretions include, but are not limited to, those conjugates in which the component peptide is a PYY, an exendin, a GLP-1, an amylin, or a hybrid, agonist, analog or derivative of any of these.

[0228] In another embodiment, certain P-PI conjugates are of use in inducing, enhancing, potentiating, or restoring glucose responsivity in pancreatic islets or cells. Assays for determining such activity are known in the art and described, for example, in U.S. Pat. Application Publication No. 2004/0228846. Exemplary P-PI conjugate compounds for use in inducing, enhancing, potentiating, or restoring glucose responsivity in pancreatic islets or cells include, but are not limited to, those conjugates in which the component peptide is a PYY, an NPY, or a hybrid, agonist, analog or derivative of any of these.

[0229] In another aspect, methods for treating gastrointestinal disorders that are associated with excess intestinal electrolyte and water secretion as well as decreased absorption are provided, where the methods comprise administering to a subject an effective amount of a P-PI conjugate. Such gastrointestinal disorders include infectious diarrhea, inflammatory diarrhea, short bowel syndrome, or the diarrhea which typically occurs following surgical procedures, *e.g.*, ileostomy. (*Harrison's Principles of Internal Medicine*, McGraw-Hill Inc., New York, 12th Ed.) Examples of infectious diarrhea include, without limitation, acute viral diarrhea, acute bacterial diarrhea (*e.g.*, salmonella, campylobacter, and clostridium or due to protozoal infections), or traveller's diarrhea (*e.g.*, Norwalk virus or rotavirus). Examples of inflammatory diarrhea include, without limitation, malabsorption syndrome, tropical sprue, chronic pancreatitis, Crohn's disease, diarrhea, and irritable bowel syndrome. GLP-2 promotes growth of intestinal tissue and would benefit those subjects suffering from diseases or

conditions marked by abnormalities in the small intestinal tract mucosa such as those listed herein. In some embodiments, P-PI conjugates may be used to treat an emergency or life-threatening situation involving a gastrointestinal disorder, *e.g.*, after surgery or due to cholera. Exemplary P-PI conjugate compounds for use in methods for treating gastrointestinal disorders that are associated with excess intestinal electrolyte and water secretion and with decreased absorption include, but are not limited to, those conjugates in which the component peptide is a GLP-2, PYY, or a hybrid, agonist, analog or derivative of any these.

**[0230]** Compounds provided herein may also be useful for treating or preventing intestinal damage as opposed to merely treating the symptoms associated with the intestinal damage (*e.g.*, diarrhea). Such damage to the intestine may be, or a result of, ulcerative colitis, inflammatory bowel disease, bowel atrophy, loss bowel mucosa, loss of bowel mucosal function, or any combination thereof. Assays for such activity are known in the art and described, for example, in PCT Publication No. WO 03/105763 and Morris et al. (1989) *Gastroenterology* **96**:795-803. Exemplary P-PI conjugate compounds for use in methods for treating intestinal damage include, but are not limited to, those conjugates in which the component peptide is a PYY, or a hybrid, agonist, analog or derivative of any PYY.

**[0231]** In another aspect, methods for treating or preventing pancreatic tumors are provided, where the methods comprise administering to a subject an effective amount of a P-PI conjugate. Accordingly, methods for inhibiting or reducing proliferation of pancreatic tumor cells are provided. Methods are also provided for inhibiting growth of a pancreatic tumor. The pancreatic tumor and tumor cells may be benign or malignant. Exemplary types of benign pancreatic tumor cells which may be treated by the methods described herein include serous cyst adenomas, microcystic tumors, and solid-cystic tumors. Exemplary types of malignant pancreatic tumor cells which may be treated by the methods described herein include carcinomas arising from the ducts, acini, or islets of the pancreas. Assays for such activity are known in the art and described, for example, in U.S. Pat. No. 5,574,010. Exemplary P-PI conjugate compounds for use in methods for treating pancreatic tumors include, but are not limited to, those conjugates in which the component peptide is a PYY, or a hybrid, agonist, analog or derivative of any PYY.

**[0232]** In another general aspect, methods for treating bone disorders, such as osteopenia and osteoporosis, are provided, where the methods comprise administering to a subject an effective amount of a P-PI conjugate. Certain P-PI conjugates are useful for promoting bone formation, decreasing bone resorption, decreasing plasma calcium, and inducing an analgesic effect. In

yet other embodiments, certain P-PI conjugates are useful to treat pain and painful neuropathy. Exemplary P-PI conjugate compounds for use in methods for treating such pain and or bone disorders include, but are not limited to, those conjugates in which the component peptide is an exendin, GLP-1, GLP-2, an amylin, sCT, or a hybrid, agonist, analog or derivative of any of these.

[0233] In another general aspect, methods for treating, preventing or delaying development of neurological and nervous system disorders associated with neuronal loss or dysfunction are provided, where the methods comprise administering to a subject an effective amount of a P-PI conjugate. Such neurological and nervous system disorders include, but are not limited to, Parkinson's disease, Alzheimer's disease, Huntington's disease, amyotrophic lateral sclerosis, stroke, attention deficit disorder, neuropsychiatric syndromes, neurodegenerative disorders, memory disorders, and cognitive disorders. Exemplary P-PI conjugate compounds for use in methods for treating, preventing or delaying development of such neurological and nervous system disorders include, but are not limited to, those conjugates in which the component peptide is an exendin, GLP-1, a GIP, a PYY, an NPY, or a hybrid, agonist, analog or derivative of any of these. For example, U.S. Pat. No. 6,734,166 describes the use of PYY receptor agonists for reducing aluminum concentrations in the central nervous system for treating, preventing, or delay the onset of Alzheimer's disease.

[0234] Accordingly, in another aspect, the P-PI conjugates and compositions described herein are of use in the manufacture of a medicament useful for treating, preventing, or ameliorating the disease or condition as described herein.

[0235] A "subject" is meant to include any animal, including humans, primates, and other mammals including rats, mice, pets such as cats, dogs, livestock such as horses, cattle, sheep and goats, as well as chicken, turkey and any other animal which may benefit from the compositions and methods disclosed herein, for example, those for whom metabolic disease, body weight, or cardiovascular disease may be an issue.

[0236] As used herein, and as well-understood in the art, "treatment" is an approach for obtaining beneficial or desired results, including clinical results. "Treating" or "palliating" a disease, disorder, or condition means that the extent and/or undesirable clinical manifestations of a condition, disorder, or a disease state are lessened and/or time course of the progression is slowed or lengthened, as compared to not treating the disorder. For example, in treating obesity, a decrease in body weight, *e.g.*, at least a 5% decrease in body weight, is an example

of a desirable treatment result. For purposes of the methods disclosed herein, beneficial or desired clinical results include, but are not limited to, alleviation or amelioration of one or more symptoms, diminishment of extent of disease, stabilized (i.e., not worsening) state of disease, delay or slowing of disease progression, amelioration or palliation of the disease state, and remission (whether partial or total), whether detectable or undetectable. "Treatment" can also mean prolonging survival as compared to expected survival if not receiving treatment. Further, treating does not necessarily occur by administration of one dose, but often occurs upon administration of a series of doses. Thus, a therapeutically effective amount, an amount sufficient to palliate, or an amount sufficient to treat a disease, disorder, or condition may be administered in one or more administrations.

[0237] As used herein, the term "therapeutically effective amount" means the amount of the active compounds in the composition that will elicit the biological or medical response in a tissue, system, or subject that is being sought by the researcher, veterinarian, medical doctor or other clinician, which includes alleviation or amelioration of the symptoms of the disorder being treated.

[0238] As used herein, the term "prophylactically effective amount" means the amount of the active compounds in the composition that will elicit the biological or medical response in a tissue, system, or subject that is being sought by the researcher, veterinarian, medical doctor or other clinician, to prevent the onset of the disorder, condition, or disease of interest or for which the subject is at risk (e.g., obesity or an obesity-related disorder, condition or disease in subjects at risk for obesity or the obesity-related disorder, condition or disease).

[0239] The component peptides and peptide-peptidase inhibitor (P-PI) conjugates described herein may be prepared using chemical peptide synthesis techniques known in the art, e.g., using an automated or semi-automated peptide synthesizer, standard recombinant techniques, or both.

[0240] The component peptides and P-PI conjugates may be synthesized in solution or on a solid support in accordance with conventional techniques. Various automated synthesizers are commercially available and may be used in accordance with known protocols. See, e.g., Stewart *et al.* (1984) *Solid Phase Peptide Synthesis*, 2d. ed., Pierce Chemical Co.; Tam *et al.* (1983) *J. Am. Chem. Soc.* **105**: 6442; Merrifield (1986) *Science* **232**: 341-347; and Barany *et al.* (1979) *The Peptides*, Gross *et al.*, eds., Academic Press, NY, 1-284. Solid phase peptide synthesis may be carried out using an automated or semiautomated peptide synthesizer.

Typically, using such techniques, an  $\alpha$ -N-carbamoyl protected amino acid and an amino acid attached to the growing peptide chain on a resin are coupled at room temperature in an inert solvent such as dimethylformamide, N-methylpyrrolidinone or methylene chloride in the presence of coupling agents such as dicyclohexylcarbodiimide and 1-hydroxybenzotriazole in the presence of a base such as diisopropylethylamine. The  $\alpha$ -N-carbamoyl protecting group is removed from the resulting peptide-resin using a reagent such as trifluoroacetic acid or piperidine, and the coupling reaction repeated with the next desired N-protected amino acid to be added to the peptide chain. Suitable N-protecting groups are well known in the art, with t-butyloxycarbonyl (tBoc) and fluorenylmethoxycarbonyl (Fmoc) as examples. For example, solid phase peptide synthesis may be carried out with an automated peptide synthesizer (e.g., Model 430A, Applied Biosystems Inc., Foster City, CA) using the NMP/HOBt (Option 1) system and tBoc or Fmoc chemistry with capping (see, Applied Biosystems User's Manual for the ABI 430A Peptide Synthesizer, Version 1.3B July 1, 1988, section 6:49-70). Peptides may also be assembled using an Advanced ChemTech Synthesizer (Model MPS 350, Louisville, KY). Peptides may be purified by RP-HPLC (preparative and analytical) using, e.g., a Waters® DELTA-PREP™ 3000 system (Waters Corp., Milford, MA) and a C<sub>4</sub>, C<sub>8</sub>, or C<sub>18</sub> preparative column (10  $\mu$ , 2.2x25 cm; Grace Vydac, Hesperia, CA). The peptide can be readily synthesized and then screened in assays designed to identify peptides with particular activities. Other methods of synthesizing and purifying peptides are known to the skilled artisan.

**[0241]** The component peptides and P-PI inhibitor conjugates disclosed herein may alternatively be produced by recombinant techniques well known in the art. See, e.g., Sambrook *et al.* (1989) *Molecular Cloning: A Laboratory Manual*, 2d ed., Cold Spring Harbor, NY. The peptides produced by recombinant technologies may be expressed from a polynucleotide. One skilled in the art will appreciate that the polynucleotides, including DNA and RNA, that encode such the various fragments of the peptides may be obtained from the wild-type cDNA, taking into consideration the degeneracy of codon usage, or may be engineered as desired. These polynucleotide sequences may incorporate codons facilitating transcription and translation of mRNA in microbial hosts. Such manufacturing sequences may readily be constructed according to the methods well known in the art. The polynucleotides above may also optionally encode an N-terminal methionyl residue. The polynucleotides above may also optionally encode a C-terminal glycyl residue for proper amide formation. Non-peptide compounds useful in composition and methods provided herein may be prepared

by art-known methods. For example, phosphate-containing amino acids and peptides containing such amino acids may be prepared using methods known in the art. See, *e.g.*, Bartlett *et al.* (1986) *Bioorg. Chem.* **14**: 356-377.

[0242] A variety of cell types may be used to contain and express a peptide coding sequence including, for example, bacteria, yeast, algae, insect cells, plant cells, and animal cells such as mammalian and avian cells. A variety of expression vector/host systems may be used, including, but are not limited to microorganisms such as bacteria transformed with recombinant bacteriophage, plasmid or cosmid DNA expression vectors; yeast transformed with yeast expression vectors; insect cell systems infected with virus expression vectors (*e.g.*, baculovirus); plant cell systems transfected with virus expression vectors (*e.g.*, cauliflower mosaic virus (CaMV); tobacco mosaic virus (TMV) or transformed with bacterial expression vectors (*e.g.*, Ti or pBR322 plasmid); or animal cell systems. Mammalian cells and cell lines that are useful in recombinant protein productions include, but are not limited to, VERO (African green monkey kidney) cells, HeLa cells, Chinese hamster ovary (CHO) cell lines, COS cells (such as COS-7), WI38 (human lung fibroblasts), baby hamster kidney (BHK) cells, HepG2, 3T3, RIN, Madin-Darby canine kidney epithelial (MDCK) cells, A549, PC12, K562 and 293 cells. Exemplary protocols for the recombinant expression of polypeptides are well known in the art.

[0243] Host cell strains may be chosen for a particular ability to process the expressed peptide or produce certain post-translation modifications that will be useful in providing peptide activity. Such modifications of the polypeptide include, but are not limited to, acetylation, carboxylation, glycosylation, phosphorylation, lipidation, acylation, and amidation, for example, carboxy-terminal amidation. Post-translational processing, which cleaves a "prepro" form of the polypeptide, may also be important for correct insertion, folding and/or function. Different host cells, such as CHO, HeLa, MDCK, 293, WI38, and the like, have specific cellular machinery and characteristic mechanisms for such post-translational activities, and may be chosen to ensure the correct modification and processing of the introduced foreign protein.

[0244] Component peptides and P-PI inhibitor conjugates described herein may be produced using a combination of both automated peptide synthesis and recombinant techniques. For example, a peptide may contain a combination of modifications including deletion, substitution, and insertion by PEGylation. Such a peptide may be produced in stages. For example, in the first stage, an intermediate peptide containing the modifications of deletion,

substitution, insertion, and any combination thereof, may be produced by recombinant techniques as described. Then, after an optional purification step, the intermediate peptide is PEGylated through chemical modification with an appropriate PEGylating reagent (*e.g.*, from Nektar Therapeutics, San Carlos, CA) to yield the desired peptide. Amidation of a peptide may also be done in stages. One skilled in the art will appreciate that the above-described procedure may be generalized to apply to a peptide containing a combination of modifications selected from deletion, substitution, insertion, derivation, and other means of modification well known in the art and contemplated herein.

[0245] Component peptides and P-PI inhibitor conjugates described herein may also be produced using chemical ligation schemes known in the art, including those described, for example, in U.S. Pat. Application Publication Nos. 2003/0191291, 2003/0208046, and 2004/0115774. Chemical ligation refers to a chemoselective reaction involving the covalent joining of two chemical moieties, each of which moieties bears a mutually reactive functional group that is uniquely capable of forming a non-reversible covalent bond with the other.

Unique, mutually reactive, functional groups present on the first and second components can be used to render the ligation reaction chemoselective. For example, the chemical ligation of peptides and polypeptides involves the chemoselective reaction of peptide or polypeptide segments bearing compatible unique, mutually reactive, C-terminal and N-terminal amino acid residues. Chemical ligation includes covalent ligation of (1) a first peptide or polypeptide bearing a uniquely reactive C-terminal group with (2) a second peptide or polypeptide bearing a uniquely reactive N-terminal group, where the C-terminal and N-terminal reactive groups form a non-reversible covalent bond therein between. It also includes N-terminal to N-terminal and C-terminal to C-terminal ligation. In particular, chemical ligation includes any chemoselective reaction chemistry that can be applied to ligation of unprotected peptide segments. Several different chemistries have been utilized for this purpose, examples of which include native chemical ligation, oxime forming chemical ligation, thioester forming ligation (Schnolzer *et al.* (1992) *Science* **256**:221-225; Gieselman *et al.* (2001) *Org. Lett.* **3**:1331-1334), thioether forming ligation (Englebretsen *et al.* (1995) *Tot. Leffs.* **36**:8871-8874), hydrazone forming ligation (Gaertner, *et al.* (1994) *Bioconj. Chem.* **5**:333-338), and thiazolidine forming ligation and oxazolidine forming ligation (Zhang *et al.* (1998) *Proc. Natl. Acad. Sci. USA* **95**:9184-9189; PCT Publication No. WO 95/00846; U.S. Pat. No. 5,589,356); and Staudinger amide forming chemical ligation (Saxon *et al.* (2000) *Org. Lett.* **2**:2141-2143).

[0246] Reaction conditions for a given ligation chemistry are generally selected to maintain the desired interaction of the peptide or polypeptide segments employed for ligation. For example, pH and temperature, water-solubility of the ligation components, ratio of the first segment to the second segment, water content and composition of the reaction mixture can be varied to optimize ligation. Addition or exclusion of reagents that solubilize the ligation segments to different extents may further be used to control the specificity and rate of the desired ligation reaction, *i.e.*, control exposure and presentation of reactive groups by manipulating solubility of the peptide or polypeptide segments. Reaction conditions are readily determined by assaying for the desired chemoselective reaction product compared to one or more internal and/or external controls. These methodologies have proven a robust methodology for generating a native amide bond at the ligation site.

[0247] In conjunction with the design of the P-PI conjugates, the peptides or polypeptide segments utilized for synthesizing the polypeptide backbone are constructed. Methods useful in the synthesis of peptides and polypeptides backbones are described in, for example, U.S. Pat. Application Publication Nos. 2004/0138412 (extended native chemical ligation), 2003/0208046 (pseudo-native chemical ligation), 2005/0261473 (carboxy protection strategies for acidic C-terminal amino acids in chemical ligation to eliminate formation of unwanted side products), 2005/0064538 and 2005/0113563 (native chemical ligation with improved efficiency of ligation and chemical ligation with three or more components); in PCT Publication Nos. WO2004/105685 (aqueous-compatible solid phase chemical ligation using a displaceable linker) and WO2004/060925 (multiplex polymer ligation with water-soluble polymeric protecting groups and their replacement with desired adducts); and in U.S. Pat. Nos. 6,307,018 and 6,184,344 (native chemical ligation), 6,326,468 (solid phase native chemical ligation), 6,217,873 (polyoxime compounds), 6,174,530 (homogenous polyoxime compositions), 6,001,364 (hetero-polyoxime compounds), and 6,451,543 (lipid-matrix assisted synthesis). In general, synthesis of a peptide or polypeptide backbone by chemical ligation involves selection of suitable ligation sites that are chosen based on the ligation chemistry selected for assembling the various polypeptide backbone segments, the reversible (or cleavable) polymer attachment chemistry chosen for a given target peptide, and the particular polymer attachment sites. When native chemical ligation is employed, cysteine ligation sites are determined by scanning the target polypeptide backbone amino acid sequence for suitable naturally occurring cysteine residue. When "extended native chemical ligation" is employed, ligation sites can be selected by scanning the target polypeptide backbone amino acid sequence

for suitable naturally occurring ligation site junctions that permit robust ligations. Because extended native chemical ligation is not limited to ligation at cysteine residues, any number of residues may serve as the ligation site junction. In some instances, a combination of native and extended native chemical ligation may be part of the design.

5 [0248] In some embodiments, native chemical ligation is used to generate part or all of the full-length polypeptide chain. Cysteines present in the naturally occurring protein or peptide backbone can be used as the chemical ligation sites. Alternatively, where a desired ligation junction is devoid of a suitable cysteine, the non-cysteine amino acid at that position can be replaced with a cysteine or a cysteine can be inserted so as to permit native chemical ligation at  
10 that site. If desired, the newly introduced cysteine can be converted to a pseudo amino acid residue corresponding to the original amino acid at that position. Formation of a pseudo amino acid by conversion of a cysteine at native chemical ligation sites is referred to “pseudo native chemical ligation.” Alternatively, when the cysteine is introduced at a site for polymer protecting group modification, the side chain thiol can be exploited for the attachment of a  
15 thiol reactive water-soluble polymer construct, provided that all other cysteines in the target polypeptide that one does not wish to modify are protected. In another embodiment, extended native chemical ligation can be utilized to generate part or all of the full-length polypeptide. Peptides used for thioester-mediated ligation, such as for native chemical ligation, can be made following standard protocols as well, for example see U.S. Pat. Nos. 6,307,018 and 6,184,344.

20 [0249] As used herein, the term “purified peptide” is intended to refer to a composition, isolated from other components, wherein the peptide is purified to any degree relative to its naturally obtainable state. A purified peptide therefore also refers to a peptide, free from the environment in which it may naturally occur. Generally, “purified” will refer to a component peptide or P-PI conjugate composition that has been subjected to fractionation to remove  
25 various other components, and which composition substantially retains a biological activity. Where the term “substantially purified” is used, this designation will refer to a composition in which the component peptide or P-PI conjugate forms the major component of the composition, such as constituting about 50%, about 60%, about 70%, about 80%, about 90%, about 95% or more of the component peptide or P-PI conjugate in the composition.

30 [0250] It may be desirable to purify the component peptides and P-PI conjugates generated by the methods described herein. Peptide purification techniques are well known to those of skill in the art. These techniques involve, at one level, the crude fractionation of the cellular milieu to polypeptide and non-polypeptide fractions. Having separated the polypeptide from

other proteins, the polypeptide of interest may be further purified using chromatographic and electrophoretic techniques to achieve partial or complete purification (or purification to homogeneity). Purification techniques include, for example, precipitation with ammonium sulfate, PEG, antibodies, and the like; heat denaturation, followed by centrifugation; 5 chromatography steps such as ion exchange, gel filtration, reverse phase, hydroxylapatite and affinity chromatography; isoelectric focusing; gel electrophoresis; and combinations of such and other techniques. Analytical methods particularly suited to the preparation of a pure peptide are ion-exchange chromatography, exclusion chromatography, polyacrylamide gel electrophoresis, and isoelectric focusing. A particularly efficient method of purifying peptides 10 is reverse phase HPLC, followed by characterization of purified product by liquid chromatography/mass spectrometry (LC/MS) and Matrix-Assisted Laser Desorption Ionization (MALDI) mass spectrometry. Additional confirmation of purity is obtained by determining amino acid analysis. As is generally known in the art, it is believed that the order of conducting the various purification steps may be changed, or that certain steps may be omitted, 15 and still result in a suitable method for the preparation of a substantially purified protein or peptide.

[0251] There is no general requirement that the peptides or P-PI conjugates always be provided in their most purified state. Indeed, it is contemplated that less substantially purified products will have utility in certain embodiments. Partial purification may be accomplished by 20 using fewer purification steps in combination, or by utilizing different forms of the same general purification scheme. For example, it is appreciated that a cation-exchange column chromatography performed, utilizing an HPLC apparatus, will generally result in a greater “-fold” purification than the same technique utilizing a low pressure chromatography system. Methods exhibiting a lower degree of relative purification may have advantages in total 25 recovery of protein product, or in maintaining the activity of the peptide or P-PI conjugates. In some embodiments, a combination of anion exchange and immunoaffinity chromatography may be used to produce purified peptide or P-PI conjugate compositions described herein.

[0252] The P-PI conjugate compounds disclosed herein may be administered alone or in combination with pharmaceutically acceptable carriers or excipients, in either single or 30 multiple doses. Accordingly, pharmaceutical compositions are provided comprising a therapeutically or prophylactically effective amount of at least one P-PI conjugate compound, or a pharmaceutically acceptable salt thereof, together with pharmaceutically acceptable diluents, preservatives, solubilizers, emulsifiers, adjuvants and/or carriers useful in the delivery

of the P-PI conjugate compounds. Conventional description and preparation techniques for pharmaceutical formulations are disclosed, for example, in Remington's Pharmaceutical Sciences by E. W. Martin and in Wang *et al.* (1988) *J. of Parenteral Sci. and Tech.*, Technical Report No. **10**, Supp. 42:2S.

- 5 [0253] The present P-PI conjugate compounds will be, in general, useful in the same way that the individual component peptide or peptidase inhibitor is useful in view of their pharmacological properties. One exemplary use is to peripherally administer such P-PI conjugate compounds for the treatment or prevention of metabolic conditions and disorders. In some embodiments, the P-PI compounds provided possess activity as agents to reduce nutrient  
10 availability, reduce of food intake, effect weight loss, or any combination thereof. In another embodiment, the P-PI compounds provided are administered for the treatment of diabetes or diabetes-related conditions and disorders. In another embodiment, the P-PI compounds provided are administered for the treatment of cardiovascular disease or disorders, such as congestive heart failure.
- 15 [0254] The present P-PI conjugate compounds may be formulated for peripheral administration, including formulation for injection, oral administration, nasal administration, pulmonary administration, topical administration, or other types of administration as one skilled in the art will recognize. Administration of the pharmaceutical compositions described herein may be via any common route so long as the target tissue is available *via* that route. In  
20 some embodiments, the pharmaceutical compositions may be introduced into the subject by any conventional peripheral method, *e.g.*, by intravenous, intradermal, intramuscular, intramammary, intraperitoneal, intrathecal, retrobulbar, intrapulmonary (*e.g.*, term release); by oral, sublingual, nasal, anal, vaginal, or transdermal delivery, or by surgical implantation at a particular site. In some embodiments, the pharmaceutical compositions provided are  
25 formulated so as to be suitable for parenteral administration, *e.g.*, via injection or infusion. The treatment may consist of a single dose or a plurality of doses over a period of time. Controlled continual release of the P-PI compositions is also contemplated. Parenteral administration may be carried out with an initial bolus followed by continuous infusion to maintain therapeutic circulating levels of drug product. A form of repository or "depot" slow release preparation  
30 may be used so that therapeutically effective amounts of the preparation are delivered into the bloodstream over many hours or days following transdermal injection or delivery. Those of ordinary skill in the art will readily optimize effective dosages and administration regimens as determined by good medical practice and the clinical condition of the individual patient.

[0255] The pharmaceutical formulations may be composed in various forms, *e.g.*, solid, liquid, semisolid or liquid. The term “solid”, as used herein, is meant to encompass all normal uses of this term including, for example, powders and lyophilized formulations. The presently described formulations may be lyophilized, for example for reconstitution. Aqueous compositions generally comprise an effective amount of the P-PI conjugate, dissolved or dispersed in a pharmaceutically acceptable carrier or aqueous medium. The phrase “pharmaceutically or pharmacologically acceptable” refers to molecular entities and compositions that do not produce adverse, allergic, or other untoward reactions when administered to an animal or a human. As used herein, “pharmaceutically acceptable carrier” includes any and all solvents, dispersion media, coatings, antibacterial and antifungal agents, isotonic and absorption delaying agents and the like. The use of such media and agents for pharmaceutically active substances is well known in the art. Except insofar as any conventional media or agent is incompatible with the active ingredient, its use in therapeutic compositions is contemplated. Supplementary active ingredients also may be incorporated into the compositions. In some cases, it will be convenient to provide a P-PI conjugate compound and another compound, such as a food-intake-reducing, diabetes treating, plasma glucose-lowering, or plasma lipid-altering agent, such as an amylin, an amylin agonist analog, a CCK or CCK agonist, or a leptin or leptin agonist, or an exendin or exendin agonist analog, in a single composition or solution for administration together. In other cases, it may be more advantageous to administer the additional agent separately from the P-PI conjugate. For example, when the two compositions are used, the individual agents can be administered at essentially the same time, *i.e.*, concurrently, or at separately staggered times, *i.e.*, sequentially prior to or subsequent to the administration of the other agent of the method. In some embodiments, administration in combination involves administration of separate compositions during overlapping intervals.

