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(71) Demandeur/Applicant:
ZEALAND PHARMA A/S, DK
(72) Inventeurs/Inventors:
TOLBORG, JAKOB LIND, DK;
NEERUP, TRINE SKOVLUND RYGE, DK;
FOSGERAU, KELD, DK;
OSTERLUND, TORBEN, SE;
ALMHOLT, DORTHE LENNERT CHRISTENSEN, DK;
LARSEN, LONE FROST, DK
(74) Agent: BERESKIN & PARR LLP/S.E.N.C.R.L.,S.R.L.

(54) Titre : CONJUGUES DE PEPTIDE AGONISTE DU RECEPTEUR DU GLP-1 ET DE GASTRINE
(54) Title: GLP-1 RECEPTOR AGONIST PEPTIDE GASTRIN CONJUGATES

(57) **Abrégé/Abstract:**

The present invention relates, inter alia, to certain peptide conjugates, and to the use of the conjugates in the treatment of a variety of diseases or disorders, including diabetes (type 1 and/or type 2) and diabetes-related diseases or disorders.



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(71) Applicant: ZEALAND PHARMA A/S [DK/DK]; Smedeland 36, DK-2600, Glostrup, Copenhagen (DK).

(72) Inventors: TOLBORG, Jakob Lind; Buderupvej 5, Dk-2730, Herlev (DK). NEERUP, Trine Skovlund Ryge; Bøgealle 27, Dk 3600, Frederikssund (DK). FOSGERAU, Keld; Lyngholmvej 45, Dk-2720, Rødovre (DK). ØSTER-LUND, Torben; Orkestervägen 28, S-224 72, Lund (SE). ALMHOLT, Dorthe Lennert Christensen; Godskesparken 111, Dk-2670, Greve (DK). LARSEN, Lone Frost; Sommervej 14, Dk-2920, Charlottenlund (DK).

(74) Agents: FORREST, Graham et al.; Mewburn Ellis LLP, 33 Gutter Lane, London Greater London EC2V 8AS (GB).

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(54) Title: GLP-1 RECEPTOR AGONIST PEPTIDE GASTRIN CONJUGATES

(57) Abstract: The present invention relates, inter alia, to certain peptide conjugates, and to the use of the conjugates in the treatment of a variety of diseases or disorders, including diabetes (type 1 and/or type 2) and diabetes-related diseases or disorders.



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GLP-1 RECEPTOR AGONIST PEPTIDE GASTRIN CONJUGATES

FIELD OF THE INVENTION

The present invention relates, *inter alia*, to certain peptide conjugates, and to the use of the conjugates
 5 in the treatment and/or prevention of a variety of diseases or disorders, including diabetes (type 1 and/or type 2) and diabetes-related diseases or disorders.

BACKGROUND OF THE INVENTION

Diabetes, notably type 1 and type 2 diabetes, together with obesity, which is believed to be a major
 10 causal factor in the development of type 2 diabetes, constitute a major and even growing worldwide health problem. Diseases or disorders that may develop as a consequence of diabetes include cardiovascular and peripheral vascular disease, micro- and macrovascular complications, stroke and possibly certain forms of cancer.

Diabetes is characterized by a defective physiological regulation of blood glucose levels. Among the
 15 underlying conditions that may lead to diabetes are reductions in or the loss of pancreatic β -cell mass and function, with attendant reduction in or loss of endogenous Insulin production, and/or Insulin resistance (reduced sensitivity to insulin), i.e. reduction in or loss of the ability of endogenous insulin to bring about adequate regulation of blood glucose levels.

A number of hormones that lower blood glucose levels are secreted by the gastrointestinal mucosa in
 20 response to the presence and absorption of nutrients in the gut. These include glucagon-like peptide-1 (GLP-1), glucose-dependent insulintropic peptide (GIP), gastrin, and secretin.

GLP-1 [see, e.g., Ørskov, *Diabetologia* 35: 701-711 (1992)] is produced by tissue processing of proglucagon, a 180 amino acid peptide [see, e.g., Drucker, *Diabetes* 47: 159-169 (1998)]. The overall
 25 sequence of proglucagon contains the 29 amino acid sequence of glucagon, the 36 or 37 amino acid sequence of GLP-1, and the 34 amino acid sequence of glucagon-like peptide-2 (GLP-2; an intestinotropic peptide).

The so-called exendins, which constitute another group of peptides that lower blood glucose levels, have some sequence similarity (53%) to GLP-1(7-36) [see, e.g., Goke et al., *J. Biol. Chem.* 268: 19650-19655 (1993)]. The exendins are found in the saliva of Helodermatidae species (beaded
 30 lizards). Exendin-3 is present in the saliva of *Heloderma horridum* (Mexican beaded lizard), while exendin-4 is present in the saliva of *Heloderma suspectum* (Gila monster). The amino acid sequence of exendin-4, which differs from that of exendin-3 at positions two and three, is HGEFTFTSDLSKQMEEEEAVRLFIEWLKNGGPSSGAPPPS-NH₂.

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Exendin-4 has been reported to be a potent GLP-1 receptor agonist on isolated rat insulinoma cells [Goke et al., loc. cit.]. WO 99/07404 discloses that exendin-4 administered systemically lowers blood glucose levels by 40% in diabetic db/db mice, and a long-lasting blood glucose lowering effect of once-daily intraperitoneal injection of exendin-4 in diabetic ob/ob mice has also been reported [Grieg et al.,
 5 *Diabetologia* 42: 45-50 (1999)].

US 5,424,286 and WO 98/05351 disclose that exendin-3, exendin-4 and exendin agonists may be used for the treatment of diabetes, for reducing gastric motility and delaying gastric emptying, and for prevention of hyperglycemia, and WO 98/30231 further discloses that they may be used for reducing food intake.

10 The peptide hormone gastrin is secreted from cells in the gastric mucosa and from G cells in the duodenum, and among the major physiological roles of the hormone in humans are stimulation of secretion of gastric acid (i.e. HCl) and aiding in gastric motility. There are indications that gastrin may play a role in islet neogenesis, i.e. stimulation of insulin-secreting β -cell growth in the pancreatic islets [see, e.g., Korc, M., *J. Clin. Invest.*, 92: 1113-1114 (1993); Rومان et al. *Diabetes* 51: 686-690
 15 (2002)], and thereby contribute to regulation of blood glucose.

Gastrin shares receptors with another gastrointestinal peptide hormone, cholecystokinin (CCK). The receptors CCK-A R and CCK-B R have different affinities for gastrin and CCK variants. CCK-A R (or CCK R1) acts primarily as a receptor for sulfated CCK, whereas CCK-B R (or CCK R2) binds both CCK and gastrin equally well. CCK-B R is considered to be the "gastrin receptor" due to the higher
 20 levels of gastrin compared to CCK in plasma [Foucaud et al. *Reg. Peptides* 145: 17-23 (2008)].

CCK-B R can initiate several intracellular pathways upon binding of ligand, which is considered to be the reason for the diverse physiological roles of CCK. A key pathway downstream of CCK-B R is the MAPK (mitogen activated protein kinases) or ERK (extra-cellular regulated kinases) pathway, which is also activated by several growth hormones. Since CCK-B R is expressed in the pancreas, gastrin is
 25 able to contribute to cell proliferation and islet regeneration in this tissue.

In humans, gastrin occurs primarily in three forms, viz. gastrin34, gastrin17 and gastrin14 (with reference to the total number of amino acids in the sequence in question). Gastrin6 has also been identified. The shorter forms are generated by cleavage of C-terminally amidated gastrin34; thus gastrin17 consists of the last 17 C-terminal residues of gastrin34 (corresponding to progastrin (55-71),
 30 gastrin14 consists of the last 14 C-terminal residues of gastrin34 (corresponding to progastrin(58-71), and gastrin6 consists of only the last 6 C-terminal residues of gastrin34 (corresponding to progastrin(66-71). In human gastrin17 the N-terminal amino acid residue is a pyroglutamic acid (PyroGlu) residue. The amidated C-terminal 6 amino acids are the key receptor-binding residues of gastrin.

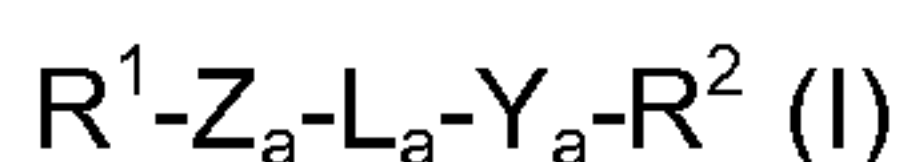
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SUMMARY OF THE INVENTION

It has now been found that certain conjugates comprising two covalently coupled or linked peptide moieties may exhibit unexpectedly high therapeutic activity in the treatment, for example, of diabetes (type 1 and/or type 2 diabetes), or of various other diabetes-related diseases or disorders, by comparison with the therapeutic activity of a combination of the two individual peptides in question.

In a broad aspect, the invention provides a peptide conjugate of a GLP-1 receptor agonist and gastrin, in particular gastrin with a substitution at position 15 in gastrin¹⁷ (corresponding to position 4 in gastrin⁶) selected from Leu, Nle, Phe and Thr. More particularly, the invention provides peptide conjugates of exendin-4 and gastrin.

In some embodiments, the invention thus provides a peptide conjugate having the formula I



wherein

R^1 is H, C₁₋₄ alkyl, acetyl, formyl, benzoyl or trifluoroacetyl;

R^2 is OH or NH₂; and

Z_a is a peptide sequence having the formula Ia

His-Gly-Glu-Gly-Thr-Phe-Thr-Ser-Z₉-Leu-Ser-Z₁₂-Z₁₃-Z₁₄-Glu-Z₁₆-Glu-Ala-Val-Z₂₀-Leu-Phe-Ile-Z₂₄-Z₂₅-Leu-Z₂₇-Z₂₈ (Ia)

wherein

Z₉ is selected from Asp and Glu;

Z₁₂ is selected from Lys, Arg and Orn;

Z₁₃ is selected from Gln and Tyr;

Z₁₄ is selected from Met and Leu;

Z₁₆ is selected from Glu, Cys, Arg, Orn and Lys;

Z₂₀ is selected from Arg, Lys and Orn;

Z₂₄ is selected from Lys, Arg, Orn and Glu;

Z₂₅ is selected from Trp, Lys, Cys and Phe;

Z₂₇ is selected from Lys, Arg and Orn; and

Z₂₈ is selected from Asn and Asp or is absent;

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La is a peptide sequence having the formula Ib

L1-L2-L3-L4 (Ib)

wherein

- 5 L1 is selected from Orn, 8Ado, Cys, Lys and Gln or is absent;
 L2 is selected from Orn, 8Ado, Cys, Lys and Gln or is absent;
 L3 is selected from Orn, 8Ado, Cys, Lys and Gln or is absent; and
 L4 is selected from Orn, 8Ado, Cys, Lys and Gln or is absent; and

- 10 Y_a is a peptide sequence having the formula Ic
 Y12-Y13-Y14-Y15-Asp-Y17 (Ic)

wherein

- Y12 is selected from Tyr and Ala or is absent;
 15 Y13 is selected from Gly and Ala or is absent;
 Y14 is selected from Trp, 1Nal and Phe;
 Y15 is selected from Met, Leu, Nle, Thr and Phe; and
 Y17 is selected from Phe and 3-(3-pyridyl)-alanine;
- 20 wherein at least one of Lys, Orn or Cys in formula Ia and Ib is further conjugated to a lipophilic and/or a biotinylc substituent and/or pegylated;
 or a pharmaceutically acceptable salt or solvate thereof.

In further embodiments, the invention provides a peptide conjugate of formula I wherein

- 25 Z_a is a peptide sequence having the formula IIa
 His-Gly-Glu-Gly-Thr-Phe-Thr-Ser-Z9-Leu-Ser-Lys-Z13-Z14-Glu-Z16-Glu-Ala-Val-Arg-Leu-Phe-Ile-Glu-Z25-Leu-Lys-Z28 (IIa)

wherein

Z9 is selected from Glu and Asp;

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Z13 is selected from Gln and Tyr;

Z14 is selected from Met and Leu;

Z16 is selected from Glu, Cys and Lys;

Z25 is selected from Lys, Phe, Cys and Trp; and

5 Z28 is selected from Asn and Asp or is absent;

L_a is a peptide sequence having the formula Ib as described above; and

Y_a is a peptide sequence having the formula IIc

10 Tyr-Gly-Trp-Y15-Asp-Phe (IIc)

wherein

Y15 is selected from Leu and Thr; and

wherein at least one of the Lys residues in position Z16 and Z25 of formula IIa is further conjugated to a lipophilic and/or a biotinyl substituent and/or pegylated;

15 or a pharmaceutically acceptable salt or solvate thereof.

In specific embodiments, the invention relates to a peptide conjugate having the formula:

H-HGEGTFTSDLSKQLEEEAVRLFIEWLKN-8Ado-K(hexadecanoyl-isoGlu)-8Ado-YGWLDF-NH₂
(Compound 1)

20 H-HGEGTFTSDLSKQLEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LKN—8Ado-8Ado-YGWLDF-NH₂
(Compound 2)

H-HGEGTFTSDLSKQLE-K(hexadecanoyl-isoGlu)-EAVRLFIEWLKN-8Ado-8Ado-YGWLDF-NH₂
(Compound 3)

25 H-HGEGTFTSDLSKQMEEEEAVRLFIEWLKN-8Ado-C(Biotin-Mal)-8Ado-YGWLDF-NH₂ (Compound 4)

H-HGEGTFTSDLSKQLEEEAVRLFIE-C(Biotin-Mal)-LKN-8Ado-8Ado-YGWLDF-NH₂ (Compound 5)

30 H-HGEGTFTSDLSKQLE-C(Biotin-Mal)-EAVRLFIEWLKN-8Ado-8Ado-YGWLDF-NH₂ (Compound 6)

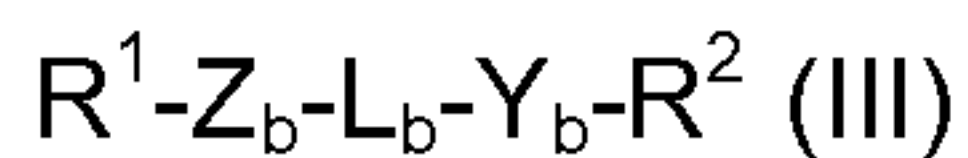
H-HGEGTFTSELSKYLEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-8Ado-8Ado-YGWLDF-NH₂
(Compound 7)

35 H-HGEGTFTSELSKYLEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-8Ado-QQYGWLDF-NH₂ (Compound 8)

or a pharmaceutically acceptable salt or solvate thereof.

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In other embodiments, the invention provides a peptide conjugate having the formula III



wherein

5 R^1 is H, C_{1-4} alkyl, acetyl, formyl, benzoyl or trifluoroacetyl;

R^2 is OH or NH_2 ; and

Z_b is a peptide sequence having the formula IIIa

10 His-Gly-Glu-Gly-Thr-Phe-Thr-Ser-Glu-Leu-Ser-Lys-Tyr-Leu-Glu-Glu-Glu-Ala-Val-Arg-Leu-Phe-Ile-Glu-Z25-Leu-Lys-Z28 (IIIa)

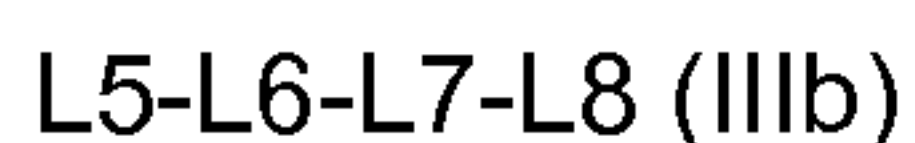
wherein

Z25 is selected from Phe and Trp; and

Z28 is selected from Asn and Asp or is absent;

15

L_b is a peptide sequence having the formula IIIb



wherein

L5 is selected from 8Ado, 8Aoc, Ala, Gly and Gln or is absent;

20 L6 is selected from 8Ado, 8Aoc, Ala, Gly and Gln or is absent;

L7 is selected from 8Ado, 8Aoc, Ala, Gly and Gln or is absent; and

L8 is selected from 8Ado, 8Aoc, Ala, Gly and Gln or is absent; and

Y_b is a peptide sequence having the formula IIIc

25 Y10-Y11-Tyr-Gly-Trp-Y15-Asp-Phe (IIIc)

wherein

Y10 is Glu or is absent;

Y11 is Ala or is absent; and

Y15 is selected from Leu and Thr;

30 or a pharmaceutically acceptable salt or solvate thereof;

provided that formula III is not

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Ado-8Ado-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKYGWLDF-NH₂; and

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Ado-YGWLDF-NH₂.

5

In further embodiments, the invention provides a peptide conjugate of formula III wherein

Z_b is a peptide sequence having the formula IVa

His-Gly-Glu-Gly-Thr-Phe-Thr-Ser-Glu-Leu-Ser-Lys-Tyr-Leu-Glu-Glu-Glu-Ala-Val-Arg-Leu-Phe-Ile-Glu-Z25-Leu-Lys-Asn (IVa)

10 wherein

Z25 is selected from Lys, Phe and Trp; and

L_b is a peptide sequence having the formula IIIb as described above

15 Y_b is a peptide sequence having the formula IVc

Tyr-Gly-Trp-Y15-Asp-Phe (IVc)

wherein

Y15 is selected from Leu and Thr;

or a pharmaceutically acceptable salt or solvate thereof.

20

In specific embodiments, the invention relates to a peptide conjugate having the formula:

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKQQYGWLDF-NH₂ (Compound 9)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKQQEAYGWLDF-NH₂ (Compound 10)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Ado-QQYGWLDF-NH₂ (Compound 11)

25 H-HGEGTFTSELSKYLEEEEAVRLFIEFLKDYGWLDF-NH₂ (Compound 12)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKAAAYGWLDF-NH₂ (Compound 13)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKGGGYGWLDF-NH₂ (Compound 14)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Aoc-YGWLDF-NH₂ (Compound 15)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKNYGWLDF-NH₂ (Compound 16)

30 H-HGEGTFTSELSKYLEEEEAVRLFIEFLKAYGWLDF-NH₂ (Compound 17)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKN-8Ado-8Ado-YGWLDF-NH₂ (Compound 18)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKD-8Ado-8Ado-YGWLDF-NH₂ (Compound 19)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKNYGWTDf-NH₂ (Compound 20)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKDYGWTDf-NH₂ (Compound 21)

H-HGEGTFTSELSKYLEEEEAVRLFIEWLKNYGWLDf-NH₂ (Compound 22)

H-HGEGTFTSELSKYLEEEEAVRLFIEWLKDYGWLDf-NH₂ (Compound 23)

5

or a pharmaceutically acceptable salt or solvate thereof.

In specific embodiments, the peptide conjugates of the invention may be manufactured by standard synthetic methods, by use of recombinant expression systems, or by any other suitable method. Thus, the conjugates may be synthesized in a number of ways, including, e.g., methods comprising:

- 10 (a) synthesizing the peptide conjugate by standard solid-phase or liquid-phase methodology, either stepwise or by fragment assembly, and isolating and purifying the final peptide conjugate product;
- (b) expressing a nucleic acid construct encoding the peptide conjugate in a host cell and recovering the expression product from the host cell culture; or
- (c) affecting cell-free *in vitro* expression of a nucleic acid construct that encodes the peptide conjugate,
- 15 and recovering the expression product;

or by any combination of the methods of (a), (b) or (c) to obtain fragments of the peptide conjugate, subsequently ligating the fragments to obtain the peptide conjugate, and recovering the peptide conjugate.

