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- (71) **Applicant:** BEIJING COSCI-REMD BIO MED TECH COMPANY LTD [CN/CN]; Shengmingyuan Road, Room 401, Building 7, No. 20, Beijing (CN).
- (72) **Inventors:** YAN, Hai; 198 Via Inez, Thousand Oaks, CA 91320 (US). SHI, Jim; 2746 Conejo Canyon Ct. Apt #27, Thousand Oaks, CA 91362 (US).
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- (54) **Title:** METHODS FOR TREATING TYPE 1 DIABETES USING GLUCAGON RECEPTOR ANTAGONISTIC ANTIBODIES

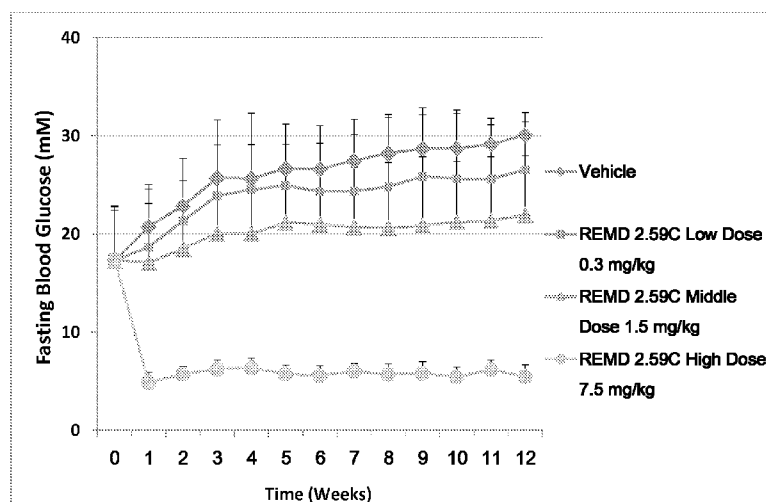


FIG. 3

- (57) **Abstract:** The present disclosure relates to methods for treating type 1 diabetes (T1D) using a glucagon receptor blocking agent. More specifically, the present disclosure relates to methods for treating T1D using substantially lower doses of insulin supplementation, or even in the absence of insulin supplementation, using antigen binding and antagonizing proteins, e.g., fully human antibodies that specifically bind to and antagonize the function of the human glucagon receptor.

METHODS FOR TREATING TYPE 1 DIABETES USING GLUCAGON RECEPTOR ANTAGONISTIC ANTIBODIES

RELATED PATENT APPLICATIONS

[001] This application claims benefit of U.S. Provisional Application No. 62/009328, filed on June 8, 2014, and U.S. Provisional Application No. 62/087182, filed on December 3, 2014, each incorporated in its entirety by reference herein.

TECHNICAL FIELD

[002] Diabetes is one of the leading causes of death by disease worldwide. Type 1 diabetes (T1D; also known as “type 1 diabetes mellitus”, “juvenile-onset diabetes” and “immune-mediated diabetes”) is the most serious form of the disease, with the highest morbidity and mortality. While the exact causes of T1D are not fully understood, T1D is thought to be a multifactorial autoimmune disease in which insulin-producing β -cells in pancreatic islets are destroyed by auto-reactive T cells. The resultant lack of insulin leads to increased blood and urine glucose. Most people affected by T1D are otherwise healthy and of a healthy weight when onset occurs, but they can lose weight quickly and dangerously, if not diagnosed in a relatively short amount of time. Diet and exercise alone cannot reverse or prevent T1D. There are currently no preventive measures that can be taken against T1D. T1D can lead to a number of serious complications, both in the short term and in the long term, e.g., in the short term, untreated T1D can lead to diabetic ketoacidosis, and in the long term it can lead to eye damage, organ damage, etc. T1D can be lethal unless treatment with exogenous insulin injections replaces the missing hormone, or a functional replacement for the destroyed pancreatic β -cells is provided (e.g., a pancreas transplant or islet cell transplantation).

[003] Insulin therapy is the major intervention for the treatment of T1D; however, insulin is not a cure in that it is hard to manage the exogenous insulin to meet body's needs in the glucose-responsive manner necessary to maintain blood glucose levels within a narrow physiological range, e.g., exogenous insulin alone cannot attain the paracrine levels of secreted insulin reaching the alpha cells to restrain glucagon synthesis and release. Exogenous insulin alone can normalize glycated hemoglobin-A1c (HbA1c), but often at the expense of creating severe iatrogenic hyperinsulinemia. And, unfortunately, insulin treatment must be continued for a lifetime, which presents long-term adverse effects that remain a serious concern, e.g., the

severe and chronic hyperinsulinemia has been associated with the induction of lipotoxicity, cardiovascular morbidities, and life-threatening hypoglycemia. While insulin injections or infusion allow a person with T1D to stay alive, they do not cure the disease, nor do they necessarily prevent the possibility of the disease's serious side effects which may include: kidney failure, blindness, nerve damage, heart attack, stroke, and pregnancy complications. Although there are various ongoing clinical trials that aim to find alternative methods of preventing or slowing T1D's development, so far none has proven successful on a permanent basis, and there remains a great need for better ways to treat patients who have diabetes or who are at risk of developing diabetes.

[004] The glucagon receptor (GCGR) is a member of the secretin subfamily (family B) of G-protein-coupled receptors. GCGR is predominantly expressed in the liver, where it regulates hepatic glucose output; in the kidney, reflecting its role in gluconeogenesis; and in the beta cells of islets, suggesting the role of glucagon, secreted from the adjacent alpha cells, having a paracrine effect on beta cells. Studies have shown that higher basal glucagon levels and lack of suppression of postprandial glucagon secretion contribute to diabetic conditions in humans (Muller et al., N Eng J Med, 283:109-115 (1970)). It has been demonstrated that targeting glucagon production or function using isolated antagonistic antigen binding proteins that specifically bind to and antagonize the human GCGR are capable of controlling and lowering blood glucose, and improving glucose tolerance, in type 2 diabetes models (see, e.g., U.S. Patent No. 7,947,809 (Yan, et al)). The ability of such antagonistic antigen binding proteins to effectively treat patients who have T1D or who are at risk of developing T1D has not yet been fully evaluated.

DISCLOSURE OF THE INVENTION

[005] The present disclosure is based in part on the inventors' unique insight that isolated antigen binding and antagonizing proteins that specifically bind to the human glucagon receptor may provide for improved, effective therapies for T1D. The present inventors propose that the beneficial effects provided by the administration of an isolated antagonistic antigen binding protein that specifically binds the human glucagon receptor, i.e., antagonizing glucagon actions by blocking the glucagon receptor, will support and compliment the effects of insulin supplementation such that the insulin supplementation is much lower than the standard daily insulin dosage, or alternatively, will allow for treatment of T1D without the need for insulin supplementation, thereby attaining better diabetic control while significantly alleviating

complications associated with insulin monotherapy, including hypoglycemia, hyperinsulinemia and hyperlipidemia and its associated atherosclerotic cardiovascular complications.

[006] Thus, in one aspect, the present disclosure relates to methods for treating a patient diagnosed with type 1 diabetes (T1D) comprising administering to the patient: (a) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (b) insulin supplementation. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody. In various embodiments, the insulin supplementation comprises administering a dose of insulin that may be between about 70%-90%, between about 50%-70%, between about 30%-50%, between about 15%-30%, between about 10-15%, between about 5-10%, and between zero and 5%, including 4%, 3.5%, 3%, 2.5%, 2%, 1.5%, 1%, .5%, .4%, .3%, .2%, or .1% of the normal daily dosage of insulin.

[007] In various embodiments, the patient may suffer from autoimmune T1D. In various embodiments, the patient may suffer from chemically-induced T1D. In various embodiments, the patient may suffer from T1D resulting from a medically or surgically dysfunctional pancreas, or removal of the pancreas, under various medical conditions. In various embodiments, the patient has been diagnosed as having T1D on the basis of one or more of the following findings: (a) hyperglycemia in conjunction with hypoinsulinemia; (b) hyperglycemia in conjunction with evidence of pancreatic β cell loss; (c) hyperglycemia in conjunction with a normal blood glucose response to insulin; (d) hyperglycemia in conjunction with ketoacidosis; (e) hyperglycemia in conjunction with insulin dependence; or (f) hyperglycemia in conjunction with hyperglucagonemia. In various embodiments, the patient may possess or display a "physiologically non-relevant amount" of insulin, where a "physiologically non-relevant amount" is defined herein as an amount that is not sufficient to attenuate, inhibit, suppress, reduce or ameliorate a type 1 diabetic phenotype. Such patients are thus distinguished from non-diabetic patients and/or patients that possess or display clinical manifestations of type 2 diabetes, which is characterized by, e.g., insulin resistance and insulin insensitivity.

[008] In another aspect, the present disclosure comprises a method for reducing, suppressing, attenuating, or inhibiting one or more symptoms associated with T1D, comprising administering to a patient diagnosed with T1D: (a) a therapeutically effective amount of an

isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (b) insulin supplementation. In various embodiments, the one or more symptoms is selected from: excess gluconeogenesis, excess glycogenolysis, hyperglycemia, hyperglucagonemia, ketosis, diabetic ketoacidosis, hypertriglyceridemia, elevated plasma free fatty acid, weight loss, catabolic syndrome, terminal illness, hypertension, diabetic nephropathy, renal insufficiency, renal failure, hyperphagia, muscle wasting, diabetic neuropathy, diabetic retinopathy, or diabetic coma, excess HbA1c levels, polydipsia (increased thirst), xerostomia (dry mouth), polyphagia (increased hunger), polyuria (frequent urination), or fatigue. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody. In various embodiments, the insulin supplementation comprises administering a dose of insulin that may be between about 70%-90%, between about 50%-70%, between about 30%-50%, between about 15%-30%, between about 10-15%, between about 5-10%, and between zero and 5%, including 4%, 3.5%, 3%, 2.5%, 2%, 1.5%, 1%, .5%, .4%, .3%, .2%, or .1% of the normal daily dosage of insulin.

[009] In another aspect, the present disclosure relates to methods for treating a patient diagnosed with type 1 diabetes (T1D) comprising administering to the patient a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody.

[010] In another aspect, the present disclosure comprises a method for reducing, suppressing, attenuating, or inhibiting one or more symptoms associated with T1D, comprising administering to a patient diagnosed with T1D a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. In various embodiments, the one or more symptoms is selected from: excess gluconeogenesis, excess glycogenolysis, hyperglycemia, hyperglucagonemia, ketosis, diabetic ketoacidosis, hypertriglyceridemia, elevated plasma free fatty acids, weight

loss, catabolic syndrome, terminal illness, hypertension, diabetic nephropathy, renal insufficiency, renal failure, hyperphagia, muscle wasting, diabetic neuropathy, diabetic retinopathy, or diabetic coma, excess HbA1c levels, polydipsia (increased thirst), xerostomia (dry mouth), polyphagia (increased hunger), fatigue, polyuria (frequent urination), or kidney dialysis. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody.

[011] In another aspect, the present disclosure provides methods for treating a patient who is at risk of developing T1D (e.g., patients who have a greater than average risk of developing T1D) or patients with new onset T1D and low residual insulin production. These treatment methods can be carried out by (a) identifying a patient who is at risk (e.g., a heightened risk) of developing T1D and (b) administering to the patient (i) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. In various embodiments, the method further comprises (ii) insulin supplementation. The patient who has been identified as at risk of developing T1D can be a patient who was diagnosed on the basis of, e.g., having a family history of T1D, with or without clinically overt impaired glucose tolerance; or having impaired glucose tolerance and evidence of pancreatic β -cell loss or functional insufficiency. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody. In various embodiments, the insulin supplementation comprises administering a dose of insulin that may be between about 70%-90%, between about 50%-70%, between about 30%-50%, between about 15%-30%, between about 10-15%, between about 5-10%, and between zero and 5%, including 4%, 3.5%, 3%, 2.5%, 2%, 1.5%, 1%, .5%, .4%, .3%, .2%, or .1% of the normal daily dosage of insulin.

[012] In another aspect, the present disclosure comprises a method for reversing hyperglycemia in a patient diagnosed with type 1 diabetes (T1D) comprising administering to a patient diagnosed with T1D a therapeutically effective amount of an isolated antagonistic

antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. In various embodiments, the method further comprises (ii) insulin supplementation. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody.

[013] In another aspect, the present disclosure comprises a method for enhancing insulin secretory function of pancreas islet β -cells in a patient diagnosed with type 1 diabetes (T1D) comprising administering to a patient diagnosed with T1D a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. In various embodiments, the method further comprises (ii) insulin supplementation. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody.

[014] In various embodiments, the isolated antibody or antigen-binding antibody fragment specifically binds to a human glucagon receptor with a dissociation constant (K_D) of at least about 1×10^{-7} M, at least about 1×10^{-8} M, at least about 1×10^{-9} M, at least about 1×10^{-10} M, at least about 1×10^{-11} M, or at least about 1×10^{-12} M.

[015] In various embodiments, the isolated antagonistic antigen binding protein that specifically binds the human glucagon receptor will be admixed with a pharmaceutically acceptable carrier to form a pharmaceutical composition that can be systemically administered to said patient via intravenous injection, intramuscular injection, subcutaneous injection, intraperitoneal injection, transdermal injection, intra-arterial injection, intrasternal injection, intrathecal injection, intraventricular injection, intraurethral injection, intracranial injection, intrasynovial injection or via infusions.

BRIEF DESCRIPTION OF THE DRAWINGS

[016] Figure 1 is a line plot depicting the *in vivo* effects on body weight (g) for animals

treated with various doses (0.3 mg/kg, 1.5 mg/kg, 7.5 mg/kg) of an anti-GCGR antibody in a streptozotocin (STZ)-induced T1D mouse study, evaluated for the efficacy of the antibody for twelve weeks.

[017] Figure 2 is a line plot depicting the *in vivo* effects on food consumption (g/day) for animals treated with various doses (0.3 mg/kg, 1.5 mg/kg, 7.5 mg/kg) of an anti-GCGR antibody in a STZ-induced T1D mouse study, evaluated for the efficacy of the antibody for twelve weeks.

[018] Figure 3 is a line plot depicting the *in vivo* effects on fasting blood glucose (mmol/L) levels for various doses (0.3 mg/kg, 1.5 mg/kg, 7.5 mg/kg) of an anti-GCGR antibody in a STZ-induced T1D mouse study, evaluated for the efficacy of the antibody for 12 weeks.

[019] Figure 4 is a bar graph depicting the *in vivo* effects on blood HbA1c (%) levels (measured at 12 weeks after treatment) at various doses (0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg) of an anti-GCGR antibody after in a STZ-induced T1D mouse study. From left to right, the bars represent the % HbA1c levels for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody.

[020] Figure 5 is a bar graph depicting the *in vivo* effects on Albumin (ALB) (g/L) and total protein (TP) (g/L) levels (each measured at 12 weeks after treatment) for various doses (0.3 mg/kg, 1.5 mg/kg, 7.5 mg/kg) of an anti-GCGR antibody in a STZ-induced T1D mouse study. From left to right, the bars represent the ALB (g/L) levels in blood for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody and TP (g/L) levels in blood for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody.

[021] Figure 6 is a bar graph depicting the *in vivo* effects on insulin (ng/mL) levels (measured pre-treatment (Baseline) and 12 weeks after treatment) for various doses (0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg) of an anti-GCGR antibody in a STZ-induced T1D mouse study. From left to right, the bars represent the baseline insulin (ng/mL) levels for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody and week 12 insulin (ng/mL) levels for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody.

[022] Figure 7 is a bar graph depicting the *in vivo* effects on C-peptide (pg/mL) and glucagon (pg/mL) levels (each measured at 12 weeks after treatment) for various doses (0.3 mg/kg, 1.5 mg/kg, 7.5 mg/kg) of an anti-GCGR antibody in a STZ-induced T1D mouse study. From left to right, the bars represent the C-peptide (pg/mL) levels for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody and glucagon (pg/mL) levels for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody.

[023] Figure 8 is a bar graph depicting the *in vivo* effects on GLP-1 (pmol/L), Acetoacetic Acid (AcAc) (mM) and β -hydroxybutyric acid (BOH) (mM) levels (each measured at

12 weeks after treatment) for various doses (0.3 mg/kg, 1.5 mg/kg, 7.5 mg/kg) of an anti-GCGR antibody in a STZ-induced T1D mouse study. From left to right, the bars represent the GLP-1 (pmol/L) levels for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody, the AcAc (mM) levels for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody, and the BOH (mM) levels for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody.

[024] Figure 9 depicts the results of histological H&E staining of various pancreatic sections from several STZ-induced T1D mice treated with an anti-GCGR antibody at various doses at 12 weeks after treatment.

[025] Figure 10 depicts the results of immunohistochemistry double staining with anti-insulin and anti-glucagon antibodies on pancreatic sections from STZ-induced T1D mice treated with an anti-GCGR antibody for 12 weeks. Alpha (α -) cells were stained with ABC-HRP method. And the positive cells were reviewed by the substrate DAB as dark brown color (arrow). Anti-insulin antibody specific for pancreatic beta (β -) cells were stained with ABC-AP kit, showing positive sign of β -cell recovery in secreting insulin. The positive labeled cells were reviewed with substrate alkaline phosphate as in red color (arrow).

[026] Figure 11A is a bar graph depicting the pancreas area in pancreatic tissue sections from several STZ-induced T1D mice treated with various doses (0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg) of an anti-GCGR antibody at 12 weeks after treatment. Figure 11B is a bar graph depicting the pancreatic islets area in the pancreatic tissue sections from several STZ-induced T1D mice treated with various doses (0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg) of an anti-GCGR antibody at 12 weeks after treatment. Figure 11C is a bar graph depicting the percentage of pancreatic islets in the pancreatic tissue sections from several STZ-induced T1D mice treated with various doses (0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg) of an anti-GCGR antibody at 12 weeks after treatment.

[027] Figure 12A is a bar graph depicting the number of pancreatic islets in each of the STZ-induced T1D mice treated with various doses (0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg) of an anti-GCGR antibody at 12 weeks after treatment. Figure 12B is a bar graph depicting the insulin area and glucagon area in each of the STZ-induced T1D mice treated with various doses (0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg) of an anti-GCGR antibody at 12 weeks after treatment. For Figure 12B, from left to right, the bars represent the insulin area for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody and the glucagon area for vehicle, 0.3 mg/kg, 1.5 mg/kg, and 7.5 mg/kg REMD2.59C antibody at 12 weeks after treatment.

[028] Figure 13 depicts blood glucose (mg/dl) levels in the alloxan-induced diabetic mice, a model of T1D, treated with buffer (n=5) or 5 mg/kg of anti-glucagon receptor antibody

REMD-477 (n=6) for 8 days.

[029] Figure 14A is a bar graph depicting phosphorylated CREB (P-CREB) levels in non-diabetic and alloxan-induced diabetic mice. Figure 14B is a bar graph depicting PEPCCK expression levels in non-diabetic and alloxan-induced diabetic mice.

[030] Figure 15A is a bar graph depicting cAMP response element binding protein (P-CREB) levels in non-diabetic mice treated with buffer, alloxan-induced diabetic mice treated with buffer, and diabetic mice treated with 5 mg of anti-glucagon receptor antibody REMD-477. Figure 15B is a bar graph depicting phosphoenolpyruvate carboxykinase PEPCCK expression levels in non-diabetic mice treated with buffer, alloxan-induced diabetic mice treated with buffer, and diabetic mice treated with 5 mg of anti-glucagon receptor antibody REMD-477.