[0256] In some embodiments, the P-PI conjugate provided herein may be prepared for administration as solutions of free base, or pharmacologically acceptable salts in water suitably mixed with a surfactant, such as hydroxypropylcellulose. Pharmaceutically-acceptable salts include the acid addition salts (formed with the free amino groups of the protein) and which are formed with inorganic acids such as, for example, hydrochloric or phosphoric acids, or such organic acids as acetic, oxalic, tartaric, mandelic, and the like. Salts formed with the free carboxyl groups also can be derived from inorganic bases such as, for example, sodium, potassium, ammonium, calcium, or ferric hydroxides, and such organic bases as

isopropylamine, trimethylamine, histidine, procaine and the like. Such products are readily prepared by procedures well known to those skilled in the art. Dispersions also can be prepared in glycerol, liquid polyethylene glycols, and mixtures thereof and in oils. Typically, these preparations contain a preservative to prevent the growth of microorganisms.

5 [0257] The terms buffer, buffer solution and buffered solution, when used with reference to hydrogen-ion concentration or pH, refer to the ability of a system, particularly an aqueous solution, to resist a change of pH on adding acid or alkali, or on dilution with a solvent. Characteristic of buffered solutions, which undergo small changes of pH on addition of acid or base, is the presence either of a weak acid and a salt of the weak acid, or a weak base and a salt  
10 of the weak base. An example of the former system is acetic acid and sodium acetate. The change of pH is slight as long as the amount of hydronium or hydroxyl ion added does not exceed the capacity of the buffer system to neutralize it. In some embodiments, the P-PI conjugate is suspended in an aqueous carrier, for example, in an isotonic buffer solution at a pH of about 3.0 to about 8.0, at a pH of about 3.5 to about 7.4, at a pH of about 3.5 to about  
15 6.0, or at a pH of about 3.5 to about 5.0. In certain embodiments, the pH of the formulation is maintained in the range of about 3.5 to 6.5, in some embodiments from about 3.7 to about 4.3 or about 3.8 to about 4.2. In some embodiments, pH may be about 4.0.

[0258] Useful buffers include sodium citrate/citric acid, and sodium phosphate/phosphoric acid, and sodium acetate/acetic acid buffers. In certain embodiments, the buffer with the  
20 compound provided herein is an acetate buffer (for example, at a final formulation concentration of from about 1-5 to about 60 mM), a phosphate buffer (for example, at a final formulation concentration of from about 1-5 to about to about 30 mM), a glutamate buffer (for example, at a final formulation concentration of from about 1-5 to about to about 60 mM), or a citrate buffer (for example, at a final formulation concentration of from about 1-5 to about 60  
25 mM). In some embodiments, the buffer is acetate (for example, at a final formulation concentration of from about 5 to about 30 mM).

[0259] The pharmaceutical compositions suitable for injectable use include sterile aqueous solutions or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersions. In all cases, the form should be sterile and should be fluid  
30 to the extent that easy syringability exists. It is generally desirable for the P-PI conjugates to be stable under the conditions of manufacture and storage and preserved against the contaminating action of microorganisms, such as bacteria and fungi.

[0260] The pharmaceutically-acceptable carrier may be a solvent or dispersion medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyethylene glycol, and the like), suitable mixtures thereof, and vegetable oils. The proper fluidity can be maintained, for example, by the use of a coating, such as lecithin, by the  
5 maintenance of the required particle size in the case of dispersion and by the use of surfactants.

[0261] A stabilizer may be included in the formulations of P-PI conjugates but, and importantly, is not necessarily needed. If included, however, a stabilizer useful in the provided compositions is a carbohydrate or a polyhydric alcohol. An exemplary suitable stabilizer is approximately 1.0 to 10% (w/v) of a carbohydrate or polyhydric alcohol. The polyhydric  
10 alcohols and carbohydrates share the same feature in their backbones, *i.e.*, -CHOH-CHOH-, which is responsible for stabilizing proteins. The polyhydric alcohols include such compounds as sorbitol, mannitol, glycerol, and polyethylene glycols (PEGs). These compounds are straight-chain molecules. The carbohydrates, such as mannose, ribose, sucrose, fructose, trehalose, maltose, inositol, and lactose, on the other hand, are cyclic molecules that may  
15 contain a keto or aldehyde group. These two classes of compounds have been demonstrated to be effective in stabilizing protein against denaturation caused by elevated temperature and by freeze-thaw or freeze-drying processes. Suitable carbohydrates include: galactose, arabinose, or lactose. Should the formulation be for administration to an individual with diabetes, the carbohydrate used should be one which does not have an adverse affect on the diabetic patient,  
20 *i.e.*, the carbohydrate is not metabolized to form unacceptably large concentrations of glucose in the blood. Such carbohydrates are well known in the art as suitable for diabetics. Sucrose and fructose are suitable for use with the conjugates in non-diabetic applications (*e.g.*, treating obesity).

[0262] In certain embodiments, if a stabilizer is included, the P-PI conjugate compound is  
25 stabilized with a polyhydric alcohol such as sorbitol, mannitol, inositol, glycerol, xylitol, and polypropylene/ethylene glycol copolymer, as well as various PEGs of molecular weight 200, 400, 1450, 3350, 4000, 6000, and/or 8000. Mannitol is an exemplary polyhydric alcohol in some embodiments.

[0263] Another useful feature of the lyophilized formulations provided herein is the  
30 maintenance of the tonicity of the lyophilized formulations described herein with the same formulation component that serves to maintain their stability. In some embodiments, mannitol is an exemplary polyhydric alcohol used for this purpose. In many cases, isotonic agents may be included (for example, sugars or sodium chloride). In some cases, excipients are useful in

5 maintenance of the overall tonicity of the compound. An excipient may be included in the presently described formulations at various concentrations. For example, an excipient may be included in the concentration range from about 0.02% to about 20% w/w, for example, between about 0.02% and 0.5% w/w, about 0.02% to about 10% w/w, or about 1% to about 20% w/w. In addition, similar to the present formulations themselves, an excipient may be included in solid (including powdered), liquid, semi-solid or gel form. Exemplary parenteral formulations may be isotonic or substantially isotonic.

10 **[0264]** A preservative is, in the common pharmaceutical sense, a substance that prevents or inhibits microbial growth and may be added to pharmaceutical formulations for this purpose to avoid consequent spoilage of the formulation by microorganisms. While the amount of the preservative is not great, it may nevertheless affect the overall stability of the peptide. The prevention of the action of microorganisms can be brought about by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, sorbic acid, thimerosal, and the like. While the preservative for use in the pharmaceutical compositions can range from 15 0.005 to 1.0% (w/v), in some embodiments range for each preservative, alone or in combination with others, is: benzyl alcohol (0.1-1.0%), or m-cresol (0.1-0.6%), or phenol (0.1-0.8%) or combination of methyl (0.05-0.25%) and ethyl or propyl or butyl (0.005%-0.03%) parabens. The parabens are lower alkyl esters of para-hydroxybenzoic acid.

20 **[0265]** Surfactants frequently can cause denaturation of protein, both of hydrophobic disruption and by salt bridge separation. Relatively low concentrations of surfactant may exert a potent denaturing activity, because of the strong interactions between surfactant moieties and the reactive sites on proteins. However, judicious use of this interaction can stabilize proteins against interfacial or surface denaturation. Surfactants which could further stabilize the P-PI conjugate may optionally be present in the range of about 0.001 to 0.3% (w/v) of the total 25 formulation and include polysorbate 80 (i.e., polyoxyethylene(20) sorbitan monooleate), CHAPS® (i.e., 3-[(3-cholamidopropyl) dimethylammonio] 1-propanesulfonate), Brij® (e.g., Brij 35, which is (polyoxyethylene (23) lauryl ether), poloxamer, or another non-ionic surfactant.

30 **[0266]** An exemplary vehicle for parenteral products is water. Water of suitable quality for parenteral administration can be prepared either by distillation or by reverse osmosis. Water for injection is typically the aqueous vehicle for use in the pharmaceutical formulations.

[0267] It is possible that other ingredients may be present in the pharmaceutical formulations. Such additional ingredients may include, e.g., wetting agents, emulsifiers, oils, antioxidants, bulking agents, tonicity modifiers, chelating agents, metal ions, oleaginous vehicles, proteins (e.g., human serum albumin, gelatin or proteins) and a zwitterion (e.g., an amino acid such as betaine, taurine, arginine, glycine, lysine and histidine). Additionally, polymer solutions, or mixtures with polymers provide the opportunity for controlled release of the peptide. Prolonged absorption of the injectable compositions can be brought about by the use in the compositions of agents delaying absorption (for example, aluminum monostearate and gelatin). Such additional ingredients, of course, should not adversely affect the overall stability of the provided pharmaceutical formulation.

[0268] In particular embodiments, a pharmaceutical formulation provided may contain a range of concentrations of the P-PI conjugate compound, e.g., between about 0.01% to about 98% (w/w), or between about 1 to about 98% (w/w), or between 80% and 90% (w/w), or between about 0.01% to about 50% (w/w), or between about 10% to about 25% (w/w). A sufficient amount of water for injection may be used to obtain the desired concentration of solution.

[0269] Exemplary pharmaceutical formulations contemplated may comprise approximately 0.01 to 1.0% (w/v), in certain cases 0.05 to 1.0% (w/v), of the P-PI conjugate compound, approximately 0.02 to 0.5% (w/v) of an acetate, phosphate, citrate or glutamate buffer allowing a pH of the final composition of from about 3.0 to about 7.0; approximately 1.0 to 10% (w/v) of a carbohydrate or polyhydric alcohol tonicifier and, optionally, approximately 0.005 to 1.0% (w/v) of a preservative selected from the group consisting of m-cresol, benzyl alcohol, methyl, ethyl, propyl and butyl parabens and phenol. Such a preservative is generally included if the formulated peptide is to be included in a multiple use product.

[0270] Sterile injectable solutions may be prepared by incorporating the active compounds in the required amount in the appropriate solvent with various of the other ingredients enumerated above, as required, followed by filtered sterilization. Generally, dispersions are prepared by incorporating the various sterilized active ingredients into a sterile vehicle that contains the basic dispersion medium and the required other ingredients from those enumerated herein. In the case of sterile powders for the preparation of sterile injectable solutions, exemplary methods of preparation are vacuum-drying and freeze-drying techniques that yield a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof. In certain embodiments, the compounding procedure involves dissolution of

ingredients in a specific order (for example, preservative followed by stabilizer/tonicity agents, buffers and peptide) or dissolving at the same time. In some cases, the P-PI conjugates can be lyophilized in to vials, syringes or cartridges for subsequent reconstitution. Liquid formulations provided can be filled into one or two chambered cartridges, or one or two chamber syringes.

**[0271]** Alternative formulations, e.g., non-parenteral, may not require sterilization.

However, if sterilization is desired or necessary, any suitable sterilization process can be used in developing the peptide pharmaceutical formulation provided herein. Typical sterilization processes include filtration, steam (moist heat), dry heat, gases (e.g., ethylene oxide, formaldehyde, chlorine dioxide, propylene oxide, beta-propiolactone, ozone, chloropicrin, peracetic acid methyl bromide and the like), exposure to a radiation source, and aseptic handling. Filtration is an exemplary method of sterilization for provided liquid formulations. The sterile filtration involves filtration through 0.45  $\mu\text{m}$  and 0.22  $\mu\text{m}$  (1 or 2) which may be connected in series. After filtration, the solution is filled into appropriate vials or containers.

**[0272]** Generally, a therapeutically or prophylactically effective amount of the present P-PI conjugate will be determined by the age, weight, and condition or severity of the diseases, conditions or disorders of the recipient. Appropriate dosages may be ascertained through the use of established assays for determining level of metabolic conditions or disorders in conjunction with relevant dose-response data. The final dosage regimen will be determined by the attending physician, considering factors that modify the action of drugs, e.g., the drug's specific activity, severity of the damage and the responsiveness of the patient, the age, condition, body weight, sex and diet of the patient, the severity of any infection, time of administration and other clinical factors. As studies are conducted, further information will emerge regarding appropriate dosage levels and duration of treatment for specific diseases and conditions.

**[0273]** Typically, a dosage of between about 0.001  $\mu\text{g}/\text{kg}$  body weight/day to about 1000  $\mu\text{g}/\text{kg}$  body weight/day may be used, but more or less, as a skilled practitioner will recognize, may be used. Typical doses may contain from a lower limit of about 1  $\mu\text{g}$ , 5  $\mu\text{g}$ , 10  $\mu\text{g}$ , 50  $\mu\text{g}$  to 100  $\mu\text{g}$  to an upper limit of about 100  $\mu\text{g}$ , 500  $\mu\text{g}$ , 1 mg, 5 mg, 10 mg, 50 mg or 100 mg of the pharmaceutical compound per day. The doses per day may be delivered in discrete unit doses, provided continuously in a 24 hour period or any portion of that the 24 hours. The number of doses per day may be from 1 to about 4 per day, although it could be more. Dosing may be one or more times daily, or less frequently, such as one or more times weekly or one or

more times monthly, and may be in conjunction with other compositions as described herein. It should be noted that the present methods and compositions are not limited to the dosages recited herein.

[0274] Typical doses may contain from a lower limit of about 0.5  $\mu\text{g}$ , 1  $\mu\text{g}$ , 5  $\mu\text{g}$ , 10  $\mu\text{g}$ , 50  $\mu\text{g}$  to 100  $\mu\text{g}$  to an upper limit of about 100  $\mu\text{g}$ , 500  $\mu\text{g}$ , 1 mg, 5 mg, 10 mg, 50 mg or 100 mg of the pharmaceutical compound per day. The doses per day may be delivered in discrete unit doses, provided continuously in a 24 hour period or any portion of that the 24 hours. The number of doses per day may be from 1 to about 4 per day, although it could be more.

[0275] In some embodiments, an effective dose will typically be in the range of about 1 to 30  $\mu\text{g}$  to about 5 mg/day, about 10 to 30  $\mu\text{g}$  to about 2 mg/day, about 5 to 100  $\mu\text{g}$  to about 1 mg/day, or about 5  $\mu\text{g}$  to about 500  $\mu\text{g}$ /day, for a 50 kg patient, administered in a single or divided doses. In some embodiments, dosages are between about 0.01 to about 100  $\mu\text{g}/\text{kg}/\text{dose}$ . In other embodiments, the composition is formulation so as to deliver a dose of P-PI conjugate ranging from 1  $\mu\text{g}/\text{kg}$  to 100 mg/kg body weight/day or at doses ranging from 0.1 mg/kg to about 50 mg/kg body weight/day. Dosages for certain routes, for example oral administration, may be increased to account for decreased bioavailability, for example, by about 5-100 fold.

[0276] The frequency of dosing will depend in part on the pharmacokinetic parameters of the agents and the routes of administration. Pharmaceutical formulations may influence the physical state, stability, rate of in vivo release and rate of in vivo clearance of the administered agents. Depending on the route of administration, a suitable dose may be calculated according to body weight, body surface areas or organ size. Further refinement of the calculations necessary to determine the appropriate treatment dose is routinely made by those of ordinary skill in the art without undue experimentation, especially in light of the dosage information and assays disclosed herein, as well as pharmacokinetic data observed in animals or human clinical trials.

[0277] Administration should begin whenever the desired effect, *e.g.*, suppression of nutrient availability, food intake, weight, blood glucose or plasma lipid modulation, is of benefit to the recipient, for example, at the first sign of symptoms or shortly after diagnosis of obesity, diabetes mellitus, or insulin-resistance syndrome. It will be appreciated that the pharmaceutical compositions and treatment methods provided herein may be useful in fields of human medicine and veterinary medicine.

[0278] In addition, a kit is provided comprising a P-PI conjugate compound, components suitable for preparing said P-PI conjugate compound for pharmaceutical application, and instructions for using said P-PI conjugate and components for pharmaceutical application.

[0279] As described herein, a variety of liquid vehicles are suitable for use in the formulations of peptidic anti-obesity agents, for example, water or an aqueous/organic solvent mixture or suspension.

[0280] Administration of the pharmaceutical compositions described herein may be via any common route so long as the target tissue is available *via* that route. In some embodiments, the P-PI conjugates are administered peripherally to the subjects. In some embodiments, the P-PI conjugates are administered locally to the subjects. In some embodiments, the liquid pharmaceutical formulations of the P-PI conjugate are intended for parenteral administration. Suitable routes of administration include intramuscular, intravenous, subcutaneous, intradermal, intraarticular, intrathecal, intramammary, intraperitoneal, retrobulbar, intrapulmonary (*e.g.*, term release), and the like. In some embodiments, the subcutaneous route of administration is of use. In certain embodiments, mucosal delivery is also exemplary. These routes include, but are not limited to, oral, nasal, sublingual, pulmonary, buccal, anal, vaginal, and transdermal routes which may include administration of the conjugate in liquid, semi-solid or solid form. Administration via these routes may require substantially more conjugate to obtain the desired biological effects due to decreased bioavailability compared to parenteral delivery. Parenteral administration may be carried out with an initial bolus followed by continuous infusion to maintain therapeutic circulating levels of drug product.

[0281] Controlled continual release of the P-PI conjugate compositions is also contemplated. Continuous delivery can be in the form of continuous infusions. Exemplary doses and infusion rates include from 0.005 nmol/kg to about 20 nmol/kg per discrete dose or from about 0.01/pmol/kg/min to about 10 pmol/kg/min in a continuous infusion. These doses and infusions can be delivered by intravenous administration (*i.v.*) or subcutaneous administration (*s.c.*). Exemplary total dose/delivery of the pharmaceutical composition given *i.v.* may be about 2 µg to about 8 mg per day, whereas total dose/delivery of the pharmaceutical composition given *s.c.* may be about 6 µg to about 6 mg per day.

[0282] A form of repository or “depot” slow release preparation may be used so that therapeutically effective amounts of the preparation are delivered into the bloodstream over many hours or days following transdermal injection or delivery. Those of ordinary skill in the

art will readily optimize effective dosages and administration regimens as determined by good medical practice and the clinical condition of the individual patient. Parenteral controlled release delivery can be achieved by forming polymeric microcapsules, matrices, solutions, implants and devices and administering the same parenterally or by surgical means. Examples of controlled release formulations are described in U.S. Pat. Nos. 6,368,630, 6,379,704, and 5,766,627. These dosage forms may have a lower bioavailability due to entrapment of some of the conjugates in the polymer matrix or device. See *e.g.*, U.S. Pat. Nos. 6,379,704, 6,379,703, and 6,296,842.

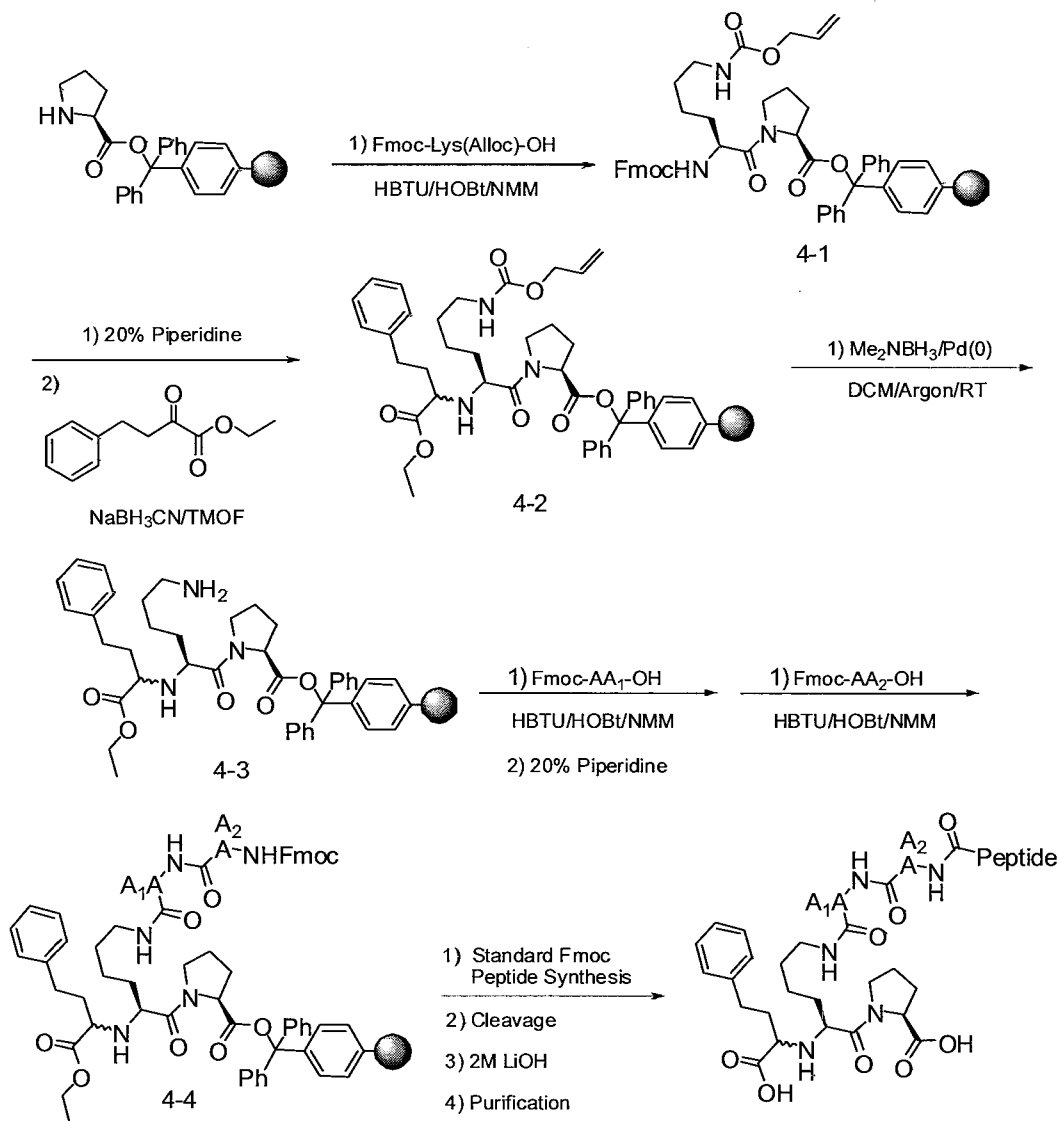
[0283] The following Examples are provided to illustrate, but not limit, the invention. Unless indicated otherwise, the numbering of chemical compounds within a scheme of a particular example contemplates only that particular example.

## EXAMPLES

### Example 1: Synthesis of Peptide-Peptidase Inhibitor Conjugates

[0284] Conjugate molecules were prepared by linking the peptide GLP-1(7-37) (SEQ ID NO:42) or [<sup>14</sup>Leu]exendin(1-28) (SEQ ID NO:70) to an angiotensin converting enzyme (ACE) inhibitor. Representative ACE inhibitors used included the small molecule lisinopril and the peptide pGluKWAP-OH (SEQ ID NO:273). The following depicts the synthesis scheme for conjugate molecules Cmpds 3633/21, 3633/24, 3633/42/1, 3633/42/2, 3633/42/3, and 3633/38 where the inhibitor motif is placed on the C-terminus of the GLP-1(7-37) and [<sup>14</sup>Leu]exendin-(1-28). AA<sub>1</sub> and AA<sub>2</sub> are 2 or 3 carbons chain.

## Scheme 4:



[0285] Preparation of resin-bound species 4-1: 0.75 g of H-Proline-Trityl-Resin (0.68 mmol/g) was swollen in dimethylformamide (DMF) for 20 min. in a 20 mL polypropylene syringe with a frit. To the resin slurry was added a mixture of Fmoc-Lys(alloc)-OH (0.6 g, 2.6 eq), HBTU (0.51 g, 2.6 eq), HOBt (0.174 g) and N-Methylmorpholine (0.22 mL, 4 eq). The resin was shaken at room temperature for 2.5 h. Chloranil test showed negative. The resin was washed with DMF (4x), DCM (2x), MeOH (2x), DCM and MeOH and dried under high vacuum. Resin loading was calculated by weight gain (0.54 mmol/g, 100% yield).

10 [0286] Preparation of resin-bound species 4-2: Resin-bound species 4-1 was swollen in DMF for 10 min., drained and then treated with 20 % piperidine in DMF for 15 min., washed with DMF (6x) and the procedure repeated. Chloranil test showed positive. The resin was then swollen in 10 mL of trimethylorthoformate (TMOF). To this mixture was added ethyl-2-oxo-4-phenylbutyrate (2.2 g, 20 eq) dissolved in 1 mL of TMOF. The resin was shaken for 1 h

followed by addition of NaBH<sub>3</sub>CN (0.673 g, 20 eq) dissolved in 5.1 mL of TMOF and 0.7 mL of MeOH. The resin slurry was shaken at room temperature for 5 h then washed with TMOF and the process repeated. A sample of resin was cleaved with 1%TFA in DCM and the crude product analyzed by LCMS. Calculated mass for C<sub>27</sub>H<sub>39</sub>N<sub>3</sub>O<sub>7</sub> (M+H)<sup>+</sup> 518.28, found 518.3.

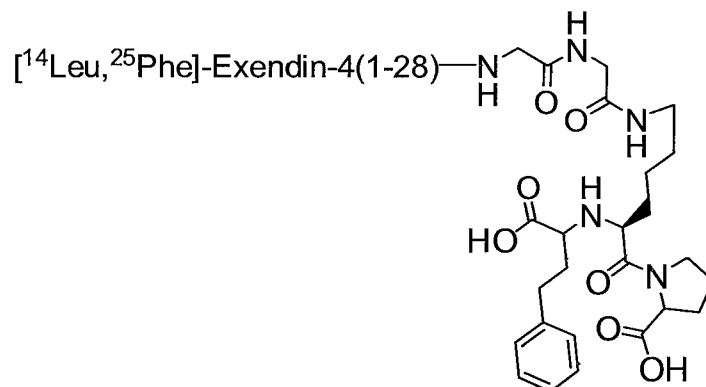
5 [0287] *Preparation of resin-bound species 4-3*: Resin-bound species **4-2** (0.78 g) was swollen in dry DCM under argon for 10 min. To the mixture was added Me<sub>2</sub>NH-BH<sub>3</sub> (0.141 g, 6 eq) under agitation, followed after 5 min. by addition of Pd(PPh<sub>3</sub>)<sub>4</sub> (0.047 g, 10 mol%). After 10 min. the solution is drained and the resin washed with DCM (4x). This procedure was repeated and then the resin washed with DCM (8x30s), DIEA 5% in DCM (3x60s) and DCM  
10 (5x30s). The resin showed a positive chloranil test. A sample of resin was cleaved with 1%TFA in DCM and the crude product analyzed by LCMS. Calculated mass for C<sub>23</sub>H<sub>35</sub>N<sub>3</sub>O<sub>5</sub> (M+H)<sup>+</sup> 434.26, found 434.3.