- Among further embodiments of the invention are methods of treatment of a variety of conditions,
- 20 diseases or disorders including diabetes (type 1 and type 2) and various diabetes-related conditions, diseases or disorders. These embodiments comprise administration of a peptide conjugate of the invention (in free form or in the form of a pharmaceutically acceptable salt or solvate thereof), as well as pharmaceutical compositions comprising a peptide conjugate or pharmaceutically acceptable salt or solvate thereof of the invention.

- 25 In some embodiments, the peptide conjugates of the present invention may be useful as pharmaceutical agents for treatment of insulin resistance, glucose intolerance, pre-diabetes, metabolic syndrome, elevated fasting glucose levels, disease states associated with elevated blood glucose levels, hyperglycemia, type 1 and/or type 2 diabetes, diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, kidney failure, hypertension and/or dyslipidemia (or a combination of these
- 30 metabolic and cardiovascular risk factors), atherosclerosis, arteriosclerosis, macrovascular disease, microvascular disease, coronary heart disease, peripheral artery disease and stroke. They may also be useful in preventing weight gain, promoting weight loss, reducing excess body weight and/or treating obesity (e.g. by control of appetite, feeding, food intake, calorie intake, and/or energy expenditure), including morbid obesity, as well as associated diseases, disorders and health conditions, including,
- 35 but not limited to, obesity-linked inflammation, obesity-linked gallbladder disease and obesity-induced

sleep apnea. Effects of the peptide conjugates of the invention on these conditions may be mediated in whole or in part via an effect on body weight, or may be independent thereof.

Among further embodiments of the invention are methods of prevention of a variety of conditions, diseases or disorders including diabetes (type 1 and type 2) and various diabetes-related conditions, diseases or disorders. These embodiments comprise administration of a peptide conjugate of the invention (in free form or in the form of a pharmaceutically acceptable salt or solvate thereof), as well as pharmaceutical compositions comprising a peptide conjugate or pharmaceutically acceptable salt or solvate thereof of the invention.

In some embodiments, the peptide conjugates of the present invention may be useful as pharmaceutical agents for prevention of insulin resistance, glucose intolerance, pre-diabetes, metabolic syndrome, elevated fasting glucose levels, disease states associated with elevated blood glucose levels, hyperglycemia, type 1 and/or type 2 diabetes, diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, kidney failure, hypertension and/or dyslipidemia (or a combination of these metabolic and cardiovascular risk factors), atherosclerosis, arteriosclerosis, macrovascular disease, microvascular disease, coronary heart disease, peripheral artery disease and stroke. They may also be useful in preventing weight gain, promoting weight loss, reducing excess body weight and/or treating obesity (e.g. by control of appetite, feeding, food intake, calorie intake, and/or energy expenditure), including morbid obesity, as well as associated diseases, disorders and health conditions, including, but not limited to, obesity-linked inflammation, obesity-linked gallbladder disease and obesity-induced sleep apnea. Effects of the peptide conjugates of the invention on these conditions may be mediated in whole or in part via an effect on body weight, or may be independent thereof.

Further aspects of the invention will become apparent from the disclosure below.

DESCRIPTION OF THE FIGURES

Figure 1. Fasted Blood Glucose levels after 3 weeks treatment

Effect of once daily SC administration of vehicle, liraglutide (100 nmol/kg/day), and Compound 18 (30 and 100 nmol/kg/day) on fasted blood glucose levels after 3 weeks treatment in db/db mice. Data are given as mean values with SEM.

Statistics: Data were compared by 1-way ANOVA followed by Bonferroni's MC test vs. vehicle or vs. liraglutide: ***p<0.001 vs. vehicle, ##p<0.01 vs. liraglutide.

Figure 2. Fasted Blood Glucose levels after 4 weeks treatment followed by 1 week drug holiday

Effect of once daily SC administration of vehicle, liraglutide (100 nmol/kg/day), and Compound 18 (30 and 100 nmol/kg/day) on fasted blood glucose levels after 4 weeks treatment followed by one week drug holiday (vehicle treatment) in db/db mice. Data are given as mean values with SEM.

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Statistics: Data were compared by 1-way ANOVA followed by Bonferroni's MC test vs. vehicle or vs. liraglutide: **p<0.01 vs. vehicle, #p<0.05 vs. liraglutide.

Figure 3. OGTT, AUC after 3 weeks treatment

- 5 Effect of once daily SC administration of vehicle, liraglutide (100 nmol/kg/day), and Compound 18 (30 and 100 nmol/kg/day) on glucose tolerance after 3 weeks treatment in db/db mice. Data are expressed as area under the curve (AUC) with SEM.

Statistics: Data were compared by 1-way ANOVA followed by Bonferroni's MC test vs. vehicle or vs. liraglutide: ***p<0.001 vs. vehicle. ###p<0.001 vs. liraglutide.

10

Figure 4. OGTT, AUC after 4 weeks treatment + 1 week drug holiday

Effect of once daily SC administration of vehicle, liraglutide (100 nmol/kg/day), and Compound 18 (30 and 100 nmol/kg/day) on glucose tolerance after 4 weeks treatment followed by one week drug holiday (vehicle treatment) in db/db mice. Data are expressed as area under the curve (AUC) with SEM.

- 15 Statistics: Data were compared by 1-way ANOVA followed by Bonferroni's MC test vs. vehicle or vs. liraglutide: *p<0.05, ***p<0.001 vs. vehicle. ###p<0.001 vs. liraglutide.

Figure 5. Delta-body weight after 4 weeks treatment

- 20 Effect of once daily SC administration of vehicle, liraglutide (100 nmol/kg/day), and Compound 18 (30 and 100 nmol/kg/day) on delta (termination – start) body weight after 4 weeks treatment in db/db mice. Data are given as mean values with SEM.

Statistics: Data were compared by 1-way ANOVA followed by Bonferroni's MC test vs. vehicle or vs. liraglutide: ***p<0.001 vs. vehicle. ##p<0.01 vs. liraglutide.

- 25 Figure 6. Fasted Blood Glucose levels after 5 weeks treatment

Effect of twice daily SC administration of vehicle, liraglutide (2x40 nmol/kg/day), and Compound 18 (2x10 and 2x40 nmol/kg/day) on fasted blood glucose levels after 5 weeks treatment in ZDF rats. Data are given as mean values with SEM.

- 30 Statistics: Data were compared by 1-way ANOVA followed by Bonferroni's MC test vs. vehicle or vs. liraglutide: **p<0.01, ***p<0.001 vs. vehicle, ###p<0.001 vs. liraglutide.

Figure 7. OGTT, AUC after 5 weeks treatment

- 35 Effect of once daily SC administration of vehicle, liraglutide (2x40 nmol/kg/day), and Compound 18 (2x10 and 2x40 nmol/kg/day) on glucose tolerance after 5 weeks treatment in db/db mice. Data are expressed as area under the curve (AUC) with SEM.

Statistics: Data were compared by 1-way ANOVA followed by Bonferroni's MC test vs. vehicle or vs. liraglutide: ***p<0.001 vs. vehicle. ###p<0.001 vs. liraglutide.

Figure 8. HbA1c levels after 6 weeks treatment

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Effect of twice daily SC administration of vehicle, liraglutide (2x40 nmol/kg/day), and Compound 18 (2x10 and 2x40 nmol/kg/day) on HbA1c levels after 6 weeks treatment in ZDF rats. Data are given as mean values with SEM.

Statistics: Data were compared by 1-way ANOVA followed by Bonferroni's MC test vs. vehicle or vs.

5 liraglutide: ***p<0.001 vs. vehicle, #p<0.05 vs. liraglutide.

DETAILED DESCRIPTION OF THE INVENTION

As indicated above, one aspect of the present invention relates to a peptide conjugate having the formula:

- 10 H-HGEGTFTSDLSKQLEEEEAVRLFIEWLKN-8Ado-K(hexadecanoyl-isoGlu)-8Ado-YGWLDF-NH₂
(Compound 1)
- H-HGEGTFTSDLSKQLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LKN-8Ado-8Ado-YGWLDF-NH₂
(Compound 2)
- 15 H-HGEGTFTSDLSKQLE-K(hexadecanoyl-isoGlu)-EAVRLFIEWLKN-8Ado-8Ado-YGWLDF-NH₂
(Compound 3)
- H-HGEGTFTSDLSKQMEEEEAVRLFIEWLKN-8Ado-C(Biotin-Mal)-8Ado-YGWLDF-NH₂ (Compound 4)
- 20 H-HGEGTFTSDLSKQLEEEEAVRLFIE-C(Biotin-Mal)-LKN-8Ado-8Ado-YGWLDF-NH₂ (Compound 5)
- H-HGEGTFTSDLSKQLE-C(Biotin-Mal)-EAVRLFIEWLKN-8Ado-8Ado-YGWLDF-NH₂ (Compound 6)
- 25 H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-8Ado-8Ado-YGWLDF-NH₂
(Compound 7)
- H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-8Ado-QQYGWLDF-NH₂ (Compound 8)
- 30 Further, in another aspect the present invention relates to a peptide conjugate having the formula:
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLKQQYGWLDF-NH₂ (Compound 9)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLKQQEAYGWLDF-NH₂ (Compound 10)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Ado-QQYGWLDF-NH₂ (Compound 11)
- 35 H-HGEGTFTSELSKYLEEEEAVRLFIEFLKDYGWLDF-NH₂ (Compound 12)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLKAAAYGWLDF-NH₂ (Compound 13)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLKGGGYGWLDF-NH₂ (Compound 14)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Aoc-YGWLDF-NH₂ (Compound 15)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLKNYGWLDF-NH₂ (Compound 16)
- 40 H-HGEGTFTSELSKYLEEEEAVRLFIEFLKAYGWLDF-NH₂ (Compound 17)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLKN-8Ado-8Ado-YGWLDF-NH₂ (Compound 18)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLKD-8Ado-8Ado-YGWLDF-NH₂ (Compound 19)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLKNYGTDF-NH₂ (Compound 20)
- H-HGEGTFTSELSKYLEEEEAVRLFIEFLKDYGTDF-NH₂ (Compound 21)

H-HGEGTFTSELSKYLEEEEAVRLFIEWLKNYGWLDF-NH₂ (Compound 22)

H-HGEGTFTSELSKYLEEEEAVRLFIEWLKDYGWLDF-NH₂ (Compound 23)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKEAYGWLDF-NH₂ (Compound 24)

5

In yet another aspect, the present invention relates to a peptide conjugate having the formula:

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKN-K(hexadecanoyl-isoGlu)-YGWLDF-NH₂ (Compound 25)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKN-K(hexadecanoyl-isoGlu)-WLDF-NH₂ (Compound 26)

10 H-HGEGTFTSELSKYLE-K(hexadecanoyl-isoGlu)-EAVRLFIEFLKNYGWLDF-NH₂ (Compound 27)

H-HGEGTFTSELSKYLE-K(hexadecanoyl-isoGlu)-EAVRLFIEFLKNWLDF-NH₂ (Compound 28)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-K(hexadecanoyl-isoGlu)-YGWLDF-NH₂ (Compound 29)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-K(hexadecanoyl-isoGlu)-WLDF-NH₂ (Compound 30)

H-HGEGTFTSELSKYLE-K(hexadecanoyl-isoGlu)-EAVRLFIEFLKYGWLDF-NH₂ (Compound 31)

15 H-HGEGTFTSELSKYLE-K(hexadecanoyl-isoGlu)-EAVRLFIEFLKWLDF-NH₂ (Compound 32)

H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-8Ado-YGWLDF-NH₂ (Compound 33)

H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LKQQYGWLDF-NH₂ (Compound 34)

20 H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-Orn-Orn-YGWLDF-NH₂ (Compound 35)

H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LKNYGWLDF-NH₂ (Compound 36)

H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LKDYGWLDF-NH₂ (Compound 37)

25 In a further aspect, the present invention relates to a peptide conjugate having the formula:

H-HGEGTFTSDLSKQLEEEEAVRLFIEC(PEG5K)LKN-8Ado-8Ado-YGWLDF-NH₂ (Compound 38)

H-HGEGTFTSELSKYLEEEEAVRLFIEC(PEG10K)LK-8Ado-8Ado-YGWLDF-NH₂ (Compound 39)

H-HGEGTFTSELSKYLEEEEAVRLFIEC(PEG20K)LK-8Ado-8Ado-YGWLDF-NH₂ (Compound 40)

30 H-HGEGTFTSELSKYLEEEEAVRLFIEC(PEG40K)LK-8Ado-8Ado-YGWLDF-NH₂ (Compound 41)

H-HGEGTFTSDLSKQMEEEEAVRLFIEWLKNYGWTDf-OH (Compound 42)

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKN-8Ado-8Ado-YGWTDf-NH₂ (Compound 43)

or a pharmaceutically acceptable salt or solvate thereof.

The abbreviations 8Ado, 8Aoc, Hexadecanoyl, isoGlu, Orn, and Biotin-Mal represent the following non-naturally occurring amino acid moieties, respectively:

5 8Ado (or Peg3): $\text{-NH-CH}_2\text{-CH}_2\text{-O-CH}_2\text{-CH}_2\text{-O-CH}_2\text{-C(O)-}$ (derived from 8-amino-3,6-dioxaoctanoic acid);

8Aoc: $\text{-NH-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-C(O)-}$ (derived from 8-aminooctanoic acid);

Hexadecanoyl: $\text{CH}_3\text{-(CH}_2\text{)}_{14}\text{-C(O)-}$;

isoGlu: $\text{-NH-CH(COOH)-CH}_2\text{-CH}_2\text{-C(O)-}$;

10 Orn: Ornithine; and

Biotin-Mal: Biotin-maleimide.

With regard to the orientation of the linker moiety in a peptide conjugate of the invention, the linker moiety -8Ado-8Ado- , for example, designates the chemical moiety

$\text{-NH-CH}_2\text{-CH}_2\text{-O-CH}_2\text{-CH}_2\text{-O-CH}_2\text{-C(O)-NH-CH}_2\text{-CH}_2\text{-O-CH}_2\text{-CH}_2\text{-O-CH}_2\text{-C(O)-}$,

15 the -NH-.... moiety at the terminus of the linker moiety in question being covalently attached to the GLP-1 agonist (e.g. exendin-4 derived) moiety of the peptide conjugate in question, and the-C(O)- moiety to the right of the linker moiety in question being attached to the gastrin-derived moiety of the peptide conjugate in question.

20 In the peptide conjugates of the invention, listed above, it is to be understood that the exendin-4(1-28) peptide sequence moiety is derived from the sequence of the Heloderma suspectum exendin-4 sequence or is an analogue thereof.

The term "exendin-4 analogue" in the context of the present invention is defined as a peptide sequence derived from any substitutions, truncations, deletions, additions or conjugations of the native Exendin-4 sequence. This includes but is not limited to the substitutions of the present invention.

25 Likewise, the [Leu4]gastrin6 moieties in the conjugates are derived synthetically from human gastrin.

Also likewise, the [Leu15]gastrin17 moieties in the conjugates are derived synthetically from human gastrin.

Each one of the above peptide conjugates 1-41 individually, i.e. compound 1 or compound 2 or compound 3...(etc., up to compound 41) or a pharmaceutically acceptable salt or solvate thereof,
30 constitutes a further, individual aspect of the present invention.

In the context of the present invention, unless amino acids are referred to by their full name (e.g. alanine, arginine, etc.), they are designated by their conventional three-letter and/or single-letter abbreviations (e.g. Ala or A for alanine, Arg or R for arginine, etc.).

5 The term "peptide conjugate" in the context of the present invention refers to a molecule in which a first peptide moiety is attached (i.e. coupled or linked), either directly or via a linking (i.e. bridging or spacing) chemical moiety, by means of covalent chemical bonding to a second peptide moiety.

In peptide conjugates of the invention, exendin-4 or Z (Z_a or Z_b) may have at least 75% identity to native *H. suspectum* exendin-4, e.g. at least 80%, 85%, 90%, 95%, 96%, 97%, 98%, 99% or 100% identity.

10 In the peptide conjugates of the invention, gastrin or Y (Y_a or Y_b) may have at least 70% identity to native human gastrin17 and/or gastrin6, e.g., where possible, at least 75%, 80%, 83%, 85%, 90%, 94%, 95%, 96%, 97%, 98%, 99% or 100% identity.

15 In some embodiments, the polypeptides of the invention may comprise the amino acid sequence set forth in any one of compound No: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40 and 41 or a functional fragment or variant thereof that is, where possible, at least about 80%, 85%, 90%, 95%, 97%, 98%, 99% or 99.5% identical to one or more of the recited sequences. Amino acid substitutions may be, for example, conservative substitutions.

20 The term "conservative substitution" as used herein denotes that one or more amino acids is replaced by another, biologically similar residue. Examples include substitution of amino acid residues with similar characteristics, e. g. small amino acids, acidic amino acids, polar amino acids, basic amino acids, hydrophobic amino acids and aromatic amino acids. For example, in a preferred embodiment of the invention Met residues are substituted with norleucine (Nle) which is a bioisostere for Met, but
25 which-as opposed to Met-is not readily oxidised. Another example of a conservative substitution with a residue normally not found in endogenous, mammalian peptides and proteins would be the conservative substitution of Arg or Lys with for example, ornithine, canavanine, aminoethylcysteine or other basic amino acid. For further information concerning phenotypically silent substitutions in peptides and proteins, see, for example, Bowie et.al. *Science* 247, 1306-1310, 1990. Conservative
30 substitutions of amino acids grouped by physicochemical properties. I: neutral, hydrophilic, II: acids and amides, III: basic, IV: hydrophobic, V: aromatic, bulky amino acids.

I	II	III	IV	V
A	N	H	M	F
S	D	R	L	Y
T	E	K	I	W
P	Q		V	
G			C	

In some embodiments, the polypeptide of the invention may comprise functional fragments or variants thereof that have at most 20, 15, 10, 9, 8, 7, 6, 5, 4, 3, 2, or 1 amino acid substitutions compared to one or more of the recited sequences. The polypeptide of the invention may further be with or without the signal sequence.

In some embodiments, one or more cysteine of the polypeptides of the invention may be substituted with other residues, such as a serine.

In some embodiments, the polypeptides of the invention share at least 99% amino acid sequence identity to any one of Compound No: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40 and 41.

The term “pharmaceutically acceptable salt” in the context of the present invention (pharmaceutically acceptable salt of a peptide conjugate of the invention) is intended to indicate a salt which is not harmful to a patient or subject to which the salt in question is administered. It may suitably be a salt chosen, e.g., among acid addition salts and basic salts. Examples of acid addition salts include chloride salts, citrate salts and acetate salts. Examples of basic salts include salts where the cation is selected among alkali metal cations, such as sodium or potassium ions, alkaline earth metal cations, such as calcium or magnesium ions, as well as substituted ammonium ions, such as ions of the type $N(R^1)(R^2)(R^3)(R^4)^+$, where R^1 , R^2 , R^3 and R^4 independently will typically designate hydrogen, optionally substituted C_{1-6} -alkyl or optionally substituted C_{2-6} -alkenyl. Examples of relevant C_{1-6} -alkyl groups include methyl, ethyl, 1-propyl and 2-propyl groups. Examples of C_{2-6} -alkenyl groups of possible relevance include ethenyl, 1-propenyl and 2-propenyl. Other examples of pharmaceutically acceptable salts are described in “Remington’s Pharmaceutical Sciences”, 17th edition, Alfonso R. Gennaro (Ed.), Mark Publishing Company, Easton, PA, USA, 1985 (and more recent editions thereof), in the “Encyclopaedia of Pharmaceutical Technology”, 3rd edition, James Swarbrick (Ed.), Informa Healthcare USA (Inc.), NY, USA, 2007, and in *J. Pharm. Sci.* 66: 2 (1977).