[031] Figure 16 is a bar graph depicting the *in vivo* effects on fasting blood glucose (mmol/L) levels for various GCGR antibodies (dosed weekly at 7.5 mg/kg) in a streptozotocin (STZ)-induced T1D mouse study, evaluated for the efficacy of the antibodies for 13 days post treatment. From left to right, the bars represent the fasting blood glucose (mmol/L) levels for vehicle, REMD 2.59 antagonizing antibody, REMD 2.45 non-antagonizing antibody and REMD 2.10 antagonizing antibody at day 10 (treatment day), the fasting blood glucose (mmol/L) levels for vehicle, REMD 2.59 antibody, REMD 2.45 antibody and REMD 2.10 antibody at day 17 (post-treatment day 7), and the fasting blood glucose (mmol/L) levels for vehicle, REMD 2.59 antibody, REMD 2.45 antibody and REMD 2.10 antibody at day 22 (post-treatment day 12).

MODE(S) FOR CARRYING OUT THE INVENTION

[032] Unless otherwise defined herein, scientific and technical terms used in connection with the present disclosure shall have the meanings that are commonly understood by those of ordinary skill in the art. Further, unless otherwise required by context, singular terms shall include pluralities and plural terms shall include the singular. Generally, nomenclatures used in connection with, and techniques of, cell and tissue culture, molecular biology, immunology, microbiology, genetics and protein and nucleic acid chemistry and hybridization described herein are those commonly used and well known in the art. The methods and techniques of the present disclosure are generally performed according to conventional methods well known in the art and as described in various general and more specific references that are cited and discussed throughout the present specification unless otherwise indicated. See, e.g., Sambrook et al. *Molecular Cloning: A Laboratory Manual*, 2nd ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. (1989) and Ausubel et al.,

Current Protocols in Molecular Biology, Greene Publishing Associates (1992), and Harlow and Lane Antibodies: A Laboratory Manual, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. (1990), incorporated herein by reference. Enzymatic reactions and purification techniques are performed according to manufacturer's specifications, as commonly accomplished in the art or as described herein. The nomenclature used in connection with, and the laboratory procedures and techniques of, analytical chemistry, synthetic organic chemistry, and medicinal and pharmaceutical chemistry described herein are those commonly used and well known in the art. Standard techniques are used for chemical syntheses, chemical analyses, pharmaceutical preparation, formulation, and delivery, and treatment of patients.

Definitions

[033] The terms "peptide" "polypeptide" and "protein" each refers to a molecule comprising two or more amino acid residues joined to each other by peptide bonds. These terms encompass, e.g., native and artificial proteins, protein fragments and polypeptide analogs (such as muteins, variants, and fusion proteins) of a protein sequence as well as post-translationally, or otherwise covalently or non-covalently, modified proteins. A peptide, polypeptide, or protein may be monomeric or polymeric. In certain embodiments, "peptides", "polypeptides", and "proteins" are chains of amino acids whose alpha carbons are linked through peptide bonds. The terminal amino acid at one end of the chain (amino terminal) therefore has a free amino group, while the terminal amino acid at the other end of the chain (carboxy terminal) has a free carboxyl group. As used herein, the term "amino terminus" (abbreviated N-terminus) refers to the free α -amino group on an amino acid at the amino terminal of a peptide or to the α -amino group (imino group when participating in a peptide bond) of an amino acid at any other location within the peptide. Similarly, the term "carboxy terminus" refers to the free carboxyl group on the carboxy terminus of a peptide or the carboxyl group of an amino acid at any other location within the peptide. Peptides also include essentially any polyamino acid including, but not limited to, peptide mimetics such as amino acids joined by an ether as opposed to an amide bond.

[034] Polynucleotide and polypeptide sequences are indicated using standard one- or three-letter abbreviations. Unless otherwise indicated, polypeptide sequences have their amino termini at the left and their carboxy termini at the right, and single-stranded nucleic acid sequences, and the top strand of double-stranded nucleic acid sequences, have their 5' termini at the left and their 3' termini at the right. A particular section of a polypeptide can be designated

by amino acid residue number such as amino acids 80 to 119, or by the actual residue at that site such as Ser80 to Ser119. A particular polypeptide or polynucleotide sequence also can be described by explaining how it differs from a reference sequence.

[035] Polypeptides of the disclosure include polypeptides that have been modified in any way and for any reason, for example, to: (1) reduce susceptibility to proteolysis, (2) reduce susceptibility to oxidation, (3) alter binding affinity for forming protein complexes, (4) alter binding affinities, and (5) confer or modify other physicochemical or functional properties. For example, single or multiple amino acid substitutions (e.g., conservative amino acid substitutions) may be made in the naturally occurring sequence (e.g., in the portion of the polypeptide outside the domain(s) forming intermolecular contacts). A "conservative amino acid substitution" refers to the substitution in a polypeptide of an amino acid with a functionally similar amino acid. The following six groups each contain amino acids that are conservative substitutions for one another:

Alanine (A), Serine (S), and Threonine (T)

Aspartic acid (D) and Glutamic acid (E)

Asparagine (N) and Glutamine (Q)

Arginine (R) and Lysine (K)

Isoleucine (I), Leucine (L), Methionine (M), and Valine (V)

Phenylalanine (F), Tyrosine (Y), and Tryptophan (W)

[036] A "non-conservative amino acid substitution" refers to the substitution of a member of one of these classes for a member from another class. In making such changes, according to certain embodiments, the hydropathic index of amino acids may be considered. Each amino acid has been assigned a hydropathic index on the basis of its hydrophobicity and charge characteristics. They are: isoleucine (+4.5); valine (+4.2); leucine (+3.8); phenylalanine (+2.8); cysteine/cystine (+2.5); methionine (+1.9); alanine (+1.8); glycine (-0.4); threonine (-0.7); serine (-0.8); tryptophan (-0.9); tyrosine (-1.3); proline (-1.6); histidine (-3.2); glutamate (-3.5); glutamine (-3.5); aspartate (-3.5); asparagine (-3.5); lysine (-3.9); and arginine (-4.5).

[037] The importance of the hydropathic amino acid index in conferring interactive biological function on a protein is understood in the art (see, for example, Kyte et al., 1982, J. Mol. Biol. 157:105-131). It is known that certain amino acids may be substituted for other amino acids having a similar hydropathic index or score and still retain a similar biological activity. In making changes based upon the hydropathic index, in certain embodiments, the substitution of

amino acids whose hydropathic indices are within ± 2 is included. In certain embodiments, those that are within ± 1 are included, and in certain embodiments, those within ± 0.5 are included.

[038] It is also understood in the art that the substitution of like amino acids can be made effectively on the basis of hydrophilicity, particularly where the biologically functional protein or peptide thereby created is intended for use in immunological embodiments, as disclosed herein. In certain embodiments, the greatest local average hydrophilicity of a protein, as governed by the hydrophilicity of its adjacent amino acids, correlates with its immunogenicity and antigenicity, i.e., with a biological property of the protein.

[039] The following hydrophilicity values have been assigned to these amino acid residues: arginine (+3.0); lysine (+3.0); aspartate (+3.0+-1); glutamate (+3.0+-1); serine (+0.3); asparagine (+0.2); glutamine (+0.2); glycine (0); threonine (-0.4); proline (-0.5+-1); alanine (-0.5); histidine (-0.5); cysteine (-1.0); methionine (-1.3); valine (-1.5); leucine (-1.8); isoleucine (-1.8); tyrosine (-2.3); phenylalanine (-2.5) and tryptophan (-3.4). In making changes based upon similar hydrophilicity values, in certain embodiments, the substitution of amino acids whose hydrophilicity values are within ± 2 is included, in certain embodiments, those that are within ± 1 are included, and in certain embodiments, those within ± 0.5 are included. Exemplary amino acid substitutions are set forth in Table 1.

Table 1

Amino Acid Substitutions

<u>Original Residues</u>	<u>Exemplary Substitutions</u>	<u>Preferred Substitutions</u>
Ala	Val, Leu, Ile	Val
Arg	Lys, Gln, Asn	Lys
Asn	Gln	
Asp	Glu	
Cys	Ser, Ala	Ser
Gln	Asn	Asn
Glu	Asp	Asp
Gly	Pro, Ala	Ala
His	Asn, Gln, Lys, Arg	Arg

Ile	Leu, Val, Met, Ala, Phe, Norleucine	Leu
Leu	Norleucine, Ile, Val, Met, Ala, Phe	Ile
Lys	Arg, 1,4 Diamino-butyric Acid, Gln, Asn	Arg
Met	Leu, Phe, Ile	Leu
Phe	Leu, Val, Ile, Ala, Tyr	Leu
Pro	Ala	Gly
Ser	Thr, Ala, Cys	Thr
Thr	Ser	
Trp	Tyr, Phe	Tyr
Tyr	Trp, Phe, Thr, Ser	Phe
Val	Ile, Met, Leu, Phe, Ala, Norleucine	Leu

[040] A skilled artisan will be able to determine suitable variants of polypeptides as set forth herein using well-known techniques. In certain embodiments, one skilled in the art may identify suitable areas of the molecule that may be changed without destroying activity by targeting regions not believed to be important for activity. In other embodiments, the skilled artisan can identify residues and portions of the molecules that are conserved among similar polypeptides. In further embodiments, even areas that may be important for biological activity or for structure may be subject to conservative amino acid substitutions without destroying the biological activity or without adversely affecting the polypeptide structure.

[041] Additionally, one skilled in the art can review structure-function studies identifying residues in similar polypeptides that are important for activity or structure. In view of such a comparison, the skilled artisan can predict the importance of amino acid residues in a polypeptide that correspond to amino acid residues important for activity or structure in similar polypeptides. One skilled in the art may opt for chemically similar amino acid substitutions for such predicted important amino acid residues.

[042] One skilled in the art can also analyze the three-dimensional structure and amino acid sequence in relation to that structure in similar polypeptides. In view of such information, one skilled in the art may predict the alignment of amino acid residues of a polypeptide with respect to its three-dimensional structure. In certain embodiments, one skilled in the art may

choose to not make radical changes to amino acid residues predicted to be on the surface of the polypeptide, since such residues may be involved in important interactions with other molecules. Moreover, one skilled in the art may generate test variants containing a single amino acid substitution at each desired amino acid residue. The variants can then be screened using activity assays known to those skilled in the art. Such variants could be used to gather information about suitable variants. For example, if one discovered that a change to a particular amino acid residue resulted in destroyed, undesirably reduced, or unsuitable activity, variants with such a change can be avoided. In other words, based on information gathered from such routine experiments, one skilled in the art can readily determine the amino acids where further substitutions should be avoided either alone or in combination with other mutations.

[043] The term "polypeptide fragment" and "truncated polypeptide" as used herein refers to a polypeptide that has an amino-terminal and/or carboxy-terminal deletion as compared to a corresponding full-length protein. In certain embodiments, fragments can be, *e.g.*, at least 5, at least 10, at least 25, at least 50, at least 100, at least 150, at least 200, at least 250, at least 300, at least 350, at least 400, at least 450, at least 500, at least 600, at least 700, at least 800, at least 900 or at least 1000 amino acids in length. In certain embodiments, fragments can also be, *e.g.*, at most 1000, at most 900, at most 800, at most 700, at most 600, at most 500, at most 450, at most 400, at most 350, at most 300, at most 250, at most 200, at most 150, at most 100, at most 50, at most 25, at most 10, or at most 5 amino acids in length. A fragment can further comprise, at either or both of its ends, one or more additional amino acids, for example, a sequence of amino acids from a different naturally-occurring protein (*e.g.*, an Fc or leucine zipper domain) or an artificial amino acid sequence (*e.g.*, an artificial linker sequence).

[044] The terms "polypeptide variant" and "polypeptide mutant" as used herein refers to a polypeptide that comprises an amino acid sequence wherein one or more amino acid residues are inserted into, deleted from and/or substituted into the amino acid sequence relative to another polypeptide sequence. In certain embodiments, the number of amino acid residues to be inserted, deleted, or substituted can be, *e.g.*, at least 1, at least 2, at least 3, at least 4, at least 5, at least 10, at least 25, at least 50, at least 75, at least 100, at least 125, at least 150, at least 175, at least 200, at least 225, at least 250, at least 275, at least 300, at least 350, at least 400, at least 450 or at least 500 amino acids in length. Variants of the present disclosure include fusion proteins.

[045] A "derivative" of a polypeptide is a polypeptide that has been chemically modified, *e.g.*, conjugation to another chemical moiety such as, for example, polyethylene glycol, albumin (*e.g.*, human serum albumin), phosphorylation, and glycosylation.

[046] The term "% sequence identity" is used interchangeably herein with the term "% identity" and refers to the level of amino acid sequence identity between two or more peptide sequences or the level of nucleotide sequence identity between two or more nucleotide sequences, when aligned using a sequence alignment program. For example, as used herein, 80% identity means the same thing as 80% sequence identity determined by a defined algorithm, and means that a given sequence is at least 80% identical to another length of another sequence. In certain embodiments, the % identity is selected from, *e.g.*, at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, or at least 99% or more sequence identity to a given sequence. In certain embodiments, the % identity is in the range of, *e.g.*, about 60% to about 70%, about 70% to about 80%, about 80% to about 85%, about 85% to about 90%, about 90% to about 95%, or about 95% to about 99%.

[047] The term "% sequence homology" is used interchangeably herein with the term "% homology" and refers to the level of amino acid sequence homology between two or more peptide sequences or the level of nucleotide sequence homology between two or more nucleotide sequences, when aligned using a sequence alignment program. For example, as used herein, 80% homology means the same thing as 80% sequence homology determined by a defined algorithm, and accordingly a homologue of a given sequence has greater than 80% sequence homology over a length of the given sequence. In certain embodiments, the % homology is selected from, *e.g.*, at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, or at least 99% or more sequence homology to a given sequence. In certain embodiments, the % homology is in the range of, *e.g.*, about 60% to about 70%, about 70% to about 80%, about 80% to about 85%, about 85% to about 90%, about 90% to about 95%, or about 95% to about 99%.

[048] Exemplary computer programs which can be used to determine identity between two sequences include, but are not limited to, the suite of BLAST programs, *e.g.*, BLASTN, BLASTX, and TBLASTX, BLASTP and TBLASTN, publicly available on the Internet at the NCBI website. See also Altschul et al., 1990, J. Mol. Biol. 215:403-10 (with special reference to the published default setting, *i.e.*, parameters $w=4$, $t=17$) and Altschul et al., 1997, Nucleic Acids Res., 25:3389-3402. Sequence searches are typically carried out using the BLASTP program when evaluating a given amino acid sequence relative to amino acid sequences in the GenBank Protein Sequences and other public databases. The BLASTX program is preferred for searching

nucleic acid sequences that have been translated in all reading frames against amino acid sequences in the GenBank Protein Sequences and other public databases. Both BLASTP and BLASTX are run using default parameters of an open gap penalty of 11.0, and an extended gap penalty of 1.0, and utilize the BLOSUM-62 matrix. See id.

[049] In addition to calculating percent sequence identity, the BLAST algorithm also performs a statistical analysis of the similarity between two sequences (see, e.g., Karlin & Altschul, Proc. Nat'l. Acad. Sci. USA, 90:5873-5787 (1993)). One measure of similarity provided by the BLAST algorithm is the smallest sum probability ($P(N)$), which provides an indication of the probability by which a match between two nucleotide or amino acid sequences would occur by chance. For example, a nucleic acid is considered similar to a reference sequence if the smallest sum probability in a comparison of the test nucleic acid to the reference nucleic acid is, e.g., less than about 0.1, less than about 0.01, or less than about 0.001.

[050] The term "isolated molecule" (where the molecule is, for example, a polypeptide, a polynucleotide, or an antibody) is a molecule that by virtue of its origin or source of derivation (1) is not associated with naturally associated components that accompany it in its native state, (2) is substantially free of other molecules from the same species (3) is expressed by a cell from a different species, or (4) does not occur in nature. Thus, a molecule that is chemically synthesized, or expressed in a cellular system different from the cell from which it naturally originates, will be "isolated" from its naturally associated components. A molecule also may be rendered substantially free of naturally associated components by isolation, using purification techniques well known in the art. Molecule purity or homogeneity may be assayed by a number of means well known in the art. For example, the purity of a polypeptide sample may be assayed using polyacrylamide gel electrophoresis and staining of the gel to visualize the polypeptide using techniques well known in the art. For certain purposes, higher resolution may be provided by using HPLC or other means well known in the art for purification.

[051] A protein or polypeptide is "substantially pure," "substantially homogeneous," or "substantially purified" when at least about 60% to 75% of a sample exhibits a single species of polypeptide. A substantially pure polypeptide or protein will typically comprise about 50%, 60%, 70%, 80% or 90% W/W of a protein sample, more usually about 95%, and e.g., will be over 99% pure. Protein purity or homogeneity may be indicated by a number of means well known in the art, such as polyacrylamide gel electrophoresis of a protein sample, followed by visualizing a single polypeptide band upon staining the gel with a stain well known in the art. For certain purposes, higher resolution may be provided by using HPLC or other means well known in the art for purification.

[052] The terms "glucagon inhibitor", "glucagon suppressor" and "glucagon antagonist" are used interchangeably. Each is a molecule that detectably inhibits glucagon action or signaling. The inhibition caused by an inhibitor need not be complete so long as the inhibition is detectable using an assay that is recognized and understood in the art as being determinative of glucagon signaling inhibition.

[053] An "antigen binding and antagonizing protein" is a protein comprising a portion that binds to an antigen and, optionally, a scaffold or framework portion that allows the antigen binding portion to adopt a conformation that promotes binding of the isolated antagonistic antigen binding protein to the antigen. Examples of antigen binding and antagonizing proteins include antibodies, antibody fragments (e.g., an antigen binding portion of an antibody), antibody derivatives, and antibody analogs. The isolated antagonistic antigen binding protein can comprise, for example, an alternative protein scaffold or artificial scaffold with grafted CDRs or CDR derivatives. Such scaffolds include, but are not limited to, antibody-derived scaffolds comprising mutations introduced to, for example, stabilize the three-dimensional structure of the isolated antagonistic antigen binding protein as well as wholly synthetic scaffolds comprising, for example, a biocompatible polymer. See, for example, Korndorfer et al., 2003, *Proteins: Structure, Function, and Bioinformatics*, Volume 53, Issue 1:121-129 (2003); Roque et al., *Biotechnol. Prog.* 20:639-654 (2004). In addition, peptide antibody mimetics ("PAMs") can be used, as well as scaffolds based on antibody mimetics utilizing fibronectin components as a scaffold.

[054] An isolated antagonistic antigen binding protein can have, for example, the structure of a naturally occurring immunoglobulin. An "immunoglobulin" is a tetrameric molecule. In a naturally occurring immunoglobulin, each tetramer is composed of two identical pairs of polypeptide chains, each pair having one "light" (about 25 kDa) and one "heavy" chain (about 50-70 kDa). The amino-terminal portion of each chain includes a variable region of about 100 to 110 or more amino acids primarily responsible for antigen recognition. The carboxy-terminal portion of each chain defines a constant region primarily responsible for effector function. Human light chains are classified as kappa and lambda light chains. Heavy chains are classified as mu, delta, gamma, alpha, or epsilon, and define the antibody's isotype as IgM, IgD, IgG, IgA, and IgE, respectively. Within light and heavy chains, the variable and constant regions are joined by a "J" region of about 12 or more amino acids, with the heavy chain also including a "D" region of about 10 more amino acids. See generally, *Fundamental Immunology* Ch. 7 (Paul, W., ed., 2nd ed. Raven Press, N.Y. (1989)) (incorporated by reference in its entirety for all

purposes). The variable regions of each light/heavy chain pair form the antibody binding site such that an intact immunoglobulin has two binding sites.