[0288] *Preparation of resin-bound species 4-4* (AA<sub>1</sub>= CH<sub>2</sub>-CH<sub>2</sub>, AA<sub>2</sub>= CH<sub>2</sub>-CH<sub>2</sub>-CH<sub>2</sub>) Resin-bound species **4-3** (0.51 g, 0.4 mmol/g) was swollen in DMF for 10 min, drained and  
15 treated with a mixture of β-Ala-OH (0.094 g, 1.5 eq), HBTU (0.115g, 1.5 eq), HOBT (0.041g, 1.5 eq) and N-methylmorpholine (0.066 mL, 3 eq) in 3 mL of DMF. After 3 h chloranil test showed a negative test. The resin was washed with DMF (6x30s) followed by treatment with 20% piperidine (2x15 min), washed with DMF (6x30s) and coupled with a mixture of γ-Abu-  
OH (0.1 g, 1.5 eq), HOBT, HBTU and N-methylmorpholine. After 3 h, the coupling was  
20 complete as indicated by chloranil test. The resin was washed with DMF (6x), DCM and MeOH, dried. A sample of resin was cleaved with 1%TFA in DCM and the crude product analyzed by LCMS. Calculated mass for C<sub>30</sub>H<sub>47</sub>N<sub>5</sub>O<sub>7</sub> (M+H)<sup>+</sup> 589.35, found 589.3. (> 90% pure).

*Synthesis of [<sup>14</sup>Leu, <sup>25</sup>Phe]Exendin-4(1-28)-Gly-Gly-CONH-Lisinopril diacid (Cmpd*  
25 *3633/42/1)*

[0289] A calculated 110 μmol of the modified trityl resin-bound species **4-4** was weighed into a reaction vessel in a Symphony® peptide synthesizer (Protein Technologies, Inc.) and the peptide elongation was carried out following standard Fmoc peptide synthesis protocol. The peptide was cleaved from the resin with 20 mL TFA/phenol/H<sub>2</sub>O/TIPS (95:2:2:1). The crude  
30 peptide was precipitated using *tert*-butyl methyl ether. Calculated mass for C<sub>174</sub>H<sub>265</sub>N<sub>43</sub>O<sub>53</sub> (M+H)<sup>+</sup> 3807.31, found by LC-MS 1269.1 (M+3H)<sup>3</sup>. The crude peptide was dissolved in 1 mL of a 60:40 mixture of H<sub>2</sub>O/ACN and to this mixture was added 0.2 mL of a 2M solution of

LiOH. The mixture was stirred at room temperature for three hours. The crude peptide was purified by LCMS-PrepExpress™ (mass triggered collection) (C<sub>18</sub>, 25-60% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient) to afford the titled compound as a white powder (23.3 mg, 5.7%): Retention time in RP-HPLC (C<sub>18</sub>, 5-75% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 9.64. LCMS Calculated mass for C<sub>172</sub>H<sub>261</sub>N<sub>43</sub>O<sub>53</sub> (M+H)<sup>+</sup> 3779.25, found by LC-MS 1259.7 (M+3H)<sup>3</sup>.



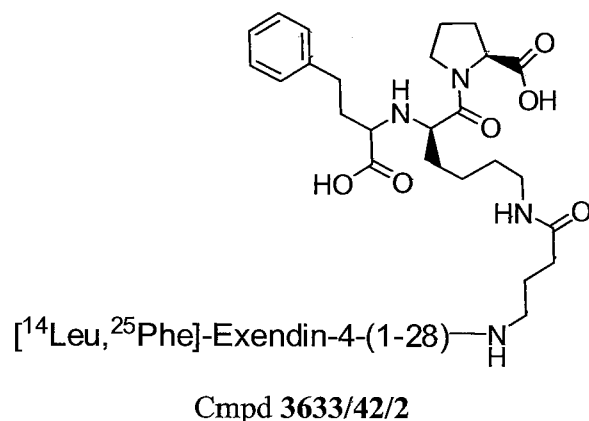
Cmpd 3633/42/1

*Synthesis of [<sup>14</sup>Leu,<sup>25</sup>Phe]Exendin-4(1-28)-γ-Abu-CONH-lisinopril diacid (Cmpd 3633/42/2)*

10 [0290] A calculated 110 μmol of the modified trityl resin-bound species 4-4 was weighed into a reaction vessel in a Symphony® peptide synthesizer and the peptide elongation was carried out following standard Fmoc peptide synthesis protocol. The peptide was cleaved from the resin with 20 mL TFA/phenol/H<sub>2</sub>O/TIPS (95:2:2:1). The crude peptide was precipitated using *tert*-butyl methyl ether. Calculated mass for C<sub>174</sub>H<sub>266</sub>N<sub>42</sub>O<sub>52</sub> (M+H)<sup>+</sup> 3778.31, found by

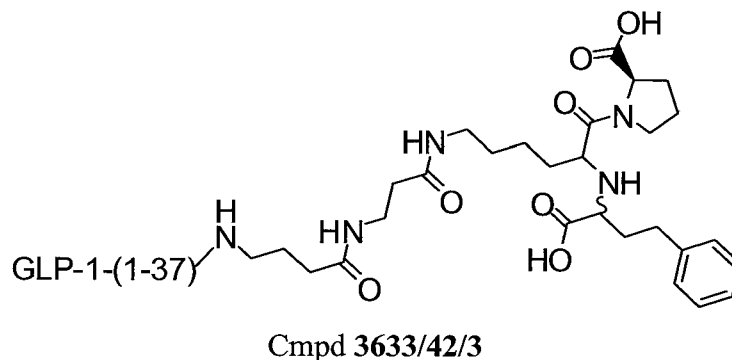
15 LC-MS 1259.4 (M+3H)<sup>3</sup>. The crude peptide was dissolved in 1 mL of a 60:40 mixture of H<sub>2</sub>O/ACN and to this mixture was added 0.2 mL of a 2M solution of LiOH. The mixture was stirred at room temperature for 3 hours. The crude peptide purified by LCMS-PrepExpress™ (mass triggered collection) (C<sub>18</sub>, 25-60% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient) to afford the titled compound as a white powder (21 mg, 5.5%): Retention time in RP-HPLC

20 (C<sub>18</sub>, 5-75% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 9.80. LCMS Calculated mass for C<sub>172</sub>H<sub>262</sub>N<sub>42</sub>O<sub>52</sub> (M+H)<sup>+</sup> 3750.26, found by LC-MS 1250.1 (M+3H)<sup>3</sup>.



*Synthesis of GLP-1(7-37)-γ-Abu-β-Ala-CONH-lisinopril diacid (Cmpd 3633/42/3)*

[0291] A calculated 110 μmol of the modified trityl resin-bound species 4-4 was weighed  
 5 into a reaction vessel in a Symphony® peptide synthesizer and the peptide elongation was  
 carried out following standard Fmoc peptide synthesis protocol. The peptide was cleaved from  
 the resin with 20 mL TFA/phenol/H<sub>2</sub>O/TIPS (95:2:2:1). The crude peptide was precipitated  
 using *tert*-butyl methyl ether and purified by LCMS-PrepExpress™ (mass triggered collection)  
 (C<sub>18</sub>, 25-60% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient) to afford the ester compound as  
 10 a white powder (5.8 mg, 1.2%): Retention time in RP-HPLC (C<sub>18</sub>, 5-50% CH<sub>3</sub>CN in 0.1%  
 TFA/H<sub>2</sub>O over 15 min) is 8.13; Calculated mass for C<sub>181</sub>H<sub>273</sub>N<sub>45</sub>O<sub>53</sub> (M+H)<sup>+</sup> 3927.36, found by  
 LC-MS 1310.7 (M+3H)<sup>3</sup>. The crude peptide was dissolved in 1 mL of a 60:40 mixture of  
 H<sub>2</sub>O/ACN to this mixture it was added 0.160 mL of a 2M solution of LiOH. The mixture was  
 stirred at room temperature for two hours. The crude peptide purified by LCMS-  
 15 PrepExpress™ (mass triggered collection) (C<sub>18</sub>, 25-60% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30  
 min gradient) to afford the titled compound as a white powder (11 mg, 2.4%): Retention time  
 in RP-HPLC (C<sub>18</sub>, 5-75% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 9.51. LCMS Calculated  
 mass for C<sub>179</sub>H<sub>269</sub>N<sub>45</sub>O<sub>53</sub> (M+H)<sup>+</sup> 3899.41, found by LC-MS 1300.8 (M+3H)<sup>3</sup>.



*Synthesis of [<sup>14</sup>Leu]Exendin-4-(1-28)-γ-Abu-β-Ala-CONH-Lisinopril (Cmpd 3633/21)*

[0292] The procedure described above was followed up to the preparation of resin-bound Species 4-4. A calculated 120 μmol of the modified trityl resin-bound species 4-4 was weighed into a reaction vessel in a Symphony® peptide synthesizer, and the peptide elongation was carried out following standard Fmoc peptide synthesis protocol. The peptide was cleaved from the resin with 20 mL TFA/phenol/H<sub>2</sub>O/TIPS (95:2:2:1). The crude peptide was precipitated using *tert*-butyl methyl ether and purified by LCMS-PrepExpress™ (mass triggered collection) (C<sub>18</sub>, 25-60% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient) to afford the precursor ester compound as a white powder (11 mg, 2.2%): Retention time in RP-HPLC (C<sub>18</sub>, 5-75% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 9.17; Calculated mass for C<sub>177</sub>H<sub>271</sub>N<sub>45</sub>O<sub>53</sub> (M+H)<sup>+</sup> 3849.39, found by LC-MS 1284.7 (M+3H)<sup>3</sup>, 963.5 (M+4H)<sup>4</sup>. A solution of 0.8 mg of the purified ester precursor in 100 μL of H<sub>2</sub>O was treated with 12 μL of a 2M LiOH solution. After two hours LCMS showed quantitative transformation to the desired compound 3633/21. LCMS Calculated mass for C<sub>175</sub>H<sub>267</sub>N<sub>45</sub>O<sub>53</sub> (M+H)<sup>+</sup> 3821.34, found by LC-MS 1274.7 (M+3H)<sup>3</sup>.

*Synthesis of GLP-1(7-37)-γ-Abu-CONH-Lisinopril (Cmpd 3633/24)*

[0293] The procedure described above was followed up to the preparation of resin-bound Species 4-4. A calculated 120 μmol of the modified trityl resin-bound species 4-4 was weighed into a reaction vessel in a Symphony® peptide synthesizer, and the peptide elongation was carried out following standard Fmoc peptide synthesis protocol. The peptide was cleaved from the resin with 15 mL TFA/phenol/H<sub>2</sub>O/TIPS (95:2:2:1). The crude peptide was precipitated using *tert*-butyl methyl ether and purified by LCMS-PrepExpress™ (mass triggered collection) (C<sub>18</sub>, 25-60% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient) to afford the precursor ester compound as a white powder (6.2 mg, 2.2%): Retention time in RP-HPLC (C<sub>18</sub>, 5-75% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 8.86; Calculated mass for C<sub>179</sub>H<sub>272</sub>N<sub>44</sub>O<sub>51</sub> (M+H)<sup>+</sup> 3856.43, found by LC-MS 1286.7 (M+3H)<sup>3</sup>, 965.5 (M+4H)<sup>4</sup>. A solution of 0.8 mg of the purified ester precursor in 100 μL of H<sub>2</sub>O was treated with 12 μL of a 2M LiOH solution. After two hours LCMS showed quantitative transformation to the desired compound 3633/24. LCMS Calculated mass for C<sub>176</sub>H<sub>264</sub>N<sub>44</sub>O<sub>52</sub> (M+H)<sup>+</sup> 3828.33, found by LC-MS 1277.1 (M+3H)<sup>3</sup>.

*Synthesis of GLP-1(7-37)- $\gamma$ -Abu-N<sup>ε</sup>Lys-(Pyr)-WAP-OH (Cmpd 3633/38)*

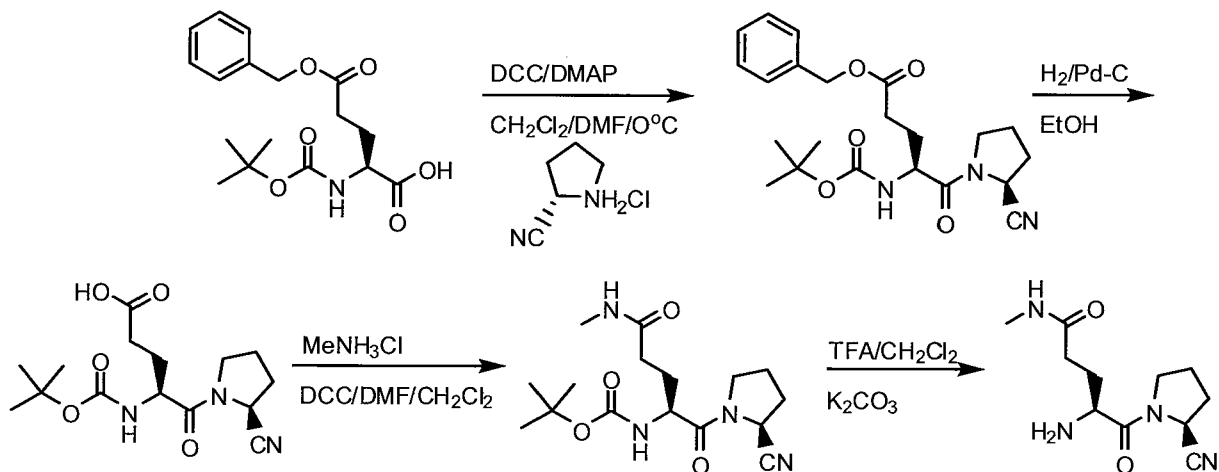
[0294] A calculated 340  $\mu$ mol of H-Pro-Trytil-resin (0.68 mmol/g) was weighed into a reaction vessel manual peptide synthesizer, and the peptide elongation was carried out following standard Fmoc peptide synthesis protocol using the following amino acids:

- 5 FmocAla-OH, FmocTrp(Boc)-OH, FmocLys(Alloc)-OH and pyroglutamic acid-OH. The pentapeptide was then treated swollen in dry DCM under argon for 10 min. To the mixture was added Me<sub>2</sub>NH-BH<sub>3</sub> (0.073 g, 6 eq) under agitation, followed after 5 min. by addition of Pd(PPh<sub>3</sub>)<sub>4</sub> (0.024 g, 10 mol%). After 10 min. the solution was drained and the resin washed with DCM (4x). This procedure was repeated and then the resin washed with DCM (8x30s),  
 10 DIEA 5% in DCM (3x60s) and DCM (5x30s). The resin shows a positive chloranil test. The modified trityl resin was weighed into a reaction vessel in a Symphony® peptide synthesizer, and the peptide elongation was carried out following standard Fmoc peptide synthesis protocol. The peptide was cleaved from the resin with 20 mL TFA/phenol/H<sub>2</sub>O/TIPS (95:2:2:1). The crude peptide was precipitated using *tert*-butyl methyl ether and purified by LCMS-  
 15 PrepExpress™ (mass triggered collection) (C<sub>18</sub>, 25-60% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient) to afford the titled compound as a white powder (8.5 mg, 2.1% yield). Retention time in RP-HPLC (C<sub>18</sub>, 5-75% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 9.86; Calculated mass for C<sub>185</sub>H<sub>274</sub>N<sub>48</sub>O<sub>54</sub> (M+H)<sup>+</sup> 4034.54, found by LC-MS 1344.8 (M+3H)<sup>3</sup>.

*Synthesis of Glu( $\gamma$ -methylamido)-(2)-S-cyanopyrrolidinamide*

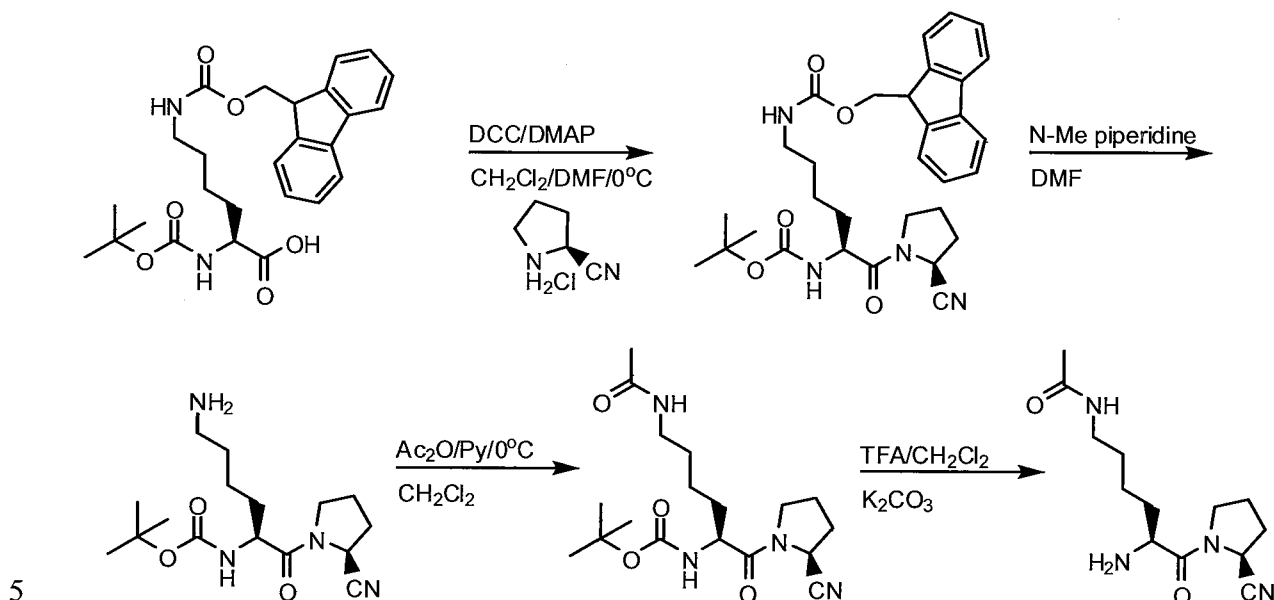
- 20 [0295] The following depicts the synthesis scheme for the DPP-IV inhibitor based molecule Glu( $\gamma$ -methylamido)-(2)-S-cyanopyrrolidinamide.

**Scheme 5:**



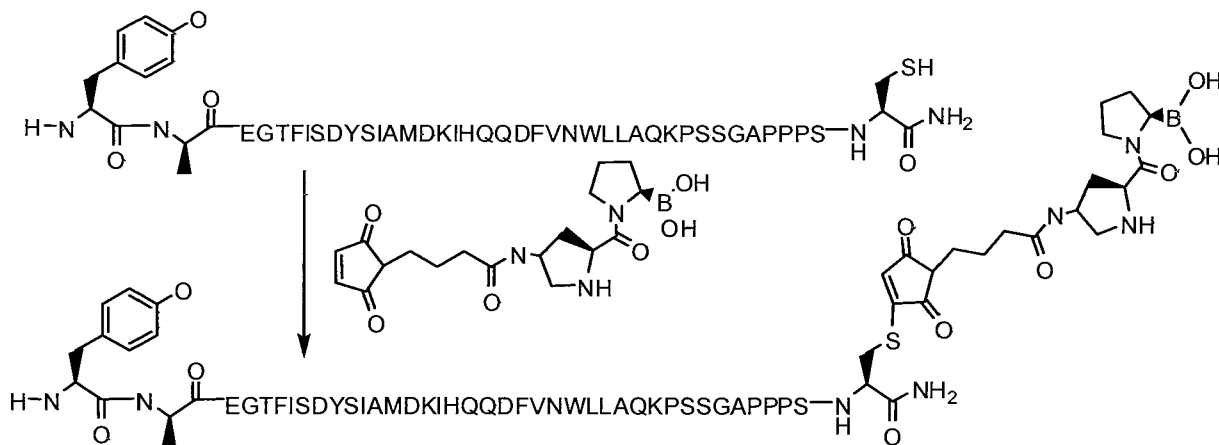
*Synthesis of Lys( $\epsilon$ -NH-acetyl)-(2)-S-cyanopyrrolidinamide*

[0296] The following depicts the synthesis scheme for the DPP-IV inhibitor based molecule Lys( $\epsilon$ -NH-acetyl)-(2)-S-cyanopyrrolidinamide.

**Scheme 6:***Synthesis of maleimido DPP-IV inhibitor – GIP analogs*

[0297] The following is a typical procedure for coupling of maleimido DPP-IV inhibitor analogs to GIP peptides, for example [D-<sup>2</sup>Ala] GIP(1-30)-Exendin-4 (31-39)-Cys-((S-maleimido propanoyl)-Lys-N-e(2-(S)-Cyano pyrrolidyl)), [D-<sup>2</sup>Ala<sub>2</sub>] GIP(1-30)-Exendin-4 (31-39)-Cys-((S-maleimido propanoyl)-(2(S)-4(S)Amino)Pro-(2-(S)-Boro pyrrolidyl))) and the like. A 25 mM HEPES buffer (5 mL) was degassed under argon for about 10 min. and added to the desired peptide (10 mg 1:1 v/v CH<sub>3</sub>CN:H<sub>2</sub>O) with a free cysteine. A solution of the maleimido-DPP-IV analog (*ca.* 2-3 equivalent) in 1:1 v/v CH<sub>3</sub>CN:H<sub>2</sub>O (5 mL) was added to the peptide and the solution was stirred under argon atmosphere. After an hour, when the LCMS showed the complete conversion to the desired product, the reaction was frozen and lyophilized. The crude peptide was purified using reverse phase HPLC with a gradient of CH<sub>3</sub>CN and H<sub>2</sub>O as eluents.

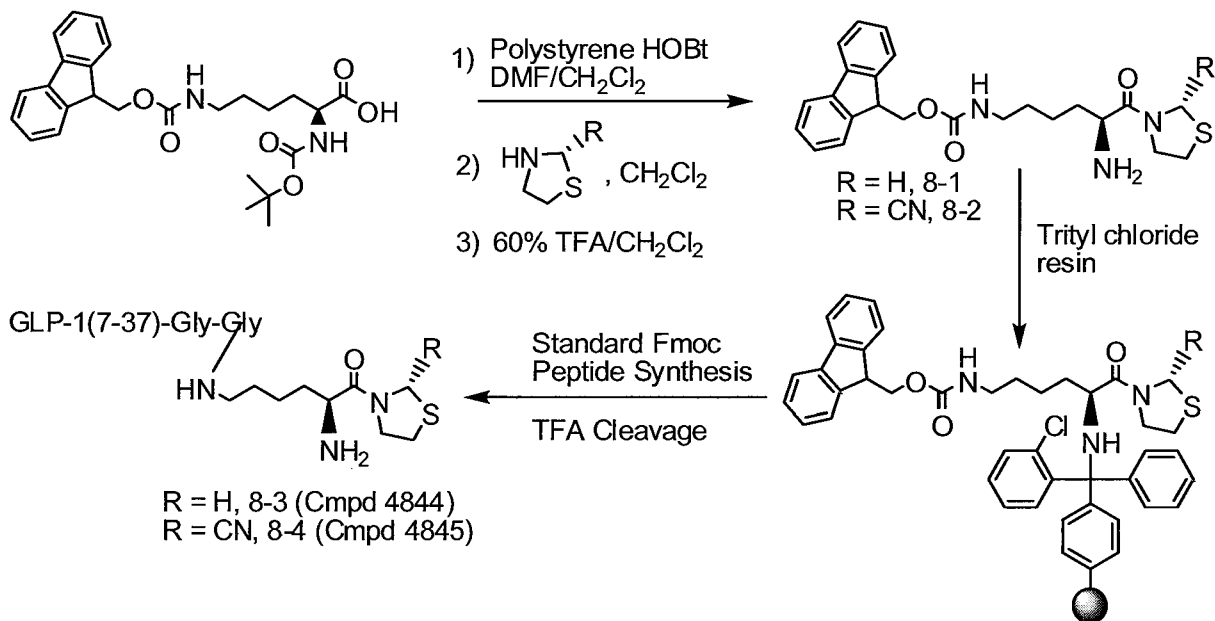
## Scheme 7:



## Example 2: Synthesis of GLP-1-Peptidase Inhibitor Conjugates

- 5 [0298] Conjugate molecules were prepared by linking the peptide GLP-1 to a peptidase inhibitor. The peptidase inhibitors used included DPP-IV inhibitors and vasopeptidase (neutral endopeptidase, ACE, and endothelin converting enzyme-1) inhibitors. The following depicts the synthesis scheme for GLP-1/DPP-IV inhibitor conjugate molecules Cmpds **4844** and **4845** where the inhibitor motif is placed on the C-terminus of the GLP-1 and GLP-1/vasopeptidase
- 10 inhibitor conjugate molecules **4983** and **4984** where the inhibitor motif is placed on the N-terminus of the GLP-1.

## Scheme 8:



**[0299]** Preparation of thiazolidinyl (S)-2-amino-6-(fluorenylmethoxycarbonyl)

*aminohexylcarbamate (Species 8-1)*: Boc-Lys(Fmoc)-OH (0.703 g, 1.5 mmol), polystyrene-HOBt (1 mmol/g, 1 g, 1 mmol), 8 ml CH<sub>2</sub>Cl<sub>2</sub>, and 2 ml DMF were added to a 20-ml reaction vessel, and the mixture was gently agitated on a horizontal shaker at room temperature for 2

5 hours. The suspension was filtered and the resin was washed extensively with DMF followed by dry CH<sub>2</sub>Cl<sub>2</sub>. The resin was re-suspended in 10 ml dry CH<sub>2</sub>Cl<sub>2</sub>, and thiazolidine (83  $\mu$ l, 1.0 mmol) was added to the suspension. The mixture was then gently agitated on a horizontal shaker at room temperature overnight. The resin was filtered off and the filtrate was collected and evaporated to dryness under reduced pressure. The residue was then treated with 10 ml  
10 50% TFA in CH<sub>2</sub>Cl<sub>2</sub> at room temperature for 2 hours. The desired product was obtained as TFA salt after drying in vacuum overnight (0.41 g, 73% yield): <sup>1</sup>H-NMR (CDCl<sub>3</sub>, 300MHz)  $\delta$  7.74 (d, J = 4.5 Hz, 2H), 7.57 (d, J = 4.1 Hz, 2H), 7.38 (t, J = 4.5 Hz, 2H), 7.29 (t, J = 4.4 Hz, 2H), 5.21 (s, b, 1H), 4.53 (t, J = 6.2 Hz, 1H), 4.41 (m, 1H), 4.34 (d, J = 4.3 Hz, 2H), 4.26 (m, 1H), 4.17 (m, 1H), 3.84 (m, 1H), 3.64 (m, 1H), 3.14 (m, 2H), 3.03 (t, J = 3.3 Hz, 1H), 2.94 (t, J  
15 = 3.8 Hz, 1H), 1.86 (m, 2H), 1.48 (m, 4H); Retention time in RP-HPLC (C<sub>18</sub>, 30-95% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 5 min) is 2.91; Calculated mass for C<sub>24</sub>H<sub>30</sub>N<sub>3</sub>O<sub>3</sub>S (M+H)<sup>+</sup> 440.2, found by LC-MS 440.2.