The term “solvate” in the context of the present invention refers to a complex of defined stoichiometry formed between a solute (*in casu*, a peptide conjugate or pharmaceutically acceptable salt thereof according to the invention) and a solvent. The solvent in this connection may, for example, be water, ethanol or another pharmaceutically acceptable, typically small-molecular organic species, such as, but

not limited to, acetic acid or lactic acid. When the solvent in question is water, such a solvate is normally referred to as a hydrate.

Some embodiments of the invention relate to a peptide conjugate or pharmaceutically acceptable salt thereof according to the invention for use as or the manufacture or preparation of a medicament, or to the use of a peptide conjugate or pharmaceutically acceptable salts thereof in methods of treating or preventing, a variety of diseases or conditions, for example:

type 1 diabetes, type 2 diabetes, pre-diabetes, insulin resistance syndrome, impaired glucose tolerance (IGT), disease states associated with elevated blood glucose levels, hyperglycemia, hypertension, atherogenic dyslipidemia, arteriosclerosis (e.g. atherosclerosis), macrovascular disease, coronary heart disease, peripheral artery disease, stroke, microvascular disease, gastric disease, metabolic syndrome, cancer (e.g. colon cancer), inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, and kidney failure.

Further diseases or disorders of possible relevance in this connection include obesity, morbid obesity, obesity-linked inflammation, obesity-linked gall bladder disease and obesity-induced sleep apnea.

In some embodiments, a medicament of the invention is a medicament for use in treating a subject in need thereof.

In further embodiments, the medicament of the invention is a medicament for inducing, in a subject in need thereof, pancreatic islet neogenesis (e.g. for promoting formation of new β -cells in the islets of the pancreas).

In further embodiments, the medicament of the invention is a medicament for inducing, in a subject in need thereof, survival of β -cells in the pancreatic islets (e.g. for preventing loss of β -cells in the pancreatic islets).

In further embodiments, the medicament of the invention is a medicament for inducing, in a subject in need thereof, proliferation of β -cells in the pancreatic islets (e.g. promoting proliferation of existing β -cells in the pancreatic islets).

In further embodiments, the medicament of the invention is a medicament for inducing, in a subject in need thereof, any combination of the above mentioned processes i.e. pancreatic islet neogenesis, survival of β -cells in the pancreatic islets, and/or proliferation of β -cells in the pancreatic islets.

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Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to embodiment claim 39, wherein the medicament is used for improving survival rate of the pancreatic islet β -cell in a subject in need thereof.

5 In yet other embodiments, the medicament of the invention is a medicament for use in preventing, in a subject in need thereof, β -cell apoptosis and/or necrosis in the pancreatic islets (e.g. for preventing loss of β -cells in the pancreatic islets).

In further embodiments, the medicament of the invention is a medicament for use in reducing, in a subject in need thereof, haemoglobin b1Ac (glycosylated haemoglobin; HbA1c) levels in the blood.

10 A further aspect of the invention relates to the use of a peptide conjugate of the invention in the manufacture or preparation of a medicament for the treatment, in a subject in need thereof, of one or more of the conditions disclosed herein.

A peptide conjugate of the invention may further be used in:

the manufacture of a medicament for inducing pancreatic islet neogenesis in a subject in need thereof;

15 the manufacture of a medicament for preventing β -cell apoptosis in the pancreatic islets in a subject in need thereof;

the manufacture of a medicament for use in inducing survival of β -cells in the pancreatic islets in a subject in need thereof;

20 the manufacture of a medicament for inducing pancreatic β -cells proliferation in a subject in need thereof; the manufacture of a medicament for reducing haemoglobin b1Ac (glycosylated haemoglobin; HbA1c) levels in the blood of a subject in need thereof;

and/or any combinations thereof.

25 Among related, additional aspects of the invention are corresponding methods of treatment of conditions, diseases or disorders among those disclosed herein. Thus, one such additional aspect of the invention relates to a method for treatment, in a subject in need thereof, of one or more of the diseases, disorders or conditions disclosed herein,

the method comprising administering to the subject a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to the invention.

30 Further embodiments of the present invention relate to a method for inducing pancreatic islet neogenesis in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to the invention.

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Additional embodiments of the invention relate to a method for promoting β -cell survival in the pancreatic islets in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to the invention.

- 5 Additional embodiments of the invention relate to a method for reducing or preventing β -cell apoptosis and/or necrosis in the pancreatic islets in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to the invention.

- 10 Additional embodiments of the invention relate to a method for inducing β -cell proliferation in the pancreatic islets in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to the invention.

- 15 Additional embodiments of the invention relate to a method for inducing any combination of the above mentioned processes, i.e. pancreatic islet neogenesis, survival of β -cells in the pancreatic islets, and/or proliferation of β -cells in the pancreatic islets in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to the invention.

- 20 Other embodiments of the invention relate to a method for reducing haemoglobin b1Ac (glycosylated haemoglobin; HbA1c) levels in the blood of a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to the invention.

Still further embodiments of the present invention relate to the following:

- 25 A method of treatment, in a subject in need thereof, of a disease state associated with elevated blood glucose levels;

A method for lowering blood glucose levels in a subject in need thereof;

A method of stimulating insulin release in a subject in need thereof;

A method for regulating gastric emptying in a subject in need thereof; and

- 30 A method for lowering plasma lipid levels in a subject in need thereof.

A method of lowering blood pressure in a subject in need thereof.

A method of lowering body weight in a subject in need thereof.

In each of the latter methods of the invention, the method comprises administering to the subject a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to the invention.

- 5 The term “therapeutically effective amount” as employed in the context of the above-described methods of treatment or other therapeutic intervention according to the invention refers to an amount that is sufficient to cure, ameliorate, alleviate or partially arrest the clinical manifestations of the particular disease, disorder or condition that is the object of the treatment or other therapeutic intervention in question e.g. as measured by established clinical endpoints or other biomarkers
- 10 (established or experimental). A therapeutically relevant amount may be determined empirically by one skilled in the art based on the indication being treated or prevented and the subject to whom the therapeutically relevant amount is being administered. For example, the skilled worker may measure one or more of the clinically relevant indicators of bioactivity described herein, e.g., blood glucose levels, insulin release, and plasma lipid levels. The skilled worker may determine a clinically relevant
- 15 amount through *in vitro* or *in vivo* measurements. Other exemplary measures include weight gain, weight loss, and change in blood pressure.

An amount adequate to accomplish any or all of these effects is defined as a therapeutically effective amount. The administered amount and the method of administration can be tailored to achieve optimal efficacy. An amount effective for a given purpose will depend, *inter alia*, on the severity of the disease, disorder or condition that is the object of the particular treatment or other therapeutic intervention, on the body weight and general condition of the subject in question, on diet, on possible concurrent medication, and on other factors well known to those skilled in the medical arts. Determination of an appropriate dosage size and dosing regimen most appropriate for administration of a peptide conjugate

20 or pharmaceutically acceptable salt or solvate thereof according to the invention to a human may be guided by the results obtained by the present invention, and may be confirmed in properly designed clinical trials. An effective dosage and treatment protocol may be determined by conventional means, starting with a low dose in laboratory animals and then increasing the dosage while monitoring the effects, and systematically varying the dosage regimen as well. Numerous factors may be taken into

25 consideration by a clinician when determining an optimal dosage for a given subject. Such considerations are well known to the skilled person.

30

The terms “treatment” and grammatical variants thereof (e.g. “treated”, “treating”, “treat”) as employed in the present context refer to an approach for obtaining beneficial or desired clinical results. For the purposes of this invention, beneficial or desired clinical results include, but are not limited to, alleviation

35 of symptoms, diminishment of extent of disease, stabilization (i.e. not worsening) of 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

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survival relative to expected survival time if not receiving treatment. A subject (e.g. a human) in need of treatment may thus be a subject already afflicted with the disease or disorder in question. The term “treatment” includes inhibition or reduction of an increase in severity of a pathological state or symptoms (e.g. weight gain or hyperglycemia) relative to the absence of treatment, and is not necessarily meant to imply complete cessation of the relevant disease, disorder or condition.

The terms “preventing” and grammatical variants thereof (e.g., “prevented”, “preventing”, “prevent”) as employed in the present context refer to an approach for preventing the development of, or altering the pathology of, a condition, disease or disorder. Accordingly, “prevention” may refer to prophylactic or preventive measures. For the purposes of this invention, beneficial or desired clinical results include, but are not limited to, prevention or slowing of symptoms, progression or development of a disease, whether detectable or undetectable. A subject (e.g. a human) in need of prevention may thus be a subject not yet afflicted with the disease or disorder in question. The term “prevention” thus includes slowing the onset of disease relative to the absence of treatment, and is not necessarily meant to imply permanent prevention of the relevant disease, disorder or condition.

The term “agonist” as employed in the context of the invention refers to a substance (ligand) that activates the receptor type in question.

The term “GLP-1 receptor agonist” as employed in the context of the invention (sometimes termed elsewhere “GLP-1 agonist”) refers to a substance (ligand) that activates a GLP-1 receptor, such as the human GLP-1 receptor. Substances that activate the human GLP-1 receptor include the native GLP-1 peptide hormones GLP-1(7-37), GLP-1(7-36)amide, oxyntomodulin, exendin-3, exendin-4, glucagon, gastric inhibitory polypeptide (GIP), and functional peptide analogues and derivatives thereof.

The term “antagonist” as employed in the context of the invention refers to a substance (ligand) that blocks, neutralizes or counteracts the effect of another substance (ligand) that functions as an agonist towards the receptor type in question.

In some embodiments of the invention, a subject in need of the particular treatment or other therapeutic intervention referred to in connection with the various aspects of the invention described above is a mammal. In further embodiments, the mammal is a human.

Additional embodiments of the invention relate to pharmaceutical compositions comprising a peptide conjugate, or a pharmaceutically acceptable salt or solvate thereof, according to the invention, together with a pharmaceutically acceptable carrier, excipient or vehicle.

Synthesis of peptide conjugates

The peptide conjugates of the invention may be manufactured by standard synthetic methods, by use of recombinant expression systems, or by any other suitable method. Thus, the conjugates may be synthesized in a number of ways, including, e.g., methods comprising:

(a) synthesizing the peptide conjugate by standard solid-phase or liquid-phase methodology, either stepwise or by fragment assembly, and isolating and purifying the final peptide conjugate product;

(b) expressing a nucleic acid construct that encodes the peptide conjugate in a host cell and recovering the expression product from the host cell culture; or

(c) affecting cell-free *in vitro* expression of a nucleic acid construct encoding the peptide conjugate, and recovering the expression product;

or by any combination of the methods of (a), (b) or (c) to obtain fragments of the peptide conjugate, subsequently ligating the fragments to obtain the peptide conjugate, and recovering the peptide conjugate.

It may be preferable to synthesize the conjugates of the invention by means of solid-phase or liquid-phase peptide synthesis. In this context, reference may be made to WO 98/11125 or, *inter alia*, Fields, G.B. et al., "Principles and Practice of Solid-Phase Peptide Synthesis"; in: *Synthetic Peptides*, Gregory A. Grant (ed.), Oxford University Press (2nd edition, 2002) and the synthesis examples herein.

One or more of the amino acid side chains in the compound of the invention may be further conjugated to a lipophilic substituent. The lipophilic substituent may be covalently bonded to an atom in the amino acid side chain, or alternatively may be conjugated to the amino acid side chain by a spacer. The amino acid may be part of the peptide Z, or a part of peptide L.

Without wishing to be bound by theory, it is thought that the lipophilic substituent binds albumin in the blood stream, thus shielding the compounds of the invention from enzymatic degradation which can enhance the half-life of the compounds. The spacer, when present, may provide spacing between the compound and the lipophilic substituent.

The lipophilic substituent may be attached to the amino acid side chain or to the spacer via an ester, a sulphonyl ester, a thioester, an amide or a sulphonamide. Accordingly it will be understood that in some embodiments the lipophilic substituent includes an acyl group, a sulphonyl group, an N atom, an O atom or an S atom which forms part of the ester, sulphonyl ester, thioester, amide or sulphonamide.

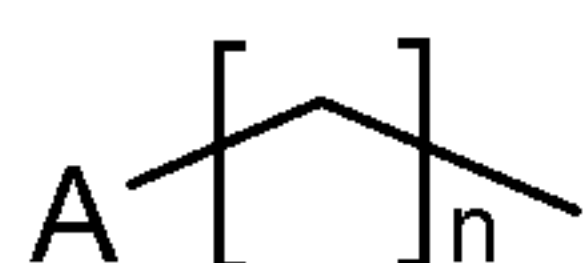
Preferably, an acyl group in the lipophilic substituent forms part of an amide or ester with the amino acid side chain or the spacer.

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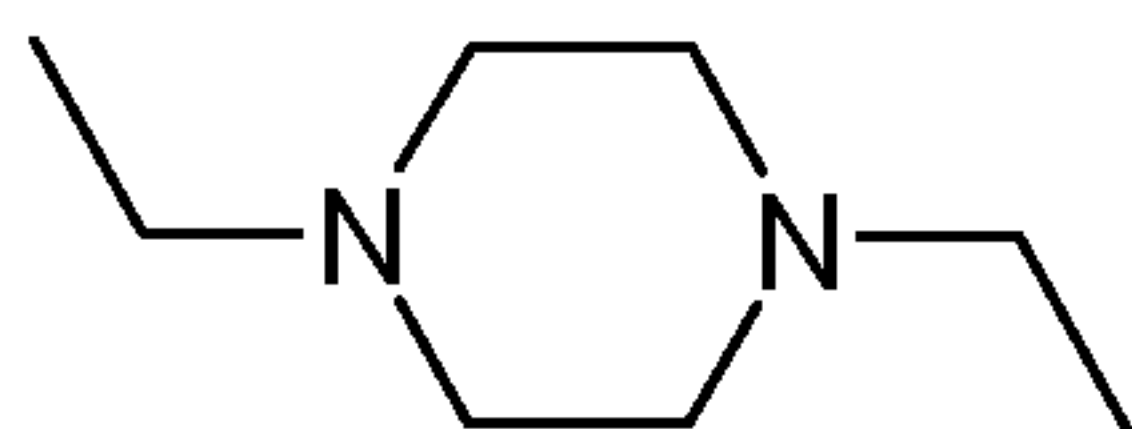
The lipophilic substituent may include a hydrocarbon chain having 4 to 30 C atoms, for example at least 8 or 12 C atoms, and preferably 24 C atoms or fewer, or 20 C atoms or fewer. The hydrocarbon chain may be linear or branched and may be saturated or unsaturated. It will be understood that the hydrocarbon chain is preferably substituted with a moiety which forms part of the attachment to the amino acid side chain or the spacer, for example an acyl group, a sulphonyl group, an N atom, an O atom or an S atom. Most preferably the hydrocarbon chain is substituted with an acyl group, and accordingly the hydrocarbon chain may be part of an alkanoyl group, for example palmitoyl, caproyl, lauroyl, myristoyl or stearoyl.

Accordingly, the lipophilic substituent may have the formula shown below:



A may be, for example, an acyl group, a sulphonyl group, NH, N-alkyl, an O atom or an S atom, preferably acyl. n is an integer from 3 to 29. In some embodiments, n is least 7 or at least 11. In some embodiments, n is 23 or less. In some embodiments, n is 19 or less.

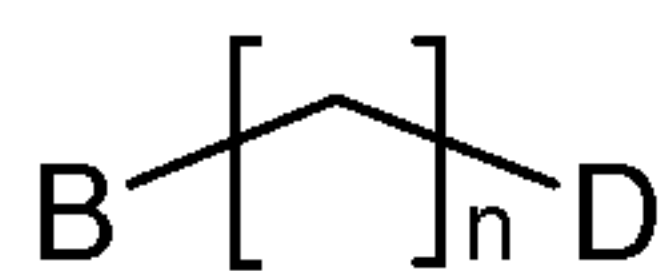
The hydrocarbon chain may be further substituted. For example, it may be further substituted with up to three substituents selected from NH₂, OH and COOH. If the hydrocarbon chain is further substituted, preferably it is further substituted with only one substituent. Alternatively or additionally, the hydrocarbon chain may include a cycloalkane or heterocycloalkane, for example as shown below:



In some embodiments, the cycloalkane or heterocycloalkane is a six-membered ring. In certain preferred embodiments, it is piperidine.

Alternatively, the lipophilic substituent may be based on a cyclopentanophenanthrene skeleton, which may be partially or fully unsaturated, or saturated. The carbon atoms in the skeleton each may be substituted with Me or OH. For example, the lipophilic substituent may be cholyl, deoxycholyl or lithocholyl.

As indicated above, the lipophilic substituent may be conjugated to the amino acid side chain by a spacer. When present, the spacer is attached to the lipophilic substituent and to the amino acid side chain. The spacer may be attached to the lipophilic substituent and to the amino acid side chain independently by an ester, a sulphonyl ester, a thioester, an amide or a sulphonamide. Accordingly, it may include two moieties independently selected from acyl, sulphonyl, an N atom, an O atom or an S atom. The spacer may have the formula:



wherein B and D are each independently selected from acyl, sulphonyl, NH, N-alkyl, an O atom or an S atom, preferably from acyl and NH. Preferably, n is an integer from 1 to 10, for example from 1 to 5.

The spacer may optionally be further substituted with one or more substituents selected from C₁₋₆ alkyl, C₁₋₆ alkyl amine, C₁₋₆ alkyl hydroxy and C₁₋₆ alkyl carboxy.

Alternatively, the spacer may have two or more repeat units of the formula above. B, D and n are each selected independently for each repeat unit. Adjacent repeat units may be covalently attached to each other via their respective B and D moieties. For example, the B and D moieties of the adjacent repeat units may together form an ester, a sulphonyl ester, a thioester, an amide or a sulphonamide. The free B and D units at each end of the spacer are attached to the amino acid side chain and the lipophilic substituent as described above.

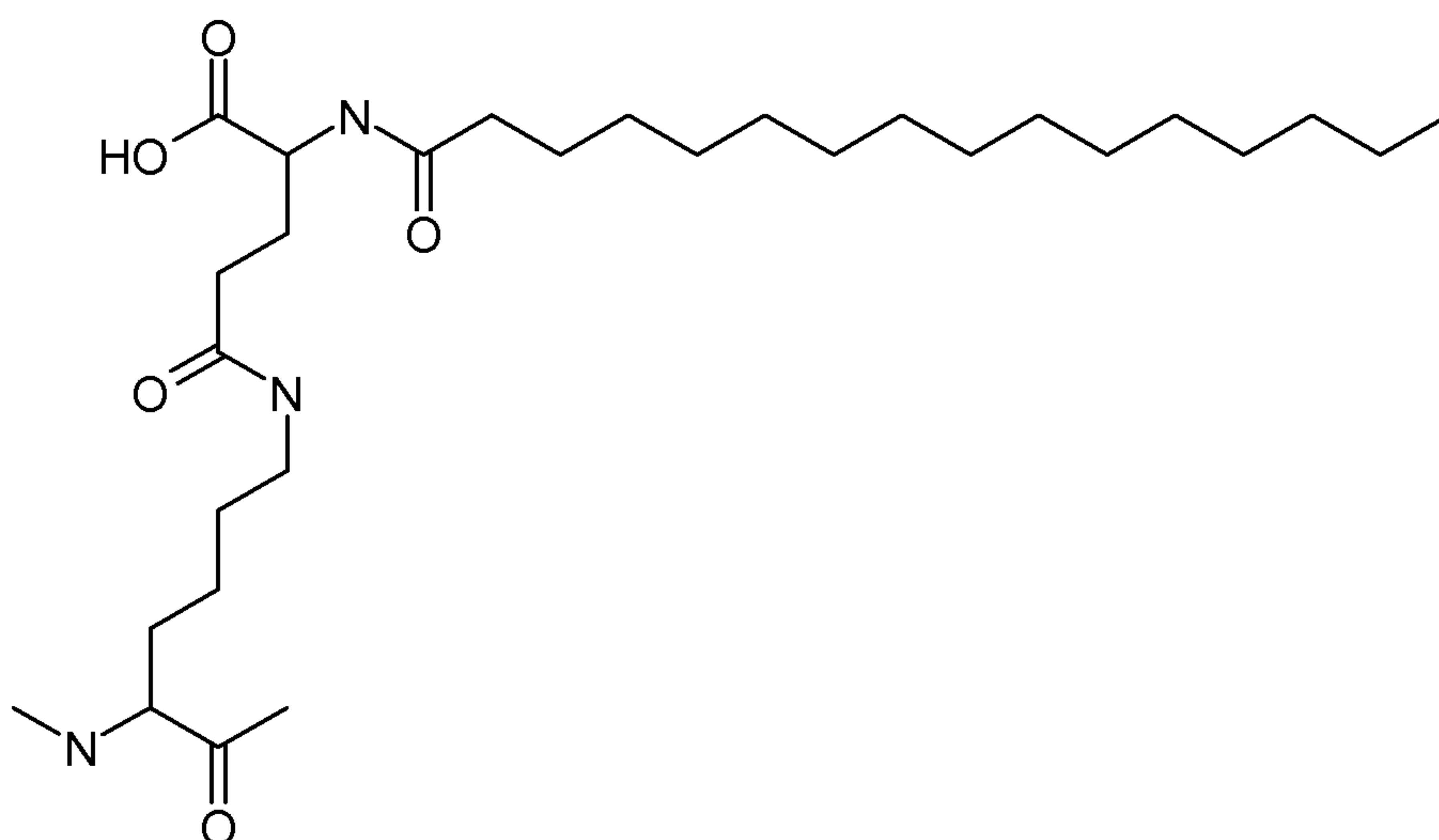
Preferably the spacer has five or fewer, four or fewer or three or fewer repeat units. Most preferably the spacer has two repeat units, or is a single unit.