[055] An "antibody" refers to a protein comprising one or more polypeptides substantially or partially encoded by immunoglobulin genes or fragments of immunoglobulin genes and having specificity to a tumor antigen or specificity to a molecule overexpressed in a pathological state. The recognized immunoglobulin genes include the kappa, lambda, alpha, gamma, delta, epsilon and mu constant region genes, as well as subtypes of these genes and myriad of immunoglobulin variable region genes. Light chains (LC) are classified as either kappa or lambda. Heavy chains (HC) are classified as gamma, mu, alpha, delta, or epsilon, which in turn define the immunoglobulin classes, IgG, IgM, IgA, IgD and IgE, respectively. A typical immunoglobulin (e.g., antibody) structural unit comprises a tetramer. Each tetramer is composed of two identical pairs of polypeptide chains, each pair having one "light" (about 25 kD) and one "heavy" chain (about 50-70 kD). The N-terminus of each chain defines a variable region of about 100 to 110 or more amino acids primarily responsible for antigen recognition.

[056] In a full-length antibody, each heavy chain is comprised of a heavy chain variable region (abbreviated herein as HCVR or V_H) and a heavy chain constant region. The heavy chain constant region is comprised of three domains, C_{H1} , C_{H2} and C_{H3} (and in some instances, C_{H4}). Each light chain is comprised of a light chain variable region (abbreviated herein as LCVR or V_L) and a light chain constant region. The light chain constant region is comprised of one domain, C_L . The V_H and V_L regions can be further subdivided into regions of hypervariability, termed complementarity determining regions (CDR), interspersed with regions that are more conserved, termed framework regions (FR). Each V_H and V_L is composed of three CDRs and four FRs, arranged from amino-terminus to carboxy-terminus in the following order: FR₁, CDR₁, FR₂, CDR₂, FR₃, CDR₃, FR₄. The extent of the framework region and CDRs has been defined. The sequences of the framework regions of different light or heavy chains are relatively conserved within a species, such as humans. The framework region of an antibody, that is the combined framework regions of the constituent light and heavy chains, serves to position and align the CDRs in three-dimensional space. Immunoglobulin molecules can be of any type (e.g., IgG, IgE, IgM, IgD, IgA and IgY), class (e.g., IgG1, IgG2, IgG 3, IgG4, IgA1 and IgA2) or subclass.

[057] Antibodies exist as intact immunoglobulins or as a number of well characterized fragments. Such fragments include Fab fragments, Fab' fragments, Fab₂, F(ab')₂ fragments, single chain Fv proteins ("scFv") and disulfide stabilized Fv proteins ("dsFv"), that bind to the target antigen. A scFv protein is a fusion protein in which a light chain variable region of an

immunoglobulin and a heavy chain variable region of an immunoglobulin are bound by a linker, while in dsFvs, the chains have been mutated to introduce a disulfide bond to stabilize the association of the chains. While various antibody fragments are defined in terms of the digestion of an intact antibody, one of skill will appreciate that such fragments may be synthesized de novo either chemically or by utilizing recombinant DNA methodology. Thus, as used herein, the term antibody encompasses e.g., monoclonal antibodies (including full-length monoclonal antibodies), polyclonal antibodies, multispecific antibodies (e.g., bispecific antibodies) formed from at least two intact antibodies, human antibodies, humanized antibodies, camelised antibodies, chimeric antibodies, single-chain Fvs (scFv), single-chain antibodies, single domain antibodies, domain antibodies, Fab fragments, F(ab')₂ fragments, antibody fragments that exhibit the desired biological activity, disulfide-linked Fvs (sdFv), intrabodies, and epitope-binding fragments or antigen binding fragments of any of the above.

[058] A Fab fragment is a monovalent fragment having the V_L, V_H, C_L and C_{H1} domains; a F(ab')₂ fragment is a bivalent fragment having two Fab fragments linked by a disulfide bridge at the hinge region; a Fd fragment has the V_H and C_{sub.H1} domains; an Fv fragment has the V_L and V_H domains of a single arm of an antibody; and a dAb fragment has a V_H domain, a V_L domain, or an antigen-binding fragment of a V_H or V_L domain (U.S. Pat. Nos. 6,846,634, 6,696,245, US App. Pub. No. 05/0202512, 04/0202995, 04/0038291, 04/0009507, 03/0039958, Ward et al., Nature 341:544-546 (1989)).

[059] A single-chain antibody (scFv) is an antibody in which a V_L and a V_H region are joined via a linker (e.g., a synthetic sequence of amino acid residues) to form a continuous protein chain wherein the linker is long enough to allow the protein chain to fold back on itself and form a monovalent antigen binding site (see, e.g., Bird et al., Science 242:423-26 (1988) and Huston et al., 1988, Proc. Natl. Acad. Sci. USA 85:5879-83 (1988)). Diabodies are bivalent antibodies comprising two polypeptide chains, wherein each polypeptide chain comprises V_H and V_L domains joined by a linker that is too short to allow for pairing between two domains on the same chain, thus allowing each domain to pair with a complementary domain on another polypeptide chain (see, e.g., Holliger et al., 1993, Proc. Natl. Acad. Sci. USA 90:6444-48 (1993), and Poljak et al., Structure 2:1121-23 (1994)). If the two polypeptide chains of a diabody are identical, then a diabody resulting from their pairing will have two identical antigen binding sites. Polypeptide chains having different sequences can be used to make a diabody with two different antigen binding sites. Similarly, tribodies and tetrabodies are antibodies comprising three and four polypeptide chains, respectively, and forming three and four antigen binding sites, respectively, which can be the same or different.

[060] An isolated antagonistic antigen binding protein may have one or more binding sites. If there is more than one binding site, the binding sites may be identical to one another or may be different. For example, a naturally occurring human immunoglobulin typically has two identical binding sites, while a "bispecific" or "bifunctional" antibody has two different binding sites.

[061] The term "human antibody" includes all antibodies that have one or more variable and constant regions derived from human immunoglobulin sequences. In one embodiment, all of the variable and constant domains are derived from human immunoglobulin sequences (a fully human antibody). These antibodies may be prepared in a variety of ways, examples of which are described below, including through the immunization with an antigen of interest of a mouse that is genetically modified to express antibodies derived from human heavy and/or light chain-encoding genes.

[062] A "humanized antibody" has a sequence that differs from the sequence of an antibody derived from a non-human species by one or more amino acid substitutions, deletions, and/or additions, such that the humanized antibody is less likely to induce an immune response, and/or induces a less severe immune response, as compared to the non-human species antibody, when it is administered to a human patient. In one embodiment, certain amino acids in the framework and constant domains of the heavy and/or light chains of the non-human species antibody are mutated to produce the humanized antibody. In another embodiment, the constant domain(s) from a human antibody are fused to the variable domain(s) of a non-human species. In another embodiment, one or more amino acid residues in one or more CDR sequences of a non-human antibody are changed to reduce the likely immunogenicity of the non-human antibody when it is administered to a human patient, wherein the changed amino acid residues either are not critical for immunospecific binding of the antibody to its antigen, or the changes to the amino acid sequence that are made are conservative changes, such that the binding of the humanized antibody to the antigen is not significantly worse than the binding of the non-human antibody to the antigen. Examples of how to make humanized antibodies may be found in U.S. Pat. Nos. 6,054,297, 5,886,152 and 5,877,293.

[063] An isolated antagonistic antigen binding protein of the present disclosure, including an antibody, "specifically binds" to an antigen, such as the human glucagon receptor if it binds to the antigen with a high binding affinity as determined by a dissociation constant (K_d , or corresponding K_b , as defined below) value of 10^{-7} M or less. An isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor may be able to bind to glucagon receptors from other species as well with the same or different affinities.

[064] An "epitope" is the portion of a molecule that is bound by an isolated antagonistic antigen binding protein (e.g., by an antibody). An epitope can comprise non-contiguous portions of the molecule (e.g., in a polypeptide, amino acid residues that are not contiguous in the polypeptide's primary sequence but that, in the context of the polypeptide's tertiary and quaternary structure, are near enough to each other to be bound by an antigen binding and antagonizing protein).

[065] A "pharmaceutical composition" refers to a composition suitable for pharmaceutical use in an animal or human. A pharmaceutical composition comprises a pharmacologically and/or therapeutically effective amount of an active agent and a pharmaceutically acceptable carrier. "Pharmaceutically acceptable carrier" refers to compositions that do not produce adverse, allergic, or other untoward reactions when administered to an animal or a human. As used herein "pharmaceutically acceptable carrier" refers to any of the standard pharmaceutical carriers, vehicles, buffers, and carriers, such as a phosphate buffered saline solution, 5% aqueous solution of dextrose, and emulsions, such as an oil/water or water/oil emulsion, and various types of wetting agents and/or adjuvants. Suitable pharmaceutical carriers and formulations are described in Remington's Pharmaceutical Sciences, 21st Ed. 2005, Mack Publishing Co, Easton. A "pharmaceutically acceptable salt" is a salt that can be formulated into a compound for pharmaceutical use including, e.g., metal salts (sodium, potassium, magnesium, calcium, etc.) and salts of ammonia or organic amines.

[066] As used herein, a "therapeutically effective amount" of an isolated antagonistic antigen binding protein that specifically binds the human glucagon receptor refers to an amount of such protein that, when provided to a patient in accordance with the disclosed and claimed methods effects one of the following biological activities: treats type I diabetes; or reduces, suppresses, attenuates, or inhibits one or more symptoms of T1D selected from: excess gluconeogenesis, excess glycogenolysis, hyperglycemia, hyperglucagonemia, ketosis, diabetic ketoacidosis, hypertriglyceridemia, elevated plasma free fatty acid, weight loss, catabolic syndrome, terminal illness, hypertension, diabetic nephropathy, renal insufficiency, renal failure, hyperphagia, muscle wasting, diabetic neuropathy, diabetic retinopathy, or diabetic coma, excess HbA1c levels, polyuria (frequent urination), polydipsia (increased thirst), xerostomia (dry mouth), polyphagia (increased hunger), or fatigue. In certain embodiments, such therapeutically effective amount effects such an activity in a patient that is essentially devoid of endogenous insulin. In other embodiments, such therapeutically effective amount effects such an activity in a patient the absence of the provision of exogenous insulin.

[067] The terms "treat", "treating" and "treatment" refer to a method of alleviating or abrogating a biological disorder and/or at least one of its attendant symptoms. As used herein, to "alleviate" a disease, disorder or condition means reducing the severity and/or occurrence frequency of the symptoms of the disease, disorder, or condition. Further, references herein to "treatment" include references to curative, palliative and prophylactic treatment.

[068] As used herein and in the appended claims, the singular forms "a," "or," and "the" include plural referents unless the context clearly dictates otherwise. It is understood that aspects and variations of the disclosure described herein include "consisting" and/or "consisting essentially of" aspects and variation.

[069] Reference to "about" a value or parameter herein includes (and describes) variations that are directed to that value or parameter per se. For example, description referring to "about X" includes description of "X".

Type 1 Diabetes

[070] Diabetes is a disorder characterized by persistent variable hyperglycemia due to either inadequate production of insulin by the body and/or an inadequate response by the body to insulin. Type I diabetes (T1D) (also known as "type 1 diabetes mellitus" and "immune-mediated diabetes" and formerly known as "juvenile onset diabetes" or "insulin dependent diabetes") is an autoimmune disorder that typically develops in susceptible individuals during childhood. At the basis of T1D pathogenesis is the destruction of most insulin-producing pancreatic β -cells by an autoimmune mechanism. In short, the organism loses the immune tolerance towards the pancreatic β -cells in charge of insulin production and induces an immune response, mainly cell-mediated, associated to the production of autoantibodies, which leads to the self-destruction of β -cells.

[071] Currently millions of people suffer from T1D with the overall incidence increasing at about 3-5% per year in most populations. While approximately 50% of the background risk of T1D is believed to be due to environmental factors, the remainder is due to genetic causes with up to 20 different genes influencing susceptibility to the disorder. Of the genetic influence, approximately 50% appears to involve genetic variations within the human leukocyte antigen (HLA) class II alleles HLA-DR and HLA-DQ.

[072] Although there is currently no cure for T1D, early detection can reduce the likelihood of long-term complications, thereby both improving the quality of life and reducing costs resulting from repeated hospitalization. For example, it has been shown that children

previously identified as being autoantibody-positive had a much lower hospitalization rate at the time of diagnosis (3.3% versus 44%), lower mean glycated hemoglobin one month later, and lower mean insulin dose one year later. Predictive testing thus appears to lessen morbidity and medical costs at diagnosis and may lead to better metabolic function in the early period after diagnosis.

[073] Untreated type I diabetes can lead to, e.g., diabetic ketoacidosis, excess gluconeogenesis, excess glycogenolysis, hyperglycemia, hyperglucagonemia, ketosis, hypertriglyceridemia, elevated plasma free fatty acid, weight loss, hypertension, diabetic nephropathy, renal insufficiency, renal failure, hyperphagia, muscle wasting, diabetic neuropathy, and diabetic retinopathy. T1D is lethal unless treatment with exogenous insulin via injections replaces the missing hormone, or a functional replacement for the destroyed pancreatic β -cells is provided (e.g., a pancreas transplant or islet cell transplantation).

[074] T1D is treated with insulin replacement therapy, typically via injection or via insulin pump, along with dietary management, and careful monitoring of blood glucose levels. At present, insulin treatment must be continued for a lifetime. Unfortunately, there are both short-term and long-term disadvantages to insulin therapy. The main short-term concern with insulin monotherapy is the instability of the daily glucose profiles achieved by peripheral injections of insulin. Even optimally controlled patients have daily spikes of hyperglycemia, with occasional hypoglycemic dips, likely due to the enormous anatomical disadvantage of peripherally injected insulin, which cannot meet the high insulin requirements of proximal targets such as alpha cells and hepatocytes without far exceeding the insulin requirements of distal targets such as muscle and fat. The intra-islet concentration of endogenous insulin that perfuses alpha cells in normal islets has been estimated to be over 20X higher than the levels generated by peripheral injection, and the concentration of endogenous insulin perfusing the liver is 4- to 5-times higher. This means that even a high concentration of exogenous insulin in peripheral plasma may not approach the physiologic levels of endogenous insulin that perfuse these two proximal insulin targets, which control endogenous glucose production. The major long-term concerns of life-time insulin monotherapy are insulin resistance, a well characterized component of type I diabetes; severe and chronic iatrogenic hyperinsulinemia which has been associated with the induction of lipotoxicity and the development of hyperlipidemia, increased incidence and severity of hypoglycemia, and its atherosclerotic complications that precipitate cardiovascular disorders such as coronary artery disease and stroke, due to the lipogenic actions of insulin. While insulin injections or infusion allow a person with T1D to stay alive, they do not cure the disease, nor do they necessarily prevent the possibility of the disease's serious side effects.

[075] In certain extreme cases, a pancreas transplant or islet cell transplantation can help restore proper glucose regulation and serve as a temporary cure. Pancreas transplants are generally recommended if a kidney transplant is also necessary. The reason for this is that introducing a new kidney requires taking immunosuppressive drugs anyway, and this allows the introduction of a new, functioning pancreas to a patient with diabetes without any additional immunosuppressive therapy. In islet cell transplantation, islet cells are injected into the patient's liver, where they take up residence and begin to produce insulin. The liver is expected to be the most reasonable choice because it is more accessible than the pancreas, and the islet cells seem to produce insulin well in that environment. The patient's body, however, will treat the new cells just as it would any other introduction of foreign tissue. The immune system will attack the cells as it would a bacterial infection or a skin graft. Thus, the patient also needs to undergo treatment involving immunosuppressants, which reduce immune system activity.

[076] An accepted model of experimental chemically-induced diabetes in mice is the induction of diabetes by multiple injections of low doses of streptozotocin (LDST or STZ) (Like et al., Science, 193: 415-417, 1976; O'Brien, et al., J. Pathol., 178:176-18, 1996). Streptozotocin causes diabetes by direct β cell cytotoxicity, as well as by initiation of cell mediated autoimmune reaction against β cells (Paik et al., Proc Natl Acad Sci USA, 77:6129-6133, 1980). Adoptive transfer of activated splenocytes from LDST-treated mice has been disclosed to induce diabetes in untreated healthy mice (Id). Another accepted model of chemically-induced diabetes is the induction of diabetes by multiple injections of alloxan (S. Lenzen, Diabetologia, 51(2): 216-226, 2008). An additional accepted and widely used model of autoimmune T1D is the non-obese diabetic (NOD) mouse, which develops diabetes spontaneously after a variable period of insulinitis, similarly to human T1D. NOD mice demonstrate insulinitis from 4-5 weeks of age, and after a variable period of chronic inflammation, diabetes develops about 10-20 weeks later, with most females diabetic by 30 weeks of age (Delovitch et al., Immunity, 7:727-738, 1997; Kikutani et al., Adv Immunol., 51:285-322, 1992).

Glucagon Receptor and Antigen binding and antagonizing proteins

[077] Glucagon is a 29 amino acid hormone processed from its pre-pro-form in the pancreatic alpha cells by cell specific expression of prohormone convertase 2 (PC2), a neuroendocrine-specific protease involved in the intracellular maturation of prohormones and proneuropeptides (Furuta et al., J. Biol. Chem. 276: 27197-27202 (2001)). In vivo, glucagon is a major counter-regulatory hormone for insulin actions. During fasting, glucagon secretion

increases in response to falling glucose levels. Increased glucagon secretion stimulates glucose production by promoting hepatic glycogenolysis and gluconeogenesis (Dunning and Gerich, *Endocrine Reviews*, 28:253-283 (2007)). Thus glucagon counterbalances the effects of insulin in maintaining normal levels of glucose in animals.

[078] The biological effects of glucagon are mediated through the binding and subsequent activation of a specific cell surface receptor, the glucagon receptor. The glucagon receptor (GCGR) is a member of the secretin subfamily (family B) of G-protein-coupled receptors. The human GCGR is a 477 amino acid sequence GPCR and the amino acid sequence of GCGR is highly conserved across species (Mayo et al, *Pharmacological Rev.*, 55:167-194, (2003)). The glucagon receptor is predominantly expressed in the liver, where it regulates hepatic glucose output, on the kidney, and on islet β -cells, reflecting its role in gluconeogenesis. The activation of the glucagon receptors in the liver stimulates the activity of adenyl cyclase and phosphoinositol turnover which subsequently results in increased expression of gluconeogenic enzymes including phosphoenolpyruvate carboxykinase (PEPCK), fructose-1,6-bisphosphatase (FBPase-1), and glucose-6-phosphatase (G-6-Pase). In addition, glucagon signaling activates glycogen phosphorylase and inhibits glycogen synthase. Studies have shown that higher basal glucagon levels and lack of suppression of postprandial glucagon secretion contribute to diabetic conditions in humans (Muller et al., *N Eng J Med* 283: 109-115 (1970)). As such, methods of controlling and lowering blood glucose by targeting glucagon production or function using a GCGR antagonist have been explored.