**[0300]** Preparation of 2-cyanothiazolidinyl (S)-2-amino-6-(fluorenylmethoxycarbonyl)

*aminohexylcarbamate (Species 8-2)*: Boc-Lys(Fmoc)-OH (0.487 g, 1.0 mmol), polystyrene-HOBt (1 mmol/g, 1 g, 1.0 mmol), 8 ml CH<sub>2</sub>Cl<sub>2</sub>, and 2 ml DMF were added to a 25-ml reaction vessel, and the mixture was gently agitated in a horizontal shaker at room temperature for 2  
20 hours. The suspension was filtered and the resin was washed extensively with DMF followed by dry CH<sub>2</sub>Cl<sub>2</sub>. The resin was re-suspended in 10 ml dry CH<sub>2</sub>Cl<sub>2</sub>, and 2-cyanothiazolidine HCl salt (0.172 g, 1.1 mmol) was added to the suspension. The mixture was then gently agitated on  
25 a horizontal shaker at room temperature overnight. The suspension was filtered and the resin was washed with 10 ml CH<sub>2</sub>Cl<sub>2</sub>. The filtrate was pooled and evaporated to dryness under reduced pressure. The residue was applied to a silica gel chromatography eluted with 60% CH<sub>2</sub>Cl<sub>2</sub>/EtOAc to give the fully protected product as crystalline solid (0.186 g, 33%). The solids were treated with 10 ml 50% TFA/CH<sub>2</sub>Cl<sub>2</sub> at room temperature for 2 hours, and the  
30 solvents were removed under reduced pressure. The residue was applied to a reverse-phase HPLC column (C<sub>18</sub>, 20-50% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient) to afford the titled compound as a white powder (0.142 g, 94%): <sup>1</sup>H-NMR (CDCl<sub>3</sub>, 300MHz)  $\delta$  7.74 (d, J = 4.5 Hz, 2H), 7.56 (m, 2H), 7.38 (t, J = 4.5 Hz, 2H), 7.29 (t, J = 4.5 Hz, 2H), 5.27 (s, b, 1H),

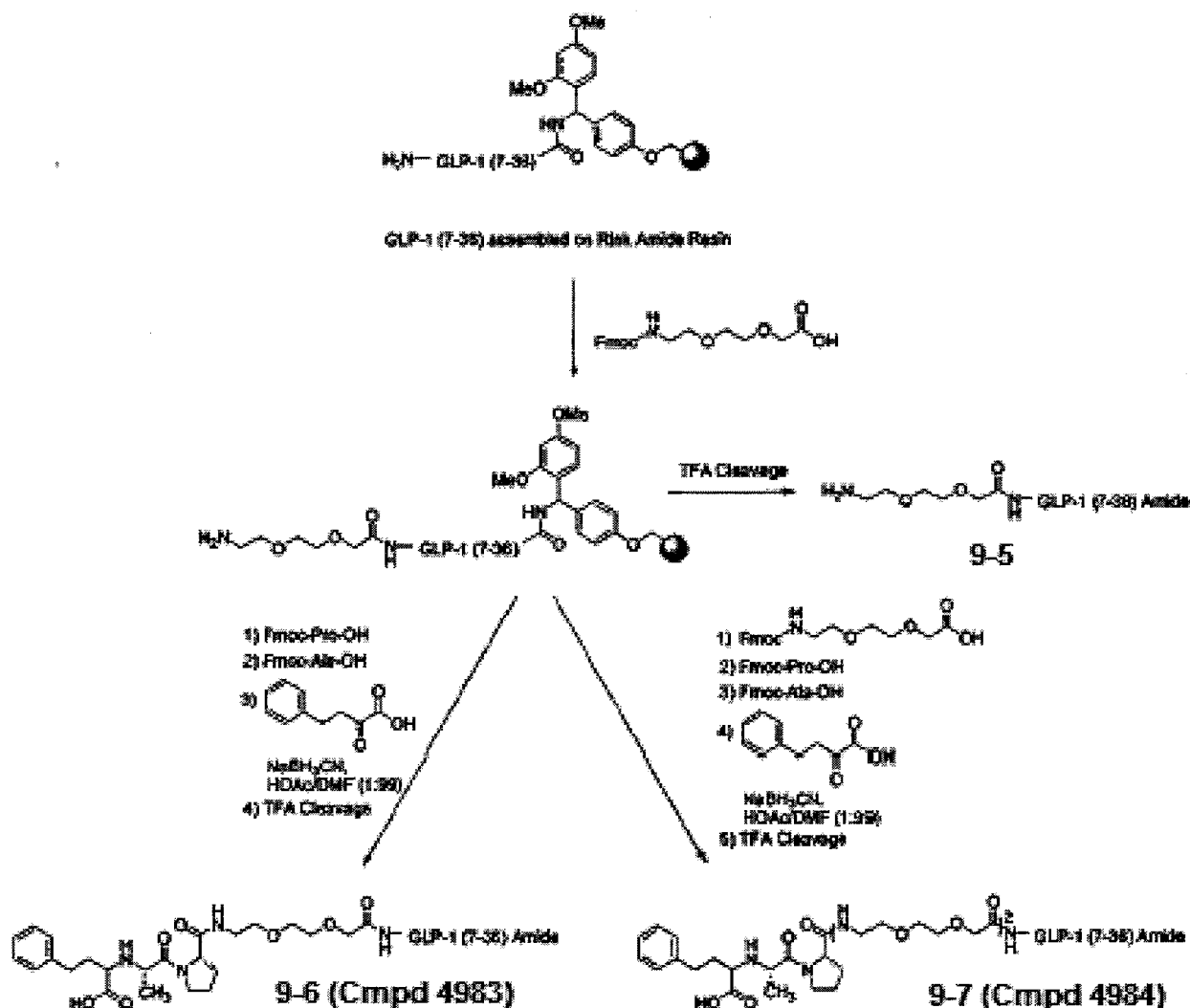
5.10 (m, 1H), 4.66 (d, J = 5.1 Hz, 1H), 4.50 (d, J = 4.8 Hz, 1H), 4.33 (d, J = 4.1 Hz, 2H), 4.18 (m, 1H), 3.22 (m, 2H), 3.13 (m, 2H), 1.91 (m, 2H), 1.47 (m, 4H); Retention time in RP-HPLC (C<sub>18</sub>, 30-95% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 5 min) is 2.96; Calculated mass for C<sub>25</sub>H<sub>29</sub>N<sub>4</sub>O<sub>3</sub>S (M+H)<sup>+</sup> 465.2, found by LC-MS 465.3.

5 [0301] *Preparation of GLP-1(7-37)-GG-(S)-2,6-diamino-1-(thiazolidin-3-yl)hexan-1-one amide (Species 8-3, Cmpd 4844)*: Thiazolidinyl (S)-2-amino-6-(fluorenylmethoxycarbonyl) aminohexylcarbamate (1) (0.41 g, 0.93 mmol), trityl chloride resin (1.0 mmol/g, 0.25 g, 0.25 mmol), 15 ml anhydrous DMF were added to a 25-ml reaction vessel, and the mixture was gently swirled at room temperature overnight. The suspension was filtered and the resin was  
10 washed sequentially with 30 ml DMF, 30 ml CH<sub>2</sub>Cl<sub>2</sub>, and 30 ml CH<sub>2</sub>Cl<sub>2</sub>/MeOH/DIPEA (17:2:1), and 30 ml CH<sub>2</sub>Cl<sub>2</sub>. The resin was dried *in vacuo* over KOH overnight. The LC-MS of the test cleavage products showed the presence of the first attached fragment. A calculated 50 μmol of the modified trityl-resin was weighed into a reaction vessel in a Symphony peptide synthesizer, and the peptide elongation was carried out following standard Fmoc peptide  
15 synthesis protocol. The peptide was cleaved from the resin with 10 ml TFA/H<sub>2</sub>O/TIPS (95:2.5:2.5) and applied to a reverse-phase HPLC column (C<sub>18</sub>, 20-50% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient) to afford the titled compound as a white powder (5.5 mg, 3%): Retention time in RP-HPLC (C<sub>18</sub>, 15-45% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 10.52; Calculated mass for C<sub>164</sub>H<sub>252</sub>N<sub>45</sub>O<sub>49</sub>S (M+H)<sup>+</sup> 3670.2, found by LC-MS 1836.0 (M+2H)<sup>2+</sup>,  
20 1224.7 (M+3H)<sup>3+</sup>, 918.5 (M+4H)<sup>4+</sup>.

[0302] *Preparation of GLP-1(7-37)-GG-(S)-2,6-diamino-1-(thiazolidin-2-cyano-3-yl)hexan-1-one amide (Species 8-4, Cmpd 4845)*: 2-Cyanothiazolidinyl (S)-2-amino-6-(fluorenylmethoxycarbonyl) aminohexylcarbamate TFA salt (2) (0.045 g, 0.078 mmol), trityl chloride resin (1.0 mmol/g, 0.10 g, 0.10 mmol), DIEA (14 μl, 0.078 mmol), 5 ml anhydrous  
25 CH<sub>2</sub>Cl<sub>2</sub> were added to a 25-ml reaction vessel, and the mixture was gently swirled at room temperature overnight. The suspension was filtered and the resin was washed sequentially with 30 ml DMF, 30 ml CH<sub>2</sub>Cl<sub>2</sub>, and 30 ml CH<sub>2</sub>Cl<sub>2</sub>/MeOH/DIPEA (17:2:1), and 30 ml CH<sub>2</sub>Cl<sub>2</sub>. The resin was dried *in vacuo* over KOH overnight. The LC-MS of the test cleavage products showed the presence of the first attached fragment. A calculated 50 μmol of the  
30 modified trityl resin was weighed into a reaction vessel in a Symphony peptide synthesizer, and the peptide elongation was carried out following standard Fmoc peptide synthesis protocol. The peptide was cleaved from the resin with 10 ml TFA/H<sub>2</sub>O/TIPS (95:2.5:2.5) and applied to a reverse-phase HPLC column (C<sub>18</sub>, 20-50% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient)

to afford the titled compound as a white powder (1.7 mg, 0.9%): Retention time in RP-HPLC ( $C_{18}$ , 15-45%  $CH_3CN$  in 0.1% TFA/ $H_2O$  over 15 min) is 10.60; Calculated mass for  $C_{165}H_{251}N_{46}O_{49}S$  ( $M+H$ )<sup>+</sup> 3695.2, found by LC-MS 1848.0 ( $M+2H$ )<sup>2+</sup>, 1232.7 ( $M+3H$ )<sup>3+</sup>, 924.5 ( $M+4H$ )<sup>4+</sup>.

5 **Scheme 9:**



[0303] *Preparation of 8-Amino-3,6-dioxaoctanoyl-GLP-1-(7-36) amide (Species 9-5, Cmpd 4992):* The titled peptide was assembled on 0.20 mmol Rink amide resin (0.610 mmol/g, 0.328g) with an ABI-433A peptide synthesizer following the standard FastMoc® protocol.

- 10 The final Fmoc group was removed and the resin was dried in vacuum to give a dry weight of 0.90 g. One third of the resin, 0.30 g, was treated with 10 ml TFA/ $H_2O$ /TIPS (95:2.5:2.5) in a reaction vessel fitted with a filtration frit for 2 hours, and the cleavage solution was filtered into 35 ml TMBE. The precipitates were collected through centrifugation and applied to a reverse-phase HPLC column ( $C_{18}$ , 20-50%  $CH_3CN$  in 0.1% TFA/ $H_2O$  over 30 min gradient, 20
- 15 ml/min flow rate) to afford the titled compound as a white powder (3.0 mg, 1.3%): Retention

time in RP-HPLC (C<sub>18</sub>, 15-45% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 10.99; Calculated mass for C<sub>155</sub>H<sub>238</sub>N<sub>41</sub>O<sub>48</sub> (M+H)<sup>+</sup> 3443.9, found by LC-MS 1722.9 (M+2H)<sup>2+</sup>, 1148.6 (M+3H)<sup>3+</sup>, 861.5 (M+4H)<sup>4+</sup>.

**[0304]** Preparation of (R,S)-1-[N<sup>2</sup>-(1-carboxy-3-phenylpropyl)-L-ala]-L-pro-8-amino-3,6-dioxaoctanoyl-GLP-1-(7-36) amide (Species 9-6, Cmpd 4983): The 8-Amino-3,6-dioxaoctanoyl-GLP-1-(7-36) fragment was assembled as described previously, and one third of the resin, 0.30 g, was allowed to couple with Fmoc-Pro-OH and Fmoc-Ala-OH, sequentially, following the standard FastMoc® protocol. The Fmoc group was removed and the resin was mixed with 2-keto-4-phenylbutyric acid (0.117 g, 0.66 mmol), NaBH<sub>3</sub>CN (0.045 g, 0.72 mmol) in 4 mL DMF/HOAc (99:1). The resin was washed extensively with DMF, CH<sub>2</sub>Cl<sub>2</sub>, and MeOH, and dried in vacuum. The resin was then treated with 10 ml TFA/H<sub>2</sub>O/TIPS (95:2.5:2.5) in a reaction vessel fitted with a filtration frit for 2 hours, and the cleavage solution was filtered into 35 ml TMBE. The precipitates were collected through centrifugation and applied to a reverse-phase HPLC column (C<sub>18</sub>, 20-50% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient, 20 ml/min flow rate) to afford the titled compound as a white powder (1.8 mg, 0.7%): Retention time in RP-HPLC (C<sub>18</sub>, 15-45% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 11.58; Calculated mass for C<sub>173</sub>H<sub>260</sub>N<sub>43</sub>O<sub>52</sub> (M+H)<sup>+</sup> 3774.3, found by LC-MS 1888.0 (M+2H)<sup>2+</sup>, 1258.7 (M+3H)<sup>3+</sup>, 944.5 (M+4H)<sup>4+</sup>.

**[0305]** Preparation of (R,S)-1-[N<sup>2</sup>-(1-carboxy-3-phenylpropyl)-L-ala]-L-pro-8-amino-3,6-dioxaoctanoyl-8-amino-3,6-dioxaoctanoyl-GLP-1-(7-36) amide (Species 9-7, Cmpd 4984): The 8-amino-3,6-dioxaoctanoyl-GLP-1-(7-36) fragment was assembled as described previously, and one third of the resin, 0.30 g, was allowed to couple with Fmoc-8-amino-3,6-dioxaoctanoyl acid, Fmoc-Pro-OH and Fmoc-Ala-OH, sequentially, following the standard FastMoc® protocol. The Fmoc group was removed and the resin was incubated with 2-keto-4-phenylbutyric acid (0.117 g, 0.66 mmol), NaBH<sub>3</sub>CN (0.045 g, 0.72 mmol) in 4 ml DMF/HOAc (99:1) overnight. The resin was washed extensively with DMF, CH<sub>2</sub>Cl<sub>2</sub>, and MeOH, and dried in vacuum. The resin was then treated with 10 ml TFA/H<sub>2</sub>O/TIPS (95:2.5:2.5) in a reaction vessel fitted with a filtration frit for 2 hours, and the cleavage solution was filtered into 35 ml TMBE. The precipitates were collected through centrifugation and applied to a reverse-phase HPLC column (C<sub>18</sub>, 20-50% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient, 20 ml/min flow rate) to afford the titled compound as a white powder (6.4 mg, 2.4%): Retention time in RP-HPLC (C<sub>18</sub>, 15-45% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 15 min) is 11.49; Calculated mass for

$C_{179}H_{271}N_{44}O_{55}$  (M+H)<sup>+</sup> 3919.4, found by LC-MS 1961.1 (M+2H)<sup>2+</sup>, 1307.7 (M+3H)<sup>3+</sup>, 980.5 (M+4H)<sup>4+</sup>.

### Example 3: Characterization of GLP-1-Peptidase Inhibitor Conjugates

5 [0306] The GLP-1 receptor binding activity (RBA) of the GLP-1-peptidase inhibitor conjugates were assessed using a binding displacement assay in which the receptor source was the endogenous GLP-1 receptors expressed by RIN m5f cells. Membrane fractions were prepared from confluent cultures of RIN m5f cells. Homogenized RINm5F cell membranes were incubated in 20 mM HEPES buffer with 40,000 cpm [<sup>125</sup>I]GLP-1 tracer and varying concentrations of test compounds. The reaction mixtures were constantly mixed at 23 °C for 2  
10 hours. The reaction mixtures were filtered through glass filter pads presoaked with 0.3% PEI solution and rinsed with ice-cold phosphate buffered saline. Counts bound to the filter pads were determined using a scintillation counter and binding affinities were calculated using GraphPad PRISM® software (GraphPad Software, Inc., San Diego, CA).

15 [0307] The GLP-1-peptidase inhibitor conjugates were assessed in a GLP-1 cyclase assay as follows. Membrane fractions were prepared from confluent cultures of RIN m5f cells. The test compounds were serially diluted with an assay buffer, and then added to a 96-well assay plate containing RIN m5f cell membranes in an ATP/GTP mixture. Cyclase activities were determined by measuring the production of cAMP induced through GLP-1 receptor activation. Quantification of cAMP production was achieved through a competitive chemiluminescence  
20 assay with a biotinylated-cAMP probe using Perkin Elmer Fusion™-Alpha Microplate Analyzer (AlphaScreen™ technology). The compound EC<sub>50</sub> values were obtained through fitting the concentration-response curves to a four-parameter logistic equation within GraphPad PRISM® software. Results from the receptor binding and cyclase assays are presented in Table 1.

25 [0308] GLP-1-peptidase inhibitor conjugate compounds 4844 and 4845 were assessed in a DPP-IV inhibition assay using purified DPP-IV enzyme and chromogenic substrates. Recombinant DPP-IV (Chemicon International, Inc., Temecula, CA; purity >95%, specific activity 5.66 ± 0.49 mU) was dissolved in 100 µl buffer (20 mM Tris-HCl, pH 8.0, 5 mM CaCl<sub>2</sub>, 1 mM ZnCl<sub>2</sub>, 0.05% NaN<sub>3</sub>, pH 8.0), the solution divided into 10 microcentrifuge tubes,  
30 and stored at -20°C. For the inhibition assay, 2 µl H-Gly-Pro-pNA (5 mM, dissolved in PBS buffer, pH 7.4) was incubated in 146 µl assay buffer (25 mM Tris-HCl, 140 mM NaCl, 10 mM KCl, pH 7.4) with 1 µl compound 4844 or 4845 at varying concentrations in a 96-well flat

bottom microtiter plate at 37°C. The reactions were initiated by adding 1 µl DPP-IV enzyme (0.05 mU) into each well and the absorbance at 410 nm was measured with 20-sec intervals over a 30-min period using a SpectraMax plate reader (Molecular Devices, Corp., Sunnyvale, CA). The velocities of each reaction at different inhibitor concentrations were calculated and the reciprocal velocities were plotted against inhibitor concentrations in Dixon graphs. The IC<sub>50</sub> values of reaction velocities were calculated through fitting the plots with linear equation. The DPP-IV enzyme inhibitor Diprotin A (Ile-Pro-Ile, Calbiochem, EMD Biosciences, San Diego, CA) was used as a positive control for the reactions. The IC<sub>50</sub> value for Diprotin A was determined to be 5.1 µM, corresponding closely with the published value of 3.5 µM (Leiting *et al.* (2003) *Biochem. J.* **371**: 525). Results from the DPP-IV inhibitor assay are presented in Table 1.

**[0309]** A peptide stability assay was performed with the GLP-1-peptidase inhibitor conjugates in human kidney brush border membranes (hKBBM), a preparation rich in various peptidases. Solutions of peptides (compounds 4992, 4983, 4984, and control peptides) in 50% ACN (300 µM, 70 µl) were transferred into Eppendorf® LoBind microcentrifuge tubes (Eppendorf North America, Westbury, NY) each containing 0.78 µl hKBBM in 100 µl HEPES buffer (25 mM, pH 7.4). The tubes were incubated in VorTemp 56™ (Eurotech Labs, UK) at 37°C vortexed at 500 RPM. At time points of 0, 1, 2, 3, 4, and 5 hours, 200 µl STOP solution (50% ACN, 1% formic acid) was added to a given tube, and the samples were allowed to incubate until the end of the experiment. The samples were collected after 5 hours, centrifuged, and 200 µl of the supernatants were transferred into mass spectrometry vials. The intensities of the mother ions in each vial were analyzed with API 150EX™ mass spectrometer (Applied Biosystems, Foster City, CA) and quantified using the ANALYST™ program. Results from the hKBBM stability assay are presented in Table 1.

**[0310]** Peptide-ACE peptidase inhibitor conjugate compounds were assessed in an ACE inhibition assay using purified ACE enzyme and chromogenic substrates. An ACE stock solution was prepared by dissolving 0.1 unit of enzyme (ACE from rabbit lung, Sigma Chemical Co., St. Louis, MO) in 0.640 mL of HEPES buffer (0.1 M, pH=8). A 2 mM stock solution of substrate (N-benzyloxycarbonyl-Phe-His-Leu-OH) dissolved in methanol. The ACE inhibitor compounds were dissolved in phosphate buffer (0.1 M, pH=8) at concentrations of 0.0, 1, 10, 20, 60 and 100 µM. For the inhibition assay, six 2 mL microcentrifuge tubes were prepared containing 1.45 mL of phosphate buffer pH=8, 0.05 mL of 10% NaCl and 0.015

mL of substrate solution. To each microcentrifuge tube was added 0.015 mL of one of the ACE inhibitor compound's stock solutions. The solutions were heated at 37 °C for about 5 minutes. The reaction was started by the addition of 5 µL of the ACE stock solution to each tube mixture (30 seconds in between). The reaction mixtures were incubated at 37 °C. After 5 min, 10 min, 30 min and 60 min., aliquots of 100 µL were taken from each tube (each sample was taken in intervals of 30 seconds). Tubes containing the 100 µL sample were floated in a boiling water bath for 5 min. and then cooled. The reaction samples were then treated with 20 µL of 2M NaOH and 20 µL of 0.1% phthaldialdehyde solution. The tubes were shaken for 4 minutes and 10 µL of 6 M HCl were added. After 60-90 min., 120 µL of this solution were transferred to a 96 well flat bottom-nonbinding-surface plate (top read), and the fluorescence read at  $\lambda_{\text{ex}}=365$  nm,  $\lambda_{\text{em}}=500$  using a FlexStation® spectrofluorimeter (Molecular Devices Corp., Sunnyvale, CA). Initial rates were determined from linear portions of product release curves. Starting substrate concentration in all assays was 20 µM. Apparent binding constants ( $K_d^{\text{app}}$  or  $K_i^{\text{app}}$ ) of inhibitors to ACE were determined by fitting inhibition curves (initial rate vs. inhibitor concentration) to equation:  $v = v_0 \frac{K_i^{\text{app}}}{[I] + K_i^{\text{app}}}$ , where  $v_0$  is reaction rate in the absence of inhibitor and  $[I]$  – inhibitor concentration. Fits were done by least-squares method using KaleidaGraph 3.6 (Synergy Software, Reading PA). Results from the ACE inhibition assay are presented in Table 2.

**Table 1. GLP-1/peptidase inhibitor conjugate activity assays.**

Compound	GLP RBA IC <sub>50</sub> (nM)	GLP Cyclase EC <sub>50</sub> (nM)	DPP-IV IC <sub>50</sub> (nM)	Stability in hKBBM
GLP-1	0.15	0.28	>3300	-
4844	0.087	0.13	91	ND
4845	0.10	0.40	76	ND
4992	13.0	15	ND	+
4983	13.0	239	ND	+++
4984	8.1	135	ND	+++

(ND = not done)

**Table 2. GLP-1 analog/ACE inhibitor conjugate activity assays.**

Compound	GLP RBA IC <sub>50</sub> (nM)	GLP Cyclase EC <sub>50</sub> (nM)	ACE inhibition IC <sub>50</sub> (nM)
GLP-1	0.15	0.28	ND
3633/21	ND	ND	1200
3633/21 ester	2	0.49	>10000
3633/24	ND	ND	250
3633/24 ester	0.49	1.2	>100,000
3633/42/1	ND	ND	1500
3633/42/2	ND	ND	1500
3633/42/3	ND	ND	180
3633/38	ND	ND	>10000

(ND = not done)

- [0311]** As described in Example 2, compounds 4844 and 4845 are GLP-1/DPP-IV inhibitor conjugates where the inhibitor motif is at the C-terminus of the GLP-1(7-37) (SEQ ID NO:42). Compounds 4983 and 4984 are GLP-1/vasopeptidase inhibitor conjugates where the inhibitor motif is at the N-terminus of the GLP-1(7-37). Compound 4992 is GLP-1(7-37) with a linker at the N-terminus and the linker is the same as that in compounds 4983 and 4984. Compounds 3633/21, 3633/24, 3633/42/1, 3633/42/2, 3633/42/3, and 3633/38 are conjugate compounds where an ACE inhibitor motif is at the C-terminus of GLP-1(7-37) or [<sup>14</sup>Leu]exendin(1-28) as described in Example 1.
- [0312]** As shown in Tables 1 and 2, conjugation of the peptidase inhibitor motif to the C-terminus of GLP-1 or exendin-1 analog preserves the ability of the conjugate to interact with the GLP-1 receptor, as demonstrated in both the receptor binding assay and the cyclase assay. Compare, for example, the results for compounds 4844 and 4845 with the results with GLP-1. The conjugate compounds tested also retained DPP-IV or ACE inhibitor activity.
- [0313]** Conjugation of the peptidase inhibitor motif to the N-terminus of GLP-1 reduces the GLP-1 activities by approximately 55-80-fold in receptor binding assay and approximately 500-800-fold in cyclase assay. Compare, for example, the results for compounds 4983 and 4984 with the results with GLP-1. Compound 4992 carries a linker at the same position as

compounds 4983 and 4984 and undergoes similar reductions in activities. Accordingly, the decreases in activities seen in compounds 4983 and 4984 essentially can be attributed to the positional effect of the linker and inhibitor motif.

[0314] Fig. 3 depicts analysis of the peptide stabilities in hKBBM analyzed by an LC-MS system in which the parent ions were followed over the course of the incubation and quantified through ion intensities. As shown in Fig. 3A, GLP-1(7-36) amide (SEQ ID NO:42) degraded rapidly in 1 hour while the N-terminus acylated GLP-1 analog 4992 degraded at a slower rate. The incretin mimetic exendin-4 (SEQ ID NO:64) showed essentially complete stability over the course of the incubation. The GLP-1 conjugate compounds 4983 and 4984 were remarkably stable compared to GLP-1(7-36) and the N-terminus acylated GLP-1, with greater than 80% of the intact conjugate compound being present after 4 hours. The hKBBM assay was also performed in the presence of valinepyrrolidide, a DPP-IV inhibitor. As shown in Fig. 3B, in the presence of valinepyrrolidide, the stabilities of all peptides tested improved to some degree. Since the stabilities did not improve to the full extent, the hKBBM assay appears to involve other peptidases.