The spacer (or one or more of the repeat units of the spacer, if it has repeat units) may be, for example, a natural or unnatural amino acid. It will be understood that for amino acids having functionalized side chains, B and/or D may be a moiety within the side chain of the amino acid. The spacer may be any naturally occurring or unnatural amino acid. For example, the spacer (or one or more of the repeat units of the spacer, if it has repeat units) may be Gly, Pro, Ala, Val, Leu, Ile, Met, Cys, Phe, Tyr, Trp, His, Lys, Arg, Gln, Asn, α -Glu, γ -Glu, Asp, Ser Thr, Gaba, Aib, bAla, 5-aminopentanoyl, 6-aminohexanoyl, 7-aminoheptanoyl, 8-aminooctanoyl, 9-aminononanoyl or 10-aminodecanoyl.

For example, the spacer may be a single amino acid selected from γ -Glu, Gaba, b-Ala and α -Gly.

The lipophilic substituent may be conjugated to any amino acid side chain in the compounds of the invention. Preferably, the amino acid side chain includes a carboxy, hydroxyl, thiol, amide or amine group, for forming an ester, a sulphonyl ester, a thioester, an amide or a sulphonamide with the spacer or lipophilic substituent. For example, the lipophilic substituent may be conjugated to Asn, Asp, Glu, Gln, His, Lys, Arg, Ser, Thr, Tyr, Trp, Cys or Dbu, Dpr or Orn. Preferably, the lipophilic substituent is conjugated to Lys or Cys. However, any amino acid shown as Lys in the formulae provided herein may be replaced by Dbu, Dpr or Orn where a lipophilic substituent is added.

An example lipophilic substituent and spacer is shown in the formula below:



Here, a Lys from the compound of the present invention (e.g. from X) is covalently attached to γ -Glu (the spacer) by via an amide moiety. Palmitoyl is covalently attached to the γ -Glu spacer via an amide moiety.

Alternatively or additionally, one or more of the amino acid side chains in the compound of the invention may be further conjugated to a biotinyllic substituent. The biotinyllic substituent may be covalently bonded to an atom in the amino acid side chain, or alternatively may be conjugated to the amino acid side chain by a spacer. The amino acid may be part of the peptide Z, or a part of peptide L.

Without wishing to be bound by theory, it is thought that the biotinyllic substituent binds albumin in the blood stream, thus shielding the compounds of the invention from enzymatic degradation which can enhance the half-life of the compounds. The spacer, when present, is used to provide spacing between the compound and the biotinyllic substituent.

The biotinyllic substituent may be attached to the amino acid side chain or to the spacer via an maleimide ester, a sulphonyl ester, a thioester, an amide or a sulphonamide. Accordingly it will be understood that preferably the biotinyllic substituent includes a maleimido group, an acyl group, a sulphonyl group, an N atom, an O atom or an S atom which forms part of the ester, sulphonyl ester, thioester, amide or sulphonamide.

In preferred embodiments the biotin moiety is first coupled to a spacer before the spacer is coupled to the peptide. A number of biotin-spacer conjugates are commercially available with a spacer functionality that will allow coupling to side chains of Lysines or Cysteines. In more preferred embodiments the biotin-spacer conjugate contains a maleimide functionality that can couple selectively to a sulfhydryl group on a Cysteine side chain.

CC(=O)C(NC)CSC1C(=O)N(CCCC(=O)NNC(=O)CCCCC2C(=O)N3C(=O)SC[C@H]3N2)C1=O

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The skilled worker will be well aware of suitable techniques which can be used to perform the coupling reaction. For example, a PEG moiety carrying a methoxy group can be coupled to a Cys thiol group by a maleimido linkage using reagents commercially available from Nektar Therapeutics AL. See also WO 2008/101017, and the references cited above for details of suitable chemistry.

- 5 In some embodiment of the present invention, a maleimide functionalised PEG is conjugated to the side chain sulphydryl group of a Cystein.

Efficacy

- 10 A peptide conjugate of the invention has one or more biological activities of exendin-4 and one or more biological activities of gastrin.

The peptide Z (Z_a , Z_b) in the absence of the gastrin-like component Y (Y_a , Y_b) and any linker component L (L_a , L_b), has one or more biological activities of exendin-4. That is to say, a compound R^1 -Z- R^2 would have said one or more biological activities of exendin-4.

15 The peptide Y (Y_a , Y_b) in the absence of the exendin-4-like component Z (Z_a , Z_b) and any linker component L (L_a , L_b) has one or more biological activities of gastrin. That is to say, a compound R^1 -Y- R^2 would have said one or more biological activities of gastrin.

- 20 The biological activity of exendin-4 may be agonist activity at the GLP-1 receptor. The biological activity of gastrin may be agonist activity at the CCK-B receptor.

Preferably the agonist activity is at the human GLP-1 receptor and/or the human CCK-B receptor. "Agonist activity" may involve the ability to induce intracellular cyclic AMP (cAMP) synthesis or pERK phosphorylation on binding to the relevant receptor.

25 Thus, binding of the relevant compounds to GLP-1 or CCK-B receptors may be used as an indication of agonist activity, but in general it is preferred to use a biological assay which measures intracellular signalling caused by binding of the compound to the relevant receptor. For example, activation of the GLP-1 receptor by a suitable agonist will stimulate cellular cAMP formation. Similarly, activation of the CCK-B receptor by a suitable agonist will stimulate cellular pERK phosphorylation. Thus, production of cAMP or phosphorylation of ERK (pERK) in suitable cells expressing one of these two receptors can be used to monitor the relevant receptor activity. Use of a suitable pair of cell types, each expressing one receptor but not the other, can hence be used to determine agonist activity towards both types of receptor.

35 The skilled person will be aware of suitable assay formats, and examples are provided below. The assays may employ the human GLP-1 receptor (NP_002053.3 GI:166795283) and/or the human CCK-B receptor (NM_176875.3 GI:356995851). Where sequences of precursor proteins are referred

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to, it should of course be understood that assays may make use of the mature protein, lacking the signal sequence.

In a preferred embodiment, the polypeptide of the invention may have an EC_{50} value of below 0.1 nM for GLP1-R.

- 5 In some embodiments, the polypeptide of the invention may have an EC_{50} value below 100 nM for CCKB-R

In a preferred embodiment, the polypeptide of the invention may have an EC_{50} value of below 50 nM for CCKB-R

The EC_{50} values should be measured as described in Example 4.

10 Therapeutic uses

Uses of the peptide conjugates of the invention also encompass uses of pharmaceutically acceptable salts or solvates thereof.

The peptide conjugates of the invention may provide an attractive treatment option for metabolic diseases or disorders, including diabetes, in particular type 1 and/or type 2 diabetes, and obesity.

- 15 Diabetes comprises a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Acute signs of diabetes include excessive urine production, resulting compensatory thirst and increased fluid intake, blurred vision, unexplained weight loss, lethargy, and changes in energy metabolism. The chronic hyperglycemia of diabetes is associated with macro- and microvascular complications that can lead to long-term damage,
20 dysfunction, and – in some cases – ultimately failure of various organs, particularly the eyes (notably in the form of diabetic retinopathy), kidneys (in the form of diabetic nephropathy), nerves (in the form of diabetic neuropathy), heart and blood vessels. Diabetes may be subdivided into three classes, viz. type 1 diabetes, type 2 diabetes and gestational diabetes, on the basis of pathogenetic characteristics.

- 25 Type 1 diabetes accounts for 5-10% of all diabetes cases and is caused by auto-immune destruction of insulin-secreting pancreatic β -cells.

Type 2 diabetes accounts for 90-95% of diabetes cases and is a result of a complex set of metabolic disorders. Type 2 diabetes is the consequence of endogenous insulin production and/or whole-body insulin sensitivity becoming insufficient to maintain plasma glucose levels below the diagnostic thresholds.

- 30 Gestational diabetes refers to any degree of glucose intolerance identified during pregnancy.

A condition known as pre-diabetes is also recognized. It includes, e.g., elevated fasting glucose levels and impaired glucose tolerance, and refers generally to those states that occur when blood glucose levels are elevated, but are below levels that are established for the clinical diagnosis for diabetes.

A large proportion of subjects with type 2 diabetes and pre-diabetes are at increased risk of morbidity and mortality due to the high prevalence of additional metabolic risk factors, including abdominal obesity (excessive fat tissue around the abdominal internal organs), atherogenic dyslipidemia (blood fat disorders, including high triglyceride levels, low HDL cholesterol levels and/or high LDL cholesterol levels, which foster plaque build-up in artery walls), elevated blood pressure (hypertension), a prothrombotic state (e.g. high Fibrinogen or Plasminogen activator inhibitor-1 levels in the blood), and a proinflammatory state (e.g., elevated C-reactive protein levels in the blood).

Conversely, obesity confers an increased risk of developing, for example, pre-diabetes, type 2 diabetes, certain types of cancer, obstructive sleep apnea and gall-bladder disease.

Dyslipidemia is associated with increased risk of cardiovascular disease. High Density Lipoproteins (HDLs) are of clinical importance since an inverse correlation exists between plasma HDL concentrations and the risk of atherosclerotic disease. The majority of the cholesterol stored in atherosclerotic plaques originates from Low Density Lipoproteins (LDL), and hence elevated concentrations of LDL are closely associated with atherosclerosis. The HDL/LDL ratio is a parameter employed to assess the clinical risk of atherosclerosis and coronary atherosclerosis in particular.

Without being bound by any particular theory, it appears that the peptide conjugates of the invention may unexpectedly combine the physiological effects of GLP-1 receptor agonists with those of gastrin peptides *vide supra* in a manner such that the observed activity may be significantly greater than that observed when employing a corresponding additive (non-conjugated) combination of the individual peptide components. It is consequently believed that the peptide conjugates of the invention may be of particular benefit in the treatment of pre-diabetes, diabetes (notably type 1 and/or type 2 diabetes) and diabetes-related conditions, diseases or disorders such as those discussed above, including treatment to promote pancreatic islet β -cell formation (islet neogenesis), and thereby insulin production, that will be beneficial with respect to regulation of blood glucose concentrations. Peptide conjugates of the invention may therefore be of value, *inter alia*, in limiting or arresting disease progression in type 1 and/or type 2 diabetes.

The peptides of the present invention may further be useful for promoting survival and inhibiting apoptosis of β -cells in the pancreatic islets. Effects of GLP-1 and gastrin includes effects on β -cell proliferation and maturation but also prevention of β -cell apoptosis and/or necrosis and enhanced neogenesis, thus the effects of the peptides of the invention may include such effects and thereof effects on improved insulin and glucose regulation.

The peptide conjugates of the present invention may thus be useful as pharmaceutical agents for treatment of any of the diseases, disorders, or conditions described herein. Exemplary diseases, disorders, or conditions include insulin resistance, glucose intolerance, pre-diabetes, disease states associated with elevated blood glucose levels (e.g., elevated fasting blood glucose levels), type 1 and/or type 2 diabetes, hyperglycemia, gastric disease, metabolic syndrome, hypertension and/or dyslipidemia (or a combination of these metabolic risk factors), atherosclerosis, arteriosclerosis,

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coronary heart disease, microvascular disease, macrovascular diseases, peripheral artery disease, stroke, cancer (e.g. colon cancer), inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, and kidney failure.

Exemplary effects of treatment include preventing weight gain, promoting weight loss, reducing excess
 5 body weight and/or treating obesity (e.g. by control of appetite, feeding, food intake, calorie intake, and/or energy expenditure), including morbid obesity, as well as associated diseases, disorders and health conditions, including, but not limited to, obesity-linked inflammation, obesity-linked gallbladder disease and obesity-induced sleep apnea. Effects of the peptide conjugates of the invention on these conditions may be mediated in whole or in part via an effect on body weight, or may be independent
 10 thereof.

Pharmaceutical compositions

In the following, it will be understood that reference to the inclusion of one or more of a peptide conjugate of the invention in a pharmaceutical composition also encompasses inclusion of a
 15 pharmaceutically acceptable salt or solvate of a peptide conjugate of the invention.

The peptide conjugates of the present invention may be formulated as pharmaceutical compositions which are suited for administration with or without storage, and which typically comprise a therapeutically effective amount of at least one peptide conjugate of the invention, together with a pharmaceutically acceptable carrier, excipient or vehicle.

20 The term "pharmaceutically acceptable carrier" includes any of the standard pharmaceutical carriers. Pharmaceutically acceptable carriers for therapeutic use are well known in the pharmaceutical art and are described, for example, in "Remington's Pharmaceutical Sciences", 17th edition, Alfonso R. Gennaro (Ed.), Mark Publishing Company, Easton, PA, USA, 1985. For example, sterile saline and phosphate-buffered saline at slightly acidic or physiological pH may be used. Suitable pH-buffering
 25 agents may, e.g., be phosphate, citrate, acetate, tris(hydroxymethyl)aminomethane (TRIS), N-tris(hydroxymethyl)methyl-3-aminopropanesulfonic acid (TAPS), ammonium bicarbonate, diethanolamine, histidine, arginine, lysine or acetate (e.g. as sodium acetate), or mixtures thereof. The term further encompasses any carrier agents listed in the US Pharmacopeia for use in animals, including humans.

30 A pharmaceutical composition of the invention may be in unit dosage form. In such form, the composition is divided into unit doses containing appropriate quantities of the active component or components. The unit dosage form may be presented as a packaged preparation, the package containing discrete quantities of the preparation, for example, packaged tablets, capsules or powders in vials or ampoules. The unit dosage form may also be, e.g., a capsule, cachet or tablet in itself, or it
 35 may be an appropriate number of any of these packaged forms. A unit dosage form may also be provided in single-dose injectable form, for example in the form of a pen device containing a liquid-

phase (typically aqueous) composition. Compositions may be formulated for any suitable route and means of administration. Pharmaceutically acceptable carriers or diluents include those used in formulations suitable for e.g. oral, intravitreal, rectal, vaginal, nasal, topical, enteral or parenteral (including subcutaneous (SC), intramuscular (IM), intravenous (IV), intradermal and transdermal)

5 administration or administration by inhalation. The formulations may conveniently be presented in unit dosage form and may be prepared by any of the methods well known in the art of pharmaceutical formulation.

Subcutaneous or transdermal modes of administration may be particularly suitable for the peptide conjugates of the invention.

10 A further aspect of the invention relates to devices, dosage forms and packages used to deliver the pharmaceutical formulations of the present invention. Thus, at least one peptide conjugate or specified portion or variant in either the stable or preserved formulations or solutions described herein, can be administered to a patient in accordance with the present invention via a variety of delivery methods including SC or IM injection; transdermal, pulmonary, transmucosal, implant, osmotic pump, cartridge,
15 micro pump, or other means appreciated by the skilled artisan, as well-known in the art.

A still further aspect of the invention relates to oral formulations and administration. Formulations for oral administration may rely on the co-administration of adjuvants (e.g., resorcinols and nonionic surfactants such as polyoxyethylene oleyl ether and n-hexadecylpolyethylene ether) to artificially increase the permeability of the intestinal walls, as well as the co-administration of enzymatic inhibitors
20 (e.g., pancreatic trypsin inhibitors, diisopropylfluorophosphate (DFF) and trasylol) to inhibit enzymatic degradation. The active constituent compound of the solid-type dosage form for oral administration can be mixed with at least one additive, including sucrose, lactose, cellulose, mannitol, trehalose, raffinose, maltitol, dextran, starches, agar, arginates, chitins, chitosans, pectins, gum tragacanth, gum arabic, gelatin, collagen, casein, albumin, synthetic or semisynthetic polymer, and glyceride. These dosage
25 forms can also contain other type(s) of additives, e.g., inactive diluting agent, lubricant such as magnesium stearate, paraben, preserving agent such as sorbic acid, ascorbic acid, alpha-tocopherol, antioxidants such as cysteine, disintegrators, binders, thickeners, buffering agents, pH adjusting agents, sweetening agents, flavoring agents, perfuming agents, etc.

30 Dosages

A typical dosage of a peptide conjugate of the invention as employed in the context of the present invention may be in the range from about 0.0001 to about 100 mg/kg body weight per day, such as from about 0.0005 to about 50 mg/kg body weight per day, such as from about 0.001 to about 10 mg/kg body weight per day, such as from about 0.005 to about 5 mg/kg body weight per day, e.g. from
35 about 0.01 to about 1 mg/kg body weight per day, e.g. from about 0.015 to about 0.1 mg/kg body weight per day administered in one or more doses, such as from one to three doses. As already

indicated to some extent above, the exact dosage employed will depend, *inter alia*, on: the nature and severity of the disease or disorder to be treated; the sex, age, body weight and general condition of the subject to be treated; possible other, concomitant disease or disorder that is undergoing or is to undergo treatment; as well as other factors that will be known to a medical practitioner of skill in the art.

- 5 A peptide conjugate of the invention may be administered continuously (e.g., by intravenous administration or another continuous drug administration method), or may be administered to a subject in intervals, typically in regular time intervals, depending on the desired dosage and the pharmaceutical composition selected by the skilled practitioner for the particular subject.
- 10 Regular administration dosing intervals include, e.g., once daily, twice daily, once every two, three, four, five or six days, once or twice weekly, once or twice monthly, or a regular and even less frequent dosing interval, depending on the particular dosage formulation, bioavailability, and pharmacokinetic profile of the peptide conjugate.
- 15 Such regular peptide conjugate administration regimens of the invention may, in certain circumstances such as, e.g., during chronic long term administration, be advantageously interrupted for an interval of time so that the medicated subject reduces the level of or stops taking the medication, often referred to as taking a “drug holiday.” Drug holidays are useful for, e.g., maintaining or regaining sensitivity to a drug especially during long term chronic treatment, or, to reduce unwanted side-effects of long term
- 20 chronic treatment of the subject with the drug.