[079] In various embodiments, the antigen binding and antagonizing proteins of the present disclosure may be selected to bind to membrane-bound glucagon receptors as expressed on cells, and inhibit or block glucagon signaling through the glucagon receptor. In various embodiments, the antigen binding and antagonizing proteins of the present disclosure specifically bind to the human glucagon receptor. In various embodiments, the antigen binding and antagonizing proteins binding to the human glucagon receptor may also bind to the glucagon receptors of other species. The polynucleotide and polypeptide sequences for several species of glucagon receptor (e.g., the mouse glucagon receptor (accession number AAH57988) or rat glucagon receptor (NM 172092)) are known (see, e.g., U.S. Pat. No. 7,947,809, herein incorporated by reference in its entirety for its specific teaching of polynucleotide and polypeptide sequences of a human, rat, mouse and cynomolgus glucagon receptor). In various embodiments of the present disclosure, the antigen binding and antagonizing proteins specifically bind the human glucagon receptor having the amino acid sequence set forth in SEQ ID NO: 1:

Glucagon Receptor Human (Homo sapiens) amino acid sequence
(Accession Number AAI04855)

MPPCQQRPLLLLLLLACQPQVPSAQVMDFLFEKWKLYGDQCHHNLSELLPPPTLVCNRTFD
KYSCWPDTPANTTANISCPWYLPWHHKVQHRFVKRCGPDGQWVRGPRGQPWRDASQCQ
MDGEEIEVQKEVAKMYSSFQVMYTVGYSLGALLLALAILGGLSKLHCTRNAIHANLFASFVLK
ASSVLVIDGLLRTRYSQKIGDDLSVSTWLSDGAVAGCRVAAVFMQYGIVANYCWLLVEGLYLH
NLLGLATLPERSFFSLYLIGIGWGAPMLFVVPWAVVKCLFENVQCWTSNDNMGFWWILRFPVFL
AILINFFIFVRIVQLLVAKLRARQMHHTDYKFRLAKSTLTLLIPLLGVEHVFAFVTDEHAQGTLSA
KLFFDLFLSSFQGLLVAVLYCFLNKEVQSELRWRWRLGKVLWEERNTSNHRASSSPGHG
PPSKELQFGRGGGSQDSSAETPLAGGLPRLAESPF (SEQ ID NO: 1)

In various embodiments, the antigen binding and antagonizing proteins of the present disclosure specifically bind glucagon receptors which have at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% identity (as calculated using methods known in the art and described herein) to the glucagon receptors described in the cited references are also included in the present disclosure.

[080] Methods of generating antibodies that bind to antigens such as the human glucagon receptor are known to those skilled in the art. For example, a method for generating a monoclonal antibody that binds specifically to a targeted antigen polypeptide may comprise administering to a mouse an amount of an immunogenic composition comprising the targeted antigen polypeptide effective to stimulate a detectable immune response, obtaining antibody-producing cells (e.g., cells from the spleen) from the mouse and fusing the antibody-producing cells with myeloma cells to obtain antibody-producing hybridomas, and testing the antibody-producing hybridomas to identify a hybridoma that produces a monoclonal antibody that binds specifically to the targeted antigen polypeptide. Once obtained, a hybridoma can be propagated in a cell culture, optionally in culture conditions where the hybridoma-derived cells produce the monoclonal antibody that binds specifically to targeted antigen polypeptide. The monoclonal antibody may be purified from the cell culture. A variety of different techniques are then available for testing an antigen/antibody interaction to identify particularly desirable antibodies.

[081] Other suitable methods of producing or isolating antibodies of the requisite specificity can be used, including, for example, methods which select recombinant antibody from a library, or which rely upon immunization of transgenic animals (e.g., mice) capable of producing a full repertoire of human antibodies. See e.g., Jakobovits et al., Proc. Natl. Acad.

Sci. (U.S.A.), 90: 2551-2555, 1993; Jakobovits et al., Nature, 362: 255-258, 1993; Lonberg et al., U.S. Pat. No. 5,545,806; and Surani et al., U.S. Pat. No. 5,545,807.

[082] Antibodies can be engineered in numerous ways. They can be made as single-chain antibodies (including small modular immunopharmaceuticals or SMIPsTM), Fab and F(ab')₂ fragments, etc. Antibodies can be humanized, chimerized, deimmunized, or fully human.

Numerous publications set forth the many types of antibodies and the methods of engineering such antibodies. For example, see U.S. Pat. Nos. 6,355,245; 6,180,370; 5,693,762; 6,407,213; 6,548,640; 5,565,332; 5,225,539; 6,103,889; and 5,260,203.

[083] Chimeric antibodies can be produced by recombinant DNA techniques known in the art. For example, a gene encoding the Fc constant region of a murine (or other species) monoclonal antibody molecule is digested with restriction enzymes to remove the region encoding the murine Fc, and the equivalent portion of a gene encoding a human Fc constant region is substituted (see Robinson et al., International Patent Publication PCT/US86/02269; Akira, et al., European Patent Application 184,187; Taniguchi, M., European Patent Application 171,496; Morrison et al., European Patent Application 173,494; Neuberger et al., International Application WO 86/01533; Cabilly et al. U.S. Pat. No. 4,816,567; Cabilly et al., European Patent Application 125,023; Better et al., Science, 240:1041-1043, 1988; Liu et al., Proc. Natl. Acad. Sci. (U.S.A.), 84:3439-3443, 1987; Liu et al., J. Immunol., 139:3521-3526, 1987; Sun et al., Proc. Natl. Acad. Sci. (U.S.A.), 84:214-218, 1987; Nishimura et al., Canc. Res., 47:999-1005, 1987; Wood et al., Nature, 314:446-449, 1985; and Shaw et al., J. Natl Cancer Inst., 80:1553-1559, 1988).

[084] Methods for humanizing antibodies have been described in the art. In some embodiments, a humanized antibody has one or more amino acid residues introduced from a source that is nonhuman, in addition to the nonhuman CDRs. Humanization can be essentially performed following the method of Winter and co-workers (Jones et al., Nature, 321:522-525, 1986; Riechmann et al., Nature, 332:323-327, 1988; Verhoeyen et al., Science, 239:1534-1536, 1988), by substituting hypervariable region sequences for the corresponding sequences of a human antibody. Accordingly, such "humanized" antibodies are chimeric antibodies (U.S. Patent No. 4,816,567) wherein substantially less than an intact human variable region has been substituted by the corresponding sequence from a nonhuman species. In practice, humanized antibodies are typically human antibodies in which some hypervariable region residues and possibly some framework region residues are substituted by residues from analogous sites in rodent antibodies.

[085] U.S. Patent No. 5,693,761 to Queen et al, discloses a refinement on Winter et al. for humanizing antibodies, and is based on the premise that ascribes avidity loss to problems in the structural motifs in the humanized framework which, because of steric or other chemical incompatibility, interfere with the folding of the CDRs into the binding-capable conformation found in the mouse antibody. To address this problem, Queen teaches using human framework sequences closely homologous in linear peptide sequence to framework sequences of the mouse antibody to be humanized. Accordingly, the methods of Queen focus on comparing framework sequences between species. Typically, all available human variable region sequences are compared to a particular mouse sequence and the percentage identity between correspondent framework residues is calculated. The human variable region with the highest percentage is selected to provide the framework sequences for the humanizing project. Queen also teaches that it is important to retain in the humanized framework, certain amino acid residues from the mouse framework critical for supporting the CDRs in a binding-capable conformation. Potential criticality is assessed from molecular models. Candidate residues for retention are typically those adjacent in linear sequence to a CDR or physically within 6Å of any CDR residue.

[086] In other approaches, the importance of particular framework amino acid residues is determined experimentally once a low-avidity humanized construct is obtained, by reversion of single residues to the mouse sequence and assaying antigen binding as described by Riechmann et al, 1988. Another example approach for identifying important amino acids in framework sequences is disclosed by U.S. Patent No. 5,821,337 to Carter et al, and by U.S. Patent No. 5,859,205 to Adair et al. These references disclose specific Kabat residue positions in the framework, which, in a humanized antibody may require substitution with the correspondent mouse amino acid to preserve avidity.

[087] Another method of humanizing antibodies, referred to as "framework shuffling", relies on generating a combinatorial library with nonhuman CDR variable regions fused in frame into a pool of individual human germline frameworks (Dall'Acqua et al., Methods, 36:43, 2005). The libraries are then screened to identify clones that encode humanized antibodies which retain good binding.

[088] The choice of human variable regions, both light and heavy, to be used in making the humanized antibodies is very important to reduce antigenicity. According to the so-called "best-fit" method, the sequence of the variable region of a rodent antibody is screened against the entire library of known human variable-domain sequences. The human sequence that is closest to that of the rodent is then accepted as the human framework region (framework

region) for the humanized antibody (Sims et al., J. Immunol., 151:2296, 1993; Chothia et al., J. Mol. Biol., 196:901, 1987). Another method uses a particular framework region derived from the consensus sequence of all human antibodies of a particular subgroup of light or heavy chain variable regions. The same framework may be used for several different humanized antibodies (Carter et al., Proc. Natl. Acad. Sci. (U.S.A.), 89:4285, 1992; Presta et al., J. Immunol., 151:2623, 1993).

[089] The choice of nonhuman residues to substitute into the human variable region can be influenced by a variety of factors. These factors include, for example, the rarity of the amino acid in a particular position, the probability of interaction with either the CDRs or the antigen, and the probability of participating in the interface between the light and heavy chain variable domain interface. (See, for example, U.S. Patent Nos. 5,693,761, 6,632,927, and 6,639,055). One method to analyze these factors is through the use of three-dimensional models of the nonhuman and humanized sequences. Three-dimensional immunoglobulin models are commonly available and are familiar to those skilled in the art. Computer programs are available that illustrate and display probable three-dimensional conformational structures of selected candidate immunoglobulin sequences. Inspection of these displays permits analysis of the likely role of the residues in the functioning of the candidate immunoglobulin sequence, e.g., the analysis of residues that influence the ability of the candidate immunoglobulin to bind its antigen. In this way, nonhuman residues can be selected and substituted for human variable region residues in order to achieve the desired antibody characteristic, such as increased affinity for the target antigen(s).

[090] Methods for making fully human antibodies have been described in the art. By way of example, a method for producing an anti-GCGR antibody or antigen binding antibody fragment thereof comprises the steps of synthesizing a library of human antibodies on phage, screening the library with GCGR or an antibody binding portion thereof, isolating phage that bind GCGR, and obtaining the antibody from the phage. By way of another example, one method for preparing the library of antibodies for use in phage display techniques comprises the steps of immunizing a non-human animal comprising human immunoglobulin loci with GCGR or an antigenic portion thereof to create an immune response, extracting antibody-producing cells from the immunized animal; isolating RNA encoding heavy and light chains of antibodies of the disclosure from the extracted cells, reverse transcribing the RNA to produce cDNA, amplifying the cDNA using primers, and inserting the cDNA into a phage display vector such that antibodies are expressed on the phage. Recombinant anti-GCGR antibodies of the disclosure may be obtained in this way.

[091] Again, by way of example, recombinant human anti-GCGR antibodies of the disclosure can also be isolated by screening a recombinant combinatorial antibody library. Preferably the library is a scFv phage display library, generated using human V_L and V_H cDNAs prepared from mRNA isolated from B cells. Methods for preparing and screening such libraries are known in the art. Kits for generating phage display libraries are commercially available (e.g., the Pharmacia Recombinant Phage Antibody System, catalog no. 27-9400-01; and the Stratagene SurfZAPTM phage display kit, catalog no. 240612). There also are other methods and reagents that can be used in generating and screening antibody display libraries (see, e.g., U.S. Pat. No. 5,223,409; PCT Publication Nos. WO 92/18619, WO 91/17271, WO 92/20791, WO 92/15679, WO 93/01288, WO 92/01047, WO 92/09690; Fuchs et al., *Bio/Technology*, 9:1370-1372 (1991); Hay et al., *Hum. Antibod. Hybridomas*, 3:81-85, 1992; Huse et al., *Science*, 246:1275-1281, 1989; McCafferty et al., *Nature*, 348:552-554, 1990; Griffiths et al., *EMBO J.*, 12:725-734, 1993; Hawkins et al., *J. Mol. Biol.*, 226:889-896, 1992; Clackson et al., *Nature*, 352:624-628, 1991; Gram et al., *Proc. Natl. Acad. Sci. (U.S.A.)*, 89:3576-3580, 1992; Garrad et al., *Bio/Technology*, 9:1373-1377, 1991; Hoogenboom et al., *Nuc. Acid Res.*, 19:4133-4137, 1991; and Barbas et al., *Proc. Natl. Acad. Sci. (U.S.A.)*, 88:7978-7982, 1991), all incorporated herein by reference.

[092] Human antibodies are also produced by immunizing a non-human, transgenic animal comprising within its genome some or all of human immunoglobulin heavy chain and light chain loci with a human IgE antigen, e.g., a XenoMouseTM animal (Abgenix, Inc./Amgen, Inc.--Fremont, Calif.). XenoMouseTM mice are engineered mouse strains that comprise large fragments of human immunoglobulin heavy chain and light chain loci and are deficient in mouse antibody production. See, e.g., Green et al., *Nature Genetics*, 7:13-21, 1994 and U.S. Pat. Nos. 5,916,771, 5,939,598, 5,985,615, 5,998,209, 6,075,181, 6,091,001, 6,114,598, 6,130,364, 6,162,963 and 6,150,584. XenoMouseTM mice produce an adult-like human repertoire of fully human antibodies and generate antigen-specific human antibodies. In some embodiments, the XenoMouseTM mice contain approximately 80% of the human antibody V gene repertoire through introduction of megabase sized, germline configuration fragments of the human heavy chain loci and kappa light chain loci in yeast artificial chromosome (YAC). In other embodiments, XenoMouseTM mice further contain approximately all of the human lambda light chain locus. See Mendez et al., *Nature Genetics*, 15:146-156, 1997; Green and Jakobovits, *J. Exp. Med.*, 188:483-495, 1998; and WO 98/24893.

[093] In various embodiments, the isolated antagonistic antigen binding protein of the present disclosure utilize an antibody or antigen binding antibody fragment thereof is a

polyclonal antibody, a monoclonal antibody or antigen-binding fragment thereof, a recombinant antibody, a diabody, a chimerized or chimeric antibody or antigen-binding fragment thereof, a humanized antibody or antigen-binding fragment thereof, a fully human antibody or antigen-binding fragment thereof, a CDR-grafted antibody or antigen-binding fragment thereof, a single chain antibody, an Fv, an Fd, an Fab, an Fab', or an F(ab')₂, and synthetic or semi-synthetic antibodies.

[094] In various embodiments, the isolated antagonistic antigen binding protein of the present disclosure utilize an antibody or antigen-binding fragment that binds to an immune-checkpoint protein antigen with a dissociation constant (K_D) of, e.g., at least about 1×10^{-7} M, at least about 1×10^{-8} M, at least about 1×10^{-9} M, at least about 1×10^{-10} M, at least about 1×10^{-11} M, or at least about 1×10^{-12} M. In various embodiments, the isolated antagonistic antigen binding protein of the present disclosure utilize an antibody or antigen-binding fragment that binds to an immune-checkpoint protein antigen with a dissociation constant (K_D) in the range of, e.g., at least about 1×10^{-7} M to at least about 1×10^{-8} M, at least about 1×10^{-8} M to at least about 1×10^{-9} M, at least about 1×10^{-9} M to at least about 1×10^{-10} M, at least about 1×10^{-10} M to at least about 1×10^{-11} M, or at least about 1×10^{-11} M to at least about 1×10^{-12} M.

[095] Antibodies to the glucagon receptor have been described in, e.g., U.S. Pat. Nos. 5,770,445 and 7,947,809; European patent application EP2074149A2; EP patent EP0658200B1; U.S. patent publications 2009/0041784; 2009/0252727; 2013/0344538 and 2014/0335091; and PCT publication WO2008/036341. In various embodiments of the present invention, the isolated antagonistic antigen binding protein is an anti-GCGR ("antagonistic") antibody or antigen-binding fragment which comprises the polynucleotide and polypeptide sequences set forth in, e.g., U.S. Pat. No. 7,947,809, and 8,158,759, each herein incorporated by reference in its entirety for its specific teaching of polynucleotide and polypeptide sequences of various anti-GCGR antibodies or antigen-binding fragments.

[096] In various embodiments of the present disclosure the antibody may be an anti-GCGR antibody that has the same or higher antigen-binding affinity as that of the antibody comprising the heavy chain variable region sequence as set forth in SEQ ID NO: 2. In various embodiments, the antibody may be an anti-GCGR antibody which binds to the same epitope as the antibody comprising the heavy chain variable region sequence as set forth in SEQ ID NO: 2. In various embodiments, the antibody is an anti-GCGR antibody which competes with the antibody comprising the heavy chain variable region sequence as set forth in SEQ ID NO: 2. In various embodiments, the antibody may be an anti-GCGR antibody which comprises at least one (such as two or three) CDRs of the heavy chain variable region sequence as set forth in

SEQ ID NO: 2. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the heavy chain variable region sequence as set forth in SEQ ID NO: 2. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the heavy chain variable region sequence as set forth in SEQ ID NO: 2:

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVAV
MWYDGSNKDYVDSVKGRFTISRDN SKNTLYLQMNRLRAEDTAVYYCAREKD
HYDILTGYNYYYGLDVWGQGTTVTVSS (SEQ ID NO: 2)

[097] In various embodiments of the present disclosure the antibody may be an anti-GCGR antibody that has the same or higher antigen-binding affinity as that of the antibody comprising the light chain variable region sequence as set forth in SEQ ID NO: 3. In various embodiments, the antibody may be an anti-GCGR antibody which binds to the same epitope as the antibody comprising the light chain variable region sequence as set forth in SEQ ID NO: 3. In various embodiments, the antibody is an anti-GCGR antibody which competes with the antibody comprising the light chain variable region sequence as set forth in SEQ ID NO: 3. In various embodiments, the antibody may be an anti-GCGR antibody which comprises at least one (such as two or three) CDRs of the light chain variable region sequence as set forth in SEQ ID NO: 3. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the light chain variable region sequence as set forth in SEQ ID NO: 3. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the light chain variable region sequence as set forth in SEQ ID NO: 3:

DIQMTQSPSSLSASVSGDRVTITCRASQGIRNDLGWYQQKPGKAPKRLIYAASS
LQSGVPSRFSGSGSGTEFTLTISSVQPEDFVITYYCLQHNSNPLTFGGGGTKVEIK
(SEQ ID NO: 3)

[098] In various embodiments, the antibody contains an amino acid sequence that shares an observed homology of, *e.g.*, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% with the sequences of SEQ ID NOS: 2 or 3.

[099] In various embodiments of the present disclosure the antibody may be an anti-GCGR antibody that has the same or higher antigen-binding affinity as that of the antibody comprising the heavy chain variable region sequence as set forth in SEQ ID NO: 4. In various embodiments, the antibody may be an anti-GCGR antibody which binds to the same epitope as the antibody comprising the heavy chain variable region sequence as set forth in SEQ ID NO: 4.