[0315] Additional conjugates with the ACE inhibitor lisinopril were made as assessed for biological activity. These conjugate compounds have lisinopril joined at the C-terminus of the peptide through a variety of linkers as depicted in Fig. 2. The peptide components include exendin-4 and GLP-1 analogs as indicated in Table 3. The compounds were tested in ACE inhibition assays as described herein. Results from these assays are presented in Table 3.

[0316] The conjugates described in Table 3 were tested for GLP-1 cyclase activity using a whole cell assay which measure increases in cAMP in a cell line via the peptide-induced activation of the endogenously expressed GLP-1 receptor. Cells from the thyroid c-cell carcinoma line 6-23 were grown to confluence and harvested by treatment with Versene (0.5M EDTA). Upon harvest, cells were washed free of EDTA and resuspended in stimulation buffer (1X HBSS, 0.1% BSA, 5mM HEPES, 500uM IBMX, pH 7.4) at a concentration of  $2.5 \times 10^6$  cell/ml. Accumulation of cAMP was measured following 30' conjugate or control agent treatment using an HTRF® cell-based cAMP assay kit (Cisbio-US, Inc., Bedford, MA) in 384-well format. The compounds were tested at final concentrations from 1  $\mu$ M to 10 pM. The cell-conjugate mixture was incubated for 30' at room temperature, at which time the reaction was terminated by the addition of kit-provided  $\alpha$ -cAMP Cryptate solution. Plates were then sealed and stored at room temperature overnight to allow components to come to full equilibrium. cAMP content was then measured by time resolved fluorescence. Efficacy of the

tested agents was determined relative to cell treatment with 10 $\mu$ M forskolin (a constitutive activator of adenylate cyclase), and potency ( $EC_{50}$ ) of test agents was determined by the analysis of a concentration-response curve using non-linear regression analysis fitted to a 4-parameter model. Results from the GLP-1 cyclase assays are presented in Table 3. Unlike the other results in Table 3, the GLP-1 cyclase assay result for compound 5711 was from a cell membrane assay as described above.

**Table 3.**

Compound	Peptide	Linker type (see Fig. 2)	GLP Cyclase $EC_{50}$ (nM)	ACE inhibition $IC_{50}$ (nM)
5545	[ <sup>14</sup> Leu]exendin(1-28) (SEQ ID NO:70)	B6	0.15	1500
5546	[ <sup>14</sup> Leu]exendin(1-28) (SEQ ID NO:70)	A5	0.06	1500
5609	[ <sup>14</sup> Leu]exendin(1-28) (SEQ ID NO:70)	E17	0.65	1000
5605	[ <sup>14</sup> Leu]exendin(1-28) (SEQ ID NO:70)	F19	1.24	300
5606	[ <sup>14</sup> Leu]exendin(1-28) (SEQ ID NO:70)	G21	0.23	700
4828	[ <sup>14</sup> Leu]exendin(1-28) (SEQ ID NO:70); not conjugated	none	0.025	25
5547	GLP-1(7-37) (SEQ ID NO:42)	C9	0.40	180
5608	GLP-1(7-37) (SEQ ID NO:42)	D9	2.20	190
5607	GLP-1(7-37) (SEQ ID NO:42)	G21	0.55	100
5610	[Gly <sup>8</sup> ]GLP-1(7-37) (SEQ ID NO:272)	C9	2.0	50

5711	[Gly <sup>8</sup> ]GLP-1(7-37) (SEQ ID NO:272)	G21	11.0 (membr. assay)	460
5712	[ <sup>8</sup> Aib]GLP-1(7-37) (SEQ ID NO:271)	C9	0.35	100
3521	GLP-1(7-37) (SEQ ID NO:42); not conjugated	none	0.02	ND
5713	fGLP-1 (SEQ ID NO:45)	G21	2.89	700
5714	fGLP-1 (SEQ ID NO:45)	C9	2.93	350
5715	[ <sup>14</sup> Leu, <sup>28</sup> Gln]exendin- 4(1-32)-fGLP-1(33-37) (SEQ ID NO:269)	G21	0.06	260
5716	[ <sup>14</sup> Leu, <sup>28</sup> Gln]exendin- 4(1-32)-fGLP-1(33-37) (SEQ ID NO:269)	C9	0.14	140
4202	fGLP-1 (SEQ ID NO:45)	none	0.03	ND
5131	[ <sup>14</sup> Leu, <sup>28</sup> Gln]exendin- 4(1-32)-fGLP-1(33-37) (SEQ ID NO:269)	none	0.02	ND
Lisinopril (commercial; synthesized)	-	-	ND	1.3; 2.8

(ND = not done)

[0317] Additional conjugates with the ACE inhibitor lisinopril were made as assessed for biological activity. These conjugate compounds have lisinopril joined at the C-terminus of the peptide through a variety of linkers as depicted in Fig. 2. The peptide components include  
5 exendin-4 and GLP-1 analogs as indicated in Table 3. The compounds were tested in GLP-1 cyclase assays and ACE inhibition assays as described herein. Results from these assays are presented in Table 3.

#### Example 4: Characterization of GLP-1-Peptidase Inhibitor Conjugate Stability

[0318] DPP-IV resistance of the GLP-1-peptidase inhibitor conjugate compounds was also  
10 assessed using mass spectrometry. Mass spectrometry provides an excellent tool for analyzing

the degradation products of peptides *in vitro*. For the stability assay, 2  $\mu$ l of GLP-1, compound 4844, or compound 4845 (1 mM, dissolved in PBS buffer, pH 7.4, 2 nmol) was incubated in 146  $\mu$ l assay buffer (25 mM Tris-HCl, 140 mM NaCl, 10 mM KCl, pH 7.4) with 2  $\mu$ l recombinant DPP-IV (0.05 mU/ $\mu$ l) at room temperature for 15 hours in microcentrifuge tubes.

5 The peptides were then desalted and concentrated on a C18 peptide micro trap (Michrom Bioresources, Inc., Auburn, CA) prior to introduction to a LTQ FT<sup>TM</sup> mass spectrometer (Thermo-Electron Corp., Waltham, MA) via an autosampler (Michrom Bioresources, Inc.). Peptides were eluted from a C5 packed 75  $\mu$ m fused silica pico-frit column (New Objective, Inc., Woburn, MA) using a 5-60% acetonitrile/water gradient over 50 minutes at a flow rate of  
10 500 nl/min. Extracted ion mass windows for the calculated m/z values of the most dominant charge states were used to search for both the parent compound and the theoretical hydrolyzed products within a given chromatogram. Exact mass was confirmed for each charge state by FT. The percentage of hydrolysis catalyzed by DPP-IV was estimated by dividing the area of product ions by the area of the total (parent + product) ions.

15 **[0319]** As demonstrated in Fig. 4, the DPP-IV mediated cleavage of GLP-1 (7-36) to produce GLP-1 (9-36) can be monitored with ESI-MS with high sensitivity, and both the presence of mother ions and product ions can be quantified using the ion-extraction protocol. Fig. 4A depicts results of 50 fmol of GLP-1 in the assay buffer and Fig. 4B depicts results of 50 fmol of GLP-1 treated with 0.1 mU DPP-IV enzyme in the assay buffer for 12 hours. Fig. 4C  
20 depicts results of 200 fmol of conjugate compound 4844 treated with 0.1 mU DPP-IV enzyme in the assay buffer for 12 hours and Fig. 4D depicts results of 200 fmol of conjugate compound 4845 treated with 0.1 mU DPP-IV enzyme in the assay buffer for 12 hours. The N-terminal two-residue cleaved product was only observed in GLP-1 (Fig. 4B) and not in compound 4844, compound 4845, or GLP-1 alone (Fig. 4C, Fig. 4D, Fig. 4A, respectively). The estimated  
25 cleavage product conversion is based on the ratio of the ion extract area (indicated on top of the peaks) for [product ion]<sup>5+</sup> over that for total ions ([Mother Ion]<sup>5+</sup>+ [product ion]<sup>5+</sup>). The m/z ratios used to search for the expected ions are listed on the right side of the plots.

**[0320]** For GLP-1, it was found that the DPP-IV catalyzed cleavage afforded the GLP-1 (9-36) product in 17% yield. For the compounds 4844 and 4845 (DPP-IV inhibitory motif  
30 conjugated to the C-terminus of GLP-1), the expected product ions were not observed, indicating that these two compounds are DPP-IV resistant under the test conditions. Accordingly, the conjugate compounds have improved peptide stability against peptidase-mediated cleavage.

**Example 5: Characterization of GLP-1-Peptidase Inhibitor Conjugate Activity**

[0321] Glucose lowering effects of GLP-1 analog-peptidase inhibitor conjugates were determined in oral glucose tolerance tests (OGTT). Test compounds were injected IP (t = 0 min) immediately following baseline measurements of 2 hour fasted NIH/Swiss mice. Blood samples were taken at 60, 120, and 180 minutes after injection. In some assays, samples were also taken at 240 minutes after the injection. Blood glucose was measured with a One-Touch® Ultra® glucose meter (LifeScan, Inc., Milpitas, CA). Analysis of variance (ANOVA) was performed and, in Figs. 5 and 6, the data are represented as mean ± SEM and significant differences versus the vehicle control are indicated by \* (P-value <0.05).

[0322] Results from glucose lowering assays with conjugate compounds 4844 and 4845 are presented in Fig. 5. Results from glucose lowering assays with conjugate compounds 4983 and 4984 are presented in Fig. 6. These data demonstrate that these conjugate compounds not only retain the glucose-lowering activity of GLP-1 but generally offer enhance glucose-lowering action compared to GLP-1. Conjugate compound 4984, for example, demonstrated a prolonged effect 4 hours after dosing. Although compounds 4983 and 4984 were significantly less active *in vitro* in the GLP-1 cyclase assay (see Table 1), the prolonged duration of action by these conjugates support the importance of peptide half-life for activity *in vivo*.

**Example 6: GIP-Peptidase Inhibitor Conjugates**

[0323] Peptide-peptidase inhibitor conjugate molecules with a GIP analog as the peptide component were prepared using peptidase inhibitor and linker components described herein. In some conjugates, an N-(substituted glycyloxy)-2-cyanopyrrolidine was used as a DPP-IV inhibitor.

[0324] The GIP receptor binding activity (RBA) of the GIP analog-peptidase inhibitor conjugates was assessed using a binding displacement assay in which the receptor source was an HEK293 cell line stably expressing the human GIP receptor (HEK-GIPR). Membrane fractions were prepared from confluent cell cultures of HEK-GIPR, snap frozen, and stored at -80 °C until use. At the time of assay, membranes were thawed on ice and diluted to 0.02 mg/mL in ice cold binding buffer (20mM HEPES pH 7.4, 0.5% BSA, 5 mM MgCl<sub>2</sub>, 1 mM CaCl<sub>2</sub>, 170 μM Phosphoramidon, 1.5 mM Bestatin-HCl, and 70 mM Bacitracin).

Heterologous binding assays were initiated by combining membranes with 30 pM <sup>125</sup>I-GIP and 10 nM unlabeled GIP-peptidase inhibitor conjugates diluted in assay buffer. Reactions were allowed to proceed to equilibrium for 90 minutes at room temperature with constant shaking.

The reaction mixtures were then filtered through 96-well glass fiber filter plates separating bound and unbound fractions of radioligand. Displacement of radioligand for each conjugate was calculated relative to maximal displacement by human GIP (100%) and to non-specific binding (0%) in the absence of any competing ligand. Results for the GIP RBA (% inhibition at 10 nM) are shown in Table 4.

**[0325]** Glucose lowering effects of GIP analog-peptidase inhibitor conjugates were determined in oral glucose tolerance tests (OGTT). The tests were performed as described in Example 5. Results from the glucose lowering assays (% maximal decrease) using the conjugate at 30 nM/kg are shown in Table 4.

**Table 4.**

GIP analog-peptidase inhibitor conjugate	GIP RBA % inhibition at 10 nM	OGTT (30 nM/kg) % maximal decrease
Lys <sup>30</sup> N-ε-(Ado-(γ-L-Glu-2-(S)-cyano pyrrolidyl)) GIP(1-30)-exendin-4(31-39)	90%	-11%
Lys <sup>30</sup> N-ε-(Ado-(γ-L-Glu-2-(S)-cyano pyrrolidyl)) GIP(1-30)	33%	-10%
N-(γ-L-Glu-2-(S)-cyano pyrrolidyl)-Ado-Ado) GIP(1-30)-exendin-4(31-39)	25%	3%
N-(γ-L-Glu-2-(S)-cyano pyrrolidyl)-Ado-Ado) GIP(1-30)	32%	-8%
GIP(1-30)-exendin-4(31-39)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	98%	-18%
GIP(1-30)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	99%	-18%
GIP(1-30)-exendin-4(31-39)-Ado-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	100%	-22%
GIP(1-30)-Ado-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	97%	-17%
[ <sup>14</sup> Leu] GIP(1-30)-exendin-4(31-39)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	99%	-24%
[ <sup>14</sup> Leu] GIP(1-30)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	100%	-9%
[ <sup>2</sup> D-Ala] GIP(1-30)-exendin-4(31-39)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	93%	-20%

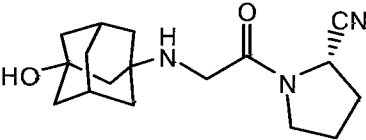
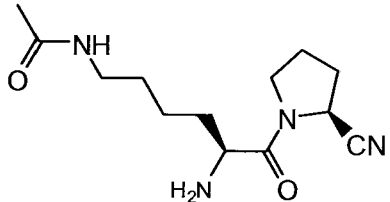
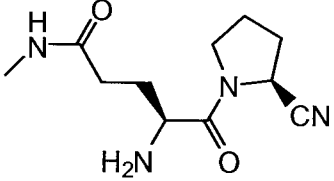
[ <sup>16</sup> Lys (N-ε-(Aun-Aun-(γ-L-Glu-2-(S)-cyano pyrrolidyl)))] GIP(1-30)-exendin(31-39)	ND	-3%
[ <sup>2</sup> D-Ala <sup>14</sup> Leu] GIP(1-30)-βAla-βAla-ε-NH-Lys(α-NH-Pyroglutamoyl)-Trp-Ala-Pro	66%	-12
[ <sup>2</sup> D-Ala] GIP(1-30)-Ado-Ado-Aun-βAla-βAla-ε-NH-Lys(α-NH-Pyroglutamoyl)-Trp-Ala-Pro	70%	-6%
[ <sup>2</sup> D-Ala <sup>14</sup> Leu] GIP(1-30)-exendin-4(31-39)-Ado-Ado-Aun-βAla-βAla-ε-NH-Lys(α-NH-Pyroglutamoyl)-Trp-Ala-Pro	86%	-21%

(ND = not done)

**[0326]** DPP-IV inhibition assays with GIP analog-DPP-IV inhibitor conjugates and control compounds were performed as described in Example 3. Results from the DPP-IV inhibition assays (IC<sub>50</sub>) are shown in Table 5. The IC<sub>50</sub> (nM) values in Table 5 are expressed as the mean SEM of at least three independent determinations.

**Table 5.**

GIP-1 analog-peptidase inhibitor conjugate or control compound	DPP-IV IC <sub>50</sub> (nM)
Lys <sup>30</sup> N-ε-(Ado-(γ-L-Glu-2-(S)-cyano pyrrolidyl)) GIP(1-30)-exendin-4(31-39)	164 ± 14
Lys <sup>30</sup> N-ε-(Ado-(γ-L-Glu-2-(S)-cyano pyrrolidyl)) GIP(1-30)	49 ± 6
N-(γ-L-Glu-2-(S)-cyano pyrrolidyl)-Ado-Ado) GIP(1-30)-exendin-4(31-39)	110 ± 2
N-(γ-L-Glu-2-(S)-cyano pyrrolidyl)-Ado-Ado) GIP(1-30)	64 ± 8
GIP(1-30)-exendin-4(31-39)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	103 ± 2
GIP(1-30)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	98 ± 5
GIP(1-30)-exendin-4(31-39)-Ado-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	133 ± 9
GIP(1-30)-Ado-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	114 ± 17
[ <sup>14</sup> Leu] GIP(1-30)-exendin-4(31-39)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	82 ± 2
[ <sup>14</sup> Leu] GIP(1-30)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	109 ± 1
[ <sup>2</sup> D-Ala] GIP(1-30)-exendin-4(31-39)-Ado-Lys-N-ε-(2-(S)-cyano pyrrolidyl)	85 ± 4
VILDAGLIPTIN (LAF237)	3.4 ± 0.2

	
<p>Lys(<math>\epsilon</math>-NH-acetyl)-(2)-S-cyanopyrrolidinamide</p> 	1400 ± 140
<p>Glu(<math>\gamma</math>-methylamido)-(2)-S-cyanopyrrolidinamide</p> 	4840 ± 280

[0327] A peptide stability assay was performed with GIP analog-DPP-IV inhibitor conjugates in human kidney membrane proteins, a preparation rich in various peptidases. A solution of Kidney Membrane Protein (KMP) for use in the assay was prepared by diluting a KMP preparation (approximately 7.7 ug protein/ul solution in 5 mM Tris-HCl) 1:125 in phosphate-buffered saline (PBS). The diluted KMP solution (630 ul) was dispensed in a deep well plate and a conjugate compound or control peptide (70 ul of 200 ug/ml) was mixed with the KMP solution. The deep well plate was incubated in a VorTemp 56™ incubator/shaker (Labnet International, Inc., Woodbridge, NJ) at 37°C while mixing at 500 PRM over a period of 5 hours. At time points of 0, 1, 2, 3, 4, 4, and 5 hours, aliquots of 25 ul were removed from each well and mixed with 100 ul of 5% phosphoric acid to a final conjugate or peptide concentration of 4 ug/ml. All samples were analyzed in triplicates over the time course. The plates were covered with plate mats and analyzed by on-line solid phase extraction LC/MS methods of the API 4000 Q TRAP or the API 3000 LC/MS/MS system.

[0328] The LC/MS results were quantified with ANALYST™ software by generating quantitation tables where a select compound ion is integrated and listed as peak area in triplicates and at 6 time points. Positive control and negative control compounds were included in the analysis and the final results are presented as % area under the curve and normalized to 100% positive control. Results from this assay for several of the conjugate compounds are shown in Fig. 7 and plotted as % parent peptide remaining based on peak area ratios versus time in KMP.

[0329] As shown in Table 4, conjugation of the peptidase inhibitor motif to the N-terminus or C-terminus of a GIP analog preserves the ability of the conjugate to interact with the GIP receptor. Three of the four conjugates shown in Table 4 with the peptidase inhibitor motif conjugated to the N-terminus of GIP had a reduced GIP receptor binding capacity compared to the conjugates with the peptidase inhibitor motif conjugated to the C-terminus of GIP. The GIP analog-peptidase inhibitor conjugate compounds have glucose lowering activity (Table 4). The GIP analog-DPP-IV inhibitor conjugate compounds retained DPP-IV inhibitor activity (Table 5). Fig. 7 depicts analysis of the peptide stabilities in kidney membrane extract analyzed by an LC-MS system in which parent ions were followed over the course of the incubation and quantified through ion intensities. As shown in Fig. 7, the GIP analog-peptidase inhibitor conjugates were remarkably stable compared to GIP in the kidney membrane assay.

#### **Example 7: Characterization of Carboxypeptidase Inhibitor Activity**

[0330] Cleavage of the C-terminal tyrosylamide from PYY(3-36) forming PYY(3-35) (SEQ ID NO:245) has been demonstrated in rat, mouse and human plasma. This plasma carboxypeptidase appears to be a serine protease since its activity was inhibited by 4-(2-aminoethyl)-benzenesulfonylfluoride (AEBSF) but not by the metalloprotease inhibitors EDTA or phosphoramidon (each protease inhibitor at a final concentration of 1 mM). Carboxypeptidase activity assays were performed in the presence of various agents to test for carboxypeptidase inhibitor activity of the agents.

[0331] Carboxypeptidase activity assays were performed by preparing 10 µg/ml of amidated PYY(3-36) as substrate in human plasma in a sufficient volume to remove 100 µL samples every 10 minutes for sixty minutes, starting at the zero time point. Following the addition of substrate PYY(3-36) to the human plasma, the sample is mixed gently and a 100 µl sample of the mixture was transferred to a microcentrifuge tube to represent the zero time point. The remainder of the sample was placed in an incubator at 37°C, mixing at 600 RPM for sixty minutes. At 10 minute intervals, a 100 µl sample of the mixture was removed and transferred to a separate microcentrifuge tubes. Following the transfer of the 100 µL sample at the zero time point and each 10 minute interval, each collected sample was extracted by slow addition of 100 µl cold 0.2 % formic acid:acetonitrile, while mixing. After addition of the acetonitrile solution, the sample was vortex mixed at high speed for 15 seconds. The extracted samples were stored at -20 °C for at least 20 minutes and then centrifuged at 11,000 x g for 10 minutes at 5 °C. The supernatant of each sample was transferred to a new microcentrifuge tube,

centrifuged again, and finally transferred for LC/MS analysis. The MS analysis was a Q1 single ion monitoring method that detects the most intense ion of the parent molecule and the peptide fragment of interest. The carboxypeptidase activity was measured by the appearance of PYY(3-35).

5 [0332] As shown in Fig. 8, incubation of PYY(3-36) in human plasma results in a disappearance of PYY(3-36) and an accompanying appearance of PYY(3-35) (SEQ ID NO:245), the metabolite of PYY(3-36).

[0333] A series of peptide-based inhibitors were created by adding a methyl group to the  $\alpha$ -amino nitrogen on Tyr<sup>36</sup> of PYY (<sup>36</sup>N-methyl-Tyr-amide-PYY(3-36)) and N-terminal  
10 truncations of this peptide. The peptide-based inhibitors were tested for inhibitor activity in the carboxypeptidase activity assay. <sup>36</sup>N-methyl-Tyr-amide-PYY(3-36) demonstrated inhibitory activity in the presence of PYY(3-36) inhibiting the formation of PYY(3-35) by ~100% at 0.5mM in human plasma. See, for example, Fig. 9. As shown in Fig. 10, <sup>36</sup>N-methyl-Tyr-amide-PYY(22-36) (0.5mM) had measurable but lower activity to inhibit the formation of  
15 PYY(3-35). Shorter fragments of this peptide, <sup>36</sup>N-methyl-Tyr-amide-PYY(34-36) and N-methyl-Tyr-NH<sub>2</sub> did not inhibit the formation of PYY(3-35) at 0.5mM (Figs. 11 and 12, respectively).

#### **Example 8: Peptide-Peptidase Inhibitor Conjugates in Congestive Heart Failure Assay**

[0334] P-PI conjugates comprising an exendin analog and the ACE inhibitor lisinopril were  
20 tested in a congestive heart failure (CHF) *in vivo* assay. The conjugates tested were compounds 5715 and 5131 as described in Table 3. In this assay, Dahl salt-sensitive (DSS) male rats were weaned at 21 days of age, maintained on a low-salt (LS) diet (0.2% NaCl) for 2 weeks. Rats were anesthetized with ketamine/xylazine (50 mg/kg/10 mg/kg, IP) and telemetry transmitters (Data Sciences, Inc.) were inserted to the aortic artery when rats were at 5 weeks  
25 of age. After surgery, the rats were allowed 10 days to recuperate before their BP (systolic and diastolic pressures) was recorded.

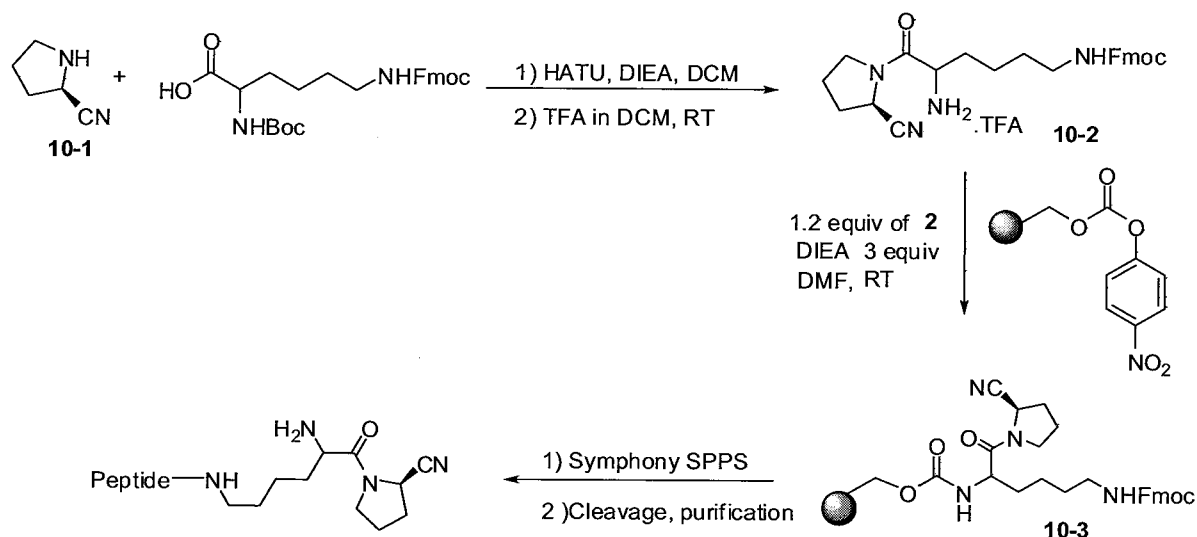
[0335] Starting from 5 weeks of age, DSS rats were fed a high-salt (HS) diet (8% NaCl,) and were infused subcutaneously with conjugate compound 5715 (10  $\mu$ g/kg/day) (n = 3 rats) or conjugate compound 5131 (10  $\mu$ g/kg/day) (n = 7 rats) via osmotic Alzet® pumps (Durect  
30 Corp., Cupertino, CA) for 5 weeks. HS control animals (n = 10 rats) were administered vehicle (50% DMSO) and fed HS in the same manner. LS control animals (n = 5 rats) were maintained on the LS diet.

[0336] Fig. 13 depicts the mean diastolic (Fig. 13A) and systolic (Fig. 13B) blood pressure determined at week 5 (mean of all the animals in each group). As measured at week 5, administration of the P-PI conjugates to the animals on a HS diet resulted in a mean lower diastolic blood pressure (134 mmHg for compound 5131 and 112 mmHg for compound 5715) and systolic blood pressure (175 mmHg for compound 5131 and 161 mmHg for compound 5715) compared to that of the animals in the HS control (167 mmHg diastolic and 213 mmHg systolic). Also at week 5, the mean heart rate of the animals was 363 for those receiving compound 5131, 381 for those receiving compound 5715, 401 for the HS control animals and 386 for the LS control animals.

### 10 Example 9: Synthesis of Peptide-Linker-DPP-IV Inhibitor Conjugates

[0337] Conjugate molecules can be prepared by linking peptides, including without limitation hybrid GLP-1, GLP-2, GIP, exendin, PYY, amylin, calcitonin, or leptin compounds or analogs thereof, to DPP-IV inhibitors through a linker as described herein; see Scheme 10.