The timing of a drug holiday depends on the timing of the regular dosing regimen and the purpose for taking the drug holiday (e.g., to regain drug sensitivity and/or to reduce unwanted side effects of continuous, long term administration). In some embodiments, the drug holiday may be a reduction in

25 the drug (e.g., below the therapeutically effective amount for a certain interval of time). In other embodiments, administration of the drug is stopped for a certain interval of time before administration is started again, at the same or at a different dosing regimen (e.g., at a lower or higher dose and/or frequency of administration).

- 30 Thus, the peptide conjugate may be delivered via an administration regime which comprises two or more administration phases separated by respective drug holiday phases.

During each administration phase, the peptide conjugate is administered to the recipient subject in a therapeutically effective amount according to a pre-determined administration pattern. The

35 administration pattern may comprise continuous administration of the drug to the recipient subject over the duration of the administration phase. Alternatively, the administration pattern may comprise administration of a plurality of doses of the peptide conjugate to the recipient subject, wherein said doses are spaced by dosing intervals.

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A dosing pattern may comprise at least two doses per administration phase, at least five doses per administration phase, at least 10 doses per administration phase, at least 20 doses per administration phase, at least 30 doses per administration phase, or more.

5 Said dosing intervals may be regular dosing intervals, which may be as set out above, including once daily, twice daily, once every two, three, four, five or six days, once or twice weekly, once or twice monthly, or a regular and even less frequent dosing interval, depending on the particular dosage formulation, bioavailability, and pharmacokinetic profile of the peptide conjugate.

10 An administration phase may have a duration of at least two days, at least a week, at least 2 weeks, at least 4 weeks, at least a month, at least 2 months, at least 3 months, at least 6 months, or more.

Where an administration pattern comprises a plurality of doses, the duration of the following drug holiday phase is longer than the dosing interval used in that administration pattern. Where the dosing
15 interval is irregular, the duration of the drug holiday phase may be greater than the mean interval between doses over the course of the administration phase. Alternatively the duration of the drug holiday may be longer than the longest interval between consecutive doses during the administration phase.

20 The duration of the drug holiday phase may be at least twice that of the relevant dosing interval (or mean thereof), at least 3 times, at least 4 times, at least 5 times, at least 10 times, or at least 20 times that of the relevant dosing interval or mean thereof.

Within these constraints, a drug holiday phase may have a duration of at least two days, at least a
25 week, at least 2 weeks, at least 4 weeks, at least a month, at least 2 months, at least 3 months, at least 6 months, or more, depending on the administration pattern during the previous administration phase.

An administration regime comprises at least 2 administration phases. Consecutive administration phases are separated by respective drug holiday phases. Thus the administration regime may
30 comprise at least 3, at least 4, at least 5, at least 10, at least 15, at least 20, at least 25, or at least 30 administration phases, or more, each separated by respective drug holiday phases.

Consecutive administration phases may utilise the same administration pattern, although this may not always be desirable or necessary. However, if other drugs or active agents are administered in
35 combination with the peptide conjugate of the invention, then typically the same combination of drugs or active agents is given in consecutive administration phases. In certain embodiments, the recipient subject is human.

Combination therapy

As noted above, it will be understood that reference in the following to a peptide conjugate of the invention also extends to a pharmaceutically acceptable salt or solvate thereof as well as to a composition comprising more than one different peptide conjugate of the invention.

A peptide conjugate of the invention may be administered as part of a combination therapy together with another active agent for the treatment of the disease or disorder in question, e.g. diabetes, obesity, metabolic syndrome, dyslipidemia or hypertension, and in such cases, the two active agents may be given together or separately, e.g. as constituents in the same pharmaceutical composition or formulation, or as separate formulations.

Thus a peptide conjugate of the invention may be used in combination with an anti-diabetic agent of known type, including, but not limited to, metformin, a sulfonylurea, a glinide, a DPP-IV inhibitor, a glitazone, or insulin or an insulin analogue. In a preferred embodiment, the peptide conjugate of the invention is administered in combination with insulin or an analogue thereof, a DPP-IV inhibitor, sulfonylurea or metformin, particularly sulfonylurea or metformin, for achieving adequate glycemic control. In a more preferred embodiment, the peptide conjugate is administered in combination with insulin or an insulin analogue for achieving adequate glycemic control. Examples of appropriate insulin analogues include, but are not limited to, Lantus™, Novorapid™, Humalog™, Novomix™, Actraphane™ HM, Levemir™, Degludec™ and Apidra™. Other relevant anti-diabetic agents in this connection include GLP-1 receptor agonists, such as exenatide (Byetta™; exendin-4), and Byetta LAR™, lixisenatide (Lyxumia™) and liraglutide (Victoza™).

A peptide conjugate of the invention may also be used in combination with an anti-obesity agent of known type, including, but not limited to, peptide YY or an analogue thereof, neuropeptide Y (NPY) or an analogue thereof, a cannabinoid receptor 1 antagonist, a lipase inhibitor, Human proinsulin Peptide (HIP), a melanocortin receptor 4 agonist, liraglutide, Orlistat™ and Sibutramine™ or a melanin concentrating hormone receptor 1 antagonist, CCK, amylin or leptin, and analogues thereof.

A peptide conjugate of the invention may further be used in combination with an anti-hypertension agent of known type, including, but not limited to, an angiotensin-converting enzyme inhibitor, an angiotensin II receptor blocker, a diuretic, a beta-blocker or a calcium channel blocker.

A peptide conjugate of the invention may still further be used in combination with an anti-dyslipidemia agent of known type, including, but not limited to, a statin, a fibrate, a niacin and/or a cholesterol absorption inhibitor.

A peptide conjugate of the invention may also be used in combination with a proton pump inhibitor (i.e. a pharmaceutical agent possessing pharmacological activity as an inhibitor H⁺/K⁺-ATPase) of known type, including, but not limited to, an agent of the benzimidazole derivative type or of the imidazopyridine derivative type, such as Omeprazole™, Lansoprazole™, Dexlansoprazole™,

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Esomeprazole™, Pantoprazole™, Rabeprazole™, Zolpidem™, Alpidem™, Saripidem™ or Necopidem™.

A peptide conjugate of the invention may, moreover, be used in combination with an anti-inflammatory agent of known type, including, but not limited to:

- 5 steroids and corticosteroids, such as beclomethasone, methylprednisolone, betamethasone, prednisone, dexamethasone, and hydrocortisone;

- non-steroidal antiinflammatory agents (NSAIDs), such as propionic acid derivatives (e.g. alminoprofen, benoxaprofen, bucloxic acid, carprofen, fenbufen, fenoprofen, fluprofen, flurbiprofen, ibuprofen, indoprofen, ketoprofen, miroprofen, naproxen, oxaprozin, pirprofen, pranoprofen, suprofen, tiaprofenic
10 acid and tioxaprofen); acetic acid derivatives (e.g. indomethacin, acemetacin, alclofenac, clidanac, diclofenac, fenclofenac, fenclozic acid, fentiazac, furofenac, ibufenac, isoxepac, oxpinac, sulindac, tiopinac, tolmetin, zidometacin and zomepirac); fenamic acid derivatives (e.g. flufenamic acid, meclofenamic acid, mefenamic acid, niflumic acid and tolfenamic acid); biphenylcarboxylic acid derivatives (e.g. diflunisal and flufenisal); oxicams (e.g. isoxicam, piroxicam, sudoxicam and
15 tenoxicam); salicylates (e.g. acetylsalicylic acid and sulfasalazine); and pyrazolones (e.g. apazone, bezpiperylon, feprazone, mofebutazone, oxyphenbutazone and phenylbutazone);

- COX II inhibitors, such as rofecoxib and celecoxib; preparations of interferon beta (e.g. interferon beta-1a or interferon beta-1b);
20 and certain other compounds, such as 5-aminosalicylic acid and prodrugs and pharmaceutically acceptable salts thereof.

- Metformin has also been demonstrated to have anti-inflammatory properties [see Haffner et al.,
25 *Diabetes* 54: 1566-1572 (2005)] and as such may also be useful in the context of the present invention.

- The following examples demonstrate certain specific embodiments of the present invention. The following examples were carried out using standard techniques, which are well known and routine to
30 those of skill in the art, except where otherwise described in detail. It is to be understood that these examples are for illustrative purposes only and do not purport to be wholly definitive as to conditions or scope of the invention. As such, they should not be construed in any way as limiting the scope of the present invention.

Abbreviations employed in the examples include:

- 35 NMP: N-methylpyrrolidone

DCM: dichloromethane

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DMF: N,N-dimethylformamide

HATU: 2-(7-aza-1H-benzotriazole-1-yl)-1,1,3,3-tetramethyluronium hexafluorophosphate

DIPEA: diisopropylethylamine

EtOH: ethanol

5 Et₂O: diethyl ether

8Ado: 8-amino-3,6-dioxaoctanoyl

8Aoc: 8-aminooctanoyl

TFA: trifluoroacetic acid

MeCN: acetonitrile

10 HPLC: high performance liquid chromatography

MS: mass spectrometry

IBMX: 3-isobutyl-1-methylxanthine

BSA: bovine serum albumin

cAMP: cyclic adenosine monophosphate

15 DMEM: Dulbecco's Modified Eagle Medium

FCS: fetal calf serum

HEPES: N-2-hydroxyethylpiperazine-N'-2-ethanesulfonic acid

p-ERK: phosphorylated extracellular regulated kinase

PBS: phosphate-buffered saline

20 Boc: t-Butoxycarbonyl

NEP: N-Ethylpyrrolidone

Liraglutide: [Arg34, Lys26(Hexadecanoyl-isoGlu)]GLP-1(7-37)

Synthesis of compounds**MATERIALS AND METHODS**

Unless otherwise specified, reagents and solvents employed in the following were available commercially in standard laboratory reagent or analytical grade, and were used without further purification.

General procedure for synthesis of peptide conjugates of the invention

Solid phase peptide synthesis was performed on a CEM Liberty Peptide Synthesizer using standard Fmoc chemistry. TentaGel™ S Ram resin (1 g; 0.25 mmol/g) was swelled in NEP (10 ml) prior to use and transferred between tube and reaction vessel using DCM and NEP. Pseudoprolines, which are dipeptides employed to minimize aggregation during peptide synthesis, such as Fmoc-Phe-Thr(ψ-Me,Me-Pro)-OH and Fmoc-Asp-Ser(ψ-Me,Me-Pro)-OH, were used where appropriate, and non-natural amino acids (i.e. Fmoc-8Ado-OH) were employed without any changes to the general procedure.

Coupling:

An Fmoc-amino acid in NEP/DMF/DCM (1:1:1; 0.2 M; 5 ml) was added to the resin in a CEM Discover microwave unit together with HATU/DMF (0.5 M; 2 ml) and DIPEA/NEP (2.0 M; 1 ml). The coupling mixture was heated to 75°C for 5 min while nitrogen was bubbled through the mixture. The resin was then washed with NEP (4 x 10 ml).

Deprotection:

Piperidine/NEP (1/4 (representing 1 part piperidine to 4 parts NEP); 10 ml) was added to the resin for initial deprotection, and the mixture was microwave-heated (40°C; 30 sec.). The reaction vessel was drained and a second portion of piperidine/NEP (1/4; 10 ml) was added and heated (75°C; 3 min) again. The resin was then washed with NEP (6 x 10 ml).

Cleavage:

The resin was washed with EtOH (3 x 10 ml) and Et₂O (3 x 10 ml) and dried to constant weight at room temperature (r.t.). The crude peptide was cleaved from the resin by treatment with TFA/TIS/H₂O (90/5/5; 40 ml; 2 h; r.t.). Most of the TFA was removed under reduced pressure, and the crude peptide was precipitated and washed three times with Et₂O and dried to constant weight at room temperature.

Purification and characterisation:

The crude peptide was purified to greater than 90% purity by preparative reverse phase HPLC using a PerSeptive Biosystems VISION Workstation equipped with a suitable column and a fraction collector, and run with a gradient of buffer A (0.1% TFA, aq.) and buffer B (0.1% TFA, 90% MeCN, aq.).

Fractions were analysed by analytical HPLC and MS, and relevant fractions were pooled and lyophilised. The final product was characterised by HPLC and MS.

Example 1: _Synthesis of Compound 2 [Leu14,Lys25(Hexadecanoyl-isoGlu)]Exendin-4(1-28)-8Ado-8Ado-[Leu4]Gastrin6

5 [Leu14]Exendin-4(1-28)-8Ado-8Ado-[Leu4]Gastrin6 was synthesized on a CEM Liberty Peptide Synthesizer using TentaGel S Ram resin (1,13 g; 0.24 mmol/g) and Fmoc chemistry as described above. Fmoc-8-amino-3,6-dioxaoctanoic acid (Fmoc-8Ado-OH) was employed as well as Fmoc-Lys(Dde)-OH at the point of attachment for the acylation.

10 The resin bound protected linear peptide was washed with NMP (3x2 min). The N-terminus of the solid-phase attached peptide was Boc protected using Boc₂O (265 mg) and DIPEA (47 µl) in DCM (4 ml) and washed with NMP (5x2 min). The Dde protection group was then cleaved using hydrazine hydrate/NEP (4/96; 2x15 min), and the resin was washed with NMP (5x2 min), DIEA/NMP (1/9; 3x5 min) and NMP (8x2 min). The synthesis was completed on a CEM Liberty Peptide Synthesizer as described above using Fmoc-Glu-OtBu and Hexadecanoic acid.

15 The peptide was cleaved from the resin as described above, and the purification was performed on a Gemini-NX column (5x25 cm; 10 µm; C18) with a 35 ml/min flow of a mixture of buffer A (0.1% TFA; aq.) and buffer B (0.1% TFA; 90% MeCN; aq.). The product was eluted with a linear gradient from 30% to 65% buffer B over 47 min, and fractions (9 ml) were collected with a fraction collector. Relevant fractions were analysed by analytical HPLC and MS, pooled and lyophilised to give a white powder (39
20 mg), which was analysed by analytical HPLC as being 81% pure. The mass was 4655.53 Da as determined by MS (Calc. 4655.44 Da).

Example 2: Synthesis of Compound 6 [Cys16(Biotin-Mal),Leu14]Exendin-4(1-28)-8Ado-8Ado-[Leu4]Gastrin6

25 [Cys16,Leu14]Exendin-4(1-28)-8Ado-8Ado-[Leu4]Gastrin6 was synthesized on a CEM Liberty Peptide Synthesizer using 2 portions of TentaGel S Ram resin (1,12 g; 0.25 mmol/g) and Fmoc chemistry as described above using Fmoc-Phe-Thr(ψ-Me,Me-Pro)-OH and Fmoc-8-amino-3,6-dioxaoctanoic acid (Fmoc-8Ado-OH). The peptide was cleaved from the resin (portion no. 1) as described above.

30 Purification no. 1: The crude peptide from resin no. 1 was purified on a Gemini-NX column (5x25 cm; 10 µm; C18) with a 35 ml/min flow of a mixture of buffer A (0.1% TFA; aq.) and buffer B (0.1% TFA; 90% MeCN; aq.). The product was eluted with a linear gradient from 30% to 65% buffer B over 47 min, and fractions (9 ml) were collected with a fraction collector. Relevant fractions were analysed by analytical HPLC and MS, pooled and lyophilised to give a white powder (90 mg), which was analysed by analytical HPLC as being 68% pure.

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Purification no. 2: The product from purification no. 1 was purified on a Gemini-NX column (10 mm x 25 cm; 5 µm; C18) with a 4 ml/min flow of a mixture of buffer A (0.1% TFA; aq.) and buffer B (0.1% TFA; 90% MeCN; aq.). The product was eluted with a linear gradient from 30% to 60% buffer B over 47 min, and fractions (2 ml) were collected with a fraction collector. Relevant fractions were analysed by analytical HPLC and MS, pooled and lyophilised to give a white powder (25 mg), which was analysed by analytical HPLC as being 91% pure.

Purification no. 3: The crude peptide from resin no. 2 was purified on a Gemini column (5x25 cm; 10 µm; C18) with a 35 ml/min flow of a mixture of buffer A (0.1% TFA; aq.) and buffer B (0.1% TFA; 90% MeCN; aq.). The product was eluted with a linear gradient from 30% to 65% buffer B over 47 min, and fractions (9 ml) were collected with a fraction collector. Relevant fractions were analysed by analytical HPLC and MS, pooled and lyophilised to give a white powder (129 mg), which was analysed by analytical HPLC as being 74% pure.

Purification no. 4: The combined products from purifications no. 2 and 3 were purified on a Gemini-NX column (10 mm x 25 cm; 5 µm; C18) with a 4 ml/min flow of a mixture of buffer A (0.1% TFA; aq.) and buffer B (0.1% TFA; 90% MeCN; aq.). The product was eluted with a linear gradient from 30% to 55% buffer B over 47 min, and fractions (2 ml) were collected with a fraction collector. Relevant fractions were analysed by analytical HPLC and MS, pooled and lyophilised to give a white powder (32 mg), which was analysed by analytical HPLC as being 73% pure and another white powder (100 mg), which was analysed by analytical HPLC as being 62% pure.

Purification no. 5: The combined products from purification no. 4 was purified on a Gemini-NX column (10 mm x 25 cm; 5 µm; C18) with a 4 ml/min flow of a mixture of buffer A (0.1% TFA; aq.) and buffer B (0.1% TFA; 90% MeCN; aq.). The product was eluted with a linear gradient from 30% to 55% buffer B over 47 min, and fractions (2 ml) were collected with a fraction collector. Relevant fractions were analysed by analytical HPLC and MS, pooled and lyophilised to give a white powder (30 mg), which was analysed by analytical HPLC as being 90% pure. The mass was 4320.24 Da as determined by MS (Calc. 4320.12 Da).

Conjugation: The product from purification no. 5 was dissolved in PBS buffer (6 ml; pH 7.4) resulting in a cloudy solution (pH 6.2). Biotin-Maleimide (10.7 mg) was dissolved in DMSO (1.1 ml) and added to the peptide solution. The reaction was monitored by analytical HPLC and purified after 3 hours using a Gemini-NX column (10 mm x 25 cm; 5 µm; C18) with a 4 ml/min flow of a mixture of buffer A (0.1% TFA; aq.) and buffer B 60 55% buffer B over 47 min, and fractions (2 ml) were collected with a fraction collector. Relevant fractions were analysed by analytical HPLC and MS, pooled and lyophilised to give a white powder (18 mg), which was analysed by analytical HPLC as being 84% pure. The mass was 4771.35 Da as determined by MS (Calc. 4771.31 Da).

Example 3: Synthesis of compound 9 [Glu9,Leu14,Phe25,Tyr13]Exendin-4(1-27)-QQ-[Leu4]Gastrin6

The peptide was synthesized on a CEM Liberty Peptide Synthesizer using TentaGel S Ram resin (1.10 g; 0.25 mmol/g) and Fmoc chemistry as described above using Fmoc-Phe-Thr(ψ -Me,Me-Pro)-OH. The peptide was cleaved from the resin as described above. The crude peptide was purified on a Gemini-NX column (5x25 cm; 10 μ m; C18) with a 35 ml/min flow of a mixture of buffer A (0.1% TFA; aq.) and buffer B (0.1% TFA; 90% MeCN; aq.). The product was eluted with a linear gradient from 20% to 50% buffer B over 47 min, and fractions (9 ml) were collected with a fraction collector. Relevant fractions were analysed by analytical HPLC and MS, pooled and lyophilised to give a white powder (137 mg), which was analysed by analytical HPLC as being 78% pure. The mass was 4208.11 Da as determined by MS (Calc. 4208.09 Da).