In various embodiments, the antibody is an anti-GCGR antibody which competes with the antibody comprising the heavy chain variable region sequence as set forth in SEQ ID NO: 4. In various embodiments, the antibody may be an anti-GCGR antibody which comprises at least one (such as two or three) CDRs of the heavy chain variable region sequence as set forth in SEQ ID NO: 4. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the heavy chain variable region sequence as set forth in SEQ ID NO: 4. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the heavy chain variable region sequence as set forth in SEQ ID NO: 4:

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWV
AVMWYDGSNKDYVDSVKGRFTISRDNKNTLYLQMNSLRAEDTAVYYCARE
KDHYDILTGYNYYYGLDVWGQGTTVTSS (SEQ ID NO: 4)

[0100] In various embodiments of the present disclosure the antibody may be an anti-GCGR antibody that has the same or higher antigen-binding affinity as that of the antibody comprising the light chain variable region sequence as set forth in SEQ ID NO: 5. In various embodiments, the antibody may be an anti-GCGR antibody which binds to the same epitope as the antibody comprising the light chain variable region sequence as set forth in SEQ ID NO: 5. In various embodiments, the antibody is an anti-GCGR antibody which competes with the antibody comprising the light chain variable region sequence as set forth in SEQ ID NO: 5. In various embodiments, the antibody may be an anti-GCGR antibody which comprises at least one (such as two or three) CDRs of the light chain variable region sequence as set forth in SEQ ID NO: 5. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the light chain variable region sequence as set forth in SEQ ID NO: 5. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the light chain variable region sequence as set forth in SEQ ID NO: 5:

DIQMTQSPSSLSASVGDRVTITCRASQGIRNDLGWYQQKPGKAPKRLIYAASS
LQSGVPSRFSGSGSGTEFTLTISLQPEDFVTTYCLQHNSNPLTFGGGTKVEIK
(SEQ ID NO: 5)

[0101] In various embodiments, the antibody contains an amino acid sequence that shares an observed homology of, *e.g.*, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% with the sequences of SEQ ID NOS: 4 or 5.

[0102] In various embodiments of the present disclosure the antibody may be an anti-GCGR antibody that has the same or higher antigen-binding affinity as that of the antibody comprising the heavy chain variable region sequence as set forth in SEQ ID NO: 6. In various embodiments, the antibody may be an anti-GCGR antibody which binds to the same epitope as the antibody comprising the heavy chain variable region sequence as set forth in SEQ ID NO: 6. In various embodiments, the antibody is an anti-GCGR antibody which competes with the antibody comprising the heavy chain variable region sequence as set forth in SEQ ID NO: 6. In various embodiments, the antibody may be an anti-GCGR antibody which comprises at least one (such as two or three) CDRs of the heavy chain variable region sequence as set forth in SEQ ID NO: 6. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the heavy chain variable region sequence as set forth in SEQ ID NO: 6. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the heavy chain variable region sequence as set forth in SEQ ID NO: 6:

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVA
VMWYDGSN KDYVDSVKGRFTISRDN SKNTLYLQMNRLRAEDTAVYYCAREK
DHYDILTGYNYYYGLDVWGQGTTVTVSS (SEQ ID NO: 6)

[0103] In various embodiments of the present disclosure the antibody may be an anti-GCGR antibody that has the same or higher antigen-binding affinity as that of the antibody comprising the light chain variable region sequence as set forth in SEQ ID NO: 7. In various embodiments, the antibody may be an anti-GCGR antibody which binds to the same epitope as the antibody comprising the light chain variable region sequence as set forth in SEQ ID NO: 7. In various embodiments, the antibody is an anti-GCGR antibody which competes with the antibody comprising the light chain variable region sequence as set forth in SEQ ID NO: 7. In various embodiments, the antibody may be an anti-GCGR antibody which comprises at least one (such as two or three) CDRs of the light chain variable region sequence as set forth in SEQ ID NO: 7. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the light chain variable region sequence as set forth in SEQ ID NO: 7. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the light chain variable region sequence as set forth in SEQ ID NO: 7:

DIQMTQSPSSLSASVGDRTITCRASQGIRNDLGWYQQKPGKAPKRLIYAASS
LESGVPSRFSGSGSGTEFTLTISSVQPEDFVTTYCLQHNSNPLTFGGGTKVEIK
(SEQ ID NO: 7)

[0104] In various embodiments, the antibody contains an amino acid sequence that shares an observed homology of, *e.g.*, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% with the sequences of SEQ ID NOS: 6 or 7.

[0105] In various embodiments of the present disclosure the antibody may be an anti-GCGR antibody that has the same or higher antigen-binding affinity as that of the chimeric antibody comprising the heavy chain sequence as set forth in SEQ ID NO: 8. In various embodiments, the antibody may be an anti-GCGR antibody which binds to the same epitope as the antibody comprising the heavy chain sequence as set forth in SEQ ID NO: 8. In various embodiments, the antibody is an anti-GCGR antibody which competes with the antibody comprising the heavy chain sequence as set forth in SEQ ID NO: 8. In various embodiments, the antibody may be an anti-GCGR antibody which comprises at least one (such as two or three) CDRs of the heavy chain sequence as set forth in SEQ ID NO: 8. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the heavy chain sequence as set forth in SEQ ID NO: 8. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the heavy chain sequence as set forth in SEQ ID NO: 8.

MEFGLSWVFLVALLRGVQCQVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWV
 RQAPGKGLEWVAVMWYDGSNKDYVDSVKGRFTISRDNKNTLYLQMNRLRAEDTAV
 YYCAREKDHYDILTGYNYYYGLDVWGQGTITVSSAKTTPPSVYPLAPGSAAQTNSMV
 TLGCLVKGYFPEPVTVTWNSGSLSSGVHTFPAVLQSDLYTLSSSVTPSSTWPSETVT
 CNVAHPASSTKVDKKIVPRDCGCKPCICTVPEVSSVFIFPPKPKDVLITLTPKVTCTVVV
 DISKDDPEVQFSWFVDDVEVHTAQTQPREEQFNSTFRSVSELPIMHQDWLNGKEFKC
 RVNSAAFPAPIEKTISKTKGRPKAPQVYTIPPPKEQMAKDKVSLTCMITDFFPEDITVEW
 QWNGQPAENYKNTQPIMDTDGSYFVYSKLVNPKSNWEAGNTFTCSVLHEGLHNHHT
 EKSLSHSPGK (SEQ ID NO: 8)

[0106] In various embodiments of the present disclosure the antibody may be an anti-GCGR antibody that has the same or higher antigen-binding affinity as that of the chimeric antibody comprising the light chain sequence as set forth in SEQ ID NO: 9. In various embodiments, the antibody may be an anti-GCGR antibody which binds to the same epitope as the antibody comprising the light chain sequence as set forth in SEQ ID NO: 9. In various embodiments, the antibody is an anti-GCGR antibody which competes with the antibody comprising the light chain sequence as set forth in SEQ ID NO: 9. In various embodiments, the antibody may be an anti-GCGR antibody which comprises at least one (such as two or three) CDRs of the light chain sequence as set forth in SEQ ID NO: 9. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the light chain sequence as set forth

in SEQ ID NO: 9. In various embodiments, the antibody may be an anti-GCGR antibody which comprises the light chain sequence as set forth in SEQ ID NO: 9:

MDMRVPAQLLGLLLLWFPGARCDIQMTQSPSSLSASVGDRVTITCRASQGIRNDLGWYQ
QKPGKAPKRLIYAASSLESGVPSRFSGSGSGTEFTLTISVQPEDFVTYYCLQHNSNPLT
FGGGTKVEIKRADAAPTVSIFPPSSEQLTSGGASVVCFLNNFYPKDINVKWKIDGSERQN
GVLNSWTDQDSKDYMSSTLTLTKDEYERHNSYTCEATHKSTSTSPIVKSFNREK
(SEQ ID NO: 9)

[0107] In various embodiments, the antibody contains an amino acid sequence that shares an observed homology of, *e.g.*, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% with the sequences of SEQ ID NOS: 8 or 9.

[0108] In various embodiments of the present disclosure the antibody may be an anti-GCGR antibody which comprises a heavy chain variable region sequence selected from SEQ ID NO: 10, SEQ ID NO: 11, SEQ ID NO: 12, SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24, SEQ ID NO: 25, SEQ ID NO: 26, SEQ ID NO: 27, and SEQ ID NO: 28, and a light chain variable region sequence selected from, SEQ ID NO: 29, SEQ ID NO: 30, SEQ ID NO: 31, SEQ ID NO: 32, SEQ ID NO: 33, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41, SEQ ID NO: 42, SEQ ID NO: 43, SEQ ID NO: 44, SEQ ID NO: 45, SEQ ID NO: 46, and SEQ ID NO: 47. In various embodiments, the antibody contains an amino acid sequence that shares an observed homology of, *e.g.*, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, or at least 99% with the sequences of SEQ ID NOS: 10-28 or SEQ ID NOS: 29-47.

Examples of Anti-GCGR Antibodies

HCVR	LCVR
SEQ ID NO: 2	SEQ ID NO: 3
SEQ ID NO: 4	SEQ ID NO: 5
SEQ ID NO: 6	SEQ ID NO: 7
SEQ ID NO: 10	SEQ ID NO: 29
SEQ ID NO: 11	SEQ ID NO: 30
SEQ ID NO: 12	SEQ ID NO: 31

SEQ ID NO: 13	SEQ ID NO: 32
SEQ ID NO: 14	SEQ ID NO: 33
SEQ ID NO: 15	SEQ ID NO: 34
SEQ ID NO: 16	SEQ ID NO: 35
SEQ ID NO: 17	SEQ ID NO: 36
SEQ ID NO: 18	SEQ ID NO: 37
SEQ ID NO: 19	SEQ ID NO: 38
SEQ ID NO: 20	SEQ ID NO: 39
SEQ ID NO: 21	SEQ ID NO: 40
SEQ ID NO: 22	SEQ ID NO: 41
SEQ ID NO: 23	SEQ ID NO: 42
SEQ ID NO: 24	SEQ ID NO: 43
SEQ ID NO: 25	SEQ ID NO: 44
SEQ ID NO: 26	SEQ ID NO: 45
SEQ ID NO: 27	SEQ ID NO: 46
SEQ ID NO: 28	SEQ ID NO: 47

[0109] An isolated anti-GCGR antibody, antibody fragment, or antibody derivative of the present disclosure can comprise any constant region known in the art. The light chain constant region can be, for example, a kappa- or lambda-type light chain constant region, e.g., a human kappa- or lambda-type light chain constant region. The heavy chain constant region can be, for example, an alpha-, delta-, epsilon-, gamma-, or mu-type heavy chain constant regions, e.g., a human alpha-, delta-, epsilon-, gamma-, or mu-type heavy chain constant region. In various embodiments, the light or heavy chain constant region is a fragment, derivative, variant, or mutein of a naturally occurring constant region.

[0110] Techniques are known for deriving an antibody of a different subclass or isotype from an antibody of interest, i.e., subclass switching. Thus, IgG antibodies may be derived from an IgM antibody, for example, and vice versa. Such techniques allow the preparation of new antibodies that possess the antigen-binding properties of a given antibody (the parent antibody), but also exhibit biological properties associated with an antibody isotype or subclass different from that of the parent antibody. Recombinant DNA techniques may be employed. Cloned DNA encoding particular antibody polypeptides may be employed in such procedures, e.g., DNA encoding the constant domain of an antibody of the desired isotype. See also Lanitto et al., Methods Mol. Biol. 178:303-16 (2002).

[0111] In various embodiments, an isolated antigen binding protein of the present disclosure comprises the constant light chain kappa region as set forth in SEQ ID NO: 48, or a fragment thereof. In various embodiments, an isolated antigen binding protein of the present

disclosure comprises the constant light chain lambda region as set forth in SEQ ID NO: 49, or a fragment thereof. In various embodiments, an isolated antigen binding protein of the present disclosure comprises a IgG2 heavy chain constant region set forth in SEQ ID NO: 50, or a fragment thereof.

[0112] In various embodiments, an isolated antagonistic antigen binding protein of the present disclosure comprises a heavy chain sequence as set forth in SEQ ID NO: 51 and comprises a light chain as set forth in SEQ ID NO: 52.

[0113] In various embodiments of the present disclosure, the isolated antagonistic antigen binding protein is a hemibody. A "hemibody" is an immunologically-functional immunoglobulin construct comprising a complete heavy chain, a complete light chain and a second heavy chain Fc region paired with the Fc region of the complete heavy chain. A linker can, but need not, be employed to join the heavy chain Fc region and the second heavy chain Fc region. In various embodiments, the hemibody is a monovalent antigen binding protein comprising (i) an intact light chain, and (ii) a heavy chain fused to an Fc region (e.g., an IgG2 Fc region). Methods for preparing hemibodies are described in, e.g., U.S. patent application 2012/0195879, herein incorporated by reference in its entirety herein for purposes of teaching the preparation of such hemibodies.

Pharmaceutical Compositions

[0114] In another aspect, the present disclosure provides a pharmaceutical composition comprising an isolated antagonistic antigen binding protein as described herein, with one or more pharmaceutically acceptable carrier(s). The pharmaceutical compositions and methods of uses described herein also encompass embodiments of combinations (co-administration) with other active agents, as detailed below.

[0115] Generally, the antagonistic antigen binding proteins of the present disclosure are suitable to be administered as a formulation in association with one or more pharmaceutically acceptable carrier(s). The term 'carrier' is used herein to describe any ingredient other than the compound(s) of the disclosure. The choice of carrier(s) will to a large extent depend on factors such as the particular mode of administration, the effect of the carrier on solubility and stability, and the nature of the dosage form. As used herein, "pharmaceutically acceptable carrier" includes any and all solvents, dispersion media, coatings, antibacterial and antifungal agents, isotonic and absorption delaying agents, and the like that are physiologically compatible. Some examples of pharmaceutically acceptable carriers are water, saline, phosphate buffered saline,

dextrose, glycerol, ethanol and the like, as well as combinations thereof. In many cases, the composition will include isotonic agents, for example, sugars, polyalcohols such as mannitol, sorbitol, or sodium chloride in the composition. Additional examples of pharmaceutically acceptable substances are wetting agents or minor amounts of auxiliary substances such as wetting or emulsifying agents, preservatives or buffers, which enhance the shelf life or effectiveness of the antibody. Pharmaceutical compositions of the present disclosure and methods for their preparation will be readily apparent to those skilled in the art. Such compositions and methods for their preparation may be found, for example, in Remington's Pharmaceutical Sciences, 19th Edition (Mack Publishing Company, 1995). The pharmaceutical compositions are generally formulated as sterile, substantially isotonic and in full compliance with all GMP regulations of the U.S. Food and Drug Administration.

[0116] The pharmaceutical compositions of the present disclosure are typically suitable for parenteral administration. As used herein, "parenteral administration" of a pharmaceutical composition includes any route of administration characterized by physical breaching of a tissue of a patient and administration of the pharmaceutical composition through the breach in the tissue, thus generally resulting in the direct administration into the blood stream, into muscle, or into an internal organ. Parenteral administration thus includes, but is not limited to, administration of a pharmaceutical composition by injection of the composition, by application of the composition through a surgical incision, by application of the composition through a tissue-penetrating non-surgical wound, and the like. In particular, parenteral administration is contemplated to include, but is not limited to, subcutaneous injection, intraperitoneal injection, intramuscular injection, intrasternal injection, intravenous injection, intraarterial injection, intrathecal injection, intraventricular injection, intraurethral injection, intracranial injection, intrasynovial injection or infusions; or kidney dialytic infusion techniques.

[0117] Formulations of a pharmaceutical composition suitable for parenteral administration typically generally comprise the active ingredient combined with a pharmaceutically acceptable carrier, such as sterile water or sterile isotonic saline. Such formulations may be prepared, packaged, or sold in a form suitable for bolus administration or for continuous administration. Injectable formulations may be prepared, packaged, or sold in unit dosage form, such as in ampoules or in multi-dose containers containing a preservative. Formulations for parenteral administration include, but are not limited to, suspensions, solutions, emulsions in oily or aqueous vehicles, pastes, and the like. Such formulations may further comprise one or more additional ingredients including, but not limited to, suspending, stabilizing, or dispersing agents. In one embodiment of a formulation for parenteral administration, the

active ingredient is provided in dry (i.e. powder or granular) form for reconstitution with a suitable vehicle (e.g. sterile pyrogen-free water) prior to parenteral administration of the reconstituted composition. Parenteral formulations also include aqueous solutions which may contain carriers such as salts, carbohydrates and buffering agents (preferably to a pH of from 3 to 9), but, for some applications, they may be more suitably formulated as a sterile non-aqueous solution or as a dried form to be used in conjunction with a suitable vehicle such as sterile, pyrogen-free water. Exemplary parenteral administration forms include solutions or suspensions in sterile aqueous solutions, for example, aqueous propylene glycol or dextrose solutions. Such dosage forms can be suitably buffered, if desired. Other parentally-administrable formulations which are useful include those which comprise the active ingredient in microcrystalline form, or in a liposomal preparation. Formulations for parenteral administration may be formulated to be immediate and/or modified release. Modified release formulations include delayed-, sustained-, pulsed-, controlled-, targeted and programmed release.

[0118] For example, in one aspect, sterile injectable solutions can be prepared by incorporating the isolated antagonistic antigen binding protein in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by filtered sterilization. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle that contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, methods of preparation such as vacuum drying and freeze-drying yield a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof. The proper fluidity of a solution can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. Prolonged absorption of injectable compositions can be brought about by including in the composition an agent that delays absorption, for example, monostearate salts and gelatin. In various embodiments, the injectable compositions will be administered using commercially available disposable injectable devices.

[0119] The isolated antagonistic antigen binding protein of the present disclosure can be administered intranasally or by inhalation, typically in the form of a dry powder (either alone, as a mixture, or as a mixed component particle, for example, mixed with a suitable pharmaceutically acceptable carrier) from a dry powder inhaler, as an aerosol spray from a pressurized container, pump, spray, atomiser (preferably an atomiser using electrohydrodynamics to produce a fine mist), or nebulizer, with or without the use of a suitable

propellant, or as nasal drops.

[0120] The pressurized container, pump, spray, atomizer, or nebulizer generally contains a solution or suspension of an isolated antagonistic antigen binding protein of the disclosure comprising, for example, a suitable agent for dispersing, solubilizing, or extending release of the active, a propellant(s) as solvent.

[0121] Prior to use in a dry powder or suspension formulation, the drug product is generally micronized to a size suitable for delivery by inhalation (typically less than 5 microns). This may be achieved by any appropriate comminuting method, such as spiral jet milling, fluid bed jet milling, supercritical fluid processing to form nanoparticles, high pressure homogenization, or spray drying.

[0122] Capsules, blisters and cartridges for use in an inhaler or insufflator may be formulated to contain a powder mix of the isolated antagonistic antigen binding protein of the disclosure, a suitable powder base and a performance modifier.

[0123] Suitable flavours, such as menthol and levomenthol, or sweeteners, such as saccharin or saccharin sodium, may be added to those formulations of the disclosure intended for inhaled/intranasal administration.

[0124] Formulations for inhaled/intranasal administration may be formulated to be immediate and/or modified release. Modified release formulations include delayed-, sustained-, pulsed-, controlled-, targeted and programmed release.

[0125] In the case of dry powder inhalers and aerosols, the dosage unit is determined by means of a valve which delivers a metered amount. Units in accordance with the disclosure are typically arranged to administer a metered dose or "puff" of an antibody of the disclosure. The overall daily dose will typically be administered in a single dose or, more usually, as divided doses throughout the day.

[0126] The isolated antagonistic antigen binding protein of the present disclosure may also be formulated for an oral administration. Oral administration may involve swallowing, so that the compound enters the gastrointestinal tract, and/or buccal, lingual, or sublingual administration by which the compound enters the blood stream directly from the mouth. Formulations suitable for oral administration include solid, semi-solid and liquid systems such as tablets; soft or hard capsules containing multi- or nano-particulates, liquids, or powders; lozenges (including liquid-filled); chews; gels; fast dispersing dosage forms; films; ovules; sprays; and buccal/mucoadhesive patches.