#### Scheme 10:



*Preparation of a peptidyl-2, 6-diamino-1-(pyrrolidin-2-cyano-1-yl) hexan-1- amide.*

[0338] *Preparation of 2-cyanopyrrolidin-(S)-2 amino-6-(Fmoc)-aminohexylcarbamate (Species 10-2):* (S)-pyrrolidine-2-carbonitrile-HCl (Species 10-1) and DIEA can be dissolved in anhydrous DCM followed by the addition of HATU and Boc-Lys-Fmoc-OH. After reaction, the mixture can be diluted with DCM and washed with acid and brine, and dried. The solution can be filtered and concentrated, and the residue can be purified by flash chromatography using a gradient as known in the art to afford Species 10-2.

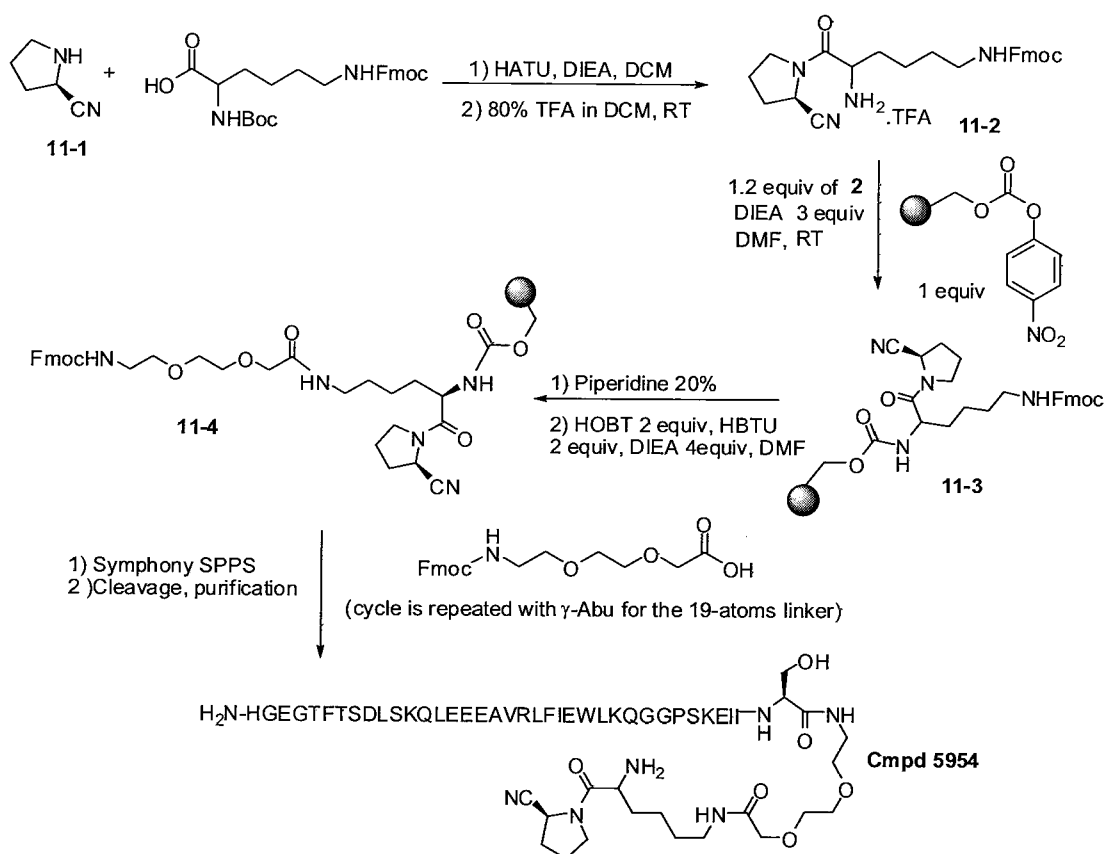
[0339] *Loading of resin 10-3:* A resin, e.g., *p*-nitrophenyl carbonate Wang resin, can be swelled in DMF followed by treatment with a mixture of Species **10-2** and a solvent, e.g., DMF. The reaction mixture can be agitated in a shaker at room temperature overnight to afford resin **10-3**.

5 [0340] *Preparation of peptide-linker-DPP-IV inhibitor conjugate:* Resin **10-3** can be weighed into a reaction vessel in a peptide synthesizer, e.g., a Symphony® peptide synthesizer (Protein Technologies, Inc.), and the peptide elongation can be carried out following standard Fmoc peptide synthesis protocol. The completed peptide can be cleaved from the resin and purified with methods well known in the art to afford the titled compound.

### 10 Example 10: Synthesis of Peptide-Linker-DPP-IV Inhibitor Conjugates

[0341] Conjugate molecules were prepared by linking peptides with sequence as described herein, to DPP-IV inhibitors through linkers as described herein; see *e.g.*, Scheme 11.

**Scheme 11:**



15 *Preparation of [<sup>14</sup>Leu,<sup>28</sup>Gln]Exendin-4-(1-32)-fGLP-1-(33-37)-miniPEG-(S)-2, 6-diamino-1-(pyrrolidin-2-cyano-1-yl) hexan-1- amide, Cmpd 5954.*

[0342] *Preparation of 2-cyanopyrrolidin-(S)-2-amino-6-(Fmoc)-aminohexylcarbamate (Species 11-2)*: 0.339 g (1.5 equiv) of (S)-pyrrolidine-2-carbonitrile-HCl and 0.869 mL (3 equiv) of DIEA were dissolved in 3 mL of anhydrous DCM followed by the addition of 0.947 g of HATU (1.5 equiv) and 0.776 g (1 equiv) of Boc-Lys-Fmoc-OH. After 3 hours, the reaction mixture was diluted with DCM and washed with 1 N HCl 2 times, with brine once and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. The solution was filtered and concentrated and the residue purified by flash chromatography in a Biotage SP1 system, using a gradient of Hex:AcOEt (4:6) to give 0.92 g of **2** (98% yield). Retention time in LCMS (C<sub>18</sub>, 30-95% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 6 min) is 2.94; Calculated mass for C<sub>31</sub>H<sub>38</sub>N<sub>4</sub>O<sub>5</sub> (M+H)<sup>+</sup> 546.66, found by LC-MS 546.3.

[0343] *Loading of resin 11-3*: 0.410 g (loading = 0.7 mmol/g) of *p*-nitrophenyl carbonate Wang resin was swelled in DMF for 10 min followed by treatment with a mixture of 0.185 g (1.2 equiv) of compound **11-2** and DIEA 0.151 mL (3 equiv) in DMF. The reaction mixture was agitated in a shaker at room temperature overnight. A small amount of resin (~10 mg) was treated with 90% TFA in DCM for 2 h, followed by LCMS analysis of the solution which confirmed the structure of the on-resin molecule. Loading of the resin by weight gain calculation was estimated to be 0.60 mmol/g.

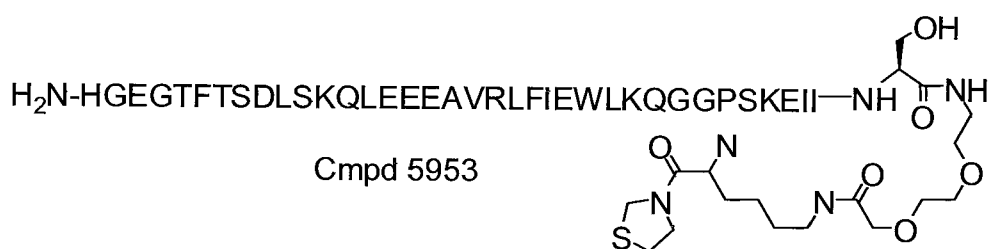
[0344] *Preparation of resin 11-4*: Resin **11-3**, 0.26 g (loading = 0.60 mmol/g) was swelled in DMF for 10 min, followed by two consecutive treatments with 20% piperidine, chloranil test confirmed a complete Fmoc deprotection. After washing 6 times with DMF, the resin slurry was treated with a mixture of 0.044 g (2 equiv) of HOBt, 0.121 g (2 equiv) of HBTU, 0.123 g (2 equiv) of Fmoc-8-amino-3, 6-dioxo octanoic acid and 0.112 mL (4 equiv) of DIEA in DMF. The reaction mixture was agitated in a shaker for 3 h at room temperature. Coupling was confirmed by a negative chloranil test. A small amount of resin (~10 mg) was treated with 90% TFA in DCM for 2 h, followed by LCMS analysis of the solution which confirmed the structure of the on-resin molecule.

[0345] *Preparation of Cmpd 5954*: A calculated 100 μmol of the modified carbamate resin **11-4** was weighed into a reaction vessel in a Symphony peptide synthesizer, and the peptide elongation was carried out following standard Fmoc peptide synthesis protocol. The peptide was cleaved from the resin with 10 ml TFA/H<sub>2</sub>O/PhOH/TIPS (95:2:2:1), precipitated by methyl-*tert*-Butyl ether and the obtained residue applied to a reverse-phase HPLC column (C<sub>18</sub>, 20-50% CH<sub>3</sub>CN in 0.1% TFA/H<sub>2</sub>O over 30 min gradient) to afford the titled compound as a white powder (49.5 mg, 16%): Retention time in RP-HPLC (C<sub>18</sub>, 5-75% CH<sub>3</sub>CN in 0.1%

TFA/H<sub>2</sub>O over 15 min) is 8.08 min; Calculated mass for C<sub>203</sub>H<sub>321</sub>N<sub>53</sub>O<sub>63</sub> (M+H)<sup>+</sup> 4512.14, found by LC-MS 1505.8 (M+3H)<sup>3+</sup>, 1129.6 (M+4H)<sup>4+</sup>, 903.5 (M+5H)<sup>5+</sup>.

*Preparation of Cmpd 5953*

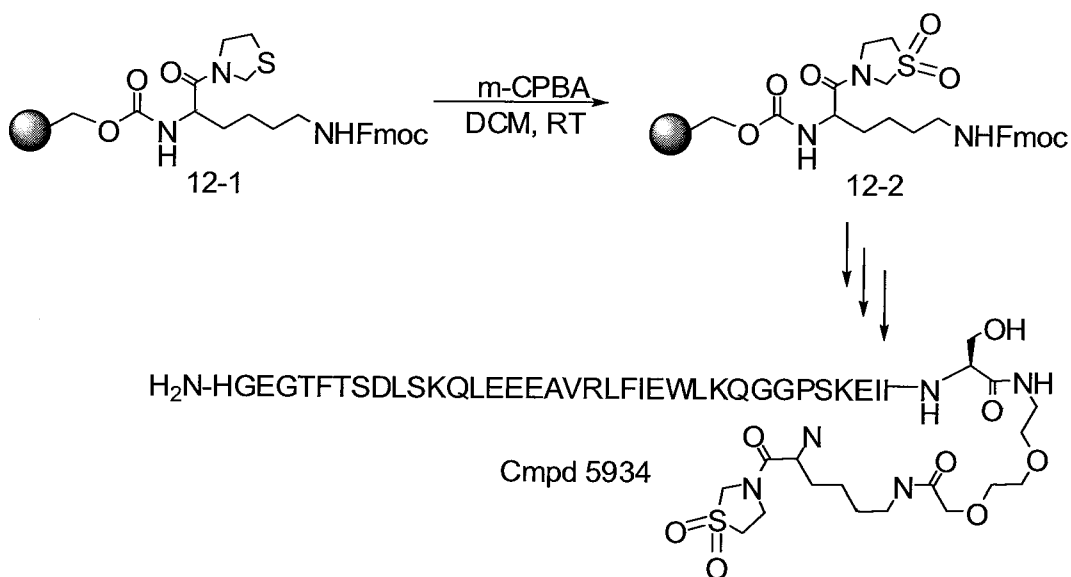
[0346] For the preparation of Cmpd **5953**, thiazolidine was used instead of (S)-pyrrolidine-2-carbonitrile-HCl (Species **11-1**) shown in Scheme 11, which scheme was then followed as described to afford Cmpd **5953**.



*Preparation of Cmpd 5934*

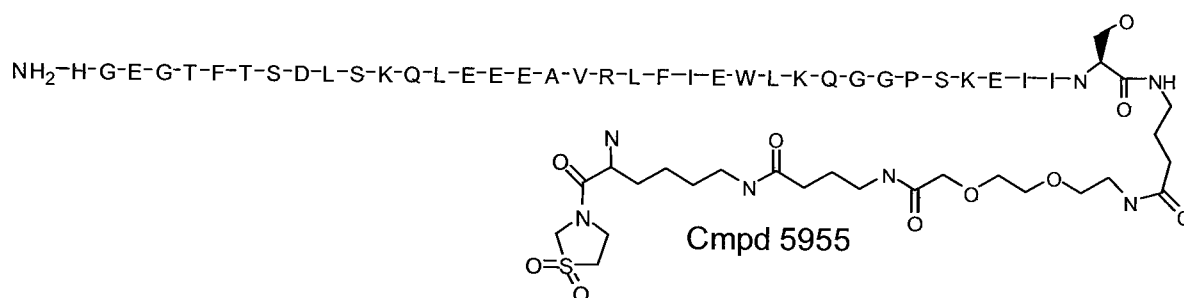
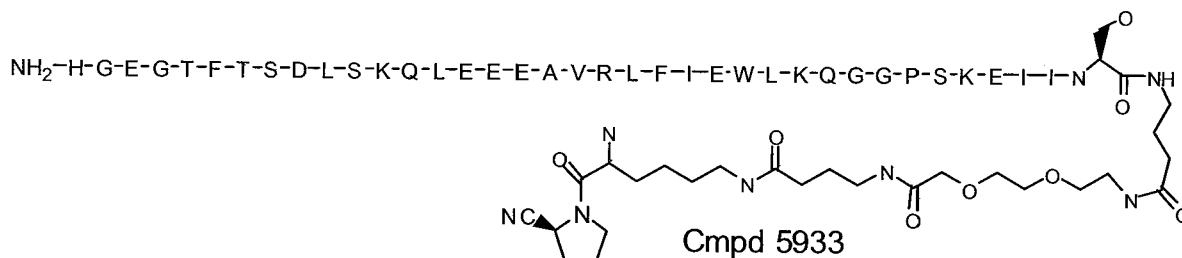
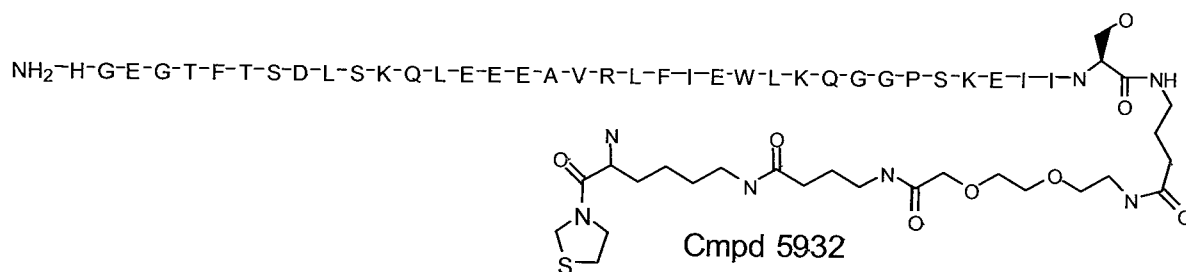
[0347] For the preparation of Cmpd **5934**, the resin resulting from the use of thiazolidine in Scheme 11 (i.e., resin **12-1** of Scheme 12) was treated with m-CPBA (5 equiv) in DCM for 3 hours. After complete oxidation of the sulfide to sulfoxide, as checked by cleavage and LCMS analysis, resin **12-2** was used for the synthesis of Cmpd **5934** following the above described scheme.

**Scheme 12:**



[0348] *Synthesis of longer linker analogs:* Synthesis of Cmpds **5932**, **5933** and **5955** containing a 19-atom linker were prepared using the experimental procedures described in Schemes 11-12, wherein the condensation represented in step 3 of Scheme 11 was repeated

with  $\gamma$ -Abu for the 19-atom linker. The chemical yields were similar in all conjugates prepared, affording the compounds with structure as follows:



5

### Example 11: Biological Activities and Stabilities of Peptide-Linker-DPP-IV Inhibitor Conjugates

[0349] Compounds of Example 10 were assessed in a GLP-1 cyclase assay as described herein and known in the art. Additionally, peptide stability assays were performed in hKBBM as described, with results presented in Table 6.

10

**Table 6.**

Compound	GLP Cyclase EC <sub>50</sub> (nM)	Stability in hKBBM	Linker size <sup>1</sup> (# of atoms)	DPP-IV moiety
5932	0.012	63%	19	thiazolidine
5933	0.012	87%	19	cyanopyrrolidine
5934	0.012	97%	9	Pyrrolidine-3-sulfoxide
5953	0.014	76%	9	thiazolidine
5954	0.017	57%	9	cyanopyrrolidine
5955	0.012	36%	19	Pyrrolidine-3-sulfoxide

<sup>1</sup> "Linker size" refers to number of atoms in linker added in Step 3 of Scheme 11.

**Example 12. DPP-IV Inhibitor Conjugates: Transient Effect on Glucose and Body Weight**

[0350] Compounds as described in Examples 10-11 and exendin-4 were assessed for transient effect on blood glucose and body weight. A subcutaneous injection (200  $\mu$ L) of vehicle (PBS) or test compound was given to NIH/Swiss female mice immediately following baseline glucose and body weight measurement. Tail blood glucose samples were measured (OneTouch® Ultra®, LifeScan Inc., Milpitas, CA) at baseline (time=0) and 2, 4, 8, 24, 48, 72 and 96 hrs. Body weight was measured daily. Significant test sample effects were identified by ANOVA ( $p < 0.05$ ) followed by Dunnett's post test (GraphPad PRISM®, version 4.00 for Windows, GraphPad Software, San Diego, CA). Points in Fig. 14A, Fig. 14B, Fig. 15A and Fig. 15B represent mean  $\pm$  SD (standard deviation). Fig. 14A provides blood glucose assay results over time for Cmpds **5933** and **5954** (250 nmol/kg) and exendin-4 (5 nmol/kg). As observed in Fig. 14B, Cmpds **5933** and **5954** elicit a decrease in body weight, measurable at day 2 which continues at least through day 5. Fig. 15A provides blood glucose assay results over time for Cmpds **5932** and **5955** (250 nmol/kg) and exendin-4 (5 nmol/kg). As observed in Fig. 15B, Cmpds **5932** and **5955** elicit a decrease in body weight, measurable at day 2. For Cmpd **5955** body weight returns to pre-treatment levels by day 5, whereas for Cmpd **5932** body weight does not return to pre-treatment levels by day 5.

[0351] While the foregoing description discloses the present invention, with examples provided for the purpose of illustration, it will be understood that the practice of the present invention encompasses all of the usual variations, adaptations, or modifications as being within the scope of the claimed invention. Therefore, descriptions and examples should not be construed as limiting the scope of the invention, which is delineated by the appended claims.

[0352] All patents and other references cited herein are indicative of the level of skill of those skilled in the art to which the references pertain, and are incorporated by reference in their entireties and for all purposes, including any tables and figures, to the same extent as if each reference had been incorporated by reference in its entirety individually.

[0353] One skilled in the art would readily appreciate that the present invention is well adapted to obtain the ends and advantages mentioned, as well as those inherent therein. The methods, variances, and compositions described herein as presently representative embodiments and are exemplary and are not intended as limitations on the scope of the

invention. Changes therein and other uses will occur to those skilled in the art, which are encompassed within the spirit of the invention, are defined by the scope of the claims.

5 [0354] It will be readily apparent to one skilled in the art that varying substitutions and modifications may be made to the invention disclosed herein without departing from the scope and spirit of the invention.

10 [0355] The invention illustratively described herein suitably may be practiced in the absence of any element or elements, limitation or limitations which is not specifically disclosed herein. Thus, for example, in each instance herein any of the terms “comprising”, “consisting essentially of” and “consisting of” may be replaced with either of the other two terms to describe distinct subject matter. The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention that in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has  
15 been specifically disclosed by certain embodiments and optional features, modification and variation of the concepts herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention as defined by the claims.

20 [0356] In addition, where features or aspects of the invention are described in terms of Markush groups or other grouping of alternatives, those skilled in the art will recognize that the invention is also thereby described in terms of any individual member or subgroup of members of the Markush group or other group.

25 [0357] Also, unless indicated to the contrary, where various numerical values are provided for embodiments, additional embodiments are described by taking any two different values as the endpoints of a range. Such ranges are also within the scope of the described invention.

## CLAIMS

We claim:

1. A method for synthesizing a peptide-peptidase inhibitor (P-PI) conjugate having peptide, linker and peptidase inhibitor components with structure

5 Peptide-linker-peptidase inhibitor

wherein said linker is optional, said method comprising:

- a) coupling a peptidase inhibitor to a resin under conditions suitable to form a resin-bound peptidase inhibitor, said peptidase inhibitor comprising a peptidase inhibitor core and an initial linker covalently bound thereto, said peptidase inhibitor  
10 comprising a first amine and a second amine, and said peptidase inhibitor coupled to said resin through said first amine;
- b) optionally coupling at said second amine an extended linker to form said optional linker, said extended linker comprising an amine which replaces said second amine;
- c) coupling said peptide, one or more amino acids, or one or more fragments of said  
15 peptide at said second amine under conditions suitable to form said P-PI conjugate; and
- d) cleaving said P-PI conjugate from said resin, thereby providing said peptide-peptidase inhibitor (P-PI) conjugate.

2. The method according to Claim 1, wherein said peptidase inhibitor is formed by  
20 coupling said peptidase inhibitor core with said initial linker under conditions suitable to form said peptidase inhibitor.

3. The method according to Claim 2, wherein said initial linker is coupled to an extended linker prior to coupling with said peptidase inhibitor core, said extended linker comprising an amine which replaces said second amine of said peptidase inhibitor, thereby providing said  
25 optional linker.

4. The method according to Claim 2, wherein said initial linker is coupled to an extended linker after coupling with said peptidase inhibitor core, said extended linker comprising an amine which replaces said second amine of said peptidase inhibitor, thereby providing said optional linker.

30 5. The method according to Claim 1, wherein step b) is conducted.

6. The method according to any one of Claims **1-5**, wherein said peptidase inhibitor is selected from the group consisting of inhibitors of angiotensin converting enzyme (ACE), vasopeptidase, neuraminadase, plasma peptidase, endothelial converting enzyme, human neutral endopeptidase, dipeptidyl peptidase IV (DPP-IV), aminopeptidase, cysteine proteases, serine proteases, and carboxypeptidases.
7. The method according to Claim **6** wherein said peptidase inhibitor is a DPP-IV inhibitor.
8. The method according to Claim **7**, wherein said DPP-IV inhibitor comprises a moiety selected from the group consisting of cyanopyrrolidine, thiazoline, pyrrolidine-3-sulfoxide, and derivatives thereof.
9. The method according to Claim **8**, wherein said DPP-IV inhibitor is selected from the group consisting of thiazolidine, cyanopyrrolidine and pyrrolidine-3-sulfoxide.
10. The method according to Claim **9**, wherein said DPP-IV inhibitor is cyanopyrrolidine.
11. The method according to Claim **7** wherein said DPP-IV inhibitor is selected from the group consisting of N-(substituted glycy)-2-cyanopyrrolidine, tetrahydroisoquinoline 3-carboxamide derivatives, fluorinated cyclic amides, adamantylglycine-based inhibitors, glycinenitrile-based inhibitors, and boropyrrolidine inhibitors.
12. The method according to any one of Claims **1-11**, wherein said initial linker comprises a diamino acid.
13. The method according to Claim **1-12**, wherein said initial linker comprises 3-8 carbon atoms.
14. The method according to Claim **12-13**, wherein said diamino acid is lysine or a homolog thereof.
15. The method according to Claim **14**, wherein said diamino acid is selected from the group consisting of homohomolysine, homolysine, lysine, ornithine, diaminobutyric acid and diamino propionic acid.
16. The method according to Claim **14**, wherein said initial linker is formed by reaction of said peptidase inhibitor core with Boc-Lys-Fmoc-OH.

17. The method according to any one of Claims **1-16**, wherein said initial linker is attached to an amine group of said peptidase inhibitor core.
18. The method according to any one of Claims **1-17**, wherein said peptidase inhibitor is attached to a carboxylic acid group of said peptide of said P-PI conjugate.
- 5 19. The method according to Claim **18**, wherein said carboxylic acid group of said peptide of said P-PI conjugate is the C-terminal carboxylic acid.
20. The method according to Claim **18**, wherein said carboxylic acid group of said peptide of said P-PI conjugate is an internal carboxylic acid.
21. The method according to any one of Claims **1-17**, wherein said peptidase inhibitor is  
10 attached to an amine group of said peptide of said P-PI conjugate.
22. The method according to Claim **21**, wherein said amine group of said peptide of said P-PI conjugate is the N-terminal amine.
23. The method according to Claim **21**, wherein said amine group of said peptide of said P-PI conjugate is an internal amine.
- 15 24. The method according to any one of Claims **1-17**, wherein said peptidase inhibitor is attached to a sulfhydryl group of said peptide of said P-PI conjugate.
25. The method according to any one of Claims **1-24**, wherein said linker, if present, comprises 5 to 24 backbone atoms.
26. The method according to Claim **25**, wherein said linker, if present, comprises 9 to 19  
20 backbone atoms.
27. The method according to any one of Claims **1-26**, wherein said linker, if present, comprises a diamino acid.
28. The method according to any one of Claims **1-27**, wherein said linker, if present, comprises one or more polyethylene oxide monomers.
- 25 29. The method according to Claim **28**, wherein said linker, if present, comprises 1 to 2 polyethylene oxide monomers.

30. The method according to any one of Claims 1-29, wherein the linker, if present, is selected from the group consisting of 8-amino-3,6-dioxo octanoic acid, [ $\beta$ -Ala]<sub>x1</sub> wherein x1 is 1 to 5, [gly]<sub>x2</sub> wherein x2 is 1 to 5, [[Gly]<sub>x3</sub>-Xaa]<sub>y3</sub> wherein x3 is 1 to 5, y3 is 1 to 5, and wherein Xaa is any naturally-occurring amino acid, and [ $\gamma$ -Abu]<sub>x4</sub> where x4 is 1 to 5.
- 5 31. The method according to any one of Claims 1-30 wherein said resin contains a chemical group that couples with a chemical group of said peptidase inhibitor while retaining the ability to allow cleavage of said P-PI from said resin.
32. The method according to Claim 31, wherein said resin is a *p*-nitrophenyl carbonate Wang resin.
- 10 33. The method according to any one of Claims 1-32, wherein said peptide of said P-PI conjugate is a therapeutic peptide susceptible to cleavage by a peptidase.
34. The method according to Claim 33, wherein said therapeutic peptide is selected from the group consisting of incretins, amylinomimetics, glucose-dependent insulinotropes, leptins, cholecystokinins, pancreatic polypeptides, and analogs thereof.
- 15 35. The method according to any one of Claims 33-34, wherein said peptide of said P-PI conjugate is a native peptide hormone.
36. The method according to any one of Claims 33-35, wherein said peptide of said P-PI conjugate is selected from the group consisting of GLP-1, GLP-2, a GIP, exendin-3, exendin-4, PYY, amylin, calcitonin, leptin, and analogs thereof.
- 20 37. The method according to any one of Claims 1-36, wherein said peptide of said P-PI conjugate is an analog, derivative or hybrid of a native peptide hormone.
38. The method according to Claim 37, wherein said hybrid of a native peptide hormone comprises one or more hormone portions selected from the group consisting of GLP-1, GLP-2, GIP, exendin-3, exendin-4, PYY, amylin, calcitonin, leptin, and analogs thereof.
- 25 39. The method according to Claim 38, wherein said hybrid of a native peptide hormone comprises portions selected from both exendin-4 and GLP-1.
40. The method according to Claim 39, wherein said hybrid of a native peptide hormone is [<sup>14</sup>Leu,<sup>28</sup>Gln]Exendin-4(1-32)-fGLP-1-(33-37) (SEQ ID NO:269).