Example 4: Activation (EC_{50}) of GLP-1 receptor and Gastrin CCK-B receptor *in vitro* by peptide conjugates of the invention

MATERIALS AND METHODS

Human GLP-1 receptor (GLP-1 R) efficacy assay:

In vitro effects of peptide conjugates of the invention were assessed by measuring the induction of cAMP following stimulation of the receptor by GLP-1(7-36), exendin-4(1-39) or conjugates of the invention using the FlashPlate™ cAMP kit from Perkin-Elmer. Briefly, HEK293 cells expressing the human GLP-1 R (stable cell line generated through transfection of the cDNA for GLP-1 R and selection of stable clones) were seeded at 40,000 cells/well in 96-well microtiter plates coated with 0.01 % poly-L-lysine, and grown for 1 day in culture in 100 μ l growth medium [DMEM, 10% FCS, Penicillin (100 IU/ml), Streptomycin (100 μ g/ml)]. On the day of analysis, growth medium was removed and the cells were washed once with 200 μ l Tyrode buffer [Tyrode's Salts (9.6 g/l), 10 mM HEPES, pH 7.4]. Cells were incubated in 100 μ l Tyrode buffer containing increasing concentrations of test compounds, 100 μ M IBMX, and 0.1% BSA for 15 min at 37° C. The reaction was stopped by addition of 25 μ l 0.5 M HCl and incubated on ice for 60 min. For further methodological details, see WO 2008/152403.

CCK-B receptor (CCK-B R) efficacy assay:

In vitro effects of peptide conjugates of the invention and the control gastrin17 analogue [Leu15]gastrin17 were estimated by measuring p-ERK (using the AlphaScreen™ SureFire p-ERK assay) in HEK293 cells stably expressing the human CCK-B R (high-affinity Gastrin receptor; stable cell line generated through transfection of the cDNA for CCK-B R and selection of stable clone)). The gastrin receptor efficacy assays (AlphaScreen™ SureFire p-ERK assay) were performed as follows: On day 1 the CCK-B R expressing cells were seeded at 20,000 cells/well in 100 μ l growth medium

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[DMEM, 10% FCS, Penicillin (100 IU/ml), Streptomycin (100 µg/ml)] in a 96-well plate coated with poly-D-lysine. The cells were incubated in an incubator (37°C, 5% CO₂) for two days. Then the growth medium was changed to 80 µl of serum-free medium [DMEM, Penicillin (100 IU/ml), Streptomycin (100 µg/ml)] per well, and incubation of the cells was continued over night in the incubator. On the day of analysis, compounds in increasing concentrations were added in 20 µl of serum-free medium containing, and the cells were incubated for 5 min. at room temperature. The stimulation medium was discarded by quickly turning the plate upside down, and 60 µl 1x lysis buffer (from the SureFire assay kit) was added per well. For further details see WO2011/134471.

The peptide conjugates of the invention were tested in the above-described assays (i.e. human GLP-1 R activation efficacy, human CCK-B R activation efficacy).

Exendin-4(1-39) was used as positive control in the human GLP-1 receptor (hGLP-1 R) activation assay, and h[Leu15]Gastrin17 was used as positive control in the human CCK-B receptor (hCCK-B R) activity assay.

The results (EC₅₀ values, in nM) are summarized in Table 1 below.

Table 1. *in vitro* activities (EC₅₀, nM) of compounds (peptide conjugates) of the invention in activation of hGLP-1 R and hCCK-B R.

Cpd No.	hGLP-1 R EC ₅₀ (nM)	hCCK-B R EC ₅₀ (nM)
	0.017	
		2.89
1	0.048	30
2	0.094	7.4
3	0.058	38
4	0.14	10
5	0.024	5.0
6	0.038	5.8
7	0.88	29
8	0.80	21

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9	0.093	18
10	0.069	13
11	0.098	59
12	0.13	23
13	0.29	75
14	0.11	28
15	0.17	30
16	0.11	45
17	0.19	85
18	0.062	18
19	0.045	13
21	0.052	94
22	0.085	31
23	0.094	18
38	0.037	61
40	0.37	133

Results

The results summarized in Table 1 above indicate that the peptide conjugates of the invention are
5 potent agonists of the two receptors in question, and that they exhibit closely similar levels of activity.

Example 5: Pharmacokinetic (PK) of selected compounds in mice

Method

C57Bl L/6J mice were given a single subcutaneous dose of 100 nmol/kg of each peptide to be tested. Blood samples were taken after 5 and 30 min and after 1, 2, 4, 6, 16 and 24 hour. At each time point,

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samples from two mice were taken. The mice were euthanized immediately after blood sampling by cervical dislocation. Plasma samples were analyzed after solid phase extraction (SPE) by liquid chromatography mass spectrometry (LC-MS/MS).

5 Table 2. $T_{1/2}$ after s.c. administration of 100 nmol /kg in mice

Compound	$T_{1/2}$ (h)
7	6.2
12	5.0
18	4.1
19	2.4
22	8.2
23	6.7

Example 6: Three weeks in vivo db/db mouse study

10 The db/db mouse model has previously been used to assess the β -cell preserving effects of potential therapeutic candidates [Rolin, B. et al., *Am. J. Physiol. Endocrinol. Metab.* 283: E745-E752 (2002)]. Several studies have demonstrated a correlation between pancreatic insulin content and β -cell mass [Rolin, B. et al. (loc.cit.); Suarez-Pinzon, W.L. et al., *Diabetes* 54: 2596-2601 (2005); Suarez-Pinzon W.L. et al., *Diabetes* 57: 3281-3288 (2008)].

15 Treatment

Db/db mice were stratified to various treatment groups according to HbA1c levels. Mice were treated once daily with subcutaneous (SC) injections for a total of 21 days. Injection volume was 5 ml/kg. During the study body weights (BW) were recorded daily and used to administer the body weight-corrected doses of peptide.

20 OGTT

On day 16, an oral glucose tolerance test was performed in the animals. Blood glucose was measured before glucose (at $t = 0$, baseline) and after glucose administration up to 2 hrs.

Termination

25 At termination the blood glucose levels were measured, and blood samples were analyzed for HbA1c levels.

Measurements

Whole blood glucose concentration (mM) was determined by the immobilized glucose oxidase method (Elite Autoanalyser, Bayer, Denmark). Blood samples were analyzed for HbA1c using the Cobas c111 analyzer (Roche Diagnostics, Mannheim, Germany).

Results

- 5 The exendin-gastrin dual agonists Compound 18 and Compound 23 both lowered the fasting blood glucose levels after 16 days treatment. Compound 18 lowered the fasted blood glucose levels to a larger extent than Compound 23. Both compounds lowered the plasma levels of HbA1c after 3 weeks treatment with no significant difference between the compounds (un-paired two-tailed t-test).
- 10 Compound 18 and Compound 23 both lowered the area under the glucose concentration curve (AUC) following an oral glucose challenge on day 16 (Table 3), where Compound 18 lowered the glucose concentration to a larger extent than Compound 23.

Finally, both Compound 18 and Compound 23 lowered the body weight gain during the 3 week course of the study (Table 3) where Compound 18 lowered the body weight gain to a larger extent than

- 15 Compound 23.

Table 3. Three weeks in vivo db/db study results

	Delta-HbA1c (%)	OGTT, AUC (nM*min)	Delta-BW (g)	Fasted BG level (mM)
Vehicle	-	-	-	-
Compound 18	+++	+++	+++	+++
Compound 23	+++	++	++	++

Legends to Table 3:

- 20 **Delta-HbA1c:** Effect of SC administration of vehicle, Compound 18 (100 nmol/kg) and Compound 23 (100 nmol/kg) on the delta-HbA1c (%) levels (the level of HbA1c at termination subtracted from the level of HbA1c at initiation of the study) following 21 days treatment of db/db mice. Data are given as mean with SEM (n=11/group). (-) indicates delta-HbA1c level above 0.5% , (+) indicates delta-HbA1c level between 0.25% and 0.5%, (++) indicates delta-HbA1c level between 0% and 0.25%, (+++) indicates delta-HbA1c level below 0%.

- OGTT Area Under the Curve (AUC):** Effect of SC administration of vehicle, Compound 18 (100 nmol/kg) and Compound 23 (100 nmol/kg) on glucose tolerance as measured by the Area Under the Curve (AUC) following a glucose load in db/db mice after 16 days of treatment. Data are given as mean with SEM (n=11/group). (-) indicates OGTT AUC above 3000mM*min, (+) indicates OGTT AUC between 2000 and 3000 mM*min, (++) indicates OGTT AUC between 1000 and 2000M*min, (+++) indicates OGTT AUC below 1000 mM*min.

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Delta-BW: Effect of SC administration of vehicle, Compound 18 (100 nmol/kg) and Compound 23 (100 nmol/kg) on the delta-BW (g) levels (the BW at termination subtracted from the BW at initiation of the study) following 21 days treatment of db/db mice. Data are given as mean with SEM (n=9-11/group). (-) indicates delta BW above 8 g, (+) indicates delta BW between 6 and 8 g, (++) indicates delta BW between 4 and 6 g, (+++) indicates delta BW below 4 g.

Fasted BG: Effect of SC administration of vehicle, Compound 18 (100 nmol/kg) and Compound 23 (100 nmol/kg) on the fasting blood glucose (mM) levels following 16 days treatment of db/db mice. Data are given as mean with SEM (n=11/group). (-) indicates fasted BG above 12 mM, (+) indicates fasted BG between 8 and 12 mM, (++) indicates fasted BG between 6 and 8 mM, (+++) indicates fasted BG below 6 mM.

Example 7: In vivo db/db mouse study: 4 weeks treatment followed by 2 weeks drug holiday

Treatment

Db/db mice were stratified to various treatment groups according to HbA1c levels. Mice were treated once daily with subcutaneous (SC) injections for a total of 4 weeks – thereafter they were dosed with vehicle for 2 weeks. Injection volume was 5 ml/kg. During the study body weights (BW) were recorded daily and used to administer the body weight-corrected doses of peptide.

OGTT

After 3 and 5 weeks, an oral glucose tolerance test was performed in the animals. Blood glucose was measured before glucose (at t = 0, baseline) and after glucose administration up to 2 hrs.

Measurements

Whole blood glucose concentration (mM) was determined by the immobilized glucose oxidase method (Elite Autoanalyser, Bayer, Denmark).

Results

The exendin-gastrin dual agonist Compound 18 lowered the fasting blood glucose levels after 3 weeks treatment compared to vehicle. Compound 18 lowered the fasted blood glucose levels to a larger extent than liraglutide at equimolar doses, see Figure 1. After 4 weeks treatment followed by 1 week drug holiday (vehicle dosing), Compound 18 significantly lowered the fasting blood glucose levels compared to vehicle. Compound 18 lowered the fasted blood glucose levels to a larger extent than did liraglutide at equimolar doses, see Figure 2.

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Compound 18 lowered the area under the glucose concentration curve (AUC) following an oral glucose challenge after 3 weeks treatment where Compound 18 lowered the glucose concentration curve (AUC) to a larger extent than did liraglutide, see Figure 3.

5 After 4 weeks treatment followed by 1 week drug holiday (vehicle dosing), Compound 18 significantly lowered the area under the glucose concentration curve (AUC) following an oral glucose challenge compared to vehicle, see Figure 4. Compound 18 lowered the glucose concentration curve (AUC) to a larger extent than did liraglutide at equimolar doses.

10 Finally, Compound 18 reduced the body weight gain during the 4 week course of the study where Compound 18 lowered the body weight to a larger extent than liraglutide at equimolar doses, see Figure 5.

Example 8: In vivo ZDF rat study: 6 weeks treatment

Treatment

15 ZDF rats were stratified to various treatment groups according to HbA1c levels. Rats were treated twice daily with subcutaneous (SC) injections for a total of 6 weeks. Injection volume was 5 ml/kg. During the study, body weights (BW) were recorded daily and used to administer the body weight-corrected doses of peptide.

OGTT

20 After 5 weeks, an oral glucose tolerance test was performed in the animals. Blood glucose was measured before glucose (at t = 0, baseline) and after glucose administration up to 2 hrs.

Termination

At termination blood samples were analyzed for HbA1c levels.

25 **Measurements**

Whole blood glucose concentration (mM) was determined by the immobilized glucose oxidase method (Elite Autoanalyser, Bayer, Denmark).

Blood samples were analyzed for HbA1c using the Cobas c111 Analyzer (Roche Diagnostics, Mannheim, Germany).

30

Results

The exendin-gastrin dual agonist Compound 18 lowered the fasting blood glucose levels after 5 weeks treatment compared to vehicle. Compound 18 lowered the fasting blood glucose levels to a larger extent than did liraglutide at equimolar doses, see Figure 6.

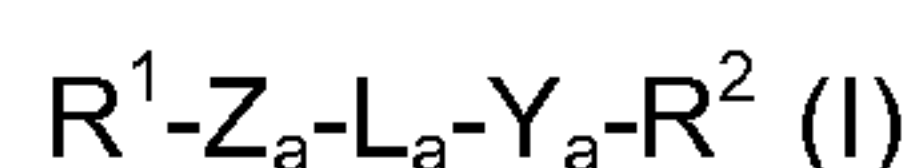
- 5 Compound 18 lowered the area under the glucose concentration curve (AUC) following an oral glucose challenge after 5 weeks treatment where Compound 18 lowered the glucose concentration curve (AUC) to a larger extent than did liraglutide, see Figure 7.

After 6 weeks treatment, Compound 18 significantly lowered the HbA1c levels compared to vehicle. Compound 18 lowered the HbA1c levels to a larger extent than did liraglutide at equimolar doses, see

- 10 Figure 8.

CLAIMS

1. A peptide conjugate having the formula I



wherein

5 R^1 is H, C₁₋₄ alkyl, acetyl, formyl, benzoyl or trifluoroacetyl; and

R^2 is OH or NH₂;

Z_a is a peptide sequence having the formula Ia

His-Gly-Glu-Gly-Thr-Phe-Thr-Ser-Z9-Leu-Ser-Z12-Z13-Z14-Glu-Z16-Glu-Ala-Val-Z20-Leu-Phe-Ile-Z24-Z25-Leu-Z27-Z28 (Ia)

10 wherein

Z9 is selected from Asp and Glu;

Z12 is selected from Lys, Arg and Orn;

Z13 is selected from Gln and Tyr;

Z14 is selected from Met and Leu;

15 Z16 is selected from Glu, Arg, Orn, Cys and Lys;

Z20 is selected from Arg, Lys and Orn;

Z24 is selected from Arg, Orn, Lys and Glu;

Z25 is selected from Trp, Lys, Cys and Phe;

Z27 is selected from Lys, Arg and Orn; and

20 Z28 is selected from Asn and Asp or is absent;

L_a is a peptide sequence having the formula Ib

L1-L2-L3-L4 (Ib)

wherein

25 L1 is selected from Orn, 8Ado, Cys, Lys and Gln or is absent;

L2 is selected from Orn, 8Ado, Cys, Lys and Gln or is absent;

L3 is selected from Orn, 8Ado, Cys, Lys and Gln or is absent; and

L4 is selected from Orn, 8Ado, Cys, Lys and Gln or is absent;

30 Y_a is a peptide sequence having the formula Ic

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Y12-Y13-Y14-Y15-Asp-Y17 (Ic);

wherein

Y12 is selected from Tyr and Ala or is absent;

Y13 is selected from Gly and Ala or is absent;

5 Y14 is selected from Trp, 1Nal and Phe;

Y15 is selected from Met, Leu, Nle, Thr and Phe; and

Y17 is selected from Phe and 3-(3-pyridyl)-alanine;

wherein at least one of Lys, Orn or Cys in formula Ia and Ib is further conjugated to a lipophilic and/or a biotinyl substituent and/or pegylated;

10 or a pharmaceutically acceptable salt or solvate thereof.

2. A peptide conjugate according to claim 1 wherein

Z_a is a peptide sequence having the formula IIa

15 His-Gly-Glu-Gly-Thr-Phe-Thr-Ser-Z9-Leu-Ser-Lys-Z13-Z14-Glu-Z16-Glu-Ala-Val-Arg-Leu-Phe-Ile-Glu-Z25-Leu-Lys-Z28 (IIa)

wherein

Z9 is selected from Glu and Asp;

Z13 is selected from Gln and Tyr;

Z14 is selected from Met and Leu;

20 Z16 is selected from Glu, Cys and Lys;

Z25 is selected from Lys, Phe, Cys and Trp; and

Z28 is selected from Asn and Asp or is absent;

L_a is a peptide sequence having the formula Ib;

25

Y_a is a peptide sequence having the formula IIc

Tyr-Gly-Trp-Y15-Asp-Phe (IIc)

wherein

Y15 is selected from Leu and Thr; and

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wherein at least one of Lys or Cys in position Z16 or Z25 of formula IIa or formula IIb is further conjugated to a lipophilic and/or a biotinyl substituent and/or pegylated;

or a pharmaceutically acceptable salt or solvate thereof.

- 5 3. A peptide conjugate or a pharmaceutically acceptable salt or solvate thereof according to claim 1 or claim 2 wherein the sequence of the peptide of formula I is selected from

H-HGEGTFTSDLSKQLEEEAVRLFIEWLKN-8Ado-K(hexadecanoyl-isoGlu)-8Ado-YGWLDF-NH₂

H-HGEGTFTSDLSKQLEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LKN-8Ado-8Ado-YGWLDF-NH₂

10

H-HGEGTFTSDLSKQLE-K(hexadecanoyl-isoGlu)-EAVRLFIEWLKN-8Ado-8Ado-YGWLDF-NH₂

H-HGEGTFTSDLSKQMEEEEAVRLFIEWLKN-8Ado-C(Biotin-Mal)-8Ado-YGWLDF-NH₂

15

H-HGEGTFTSDLSKQLEEEAVRLFIE-C(Biotin-Mal)-LKN-8Ado-8Ado-YGWLDF-NH₂

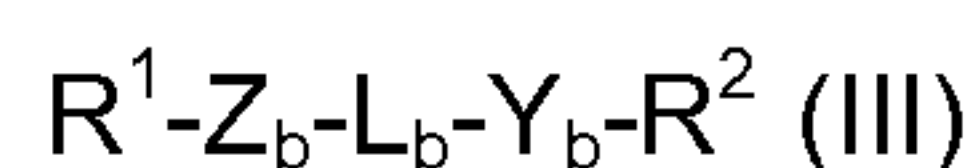
H-HGEGTFTSDLSKQLE-C(Biotin-Mal)-EAVRLFIEWLKN-8Ado-8Ado-YGWLDF-NH₂

H-HGEGTFTSELSKYLEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-8Ado-8Ado-YGWLDF-NH₂ and

20

H-HGEGTFTSELSKYLEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-8Ado-QQYGWLDF-NH₂

4. A peptide conjugate having the formula III



25

wherein

R¹ is H, C₁₋₄ alkyl, acetyl, formyl, benzoyl or trifluoroacetyl;

R² is OH or NH₂;

Z_b is a peptide sequence having the formula IIIa

30

His-Gly-Glu-Gly-Thr-Phe-Thr-Ser-Glu-Leu-Ser-Lys-Tyr-Leu-Glu-Glu-Glu-Ala-Val-Arg-Leu-Phe-Ile-Glu-Z25-Leu-Lys-Z28 (IIIa)

wherein

Z25 is selected from Phe and Trp; and

Z28 is selected from Asn and Asp or is absent;

35

L_b is a peptide sequence having the formula IIIb

L5-L6-L7-L8 (IIIb)

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wherein

L5 is selected from 8Ado, 8Aoc, Ala, Gly and Gln or is absent;

L6 is selected from 8Ado, 8Aoc, Ala, Gly and Gln or is absent;

L7 is selected from 8Ado, 8Aoc, Ala, Gly and Gln or is absent; and

5 L8 is selected from 8Ado, 8Aoc, Ala, Gly and Gln or is absent;

Y_b is a peptide sequence having the formula IIIc

Y10-Y11-Tyr-Gly-Trp-Y15-Asp-Phe (IIIc)

wherein

10 Y10 is Glu or is absent;

Y11 is Ala or is absent; and

Y15 is selected from Leu and Thr;

or a pharmaceutically acceptable salt or solvate thereof;

provided that formula III is not

15 H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Ado-8Ado-YGWLDF-NH₂;H-HGEGTFTSELSKYLEEEEAVRLFIEFLKYGWLDF-NH₂; andH-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Ado-YGWLDF-NH₂

5. A peptide conjugate according to claim 4 wherein

20 Z_b is a peptide sequence having the formula IVa

His-Gly-Glu-Gly-Thr-Phe-Thr-Ser-Glu-Leu-Ser-Lys-Tyr-Leu-Glu-Glu-Glu-Ala-Val-Arg-Leu-Phe-Ile-Glu-Z25-Leu-Lys-Asn (IVa)

wherein

Z25 is selected from Phe and Trp; and

25

L_b is a peptide sequence having the formula IIIb;Y_b is a peptide sequence having the formula IVc

Tyr-Gly-Trp-Y15-Asp-Phe (IVc)

30 wherein

Y15 is selected from Leu and Thr;

or a pharmaceutically acceptable salt or solvate thereof.