[0127] Pharmaceutical compositions intended for oral use may be prepared according to any method known to the art for the manufacture of pharmaceutical compositions and such

compositions may contain one or more agents selected from the group consisting of sweetening agents in order to provide a pharmaceutically elegant and palatable preparation. For example, to prepare orally deliverable tablets, the isolated antagonistic antigen binding protein is mixed with at least one pharmaceutical carrier, and the solid formulation is compressed to form a tablet according to known methods, for delivery to the gastrointestinal tract. The tablet composition is typically formulated with additives, e.g. a saccharide or cellulose carrier, a binder such as starch paste or methyl cellulose, a filler, a disintegrator, or other additives typically usually used in the manufacture of medical preparations. To prepare orally deliverable capsules, DHEA is mixed with at least one pharmaceutical carrier, and the solid formulation is placed in a capsular container suitable for delivery to the gastrointestinal tract. Compositions comprising isolated antagonistic antigen binding protein may be prepared as described generally in Remington's Pharmaceutical Sciences, 18th Ed. 1990 (Mack Publishing Co. Easton Pa. 18042) at Chapter 89, which is herein incorporated by reference.

[0128] In various embodiments, the pharmaceutical compositions are formulated as orally deliverable tablets containing isolated antagonistic antigen binding protein in admixture with non-toxic pharmaceutically acceptable carriers which are suitable for manufacture of tablets. These carriers may be inert diluents, such as calcium carbonate, sodium carbonate, lactose, calcium phosphate or sodium phosphate; granulating and disintegrating agents, for example, maize starch, gelatin or acacia, and lubricating agents, for example, magnesium stearate, stearic acid, or talc. The tablets may be uncoated or they may be coated with known techniques to delay disintegration and absorption in the gastrointestinal track and thereby provide a sustained action over a longer period of time. For example, a time delay material such as glyceryl monostearate or glyceryl distearate alone or with a wax may be employed.

[0129] In various embodiments, the pharmaceutical compositions are formulated as hard gelatin capsules wherein the isolated antagonistic antigen binding protein is mixed with an inert solid diluent, for example, calcium carbonate, calcium phosphate, or kaolin or as soft gelatin capsules wherein the isolated antagonistic antigen binding protein is mixed with an aqueous or an oil medium, for example, arachis oil, peanut oil, liquid paraffin or olive oil.

[0130] Liquid formulations include suspensions, solutions, syrups and elixirs. Such formulations may be employed as fillers in soft or hard capsules (made, for example, from gelatin or hydroxypropylmethylcellulose) and typically comprise a carrier, for example, water, ethanol, polyethylene glycol, propylene glycol, methylcellulose, or a suitable oil, and one or more emulsifying agents and/or suspending agents. Liquid formulations may also be prepared by the reconstitution of a solid, for example, from a sachet.

[0131] Any method for administering peptides, proteins or antibodies accepted in the art may suitably be employed for administering the isolated antagonistic antigen binding protein of the disclosure.

Methods of Treatment

[0132] In one aspect of the present disclosure, a method for treating a patient diagnosed with a disorder or condition characterized by excessive levels of glucagon and/or blood glucose comprising administering to the patient a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, is provided. As used herein the term "patient" refers to a mammal, including humans, and is used interchangeably with the term "patient". The term "treatment" encompasses alleviation or prevention of at least one symptom or other aspect of a disorder, or reduction of disease severity, and the like. An antagonistic antigen binding protein, in particular a human antibody according to the present disclosure, need not effect a complete cure, or eradicate every symptom or manifestation of a disease, to constitute a viable therapeutic agent. As is recognized in the pertinent field, drugs employed as therapeutic agents may reduce the severity of a given disease state, but need not abolish every manifestation of the disease to be regarded as useful therapeutic agents. Similarly, a prophylactically administered treatment need not be completely effective in preventing the onset of a condition in order to constitute a viable prophylactic agent. Simply reducing the impact of a disease (for example, by reducing the number or severity of its symptoms, or by increasing the effectiveness of another treatment, or by producing another beneficial effect), or reducing the likelihood that the disease will occur or worsen in a patient, is sufficient. One embodiment of the disclosure is directed to a method comprising administering to a patient an isolated antagonistic antigen binding protein such as a human antibody in an amount and for a time sufficient to induce a sustained improvement over baseline of an indicator that reflects the severity of the particular disorder.

[0133] Thus, in one aspect, the present disclosure relates to methods for treating a patient diagnosed with type 1 diabetes (T1D) comprising administering to the patient a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment,

a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody.

[0134] In various embodiments, the patient may suffer from autoimmune T1D. In various embodiments, the patient may suffer from chemically-induced T1D. In various embodiments, the patient may suffer from T1D resulting from a medically or surgically dysfunctional pancreas, or removal of the pancreas, under various medical conditions. In various embodiments, the patient has been diagnosed as having T1D on the basis of one or more of the following findings: (a) hyperglycemia in conjunction with hypoinsulinemia; (b) hyperglycemia in conjunction with evidence of pancreatic β cell loss; (c) hyperglycemia in conjunction with a normal blood glucose response to insulin; (d) hyperglycemia in conjunction with ketoacidosis; (e) hyperglycemia in conjunction with insulin dependence; or (f) hyperglycemia in conjunction with hyperglucagonemia. In various embodiments, the patient may possess or display a "physiologically non-relevant amount" of insulin, where a "physiologically non-relevant amount" is defined herein as an amount that is not sufficient to attenuate, inhibit, suppress, reduce or ameliorate a type 1 diabetic phenotype. Such patients are thus distinguished from non-diabetic patients and/or patients that possess or display clinical manifestations of type 2 diabetes, which is characterized by, e.g., insulin resistance and insulin insensitivity.

[0135] In another aspect, the present disclosure comprises a method for reducing, suppressing, attenuating, or inhibiting one or more symptoms associated with T1D, comprising administering to a patient diagnosed with T1D a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. In various embodiments, the one or more symptoms is selected from: excess gluconeogenesis, excess glycogenolysis, hyperglycemia, hyperglucagonemia, ketosis, diabetic ketoacidosis, hypertriglyceridemia, elevated plasma free fatty acids, weight loss, catabolic syndrome, terminal illness, hypertension, diabetic nephropathy, renal insufficiency, renal failure, hyperphagia, muscle wasting, diabetic neuropathy, diabetic retinopathy, or diabetic coma, excess HbA1c levels, polydipsia (increased thirst), xerostomia (dry mouth), polyphagia (increased hunger), fatigue, polyuria (frequent urination), or kidney dialysis. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a

dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody.

[0136] In another aspect, the present disclosure provides methods for treating a patient who is at risk of developing T1D (e.g., patients who have a greater than average risk of developing T1D) or patients with new onset T1D and low residual insulin production. These treatment methods can be carried out by (a) identifying a patient who is at risk (e.g., a heightened risk) of developing T1D and (b) administering to the patient a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. The patient who has been identified as at risk of developing T1D can be a patient who was diagnosed on the basis of, e.g., having a family history of T1D, with or without clinically overt impaired glucose tolerance; or having impaired glucose tolerance and evidence of pancreatic β -cell loss or functional insufficiency. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody.

[0137] In another aspect, the present disclosure comprises a method for reversing hyperglycemia in a patient diagnosed with type 1 diabetes (T1D) comprising administering to a patient diagnosed with T1D a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody.

[0138] In another aspect, the present disclosure comprises a method for enhancing insulin secretory function of pancreas islet β -cells in a patient diagnosed with type 1 diabetes (T1D) comprising administering to a patient diagnosed with T1D a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human

antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody.

[0139] An isolated antagonistic antigen binding protein that specifically binds the human glucagon receptor, in particular, the fully human antibodies of the disclosure, may be administered, e.g., once or more than once, at regular intervals over a period of time. In various embodiments, a fully human antibody is administered over a period of at least once a month or more, e.g., for one, two, or three months or even indefinitely. For treating chronic conditions, long-term treatment is generally most effective. However, for treating acute conditions, administration for shorter periods, e.g. from one to six weeks, may be sufficient. In general, the fully human antibody is administered until the patient manifests a medically relevant degree of improvement over baseline for the chosen indicator or indicators.

[0140] One example of therapeutic regimens provided herein comprise subcutaneous injection of an isolated antagonistic antigen binding protein once a week, or once every two weeks, at an appropriate dosage, to treat a condition in which blood glucose levels play a role. Weekly, bi-weekly or monthly administration of isolated antagonistic antigen binding protein would be continued until a desired result is achieved, e.g., the patient's symptoms subside. Treatment may resume as needed, or, alternatively, maintenance doses may be administered.

[0141] A patient's levels of blood glucose may be monitored before, during and/or after treatment with an isolated antagonistic antigen binding protein such as a human antibody, to detect changes, if any, in their levels. For some disorders, the incidence of elevated blood glucose may vary according to such factors as the stage of the disease. Known techniques may be employed for measuring glucose levels. Glucagon levels may also be measured in the patient's blood using known techniques, for example, ELISA.

[0142] A therapeutically effective dose can be estimated initially from cell culture assays by determining an IC₅₀. A dose can then be formulated in animal models to achieve a circulating plasma concentration range that includes the IC₅₀ as determined in cell culture. Such information can be used to more accurately determine useful doses in humans. Levels in plasma may be measured by, e.g., HPLC or immunoassays using the anti-idiotypic antibodies specific to the therapeutic drug. The exact composition, route of administration and dosage can be chosen by the individual physician in view of the patient's condition.

[0143] Dosage regimens can be adjusted to provide the optimum desired response (e.g., a therapeutic or prophylactic response). For example, a single bolus can be administered,

several divided doses (multiple or repeat or maintenance) can be administered over time and the dose can be proportionally reduced or increased as indicated by the exigencies of the therapeutic situation. It is especially advantageous to formulate parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form as used herein refers to physically discrete units suited as unitary dosages for the mammalian subjects to be treated; each unit containing a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the dosage unit forms of the present disclosure will be dictated primarily by the unique characteristics of the antibody and the particular therapeutic or prophylactic effect to be achieved.

[0144] Thus, the skilled artisan would appreciate, based upon the disclosure provided herein, that the dose and dosing regimen is adjusted in accordance with methods well-known in the therapeutic arts. That is, the maximum tolerable dose can be readily established, and the effective amount providing a detectable therapeutic benefit to a patient may also be determined, as can the temporal requirements for administering each agent to provide a detectable therapeutic benefit to the patient. Accordingly, while certain dose and administration regimens are exemplified herein, these examples in no way limit the dose and administration regimen that may be provided to a patient in practicing the present disclosure.

[0145] It is to be noted that dosage values may vary with the type and severity of the condition to be alleviated, and may include single or multiple doses. It is to be further understood that for any particular patient, specific dosage regimens should be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the compositions, and that dosage ranges set forth herein are exemplary only and are not intended to limit the scope or practice of the claimed composition. Further, the dosage regimen with the compositions of this disclosure may be based on a variety of factors, including the type of disease, the age, weight, sex, medical condition of the patient, the severity of the condition, the route of administration, and the particular antibody employed. Thus, the dosage regimen can vary widely, but can be determined routinely using standard methods. For example, doses may be adjusted based on pharmacokinetic or pharmacodynamic parameters, which may include clinical effects such as toxic effects and/or laboratory values. Thus, the present disclosure encompasses intra-patient dose-escalation as determined by the skilled artisan. Determining appropriate dosages and regimens are well-known in the relevant art and would be understood to be encompassed by the skilled artisan once provided the teachings disclosed herein.

[0146] Toxicity and therapeutic index of the pharmaceutical compositions of the disclosure can be determined by standard pharmaceutical procedures in cell cultures or experimental animals, e.g., for determining the LD₅₀ (the dose lethal to 50% of the population) and the ED₅₀ (the dose therapeutically effective in 50% of the population). The dose ratio between toxic and therapeutic effective dose is the therapeutic index and it can be expressed as the ratio LD₅₀/ED₅₀. Compositions that exhibit large therapeutic indices are generally preferred.

[0147] In various embodiments, single or multiple administrations of the pharmaceutical compositions are administered depending on the dosage and frequency as required and tolerated by the patient. In any event, the composition should provide a sufficient quantity of at least one of the isolated antagonistic antigen binding protein disclosed herein to effectively treat the patient. The dosage can be administered once but may be applied periodically until either a therapeutic result is achieved or until side effects warrant discontinuation of therapy.

[0148] The dosing frequency of the administration of the isolated antagonistic antigen binding protein pharmaceutical composition depends on the nature of the therapy and the particular disease being treated. The patient can be treated at regular intervals, such as weekly, bi-weekly or monthly, until a desired therapeutic result is achieved. Exemplary dosing frequencies include, but are not limited to: once weekly without break; once weekly, every other week; once every 2 weeks; once every 3 weeks; weakly without break for 2 weeks, then monthly; weakly without break for 3 weeks, then monthly; monthly; once every other month; once every three months; once every four months; once every five months; once every six months; once every seven months; once every eight months; once every nine months; once every ten months; once every eleven months; or yearly.

[0149] For administration to human patients, the total monthly dose of the isolated antagonistic antigen binding protein of the disclosure can be in the range of 0.5-1200 mg per patient, 0.5-1100 mg per patient, 0.5-1000 mg per patient, 0.5-900 mg per patient, 0.5-800 mg per patient, 0.5-700 mg per patient, 0.5-600 mg per patient, 0.5-500 mg per patient, 0.5-400 mg per patient, 0.5-300 mg per patient, 0.5-200 mg per patient, 0.5-100 mg per patient, 0.5-50 mg per patient, 1-1200 mg per patient, 1-1100 mg per patient, 1-1000 mg per patient, 1-900 mg per patient, 1-800 mg per patient, 1-700 mg per patient, 1-600 mg per patient, 1-500 mg per patient, 1-400 mg per patient, 1-300 mg per patient, 1-200 mg per patient, 1-100 mg per patient, or 1-50 mg per patient depending, of course, on the mode of administration. For example, an intravenous monthly dose can require about 1-1000 mg/patient. In various embodiments, the isolated antagonistic antigen binding protein of the disclosure can be administered at an intravenous monthly dose of about 1-500 mg per patient. In various embodiments, the isolated

antagonistic antigen binding protein of the disclosure can be administered at an intravenous monthly dose of about 1-400 mg per patient. In various embodiments, the isolated antagonistic antigen binding protein of the disclosure can be administered at an intravenous monthly dose of about 1-300 mg per patient. In various embodiments, the isolated antagonistic antigen binding protein of the disclosure can be administered at an intravenous monthly dose of about 1-200 mg per patient. In various embodiments, the isolated antagonistic antigen binding protein of the disclosure can be administered, at an intravenous monthly dose of about 1-150 mg per patient. In various embodiments, the isolated antagonistic antigen binding protein of the disclosure can be administered or at an intravenous monthly dose of about 1-100 mg/patient. In various embodiments, the isolated antagonistic antigen binding protein of the disclosure can be administered at an intravenous monthly dose of about 1-50 mg per patient. The total monthly dose can be administered in single or divided doses and can, at the physician's discretion, fall outside of the typical ranges given herein.

[0150] An exemplary, non-limiting weekly, or bi-weekly dosing range for a therapeutically or prophylactically effective amount of an isolated antagonistic antigen binding protein of the disclosure can be 0.001 to 100 mg/kg body weight, 0.001 to 90 mg/kg, 0.001 to 80 mg/kg, 0.001 to 70 mg/kg, 0.001 to 60 mg/kg, 0.001 to 50 mg/kg, 0.001 to 40 mg/kg, 0.001 to 30 mg/kg, 0.001 to 20 mg/kg, 0.001 to 10 mg/kg, 0.001 to 5 mg/kg, 0.001 to 4 mg/kg, 0.001 to 3 mg/kg, 0.001 to 2 mg/kg, 0.001 to 1 mg/kg, 0.010 to 50 mg/kg, 0.010 to 40 mg/kg, 0.010 to 30 mg/kg, 0.010 to 20 mg/kg, 0.010 to 10 mg/kg, 0.010 to 5 mg/kg, 0.010 to 4 mg/kg, 0.010 to 3 mg/kg, 0.010 to 2 mg/kg, 0.010 to 1 mg/kg, 0.1 to 50 mg/kg, 0.1 to 40 mg/kg, 0.1 to 30 mg/kg, 0.1 to 20 mg/kg, 0.1 to 10 mg/kg, 0.1 to 5 mg/kg, 0.1 to 4 mg/kg, 0.1 to 3 mg/kg, 0.1 to 2 mg/kg, 0.1 to 1 mg/kg, 1 to 50 mg/kg, 1 to 40 mg/kg, 1 to 30 mg/kg, 1 to 25 mg/kg, 1 to 20 mg/kg, 1 to 15 mg/kg, 1 to 10 mg/kg, 1 to 7.5 mg/kg, 1 to 5 mg/kg, 1 to 4 mg/kg, 1 to 3 mg/kg, 1 to 2 mg/kg, or 1 mg/kg body weight. It is to be noted that dosage values may vary with the type and severity of the condition to be alleviated. It is to be further understood that for any particular patient, specific dosage regimens should be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the compositions, and that dosage ranges set forth herein are exemplary only and are not intended to limit the scope or practice of the claimed composition.

[0151] In various embodiments, the total dose administered will achieve a plasma antibody concentration in the range of, e.g., about 1 to 1000 µg/ml, about 1 to 750 µg/ml, about 1 to 500 µg/ml, about 1 to 250 µg/ml, about 10 to 1000 µg/ml, about 10 to 750 µg/ml, about 10 to 500 µg/ml, about 10 to 250 µg/ml, about 20 to 1000 µg/ml, about 20 to 750 µg/ml, about 20 to

500 µg/ml, about 20 to 250 µg/ml, about 30 to 1000 µg/ml, about 30 to 750 µg/ml, about 30 to 500 µg/ml, about 30 to 250 µg/ml.

[0152] In various embodiments, either as monotherapy, or in combination with insulin supplementation, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 0.01 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 0.025 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 0.05 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 0.075 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 0.1 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 0.25 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 0.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 0.75 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 1 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 1.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 2 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 2.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 3 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 3.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 4 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically

effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 4.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 5.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 6 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 6.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 7 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 7.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 8 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 8.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 9 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 9.5 mg/kg body weight. In various embodiments, the weekly or bi-weekly dose for a therapeutically effective amount of an isolated antagonistic antigen binding protein of the disclosure will be 10 mg/kg body weight.

Insulin Supplementation

[0153] In T1D, the pancreas no longer produces insulin, so patients with T1D need to take insulin injections, or use an insulin pump in order to compensate for the pancreas' inability to produce insulin. Normal daily dosage of insulin for TD1 is 90-120 units per day, or 60-90 units per day or 30-60 units per day. In various embodiments, the methods of the present disclosure contemplate insulin supplementation, but at lower levels, such as between about 80% and 90%, below 90%, between about 70% and 80%, below 80%, between about 60% and 70%, below 70%, between about 50% and 60%, below 60%, between about 40% and 50%, below 50%,

between about 30% and 40%, below 40%, between about 20% and 30%, below 30%, between about 10% and 20%, below 20%, between about 10-15%, between about 5-10%, and between zero and 5%, including 4%, 3.5%, 3%, 2.5%, 2%, 1.5%, 1%, .5%, .4%, .3%, .2%, or .1% of the normal daily dosage of insulin. It is envisioned that the methods of the present disclosure may allow a given patient to have an incremental, gradual reduction of insulin dosage after commencing treatment with the isolated antagonistic antigen binding protein that specifically binds the human glucagon receptor, and in some instances to no longer require insulin supplementation.