41. The method according to Claim 33, wherein said peptidase is DPP-IV, and wherein said peptide of said P-PI conjugate is selected from the group consisting of GLP-1, GIP, PYY, NPY and exendin-4, or an analog or derivative thereof.
42. A composition comprising a resin-bound peptidase inhibitor,  
5 wherein peptidase inhibitor comprises a peptidase inhibitor core and an initial linker covalently bound thereto,  
wherein said peptidase inhibitor comprises a first amine and a second amine,  
wherein said peptidase inhibitor is coupled to said resin through said first amine,  
wherein said peptidase inhibitor is optionally coupled to a linker, said linker comprising  
10 an extended linker coupled to said second amine, and said extended linker comprising an amine which replaces said second amine.
43. The composition according to Claim 42, wherein said peptidase inhibitor is a DPP-IV inhibitor.
44. The composition according to Claim 43, wherein said DPP-IV inhibitor is selected from  
15 the group consisting of pyrrolidine, cyanopyrrolidine, thiazoline, and derivatives thereof.
45. The composition according to any one of Claims 42-44, wherein said resin is a *p*-nitrophenyl carbonate Wang resin.
46. The composition according to any one of Claims 42-44, wherein said extended linker is an amino carboxylic acid.
- 20 47. The composition according to any one of Claims 42-46, wherein said extended linker is selected from the group consisting of 8-amino-3,6-dioxo octanoic acid and  $\gamma$ -Abu.
48. The composition according to Claim 42, further comprising one or more amino acids coupled to said second amine.

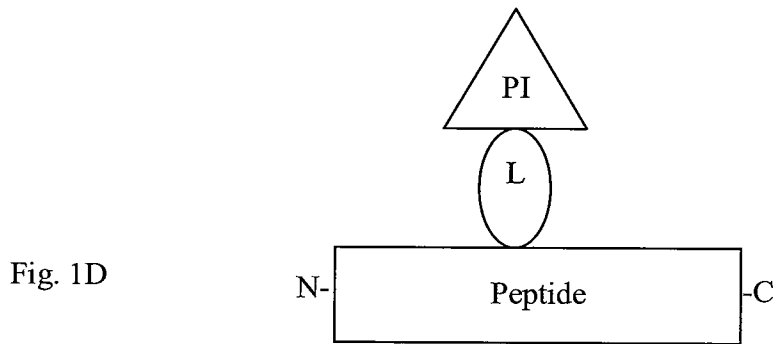
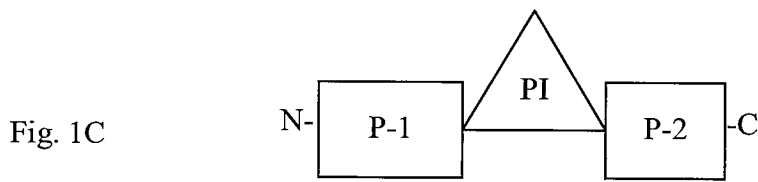
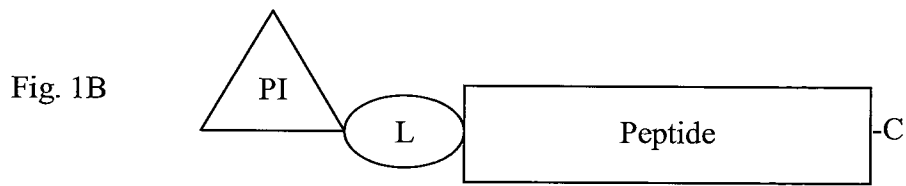
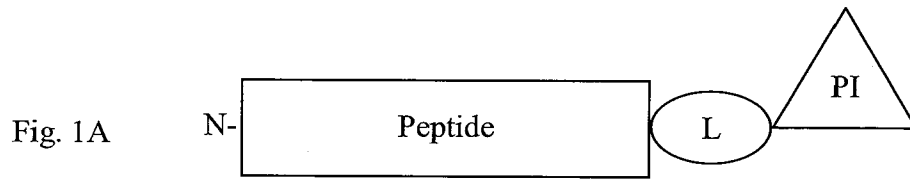