6. A peptide conjugate or a pharmaceutically acceptable salt or solvate thereof according to claim 4 or claim 5 wherein the sequence of the peptide of formula III is selected from

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKQQYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKQQEAYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Ado-QQYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKDYGWLDF-NH₂;

10 H-HGEGTFTSELSKYLEEEEAVRLFIEFLKAAAYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKGGGYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-8Aoc-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKNYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKAYGWLDF-NH₂;

15 H-HGEGTFTSELSKYLEEEEAVRLFIEFLKN-8Ado-8Ado-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKD-8Ado-8Ado-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKNYGTDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKDYGWTDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEWLKNYGWLDF-NH₂;

20 H-HGEGTFTSELSKYLEEEEAVRLFIEWLKDYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKEAYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKN-K(hexadecanoyl-isoGlu)-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLKN-K(hexadecanoyl-isoGlu)-WLDF-NH₂;

H-HGEGTFTSELSKYLE-K(hexadecanoyl-isoGlu)-EAVRLFIEFLKNYGWLDF-NH₂;

25 H-HGEGTFTSELSKYLE-K(hexadecanoyl-isoGlu)-EAVRLFIEFLKNWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-K(hexadecanoyl-isoGlu)-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEFLK-K(hexadecanoyl-isoGlu)-WLDF-NH₂;

H-HGEGTFTSELSKYLE-K(hexadecanoyl-isoGlu)-EAVRLFIEFLKYGWLDF-NH₂;

H-HGEGTFTSELSKYLE-K(hexadecanoyl-isoGlu)-EAVRLFIEFLKWLDF-NH₂;

30 H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-8Ado-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LKQQYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LK-Orn-Orn-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LKNYGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIE-K(hexadecanoyl-isoGlu)-LKDYGWLDF-NH₂;

H-HGEGTFTSDLSKQLEEEEAVRLFIEC(PEG5K)LKN-8Ado-8Ado-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEC(PEG10K)LK-8Ado-8Ado-YGWLDF-NH₂;

5 H-HGEGTFTSELSKYLEEEEAVRLFIEC(PEG20K)LK-8Ado-8Ado-YGWLDF-NH₂;

H-HGEGTFTSELSKYLEEEEAVRLFIEC(PEG40K)LK-8Ado-8Ado-YGWLDF-NH₂;

H-HGEGTFTSDLSKQMEEEEAVRLFIEWLKNYGWTDf-OH; and

10 H-HGEGTFTSELSKYLEEEEAVRLFIEFLKN-8Ado-8Ado-YGWTDf-NH₂.

7. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1-6 wherein Z_a or Z_b has at least 75%, 80%, 85%, 90% or 95% identity to native *Heloderma suspectum* exendin-4.

15 8. A peptide conjugate according to any one of claims 1-6 wherein Y_a or Y_b has at least 70%, 80%, 83%, 85%, 90%, 94% or 95% identity to native human gastrin17 and/or gastrin6.

9. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1-8, for use as a medicament.

20 10. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 9, for use as a medicament for the treatment of a disease or disorder selected from:

type 1 diabetes, type 2 diabetes, pre-diabetes, insulin resistance syndrome, impaired glucose tolerance (IGT), disease states associated with elevated blood glucose levels, hyperglycemia, hypertension, 25 atherogenic dyslipidemia, arteriosclerosis (e.g. atherosclerosis), coronary heart disease, peripheral artery disease, stroke, microvascular disease, gastric disease, metabolic syndrome, cancer (e.g. colon cancer), inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, and kidney failure.

30 11. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 9, for use as a medicament for inducing pancreatic beta cell and/or islet neogenesis in a subject in need thereof.

12. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 9, for use as a medicament for inducing survival of the pancreatic islets β -cells in a subject in need thereof.

5

13. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 9, for use as a medicament for preventing β -cell apoptosis and/or necrosis in the pancreatic islets in a subject in need thereof.

10

14. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 9, for use as a medicament for inducing β -cell proliferation in the pancreatic islets in a subject in need thereof.

15

15. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 9, for use as a medicament for inducing any combination of β -cell neogenesis, islet neogenesis, β -cell survival, β -cell proliferation and or prevention of β -cell apoptosis and/or necrosis in the pancreatic islets in a subject in need thereof.

20

16. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 9-15, wherein said subject is a human.

17. A method for treatment, in a subject in need thereof, of a disease or disorder selected from the group consisting of:

25

type 1 diabetes, type 2 diabetes, pre-diabetes, Insulin resistance syndrome, impaired glucose tolerance (IGT), disease states associated with elevated blood glucose levels, hyperglycemia, hypertension, atherogenic dyslipidemia, arteriosclerosis (e.g. atherosclerosis), macrovascular disease, coronary heart disease, peripheral artery disease, stroke, microvascular disease, gastric disease, metabolic syndrome, cancer (e.g. colon cancer), inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, and kidney failure

30

the method comprising administering to said subject in need of a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1-16.

18. A method for prevention, in a subject in need thereof, of a disease or disorder selected from the group consisting of:

type 1 diabetes, type 2 diabetes, pre-diabetes, Insulin resistance syndrome, impaired glucose tolerance (IGT), disease states associated with elevated blood glucose levels, hyperglycemia, hypertension, atherogenic dyslipidemia, arteriosclerosis (e.g. atherosclerosis), macrovascular disease, coronary heart disease, peripheral artery disease, stroke, microvascular disease, gastric disease, metabolic syndrome, cancer (e.g. colon cancer), inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, and kidney failure

the method comprising administering to said subject in need of a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1-16.

19. The method according to claim 18, wherein said subject is a human.

20. A pharmaceutical composition comprising a peptide conjugate, or pharmaceutically acceptable salt or solvate thereof, according to any one of claims 1-16, and a pharmaceutically acceptable carrier, excipient or vehicle.

21. A pharmaceutical composition according to claim 19 for use in treatment of type 1 diabetes, type 2 diabetes, pre-diabetes, insulin resistance syndrome, impaired glucose tolerance (IGT), disease states associated with elevated blood glucose levels, hyperglycemia, hypertension, atherogenic dyslipidemia, arteriosclerosis (e.g. atherosclerosis), macrovascular disease, coronary heart disease, peripheral artery disease, stroke, microvascular disease, gastric disease, metabolic syndrome, cancer (e.g. colon cancer), inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, and kidney failure

22. A pharmaceutical composition according to claim 19 for use in prevention of type 1 diabetes, type 2 diabetes, pre-diabetes, insulin resistance syndrome, impaired glucose tolerance (IGT), disease states associated with elevated blood glucose levels, hyperglycemia, hypertension, atherogenic dyslipidemia, arteriosclerosis (e.g. atherosclerosis), macrovascular disease, coronary heart disease, peripheral artery disease, stroke, microvascular disease, gastric disease, metabolic syndrome, cancer

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(e.g. colon cancer), inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, and kidney failure.

23. A pharmaceutical composition according to claim 19 for use in preventing weight gain or promoting weight loss.

24. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1 to 16 for use in a method selected from improving circulating glucose levels, improving glucose tolerance and/or improving circulating cholesterol levels, lowering circulating LDL levels, increasing an HDL/LDL ratio and combinations thereof.

25. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1-16 for use in a method of treatment or prevention of a condition caused or characterized by excess body weight.

26. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1-16 for preventing weight gain or promoting weight loss in an individual in need thereof.

27. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1-16 in a method of improving circulating glucose levels, glucose tolerance and/or circulating cholesterol levels, lowering circulating LDL levels, and/or increasing an HDL/LDL ratio in an individual in need thereof.

28. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof use or method according to any one of claims 1-27 wherein the compound is administered as part of a combination therapy with a proton pump inhibitor or an agent for treating or preventing diabetes, obesity, dyslipidemia, or hypertension.

29. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof, use or method according to claim 28 wherein the agent for treating or preventing diabetes is metformin, a sulfonylurea, a glinide, a DPP-IV inhibitor, a glitazone, insulin or an insulin analogue.

5 30. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof, use or method according to claim 28 wherein the agent for treating or preventing obesity is a glucagon-like peptide receptor 1 agonist, peptide YY or analogue thereof, cannabinoid receptor 1 antagonist, lipase inhibitor, melanocortin receptor 4 agonist, or melanin concentrating hormone receptor 1 antagonist.

10 31. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof, use or method according to claim 28 wherein the agent for treating or preventing hypertension is an angiotensin-converting enzyme inhibitor, angiotensin II receptor blocker, diuretic, beta-blocker, or calcium channel blocker.

15 32. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof, use or method according to claim 28 wherein the agent for treatment or prevention of dyslipidaemia is a statin, a fibrate, a niacin and/or a cholesterol absorption inhibitor.

20 33. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof, use or method according to claim 28 wherein the proton pump inhibitor (i.e. a pharmaceutical agent possessing pharmacological activity as an inhibitor H^+/K^+ -ATPase) of known type, including, but not limited to, an agent of the benzimidazole derivative type or of the imidazopyridine derivative type

25 34. A method of synthetically manufacturing a peptide conjugate according to any one of claims 1-16.

35. A method of recombinantly manufacturing a peptide conjugate or pharmaceutically acceptable salt or solvate thereof conjugate according to any one of claims 1-16.

30 36. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1-16 in a method selected from improving circulating glucose levels, improving

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glucose tolerance and/or improving circulating cholesterol levels, lowering circulating LDL levels, increasing an HDL/LDL ratio and combinations thereof, in an individual in need thereof wherein a drug holiday dosage regimen is used.

5 37. A process for manufacturing a peptide conjugate or pharmaceutically acceptable salt or solvate thereof or according to any one of the above claims.

38. A pharmaceutical composition comprising a peptide conjugate, or pharmaceutically acceptable salt or solvate thereof, according to any one of claims 1-16, in combination with one or
10 more peptide conjugates or pharmaceutically acceptable salts or solvates thereof according to claim 1-16 together with a pharmaceutically acceptable carrier, excipient or vehicle.

39. A device comprising at least one peptide conjugate, or pharmaceutically acceptable salt or solvate thereof, according to any one of claims 1-16, for delivering the peptide conjugate or
15 pharmaceutically acceptable salt or solvate thereof to a subject.

40. A kit comprising at least one peptide conjugate, or pharmaceutically acceptable salt or solvate thereof, according to any one of claims 1-16, and packaging or instructions for use.

20 41. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of claims 1-16, for the preparation of a medicament.

42. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 9, wherein the medicament is used for the treatment or prevention of a disease or disorder
25 selected from:

type 1 diabetes, type 2 diabetes, pre-diabetes, Insulin resistance syndrome, impaired glucose tolerance (IGT), disease states associated with elevated blood glucose levels, hyperglycemia, hypertension, atherogenic dyslipidemia, arteriosclerosis (e.g. atherosclerosis), macrovascular disease, coronary heart disease, peripheral artery disease, stroke, microvascular disease, gastric disease,
30 metabolic syndrome, cancer (e.g. colon cancer), inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), diabetic neuropathy, diabetic retinopathy, diabetic nephropathy, and kidney failure in a subject in need thereof.

43. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 41, wherein the medicament is used for inducing pancreatic beta cell and/or islet neogenesis in a subject in need thereof.

5

44. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 41, wherein the medicament is used for improving survival rate of the pancreatic islet β -cell in a subject in need thereof.

10 45. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 41, wherein the medicament is used for preventing β -cell apoptosis and/or necrosis in pancreatic islets in a subject in need thereof.

15 46. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to embodiment claim 41, wherein the medicament is used for inducing proliferation of the pancreatic islet β -cell in a subject in need thereof.

47. Use of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to any one of embodiments 41-46, wherein said subject is a human.

20 48. A peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 21, wherein the condition caused or characterized by excess body weight is selected from obesity, morbid obesity, obesity linked inflammation, obesity linked gallbladder disease, obesity induced sleep apnea, metabolic syndrome, pre-diabetes, the method comprising administering to said subject a therapeutically effective amount of a peptide conjugate or pharmaceutically acceptable salt or solvate thereof according to claim 23.

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Figure 1

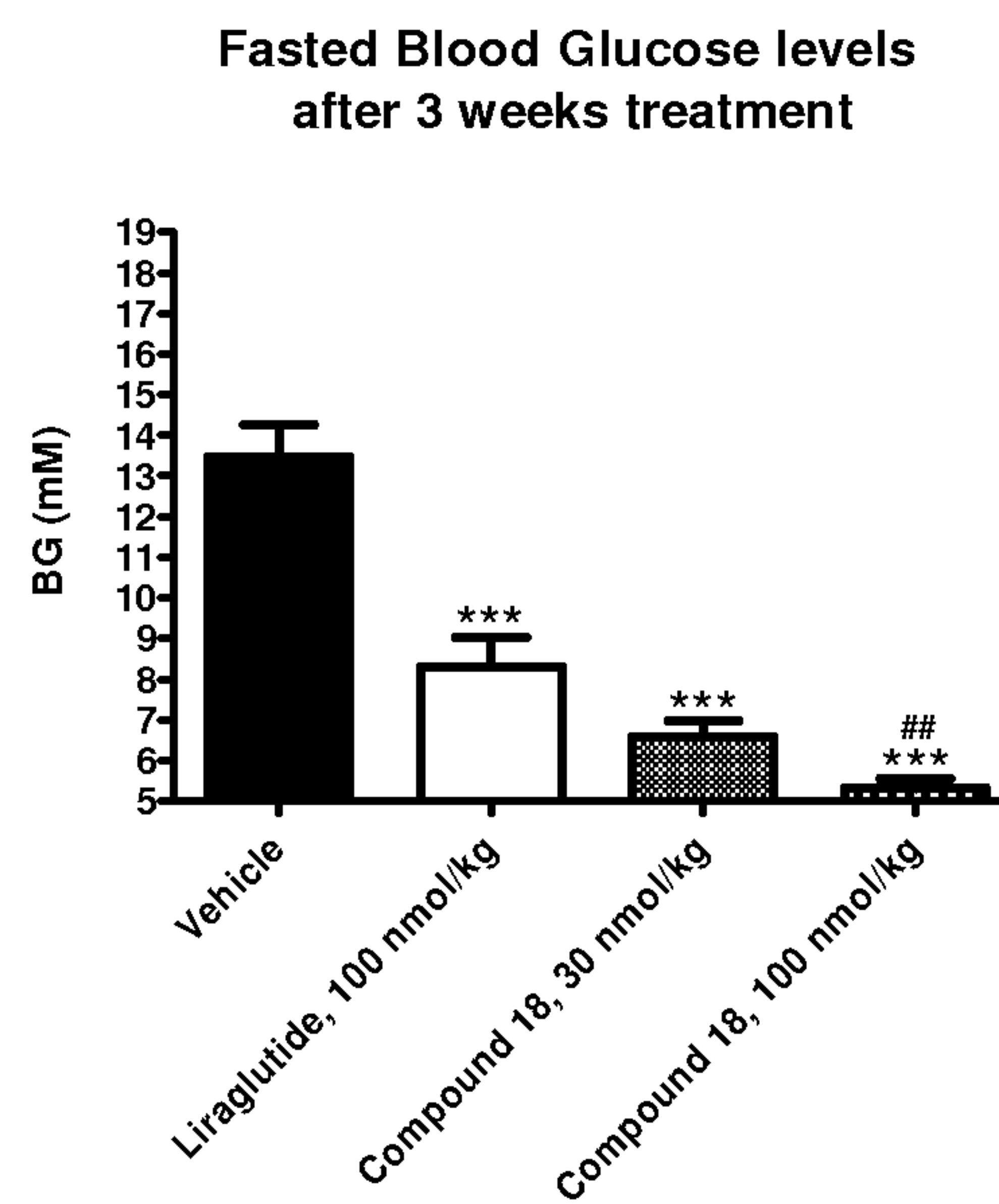
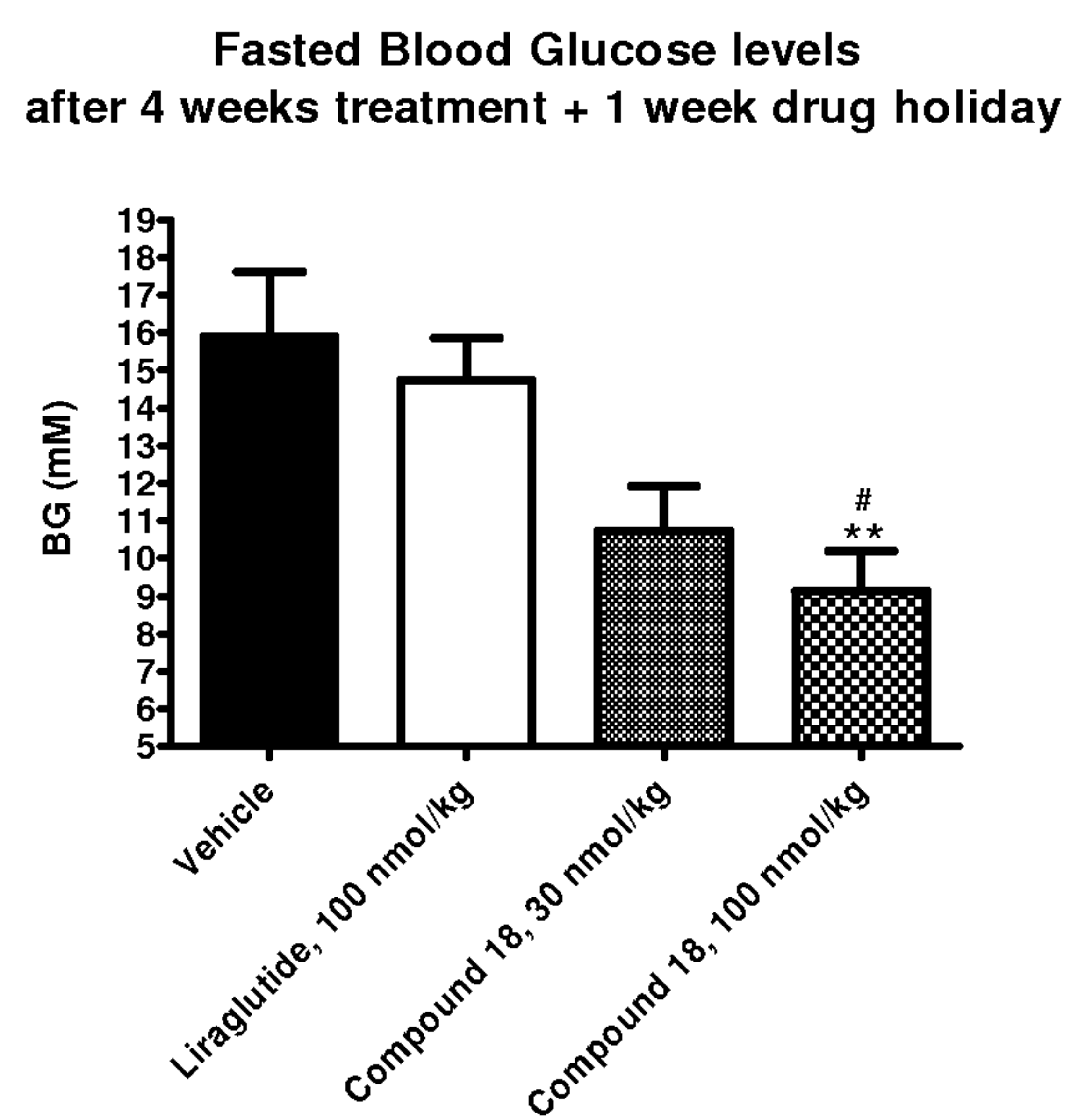