[0154] In various embodiments, the insulin to be co-administered with the isolated antagonistic antigen binding protein is selected from, e.g., rapid-acting (lispro [Humalog®], aspart [NovoLog®], glulisine [Apidra®]), short-acting (regular), intermediate-acting (NPH), and long-acting (glargine [Lantus®], detemir [Levemir®]). Insulin action (when it peaks, or when it is the strongest, and how long it lasts) may vary from person to person.

[0155] Dosing regimens, dosing schedules, injection methods and other general guidelines for a typical "monotherapy" using insulin supplementation by injection are well known and understood by those skilled in the art and will be tailored specifically for each patient. Depending upon the current clinical situation for an individual patient, insulin therapy may comprise a one injection regimen, a two injection regimen, or a multi-injection regimen. In various embodiments, the methods of the present disclosure comprise a single injection of, e.g., 0.5 to 1.0 units/kg body weight per day taken 20-30 minutes before breakfast. In various embodiments, the methods of the present disclosure comprise a two-injection regimen wherein one injection occurs before breakfast and the other injection occurs 20-30 minutes before dinner. In various embodiments, the methods of the present disclosure comprise a multi-injection regimen wherein one injection is taken 20-30 minutes before each major meal (breakfast, lunch and dinner) to provide "bolus insulin" and intermediate acting insulin is administered once or twice a day for "basal insulin." Usually bolus insulin comprises 60% of the total dose and basal insulin makes up the remaining 40%. While somewhat effective, it is understood by those skilled in the art that each of these insulin monotherapy regimens has disadvantages that limit their overall effectiveness.

[0156] Endogenous produced insulin levels are reflected by the level of a protein called C-peptide (for connecting peptide). In the course of producing insulin, the body first produces proinsulin, which is subsequently cleaved into insulin and C-peptide. Thus, in attempting to distinguish patients who have Type 1 diabetes from patients who have Type 2 diabetes, a

physician can assess C-peptide. Hypoinsulinemia, as seen in Type 1 diabetes, is reflected by a diminished level of C-peptide in circulating blood.

Combination Therapy

[0157] As used herein, the terms "co-administration", "co-administered" and "in combination with", referring to the isolated antagonistic antigen binding protein of the present disclosure and one or more other therapeutic agent(s), is intended to mean, and does refer to and include the following: simultaneous administration of such combination of isolated antagonistic antigen binding protein of the disclosure and therapeutic agent(s) to a patient in need of treatment, when such components are formulated together into a single dosage form which releases said components at substantially the same time to said patient; substantially simultaneous administration of such combination of isolated antagonistic antigen binding protein of the disclosure and therapeutic agent(s) to a patient in need of treatment, when such components are formulated apart from each other into separate dosage forms which are taken at substantially the same time by said patient, whereupon said components are released at substantially the same time to said patient; sequential administration of such combination of isolated antagonistic antigen binding protein of the disclosure and therapeutic agent(s) to a patient in need of treatment, when such components are formulated apart from each other into separate dosage forms which are taken at consecutive times by said patient with a significant time interval between each administration, whereupon said components are released at substantially different times to said patient; and sequential administration of such combination of isolated antagonistic antigen binding protein of the disclosure and therapeutic agent(s) to a patient in need of treatment, when such components are formulated together into a single dosage form which releases said components in a controlled manner whereupon they are concurrently, consecutively, and/or overlappingly released at the same and/or different times to said patient, where each part may be administered by either the same or a different route.

[0158] In another aspect, the present disclosure relates to methods for treating a patient diagnosed with type 1 diabetes (T1D) comprising administering to the patient: (a) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (b) insulin supplementation. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment,

a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody. In various embodiments, the insulin supplementation comprises administering a dose of insulin that may be between about 70%-90%, between about 50%-70%, between about 30%-50%, between about 15%-30%, between about 10-15%, between about 5-10%, and between zero and 5%, including 4%, 3.5%, 3%, 2.5%, 2%, 1.5%, 1%, .5%, .4%, .3%, .2%, or .1% of the normal daily dosage of insulin.

[0159] In various embodiments, the patient may suffer from autoimmune T1D. In various embodiments, the patient may suffer from chemically-induced T1D. In various embodiments, the patient may suffer from T1D resulting from a medically or surgically dysfunctional pancreas, or removal of the pancreas, under various medical conditions. In various embodiments, the patient has been diagnosed as having T1D on the basis of one or more of the following findings: (a) hyperglycemia in conjunction with hypoinsulinemia; (b) hyperglycemia in conjunction with evidence of pancreatic β cell loss; (c) hyperglycemia in conjunction with a normal blood glucose response to insulin; (d) hyperglycemia in conjunction with ketoacidosis; (e) hyperglycemia in conjunction with insulin dependence; or (f) hyperglycemia in conjunction with hyperglucagonemia. In various embodiments, the patient may possess or display a "physiologically non-relevant amount" of insulin, where a "physiologically non-relevant amount" is defined herein as an amount that is not sufficient to attenuate, inhibit, suppress, reduce or ameliorate a type 1 diabetic phenotype. Such patients are thus distinguished from non-diabetic patients and/or patients that possess or display clinical manifestations of type 2 diabetes, which is characterized by, e.g., insulin resistance and insulin insensitivity.

[0160] In another aspect, the present disclosure comprises a method for reducing, suppressing, attenuating, or inhibiting one or more symptoms associated with T1D, comprising administering to a patient diagnosed with T1D: (a) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (b) insulin supplementation. In various embodiments, the one or more symptoms is selected from: excess gluconeogenesis, excess glycogenolysis, hyperglycemia, hyperglucagonemia, ketosis, diabetic ketoacidosis, hypertriglyceridemia, elevated plasma free fatty acid, weight loss, catabolic syndrome, terminal illness, hypertension, diabetic nephropathy, renal insufficiency, renal failure, hyperphagia, muscle wasting, diabetic neuropathy, diabetic retinopathy, or diabetic coma, excess HbA1c levels, polydipsia (increased thirst), xerostomia (dry mouth), polyphagia (increased hunger), polyuria (frequent urination), or fatigue. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected

from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody. In various embodiments, the insulin supplementation comprises administering a dose of insulin that may be between about 70%-90%, between about 50%-70%, between about 30%-50%, between about 15%-30%, between about 10-15%, between about 5-10%, and between zero and 5%, including 4%, 3.5%, 3%, 2.5%, 2%, 1.5%, 1%, .5%, .4%, .3%, .2%, or .1% of the normal daily dosage of insulin.

[0161] In another aspect, the present disclosure provides methods for treating a patient who is at risk of developing T1D (e.g., patients who have a greater than average risk of developing T1D) or patients with new onset T1D and low residual insulin production comprising administering to the patient: (a) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (b) insulin supplementation. The patient who has been identified as at risk of developing T1D can be a patient who was diagnosed on the basis of, e.g., having a family history of T1D, with or without clinically overt impaired glucose tolerance; or having impaired glucose tolerance and evidence of pancreatic β -cell loss or functional insufficiency. In various embodiments, the isolated antagonistic antigen binding protein comprises an antibody selected from a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, or a diabody. In various embodiments, the antibody is a fully human monoclonal antibody. In various embodiments, the insulin supplementation comprises administering a dose of insulin that may be between about 70%-90%, between about 50%-70%, between about 30%-50%, between about 15%-30%, between about 10-15%, between about 5-10%, and between zero and 5%, including 4%, 3.5%, 3%, 2.5%, 2%, 1.5%, 1%, .5%, .4%, .3%, .2%, or .1% of the normal daily dosage of insulin.

[0162] In various embodiments, the patient's daily dosage of insulin will be between about 30-200 units per day prior to treatment with the isolated antagonistic antigen binding protein and will be gradually reduced to 70% post treatment. In various embodiments, the patient's daily dosage of insulin will be between about 30-200 units per day prior to treatment with the isolated antagonistic antigen binding protein and will be gradually reduced to 60% post treatment. In various embodiments, the patient's daily dosage of insulin will be between about

[illegible]

various embodiments, the patient's daily dosage of insulin will be between about 30-200 units per day prior to treatment with the isolated antagonistic antigen binding protein and will be gradually reduced to 1% post treatment.

[0163] In various embodiments, the administration of the insulin can be achieved prior to a meal. In various embodiments, the insulin can be administered more than 12 hours, more than 11 hours, more than 10 hours, more than 9 hours, more than 8 hours, more than 7 hours, more than 6 hours, more than 5 hours, more than 4 hours, more than 3 hours, more than 2 hours, more than 1 hour, more than 50 minutes, more than 40 minutes, more than 30 minutes, more than 20 minutes, more than 10 minutes, more than 5 minutes, or more than 1 minute prior to the meal. In various embodiments, the insulin can be administered less than 12 hours, less than 11 hours, less than 10 hours, less than 9 hours, less than 8 hours, less than 7 hours, less than 6 hours, less than 5 hours, less than 4 hours, less than 3 hours, less than 2 hours, less than 1 hour, less than 50 minutes, less than 40 minutes, less than 30 minutes, less than 20 minutes, less than 10 minutes, less than 5 minutes, or less than 1 minute prior to the meal. In various embodiments, the insulin can be administered between about 1 minute to about 10 minutes, between about 5 minutes to about 30 minutes, between about 20 minutes to about 60 minutes, between about 1 hour to about 3 hours, between about 2 hours to about 10 hours, or between about 5 hours to about 12 hour prior to the meal.

[0164] In various embodiments, the administration of the insulin can be achieved after a meal. In various embodiments, the insulin can be administered more than 12 hours, more than 11 hours, more than 10 hours, more than 9 hours, more than 8 hours, more than 7 hours, more than 6 hours, more than 5 hours, more than 4 hours, more than 3 hours, more than 2 hours, more than 1 hour, more than 50 minutes, more than 40 minutes, more than 30 minutes, more than 20 minutes, more than 10 minutes, more than 5 minutes, or more than 1 minute after the meal. In various embodiments, the insulin can be administered less than 12 hours, less than 11 hours, less than 10 hours, less than 9 hours, less than 8 hours, less than 7 hours, less than 6 hours, less than 5 hours, less than 4 hours, less than 3 hours, less than 2 hours, less than 1 hour, less than 50 minutes, less than 40 minutes, less than 30 minutes, less than 20 minutes, less than 10 minutes, less than 5 minutes, or less than 1 minute after the meal. In various embodiments, the insulin can be administered less than 12 hours, less than 11 hours, less than 10 hours, less than 9 hours, less than 8 hours, less than 7 hours, less than 6 hours, less than 5 hours, less than 4 hours, less than 3 hours, less than 2 hours, less than 1 hour, less than 50 minutes, less than 40 minutes, less than 30 minutes, less than 20 minutes, less than 10 minutes, less than 5 minutes, or less than 1 minute prior to the meal. In various embodiments,

the insulin can be administered between about 1 minute to about 10 minutes, between about 5 minutes to about 30 minutes, between about 20 minutes to about 60 minutes, between about 1 hour to about 3 hours, between about 2 hours to about 10 hours, or between about 5 hours to about 12 hour after the meal.

[0165] In another aspect, the present disclosure comprises a method for treating a patient diagnosed with T1D comprising administering to the patient: (a) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (b) a glucose-lowering agent that is not insulin. In various embodiments, the glucose-lowering agent is selected from biguanides, sulfonylureas, meglitinides, thiazolidinediones (TZDs), α -glucosidase inhibitors, DPP-4 inhibitors, bile acid sequestrants, dopamine-2 agonists, SGLT2 inhibitors (e.g., canagliflozin, dapagliflozin, and empagliflozin), GLP-1 agonists, GLP-1R agonists, and amylin mimetics.

[0166] In another aspect, the present disclosure comprises a method for treating a patient diagnosed with T1D comprising administering to the patient: (a) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (b) an anti-obesity agent. In various embodiments, the anti-obesity agent is selected from gut-selective MTP inhibitors, CCKa agonists, 5HT_{2c} agonists, MCR4 agonists, lipase inhibitors, opioid antagonists, oleoyl-estrone, obinipitide, pramlintide (SYMLIN®), tesofensine, leptin, bromocriptine, orlistat, AOD-9604, and sibutramine.

[0167] In various embodiments, the combination therapy comprises administering the isolated antagonistic antigen binding protein composition and the second agent composition simultaneously, either in the same pharmaceutical composition or in separate pharmaceutical compositions. In various embodiments, isolated antagonistic antigen binding protein composition and the second agent composition are administered sequentially, i.e., the isolated antagonistic antigen binding protein composition is administered either prior to or after the administration of the second agent composition.

[0168] In various embodiments, the administrations of the isolated antagonistic antigen binding protein composition and the second agent composition are concurrent, i.e., the administration period of the isolated antagonistic antigen binding protein composition and the second agent composition overlap with each other.

[0169] In various embodiments, the administrations of the isolated antagonistic antigen binding protein composition and the second agent composition are non-concurrent. For example, in various embodiments, the administration of the isolated antagonistic antigen binding protein composition is terminated before the second agent composition is administered. In

various embodiments, the administration second agent composition is terminated before the isolated antagonistic antigen binding protein composition is administered.

[0170] The invention having been described, the following examples are offered by way of illustration, and not limitation.

Example 1

[0171] It had been previously demonstrated that a single injection of 3 mg/kg of an anti-GCGR antibody could effectively lower blood glucose levels for 8 days in 12 week old male ob/ob treated mice (see U.S. Pat. No. 7,947,809). In this example, the *in vivo* activity of a chimeric anti-GCGR antibody (referred to herein as REMD2.59C) is evaluated in a streptozotocin (STZ)-induced T1D mouse study. REMD2.59C comprises the heavy chain sequence set forth in SEQ ID NO: 8 and the light chain sequence set forth in SEQ ID NO: 9.

[0172] Healthy Balb/c mice (male, 8-10 weeks, 20-22 g) were fasted overnight. STZ injections (60 mg/kg/day) were conducted on all animals consecutively 5 days from day 1 to day 5. After 14 days stabilization (post last dose of STZ), and based on the animal's body weight and fasting blood glucose, mice were randomly assigned to respective groups using a computer-generated randomization procedure. The mice were then dosed weekly via subcutaneous injection with either vehicle, 0.3 mg/kg (low dose), 1.5 mg/kg Middle dose), or 7.5 mg/kg (high dose) REMD2.59C antibody. Vehicle comprised 10 mM sodium acetate, 5% sorbitol, and 0.004% polysorbate 20. Test samples were prepared by mixing 1.8 mL REMD2.59C stock solution (2.37 mg/mL) into 3.887 mL vehicle (pH 5.2). The final concentration of solution was 0.75 mg/mL. This formulation was for the high dose treatment group (7.5 mg/kg). The middle and low dose formulations were made by 5 or 25 times dilutions of the high dose formulation using vehicle. The study groups and number of animals per group are shown in Table 1.

Table 1

Group	Treatment	Dose (mg/kg)	Route	Number Animals
Group 1	Vehicle	-	s.c	10
Group 2	REMD2.59C	0.3	s.c	10
Group 3	REMD2.59C	1.5	s.c	10

Group 4	REMD2.59C	7.5	s.c	10
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[0173] Various parameters are measured throughout the 12 week study, including, e.g., i) body weight (once a week); ii) weekly food consumption (food in/food out); iii) glucose determination (mice are fasted for 6 hours prior to the test and fasting blood glucose levels are measured via tail veins weekly using Accu-Chek Aviva System®; iv) hemoglobin-A1c (HbA1c) determination (prior to euthanasia, blood samples are collected via cardiac puncture into tubes with anticoagulant and HbA1c measured by using TOSHIBA TBA-40FR automated biochemical analyzer); v) insulin determination; vi) C-peptide determination; vii) GLP-1 determination; viii) glucagon determination; iv) Acetoacetic Acid (AcAc) determination; and x) β -hydroxybutyric acid (BOH)) determination. For items v) - x), blood samples are collected pre-dose and at the end of the study into tubes without any anticoagulant, immediately centrifuged and the serum transferred into separate sample tubes for evaluation by ELISA method.

Body Weight

[0174] Body weights of all animals were measured weekly throughout the study.

[0175] The results are depicted in Figure 1 and Table 2, wherein the animals treated with REMD2.59C at mid and high doses exhibited an initial weight loss, and wherein each dose exhibited a slightly different pattern.

Table 2

Group	Body Weight (gm)				
	Week -1	Week 0	week 1	week 2	week 3
Vehicle	19.5 ± 1.9	20.2 ± 2.0	21.1 ± 2.4	21.3 ± 2.6	22.1 ± 2.5
REMD2.59C Low dose	19.7 ± 1.2	20.2 ± 1.7	21.0 ± 1.7	21.4 ± 1.9	21.9 ± 2.1
REMD2.59C Middle dose	19.7 ± 1.3	20.1 ± 1.5	20.4 ± 1.7	20.8 ± 2.2	21.2 ± 2.1
REMD2.59C High dose	19.3 ± 1.0	20.3 ± 1.1	19.1 ± 1.1 *	19.4 ± 1.1	19.8 ± 1.2 *
	week 4	week 5	week 6	week 7	week 8
Vehicle	22.5 ± 2.7	22.1 ± 2.7	22.5 ± 2.5	22.3 ± 2.5	22.4 ± 2.7
REMD2.59C Low dose	21.9 ± 2.4	22.1 ± 2.4	22.3 ± 2.5	22.5 ± 2.6	22.3 ± 2.4
REMD2.59C Middle dose	21.3 ± 2.3	21.1 ± 2.5	21.0 ± 2.0	20.6 ± 1.9	20.6 ± 1.8
REMD2.59C High dose	20.1 ± 1.0	20.0 ± 1.3	20.3 ± 1.5	20.2 ± 1.4	20.4 ± 1.5
	week 9	week 10	week 11	week 12	

Vehicle	22.2 ± 2.4	22.0 ± 2.6	21.7 ± 2.5	21.9 ± 2.3	
REMD2.59C Low dose	22.4 ± 2.6	22.4 ± 2.7	22.2 ± 2.7	22.3 ± 2.6	
REMD2.59C Middle dose	20.3 ± 1.8	20.2 ± 1.8	20.0 ± 1.7	19.8 ± 1.5	
REMD2.59C High dose	20.4 ± 1.6	20.6 ± 1.7	20.7 ± 1.7	20.9 ± 1.6	

Note: * p<0.05, ** p<0.01 compared with Vehicle group (One-way ANOVA)

Food Consumption

[0176] Food consumption (food in/food out) was recorded weekly for all the animals in all study groups throughout the study.

[0177] As depicted in Figure 2 and Tables 3 and 4, the food consumption was lower in the REMD2.59C treated animals in a dose dependent fashion, reflected by the increased average of body weight/food consumption (right column, Table 4).