Fig. 2

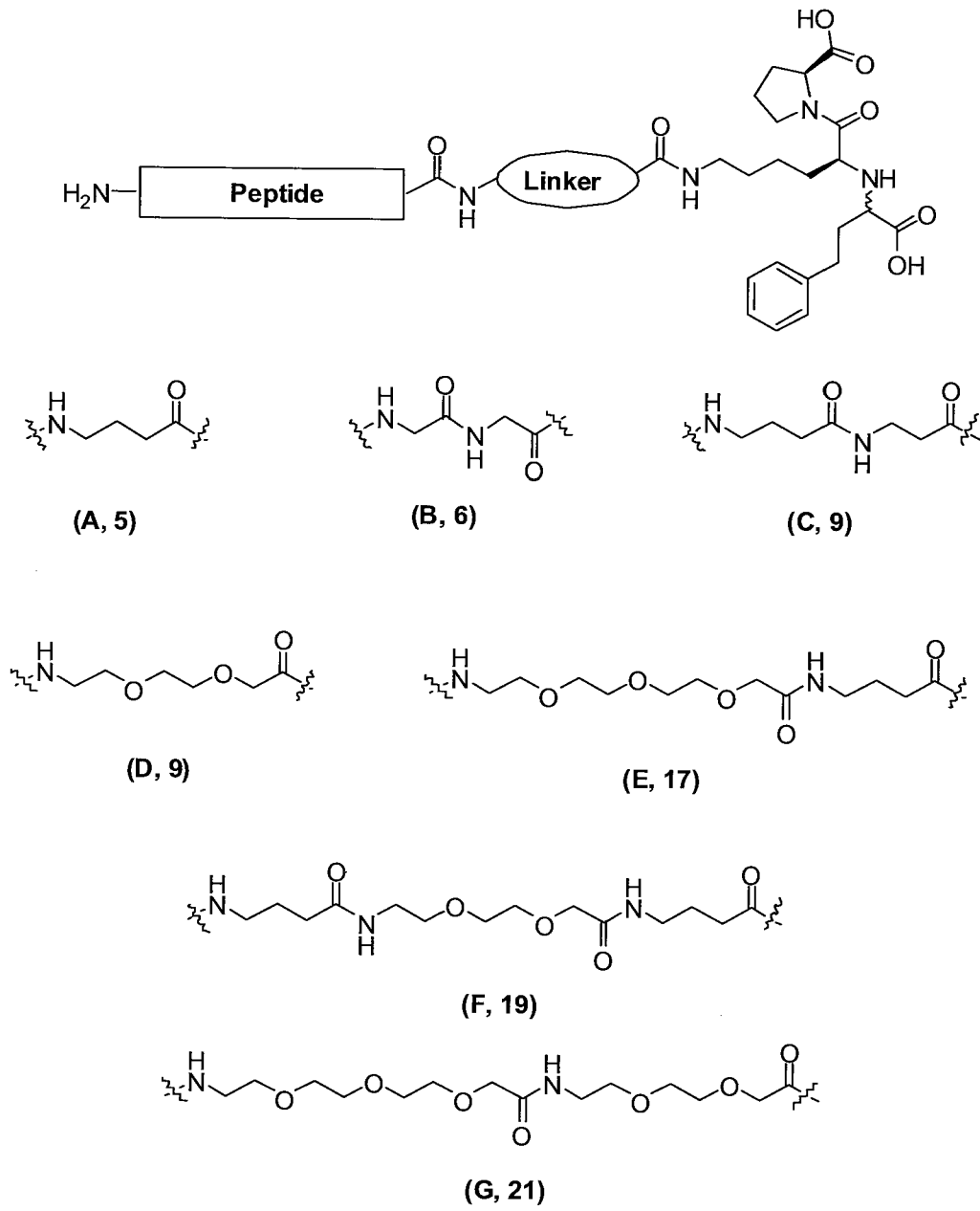


Fig. 3A

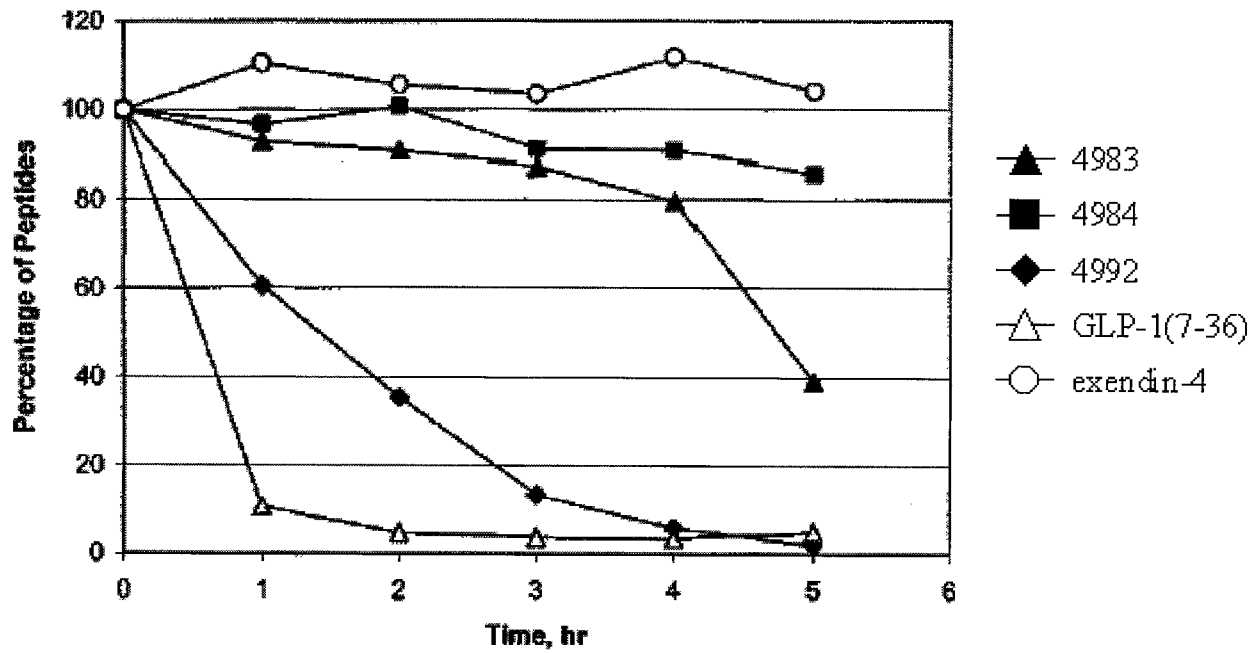


Fig. 3B

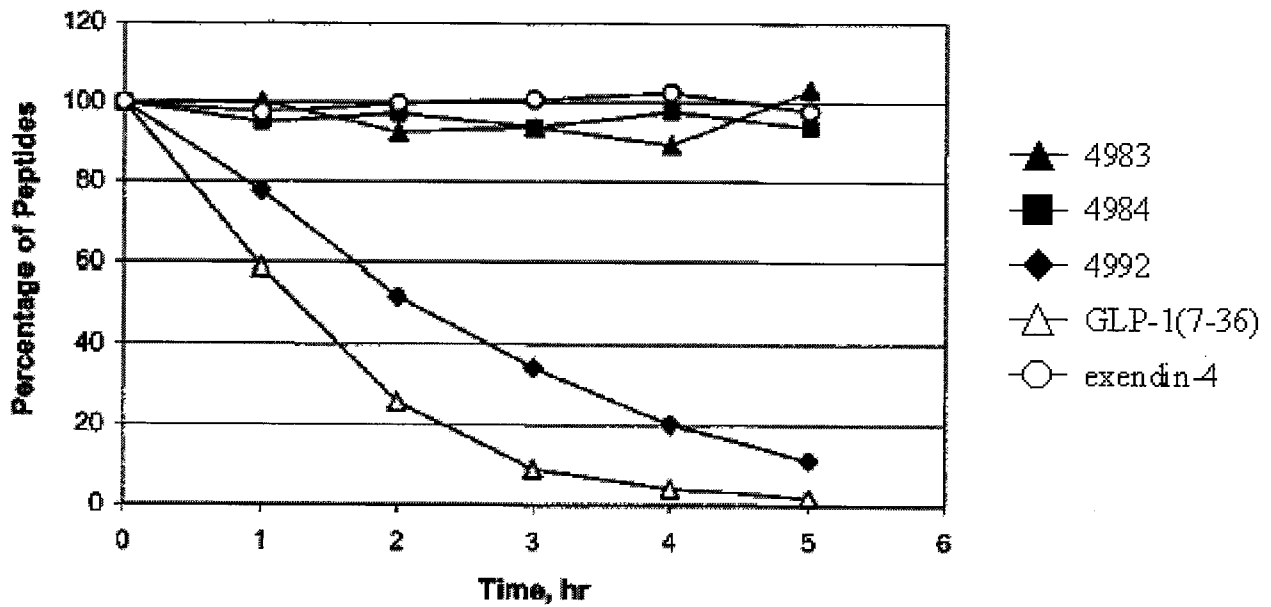


Fig. 4A

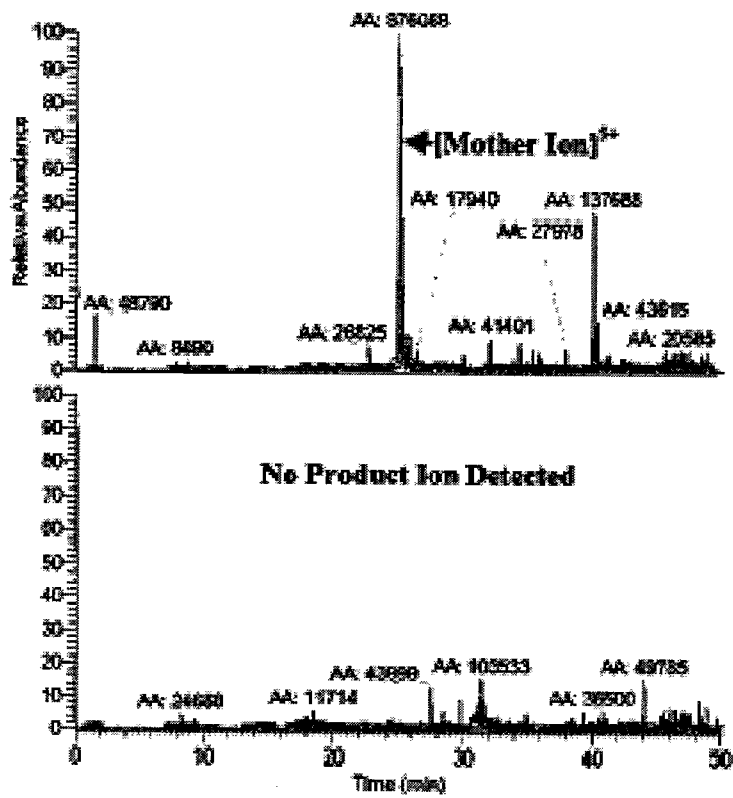


Fig. 4B

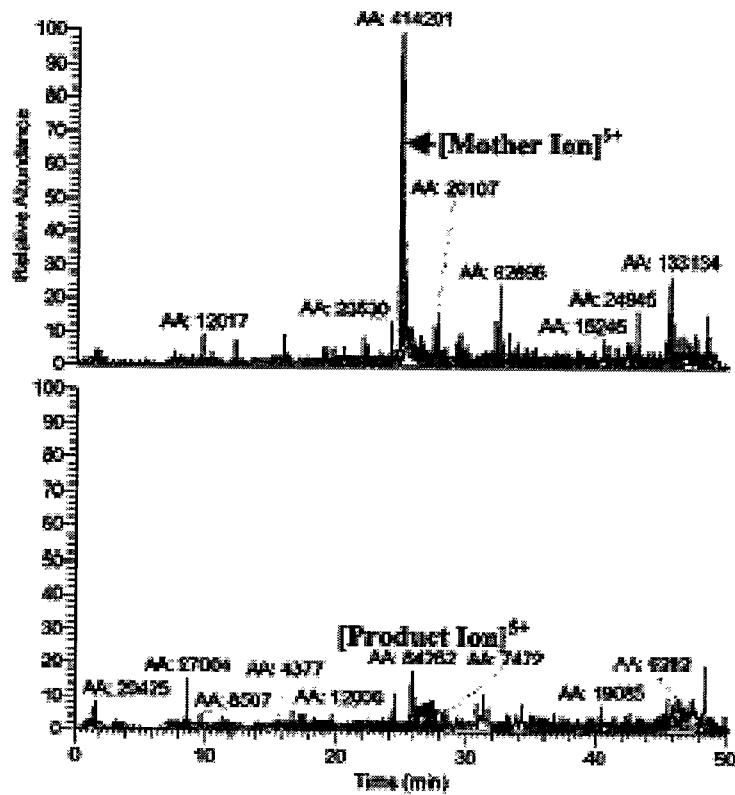


Fig. 4C

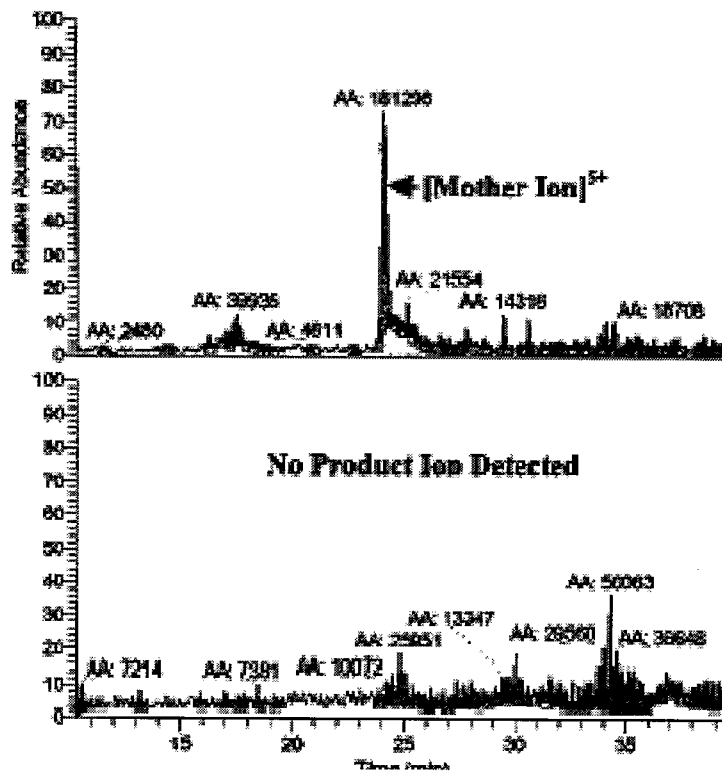


Fig. 4D

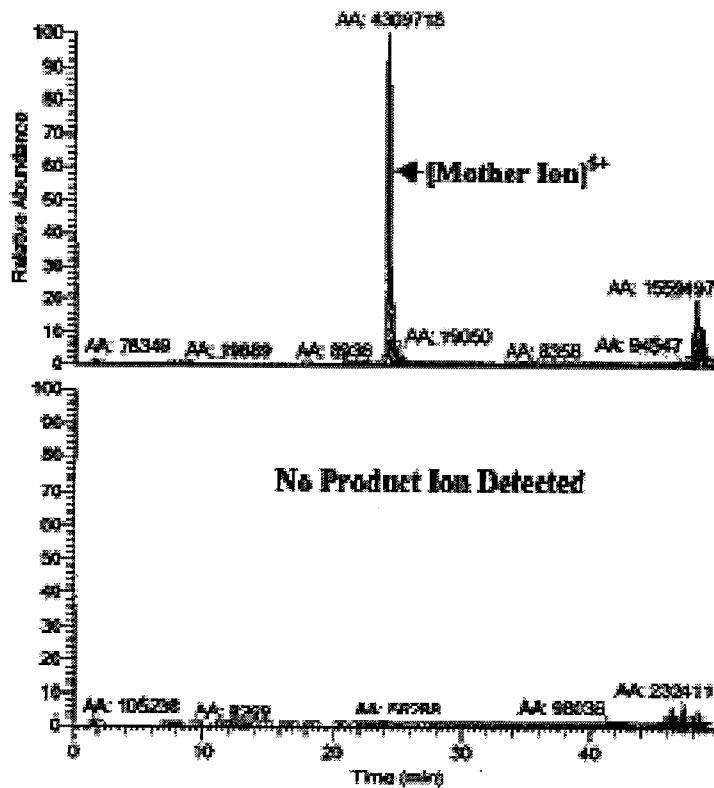


Fig. 5

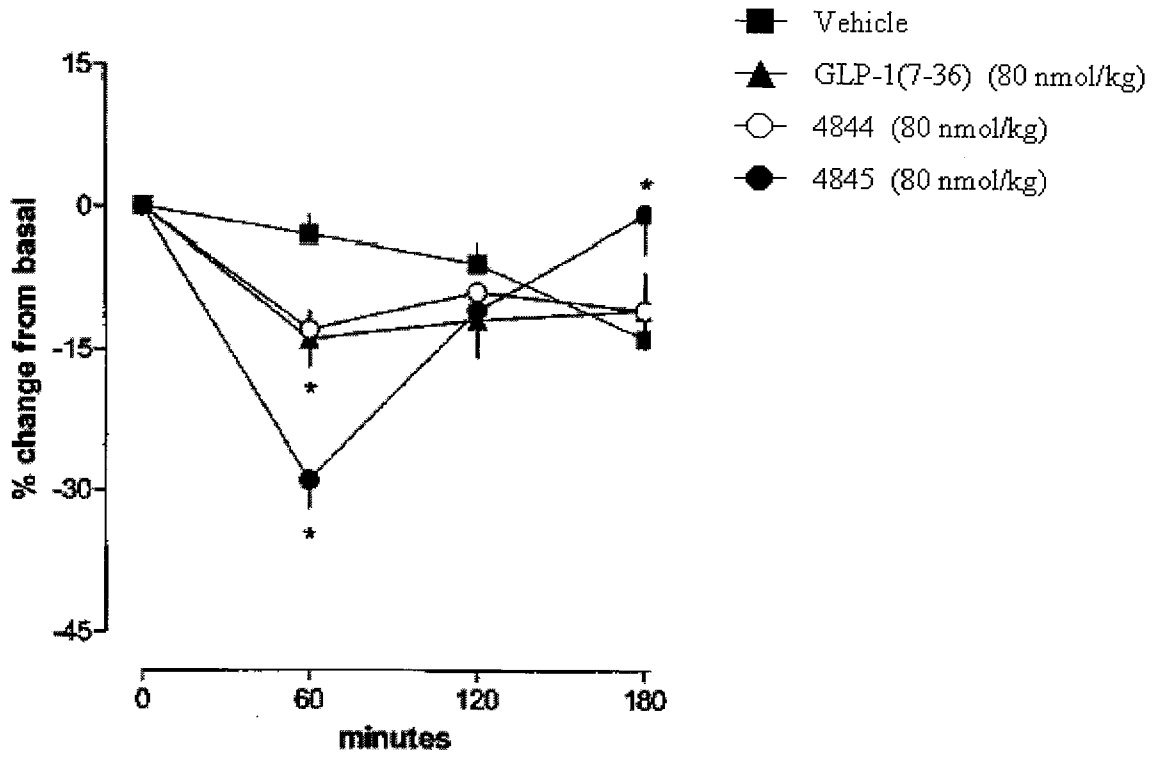


Fig. 6

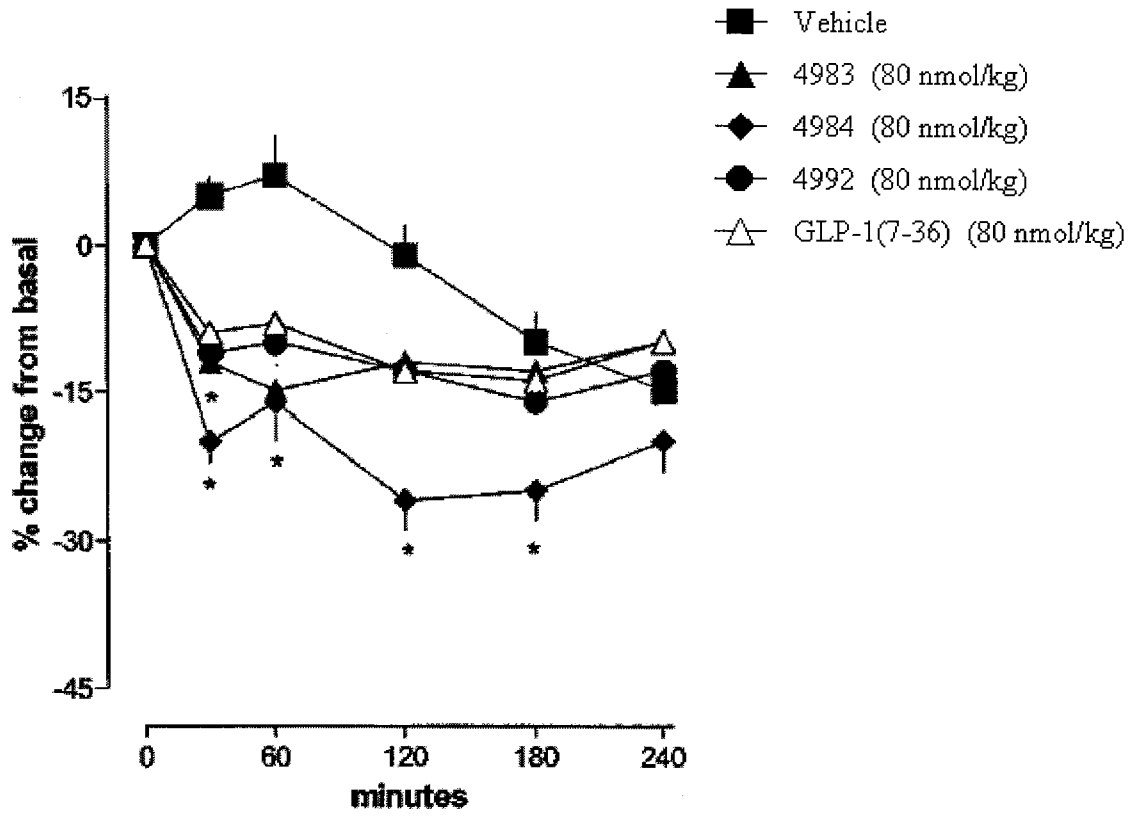
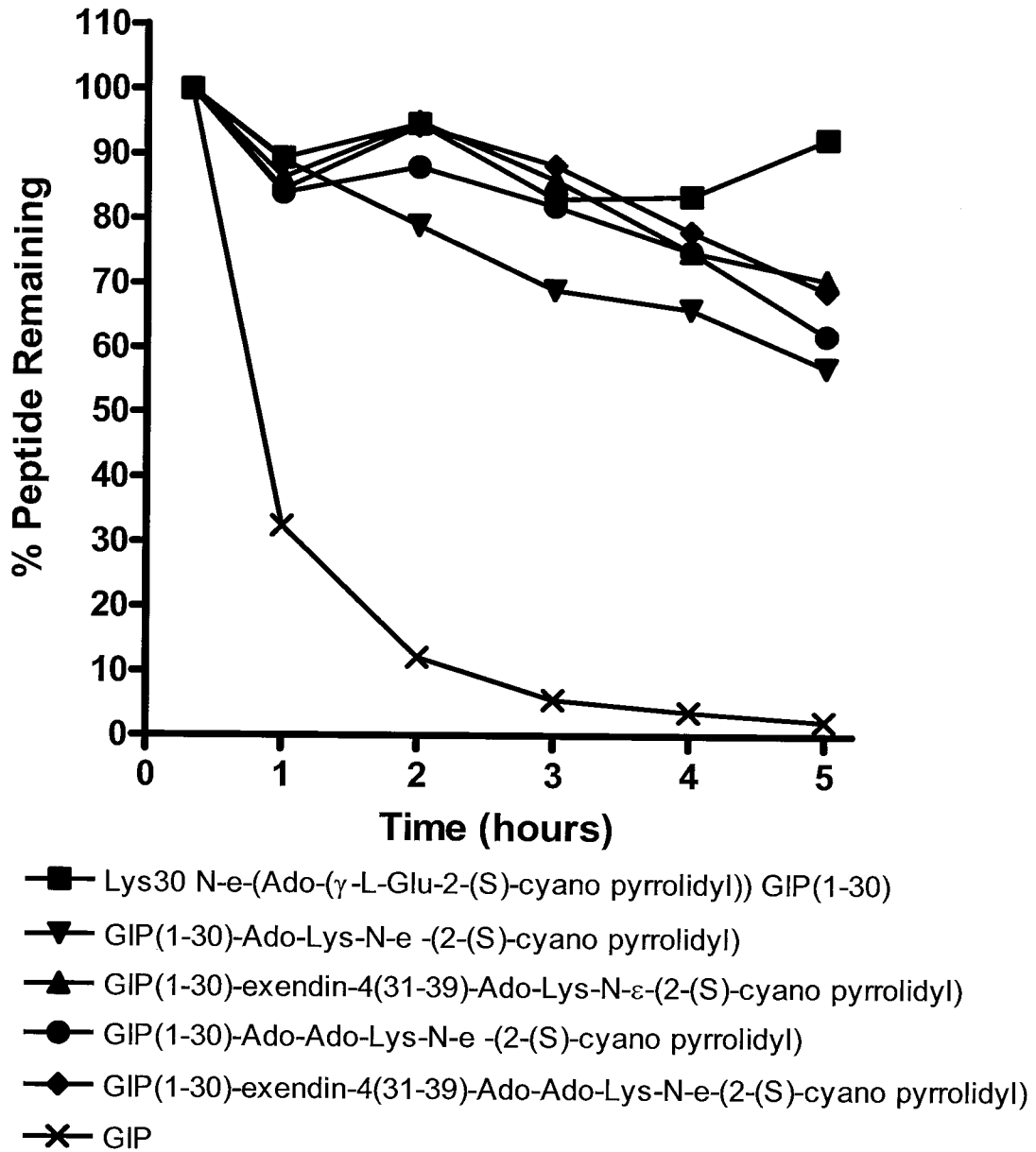
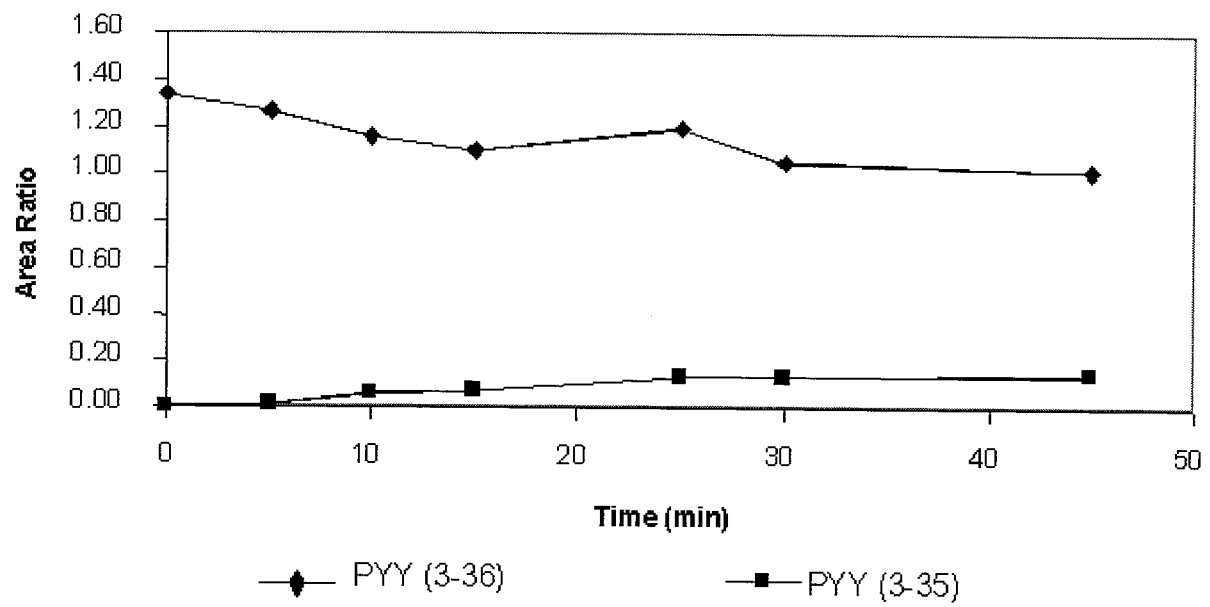


Fig. 7



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Fig. 8



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Fig. 9

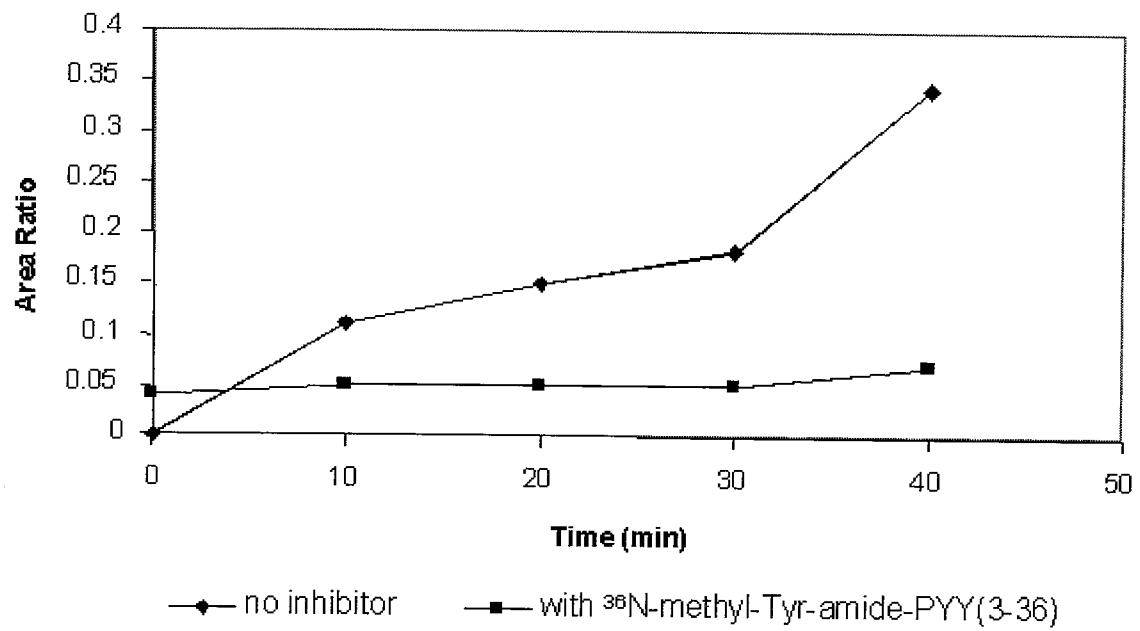
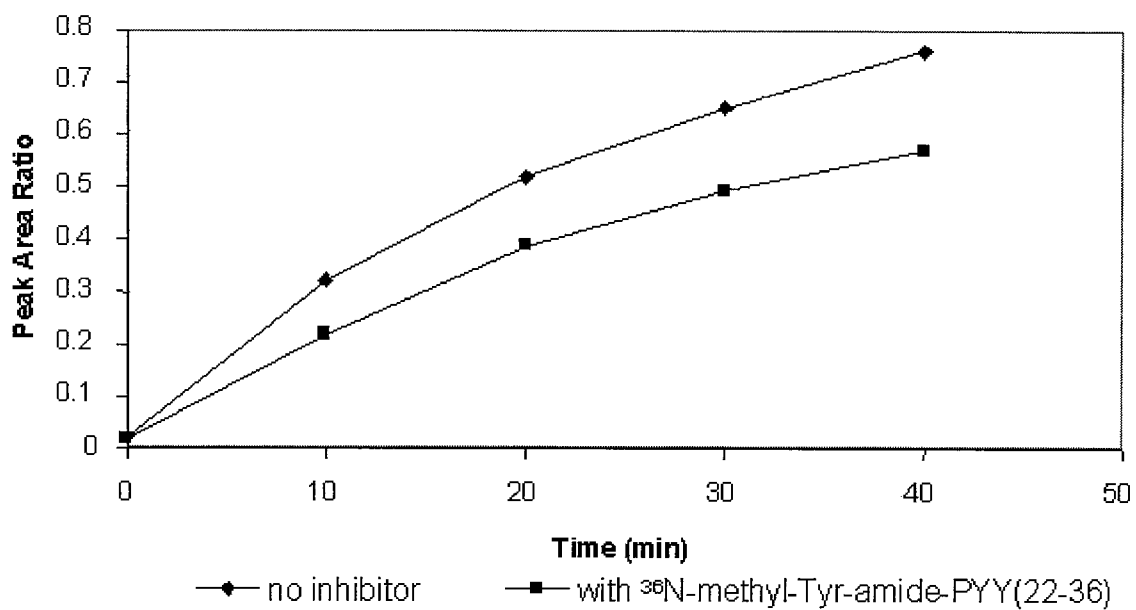
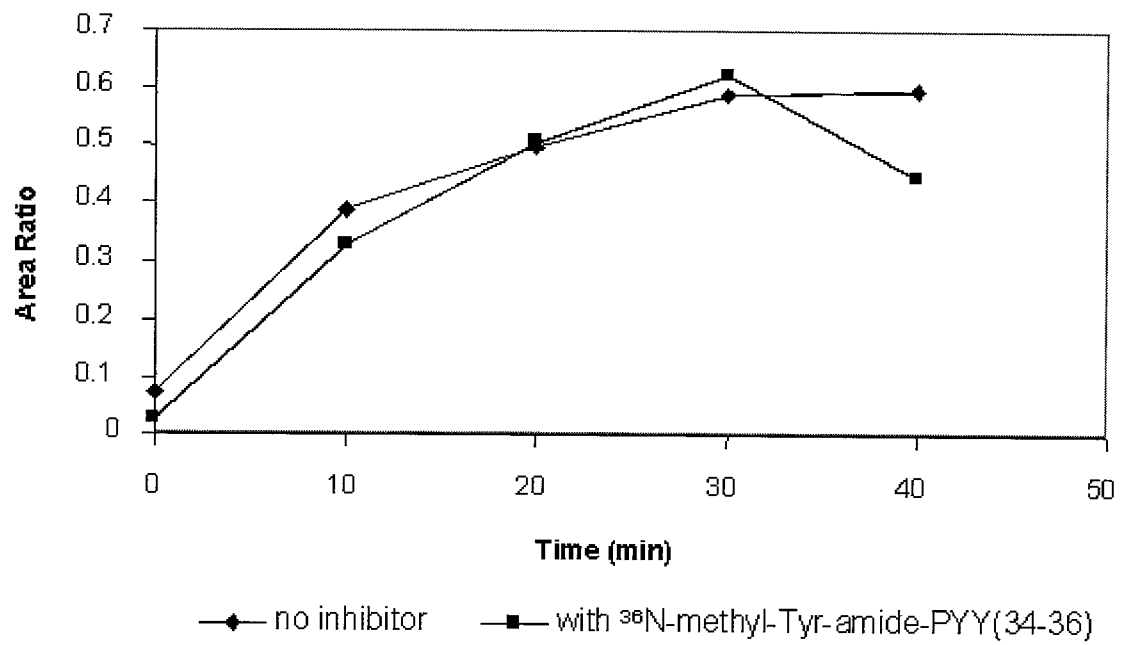


Fig. 10



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Fig. 11



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Fig. 12

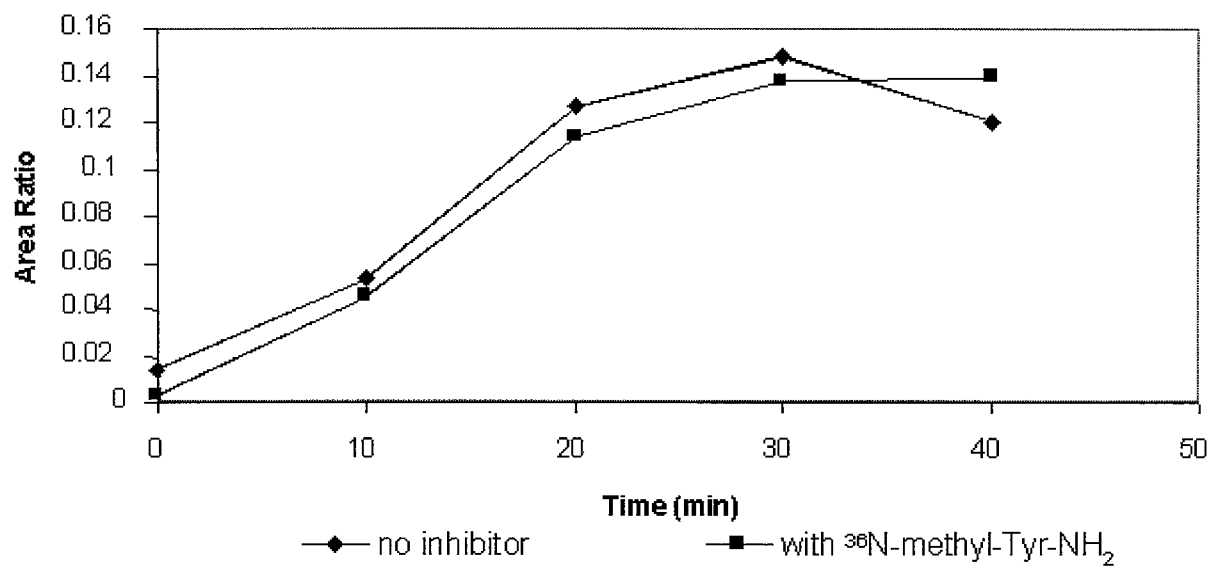


FIG. 13A

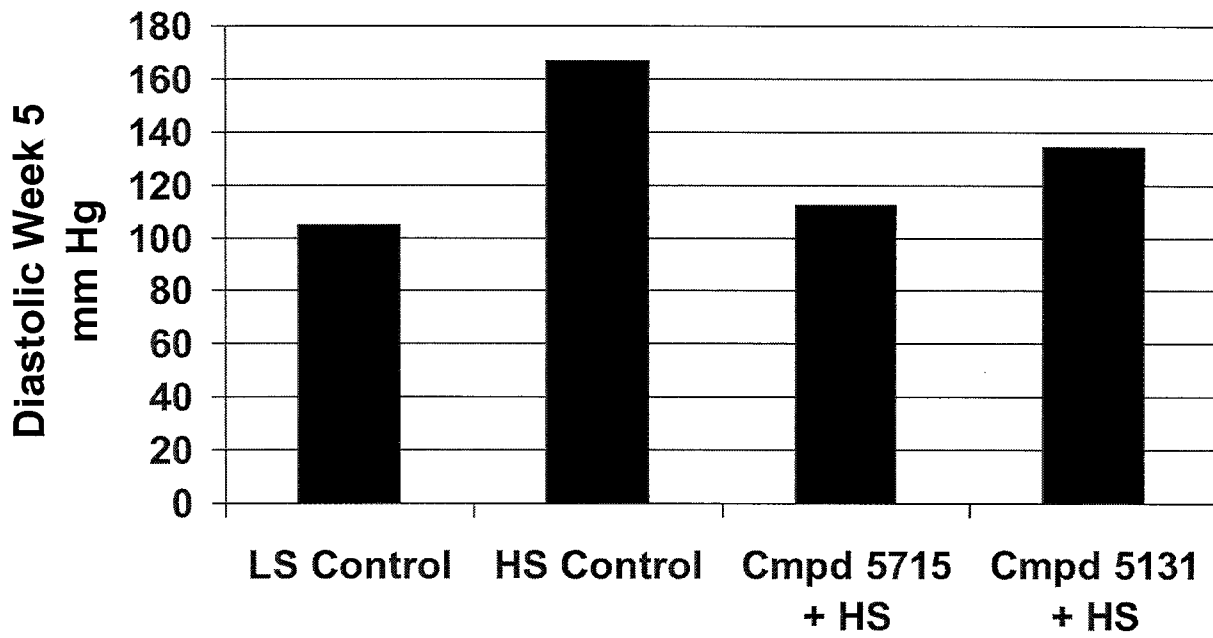


FIG. 13B

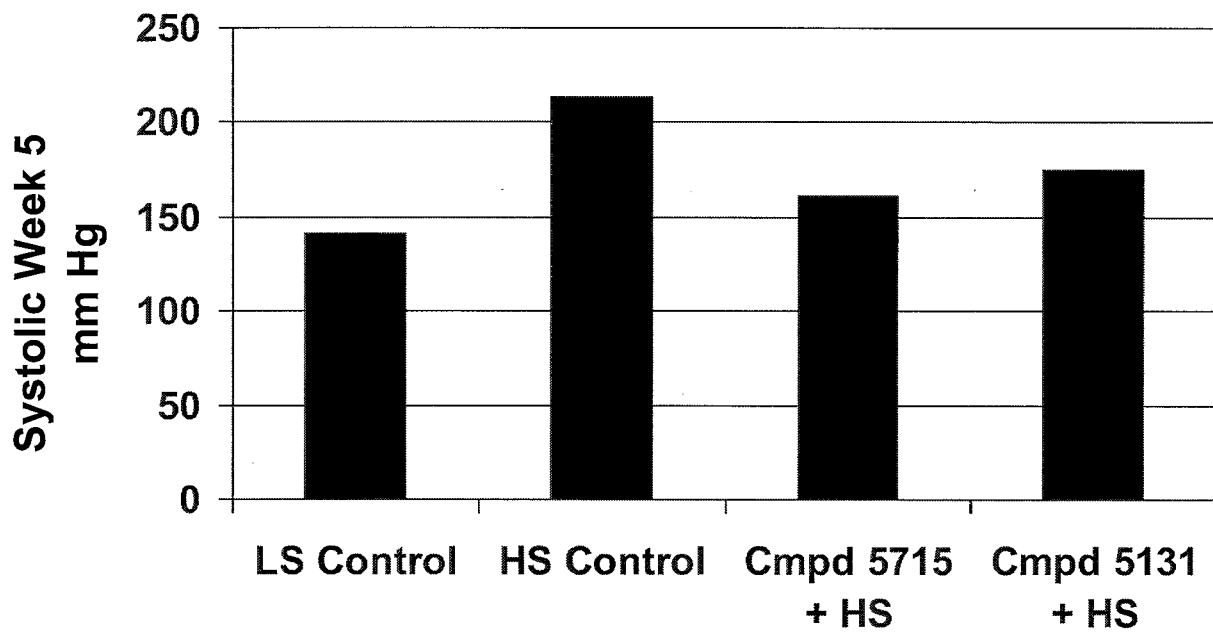


Fig. 14A

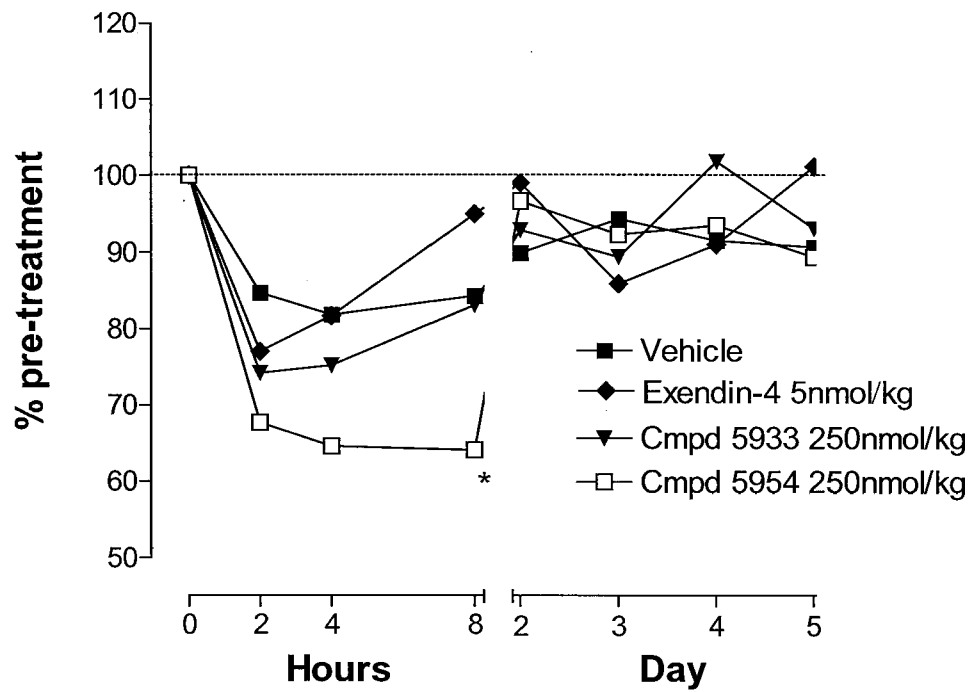


Fig. 14B

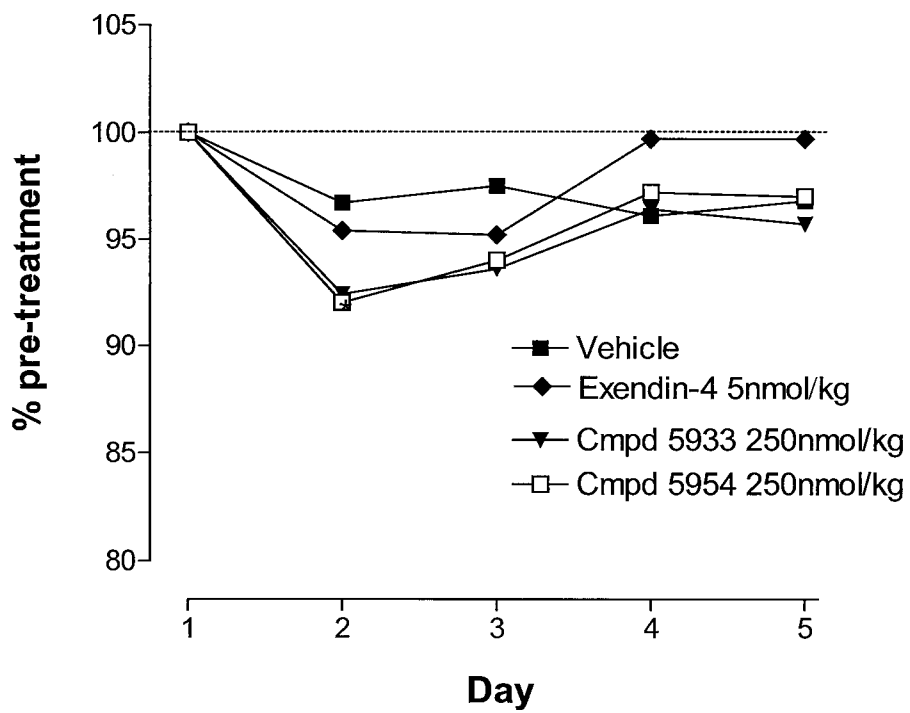


Fig. 15A

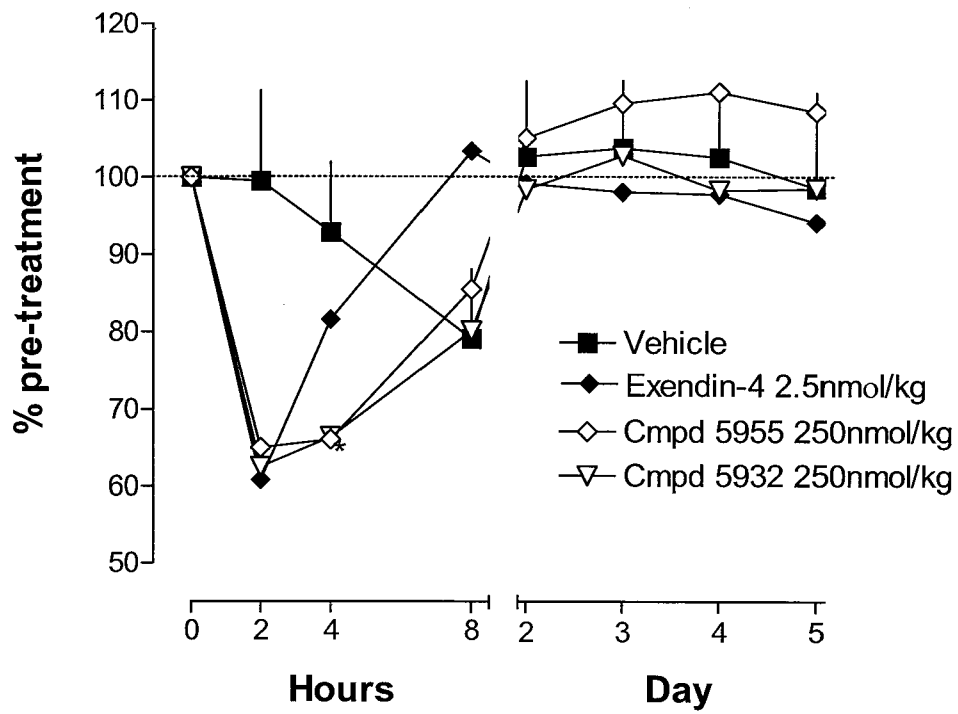


Fig. 15B