Figure 2



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Figure 3

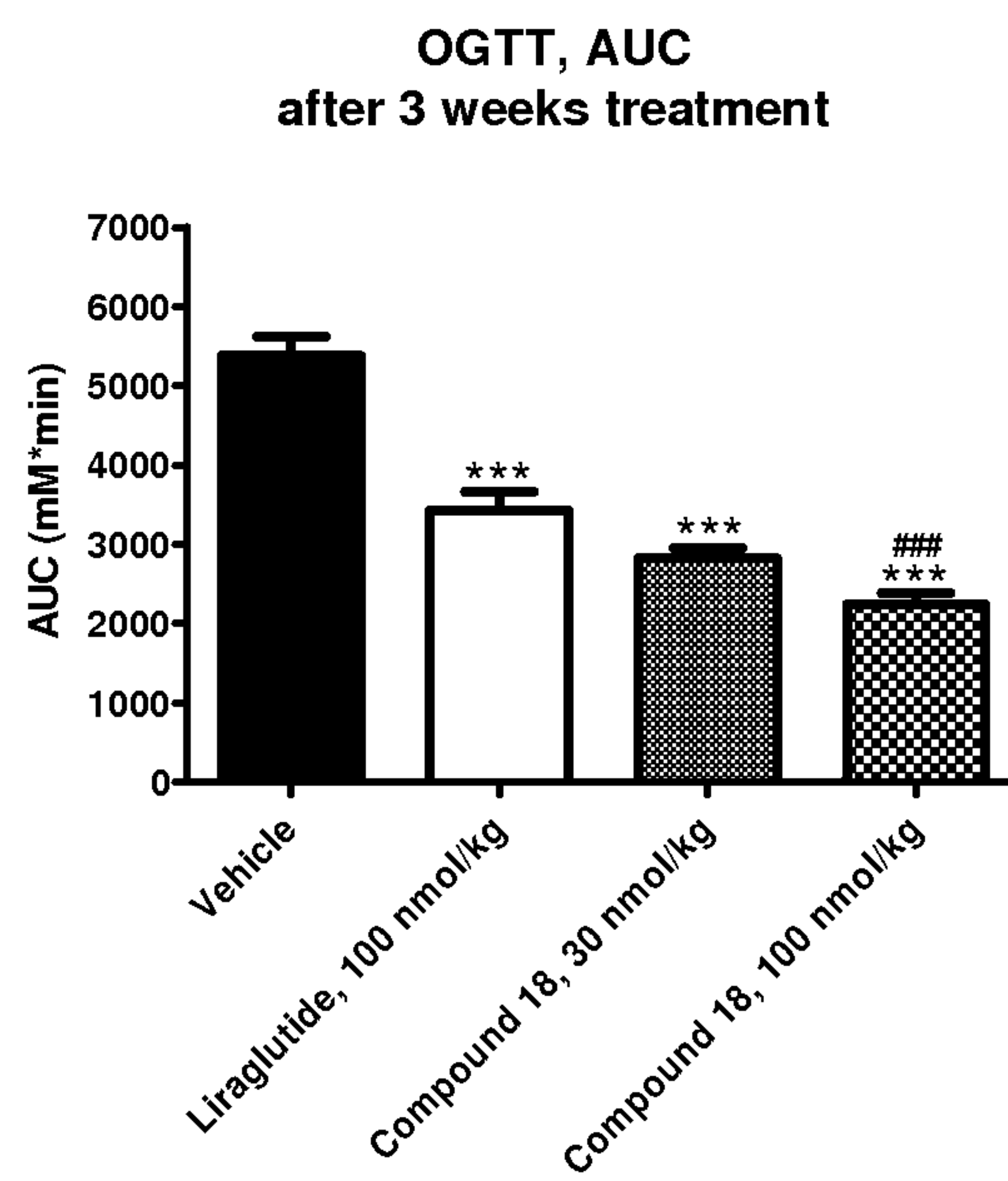
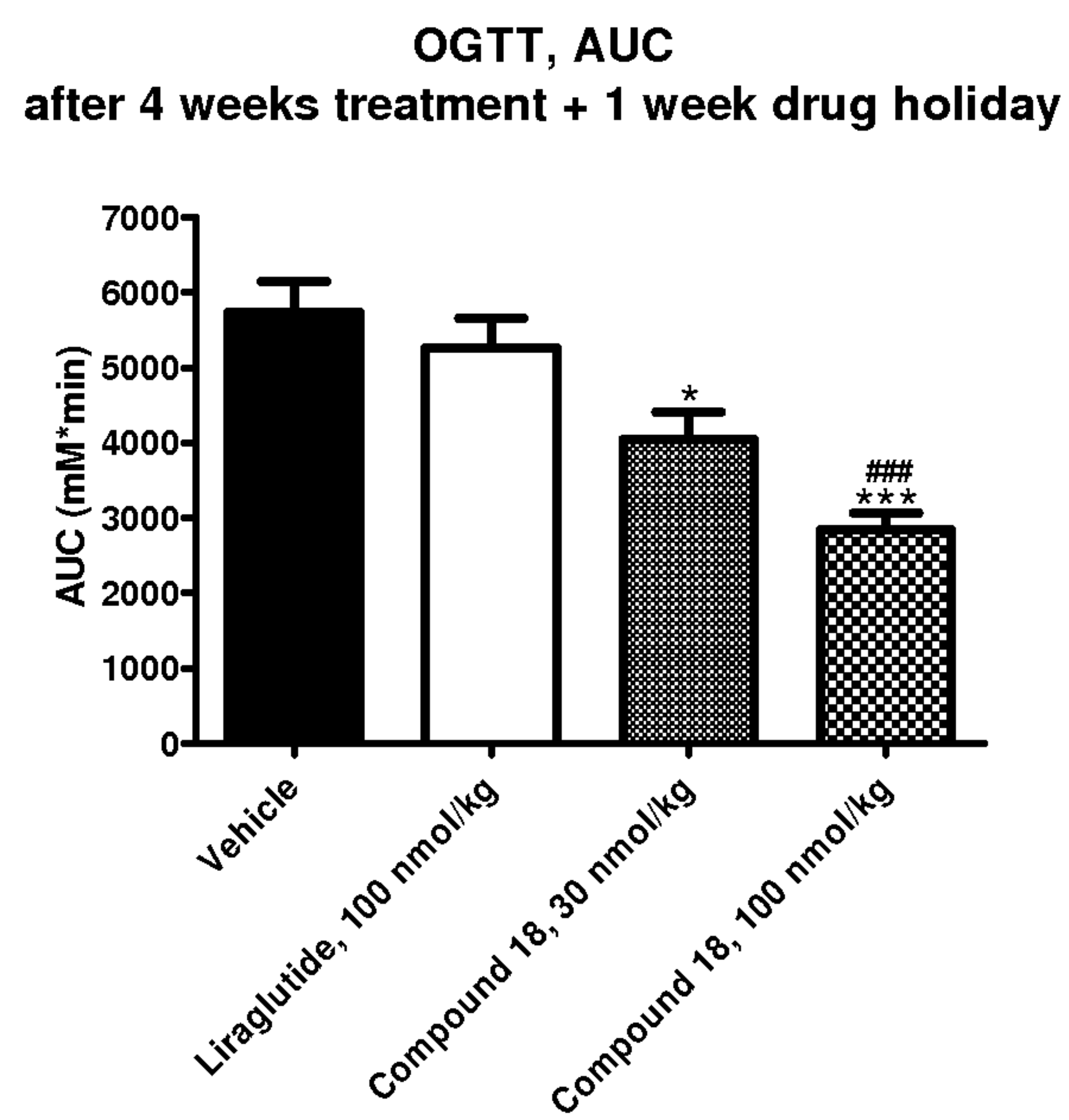


Figure 4



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Figure 5

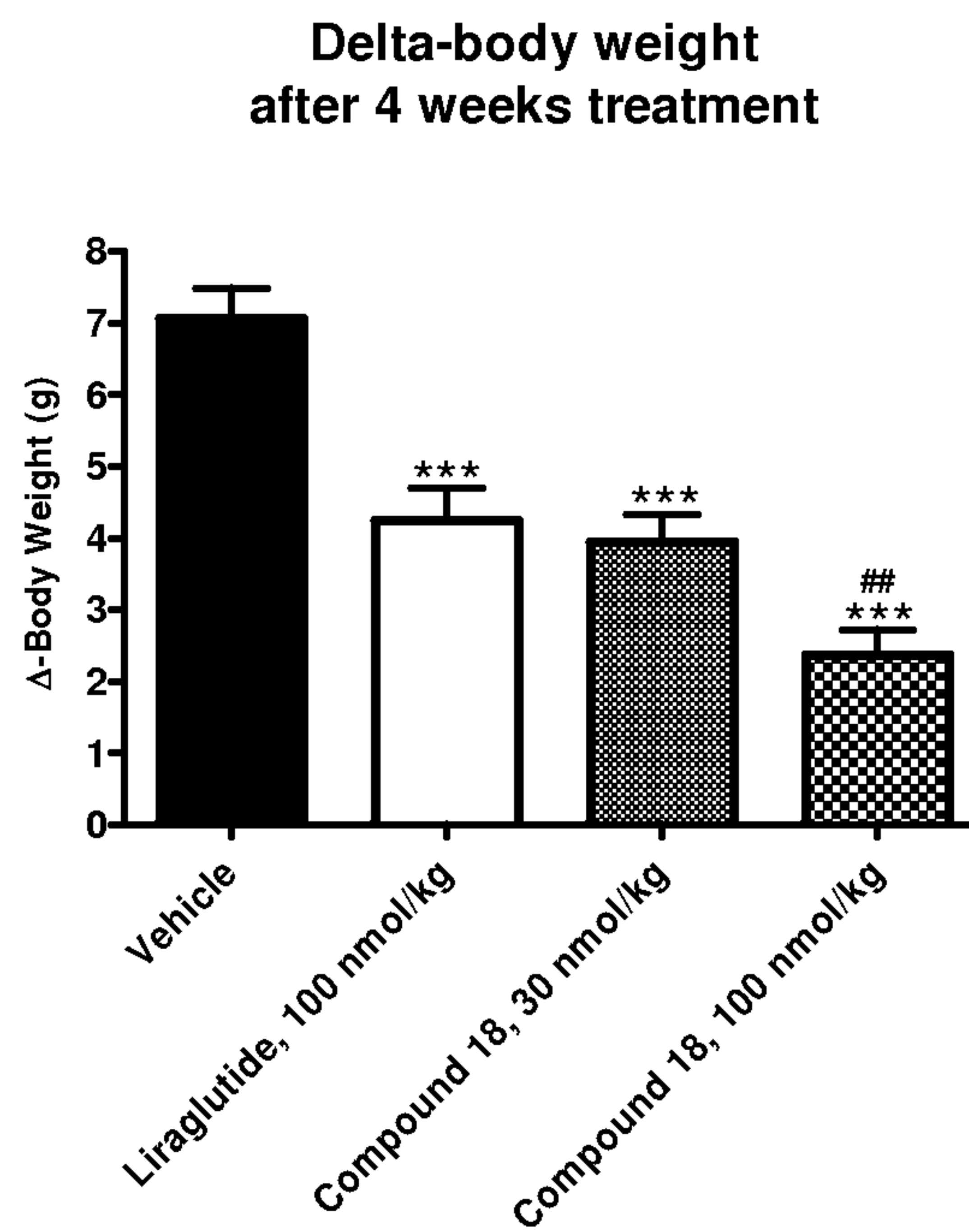


Figure 6

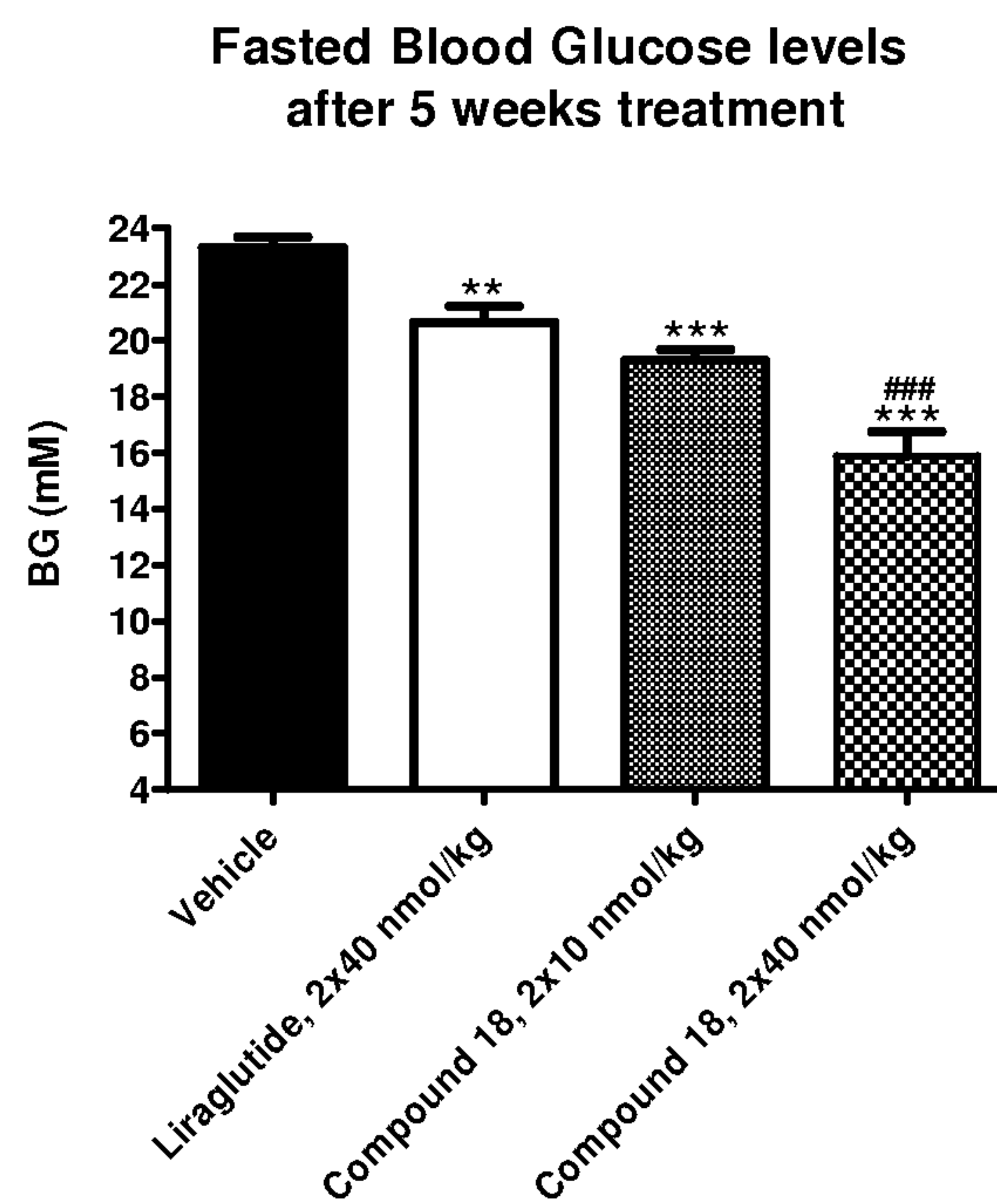


Figure 7

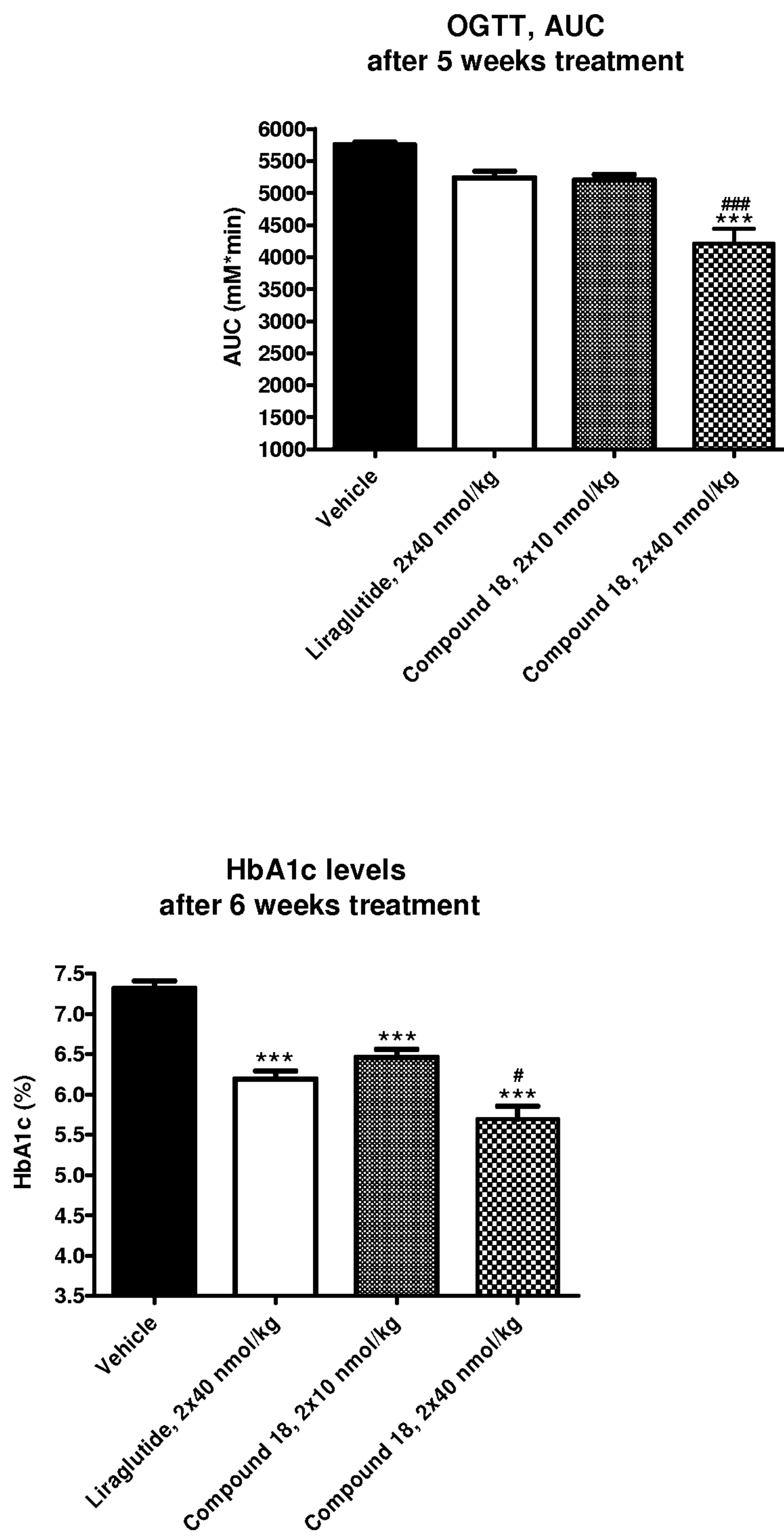


Figure 8