Table 3

Group	Food Consumption (g/day)				
	week -1	week 0	week 1	week 2	week 3
Vehicle	4.6 ± 1.0	4.4 ± 1.1	5.1 ± 0.6	5.2 ± 0.7	5.2 ± 0.7
REMD2.59C Low dose	4.4 ± 1.0	4.2 ± 0.9	5.2 ± 0.6	5.4 ± 0.4	5.2 ± 0.4
REMD2.59C Middle dose	4.3 ± 0.7	4.5 ± 0.6	4.0 ± 0.5 **	4.5 ± 0.6 *	4.1 ± 0.8 **
REMD2.59C High dose	3.7 ± 0.5	4.1 ± 0.5	3.2 ± 0.5 **	3.5 ± 0.4 **	3.1 ± 0.2 **
	week 4	week 5	week 6	week 7	week 8
Vehicle	5.2 ± 0.8	5.2 ± 0.5	5.4 ± 1.0	5.3 ± 0.8	5.4 ± 0.8
REMD2.59C Low dose	5.2 ± 0.6	5.3 ± 0.8	5.6 ± 1.0	5.5 ± 0.9	5.2 ± 1.0
REMD2.59C Middle dose	4.5 ± 0.5 *	4.2 ± 0.9 **	4.6 ± 0.7	4.2 ± 0.7 **	4.5 ± 1.0
REMD2.59C High dose	3.2 ± 0.2 **	2.9 ± 0.2 **	3.0 ± 0.2 **	2.8 ± 0.3 **	3.1 ± 0.4 **
	week 9	week 10	week 11	week 12	
Vehicle	5.4 ± 0.9	5.4 ± 0.8	5.4 ± 0.9	5.6 ± 0.6	
REMD2.59C Low dose	5.3 ± 0.7	5.3 ± 0.7	5.3 ± 0.9	5.6 ± 1.0	
REMD2.59C Middle dose	4.4 ± 0.7 **	4.3 ± 0.6 **	4.3 ± 0.8 *	4.1 ± 0.7 **	
REMD2.59C High dose	2.8 ± 0.3 **	2.9 ± 0.3 **	3.2 ± 0.5 **	2.8 ± 0.3 **	

Note: * p<0.05, ** p<0.01 compared with Vehicle group (One-way ANOVA)

Table 4

Group	Average food consumption during the treatment (g)	Average body weight during the treatment (g)	Average of bodyweight/food consumption
Vehicle	5.3	21.9	4.1
REMD2.59C Low Dose	5.4	21.9	4.1
REMD2.59C Middle Dose	4.3	20.6	4.8
REMD2.59C High Dose	3.1	20.2	6.6

Blood Glucose

[0178] The mice were fasted 6 hours prior to blood glucose test from 9 am to 3 pm, and fast blood glucose levels were measured via tail veins on weekly basis by using Accu-Chek Aviva System.

[0179] As depicted in Figure 3 and Table 5 below, T1D in the mice is confirmed by elevated fasting blood glucose levels that reached 17.3 to 22.9 mmol/L range (or 311 to 412 mg/dl range), as opposed to a normal level of below 6 mmol/L (or 108 mg/dl).

Table 5

Group	Fast Blood Glucose (mmol/L)				
	week 0	week 1	week 2	week 3	week 4
Vehicle	17.3 ± 5.2	20.8 ± 4.3	22.9 ± 2.5	25.7 ± 3.3	25.6 ± 3.5
REMD2.59C Low dose	17.3 ± 5.5	18.7 ± 5.9	21.3 ± 6.4	23.9 ± 7.7	24.5 ± 7.8
REMD2.59C Middle dose	17.3 ± 5.5	17.1 ± 6.0	18.5 ± 4.7	20.0 ± 5.8 *	20.0 ± 5.6
REMD2.59C High dose	17.4 ± 5.4	4.9 ± 1.0 **	5.7 ± 0.7 **	6.2 ± 0.9 **	6.4 ± 1.0 **
	week 5	week 6	week 7	week 8	week 9
Vehicle	26.6 ± 2.5	26.6 ± 2.6	27.5 ± 2.6	28.2 ± 3.9	28.7 ± 3.4
REMD2.59C Low dose	24.9 ± 6.2	24.3 ± 6.7	24.3 ± 7.3	24.8 ± 7.0	25.9 ± 7.0
REMD2.59C Middle dose	21.2 ± 5.5 *	21.0 ± 5.5 *	20.7 ± 6.1 *	20.6 ± 6.7 **	20.8 ± 7.0 **
REMD2.59C High dose	5.7 ± 0.9 **	5.6 ± 1.0 **	6.0 ± 0.8 **	5.7 ± 1.1 **	5.8 ± 1.2 **
	week 10	week 11	week 12		
Vehicle	28.7 ± 3.5	29.1 ± 2.7	30.1 ± 2.3		
REMD2.59C Low dose	25.6 ± 7.0	25.6 ± 5.5	26.5 ± 4.9		
REMD2.59C Middle dose	21.2 ± 6.2 **	21.3 ± 6.5 **	21.9 ± 6.0 **		
REMD2.59C High dose	5.4 ± 1.0 **	6.2 ± 1.0 **	5.5 ± 1.2 **		

Note: * $p < 0.05$, ** $p < 0.01$ compared with Vehicle group (One-way ANOVA)

The study demonstrates that REMD2.59C has significant effects on lowering fast blood glucose levels in a dose-dependent fashion, and that the high dose REMD2.59C treatment was capable of returning blood concentrations to normal as early as week 1 and was capable of maintaining normal levels for 12 weeks, without insulin.

Blood Biochemistry

[0180] Prior to scheduled termination of the study, blood samples were collected via cardiac puncture into tubes with and without anticoagulant. The samples in the test tubes which did not contain anticoagulant were immediately centrifuged at 4 °C; 8000 rpm for 15 minutes and serum was transferred into separate sample tubes. HbA1c, albumin (ALB) and total protein (TP) were measured by using TOSHIBA TBA-40FR automated biochemical analyzer. The parameters of blood chemistry of all study groups are shown in Table 6 and Figures 4 and 5.

Table 6

Group	HbA1c (g/L)	ALB (g/L)	TP (g/L)
Vehicle	11.2 ± 1.1	26.6 ± 1.3	45.8 ± 3.3
REMD2.59C Low Dose	11.0 ± 1.6	26.4 ± 2.9	46.9 ± 7.2
REMD2.59C Middle Dose	$9.1 \pm 1.7^{**}$	27.2 ± 2.5	47.6 ± 5.4
REMD2.59C High Dose	$3.8 \pm 1.0^{**}$	$30.5 \pm 2.8^{**}$	50.5 ± 4.7

Note: ** $p < 0.01$ compared with Vehicle group (One-way ANOVA)

In the diabetic mice treated with high dose REMD2.59C, HbA1c levels were normal ($4 \pm 1\%$) at 12 weeks after treatment, whereas in the vehicle treated diabetic control mice HbA1c averaged $11 \pm 1\%$ (Figure 4). This study demonstrates that REMD2.59C has significant effects on lowering and normalizing HbA1c levels in a dose-dependent fashion in STZ-induced T1D mice, even without exogenous insulin treatment. This is significant in that HbA1c levels below 6% are rare in T1D patients. Additional findings of significantly increased albumin and a trending increase in total protein levels in the high dose REMD2.59C treated diabetic mice suggests

improvement in protein anabolism and/or reduced protein catabolism (Table 6). This suggests that agents which block the glucagon action may effectively treat T1D in humans.

[0181] Various additional procedures and parameters were tested to evaluate the safety and efficacy of REMD2.59C.

Serum Insulin/C-peptide/GLP-1/AcAc/BOH/Glucagon Determination

[0182] The whole blood samples were also used for analysis of the serum levels of C-peptide, GLP-1, AcAc, BOH, insulin and glucagon, each of which was measured by an ELISA method at 12 weeks after treatment. The data is depicted in Figures 6-8.

[0183] Overall, REMD2.59C has no statistically significant effect on C-peptide, GLP-1, ketone body (AcAc, BOH) and insulin levels at currently tested conditions. There was an increase in serum glucagon serum levels, in a dose-dependent fashion, in the REMD2.59C-treated animals and serum glucagon is significantly higher in the high dose REMD2.59C treated animals (see Figure 7).

Macroscopic Measurement and Analysis

[0184] Following necropsy, the pancreas from all study animals were fixed, processed and brought up to paraffin block stage for future histological H&E staining. IHC with anti-insulin and anti-glucagon antibodies were conducted on pancreatic tissues samples.

Example 2

[0185] In this Example, pancreatic tissue samples prepared as described in Example 1 were subjected to histological H&E staining and immunohistochemistry with anti-insulin and anti-glucagon antibodies.

[0186] The sample list is shown in Table 7.

Table 7

Group	Vehicle	REMD 2.59C (0.3 mg/kg)	REMD 2.59C (1.5 mg/kg)	REMD 2.59C (7.5 mg/kg)
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ID	V30	L3	M19	H4
	V33	L11	M29	H18
	V34	L13	M36	H21
	V40	L38	M41	H22
	V43	L48	M46	H23

[0187] The results of the histological H&E staining are depicted in Figure 9.

[0188] The thickness of 3µm tissue sections were prepared for IHC. IHC was performed using Abcam® indirect antigen-antibody labeling methods and staining protocols per manufacturer's instructions and using the following reagents: a) primary antibodies: anti-glucagon antibody = rabbit polyclonal antibody (Abcam, cat# ab18461) and anti-insulin antibody = guinea pig polyclonal antibody (Abcam, cat# ab7842); b) secondary antibodies: biotinylated goat anti-rabbit IgG-H&L (Abcam, Cat# ab97049) and biotinylated goat anti guinea pig IgG - H&L (Abcam, Cat# ab6907); c) detection reagent = ABC-HRP Kit (Vector Laboratories, Cat# pk-4000) and ABC-AP Kit (Vector Laboratories, Cat# ak-5000); e) DAB peroxidase substrate kit (Vector Laboratories, Cat# sk-4100) and e) Red Alkaline Phosphatase Substrate Kit III (Vector Laboratories, Cat# sk-5100).

[0189] Anti-glucagon antibody specific for pancreatic Alpha (α -) cells were stained with ABC-HRP method. And the positive cells were visualized by the substrate DAB (3,3-diaminobenzidine) staining as dark brown color (arrow). Anti-insulin antibody specific for pancreatic Beta (β -) cells were stained with ABC-AP kit. The positive labeled cells were visualized with substrate alkaline phosphate as in red color (arrow). The glucagon and insulin double staining in the pancreatic islet is depicted in Figure 10, which shows recovery of insulin secretion from islets β -cells.

Quantification and Statistical Analysis

[0190] All the staining images from the pancreatic sections of half study animals were captured at 40 × magnifications, and all the pancreatic islets in pancreas tissues were captured at 200 × magnifications for further analysis. The quantification labeling was carried out by counting the sum area of pancreatic islets and total pancreas tissue respectively. The data was expressed as the sum area of pancreatic islets per pancreas tissue. The pancreatic islets in pancreas tissues were captured at 200 × magnifications, and the positive labeled cells in all islets were evaluated. The quantification positive labeling was carried out by measuring the defined islet area, and counting the area of individual stained cell for each marker within these

areas. The data was expressed as the area of positive cells for insulin or glucagon dividing by the total sum of area per islet.

Percentage of α -cells or β -cells = area of glucagon or insulin positive cells / area of total islet $\times 100\%$.

One-way analysis of variance (ANOVA) testing (SPSS 17.0) was applied among the groups; $p < 0.05$ was accepted as significant.

[0191] The percentage of pancreatic islets in the animal pancreas tissues is shown in Figure 11A-C. The number of pancreatic Islet, insulin area, glucagon area, and percentage of insulin and glucagon positive cells in pancreatic islet are shown in Table 8 and Figures 12A-B.

Table 8

Groups	No. of Pancreatic Islet	Insulin area (Pixels,200X)	Glucagon area (Pixels,200X)	β -cells (Insulin positive) (%)	α -cells (Glucagon positive) (%)
Vehicle	14 $\pm$ 5	8612 $\pm$ 3863	54789 $\pm$ 27579	5.97 $\pm$ 5.50	40.38 $\pm$ 6.56
REMD 2.59C (0.3 mg/kg)	16 $\pm$ 6	5415 $\pm$ 4827	63111 $\pm$ 44640	2.58 $\pm$ 1.81	31.63 $\pm$ 12.43
REMD 2.59C (1.5 mg/kg)	31 $\pm$ 9**	22652 $\pm$ 32174	177611 $\pm$ 104090	5.93 $\pm$ 8.22	44.94 $\pm$ 8.96
REMD 2.59C (7.5 mg/kg)	50 $\pm$ 14**	73114 $\pm$ 31540*	660592 $\pm$ 408850	8.33 $\pm$ 5.71	50.96 $\pm$ 5.82

The test compound REMD2.59C (7.5mg/kg) has significant effects on increasing the number of β -cells on the pancreatic tissue section from mice with STZ-induced type 1 diabetes. In addition, the data indicates that all of these cells are also functional by producing and secreting insulin. REMD2.59C also induced a secondary increase in glucagon staining in the α -cells. These observations were confirmed by IHC double labeling with anti-insulin and anti-glucagon antibodies and microscopic image quantification analysis. The histology quantification data illustrated that the area of pancreatic islets and the percentage islet area are significantly

increased on pancreatic sections from mice treated with high dose (7.5 mg/kg) of REMD2.59C in comparison with vehicle control groups. Notably, the number of α -cell seems more than β -cell which correlated well with the data from serum glucagon's levels analyzed by ELISA method, indicating secondary increase in glucagon secretion which should pose no clinical harm to treated animals under the effective blockade of the glucagon receptor by REMD2.59C.

[0192] The data in Examples 1 and 2 demonstrates that test compound REMD2.59C can achieve weight loss, can lower the blood glucose levels, reduce blood Hb1Ac, and is capable of rejuvenating the function of pancreatic endocrine cells in STZ-induced T1D mice, without insulin.

Example 3

[0193] In this example, a fully human anti-GCGR antibody which comprises the amino acid sequence encoding the heavy chain variable region of SEQ ID NO: 2 and the amino acid sequence encoding the light chain variable region of SEQ ID NO: 3 (herein referred to as REMD-477) was evaluated in a alloxan-induced diabetic mice study.

[0194] Alloxan-induced diabetic mice were injected subcutaneously with buffer (control, $n = 5$) or buffer containing 5 mg/kg of REMD-477 monoclonal antibody ($n=6$) and blood glucose concentration was monitored daily for eight days. In mice treated with REMD-477, daily blood glucose measurements averaged 85 ± 5 mg/dl and remained normoglycemic for 8 days (Figure 13), at which time livers were harvested. In contrast, the vehicle (buffer) treated mice remained hyperglycemic (blood glucose > 500 mg/dl) throughout the study.

[0195] This data demonstrates that the human anti-GCGR antibody, REMD-477, is also capable of lowering and maintaining blood glucose below 100 mg/dl.

Example 4

[0196] In this example, the ability of REMD-477 to reverse hyperglycemia in alloxan-induced diabetic mice was evaluated. cAMP response element binding protein (CREB), a transducer of the glucagon signal, and the gluconeogenic glucagon target, phosphoenolpyruvate carboxykinase (PEPCK), are key markers of glucagon action in the liver. The phosphorylation of CREB and the expression of PEPCK were measured in alloxan-induced diabetic mice and in nondiabetic mice. Total protein extracts prepared from liver tissues of mice with or without the treatment of REMD-477 were resolved by SDS-PAGE and transferred to a

nitrocellulose membrane (Bio-Rad Laboratories, Hercules CA, USA). The blotted membrane was blocked in 1 X TBS containing 0.1% Tween and 5% nonfat dry milk (TBST-MLK) for 1 hr at room temperature with gentle, constant agitation. After incubation with primary antibodies anti-phospho-CREB, anti-CREB, or anti-PEPCK (Cell Signaling Technologies, Beverly MA, USA), or anti- γ -tubulin (Sigma, St. Louis, MO) in freshly prepared TBST-MLK at 4 °C overnight with agitation, the membrane was washed two times with TBST buffer.

[0197] Compared to nondiabetic liver, there was a 3.5-fold elevation in phosphorylated CREB in alloxan-induced diabetic mice livers and a 2.5-fold increase in PEPCK expression (Figures 14A-B). To evaluate whether these differences were glucagon-mediated, alloxan-induced diabetic mice were treated with 5 mg/kg of REMD-477. In the REMD-477-treated livers, phosphorylated CREB protein was reduced to nondiabetic levels and PEPCK protein expression was reduced below that of nondiabetic mice (Figures 15A-B). This data demonstrates that the activation of hepatic gluconeogenesis in T1D mice is a result of their hyperglucagonemia. This is a new and important finding for T1D. And, more importantly, the data demonstrates that REMD-477 can also reverse hyperglycemia in alloxan-induced diabetic mice.

Example 5

[0198] In this example, the *in vivo* activity of the REMD2.59C is compared to the activity of a fully human anti-GCGR antibody which comprises the amino acid sequence encoding the heavy chain variable region of SEQ ID NO: 28 and the amino acid sequence encoding the light chain variable region of SEQ ID NO: 47 (herein referred to as RMED2.10), and to the activity of a fully human GCGR antibody which binds GCGR but which is not antagonistic (herein referred to as REMD2.45) in the streptozotocin (STZ)-induced T1D mouse study.

[0199] C57BL/6 mice (Vital River Laboratory Animal Technology Co., LTD) (male, age 8-10 weeks, 20-22 g) were fasted overnight. A single STZ injection (175 mg/kg) was conducted on all animals. After 10 days stabilization (post dosing of STZ), and based on the animal's body weight and fasting blood glucose, mice were randomly assigned to respective groups (10/group) using a computer-generated randomization procedure. The mice were then dosed weekly via subcutaneous injection with either vehicle or 7.5 mg/kg REMD2.59C antibody, REMD2.10 antibody, or REMD2.45 antibody. Vehicle comprised 10 mM sodium acetate, 5% sorbitol, and 0.004% polysorbate 20. The final concentration of solution for the test samples was 0.75 mg/mL. The treatment period was thirteen days.

Blood Glucose Determinations

[0200] Blood glucose determinations were made throughout the study. Mice were fasted 6 hours prior to blood glucose test from 9 am to 3 pm, and fast blood glucose levels were measured via tail veins on weekly basis by using Accu-Chek Aviva System.

[0201] As depicted in Figure 16 and Table 9 below, T1D in the mice is confirmed by elevated fasting blood glucose levels that reached 17.3 to 22.9 mmol/L range (or 311 to 412 mg/dl range), as opposed to a normal level of below 6 mmol/L (or 108 mg/dl).

Table 9

Group	Fast Blood Glucose(mmol/l)		
	Day 10 (treatment)	Day 17	Day 22
Vehicle	17.3 ± 4.0	22.8 ± 5.0	25.3 ± 4.0
REMD2.59C	17.3 ± 4.1	7.6 ± 4.8**	5.5 ± 2.2**
REMD2.45	17.4 ± 4.3	22.8 ± 5.2	25.4 ± 5.1
REMD2.10	17.5 ± 4.3	9.9 ± 5.0	8.3 ± 4.7**

Note: **p<0.01 compared with Vehicle group (One-way ANOVA)

The study demonstrates that, like REMD2.59C, the fully human REMD2.10 antibody has significant effects on lowering fast blood glucose levels and is capable of returning blood concentrations to levels approaching normal within 2 weeks, without insulin. The study also shows that the REMD2.45 antibody (which is not an antagonistic GCGR antibody), has no effect on lowering fast blood glucose levels.

Example 6

[0202] This Example describes one exemplary use of the methods described herein to treat a patient who has been diagnosed with T1D. Twenty T1D patients (male and female), age 18-60 years of age, and currently on an insulin supplementation regimen are identified to participate in a 5 day single dose study. Treatment groups include a placebo group and a group to be treated with 1 mg/kg body weight REMD-477. This study will assess and compare the changes in 24-hour insulin requirements from the baseline period to the post-treatment period after a single subcutaneous injection of REMD-477. Treatment with REMD-477 is expected to

significantly reduce the 24-hr insulin dose requirement as compared to the placebo control group, while maintaining the same target normal glucose levels.

Example 7

[0203] This Example describes additional exemplary uses of the methods described herein to treat a patient who has been diagnosed with T1D. The clinical goal will be to attain better diabetic control as measured by the lower glucose level and reduced HbA1c levels by eliminating the need for insulin supplementation, or alternatively, by providing insulin supplementation at a much lower dosing regimen than the normal daily dosage of insulin, which will significantly alleviate complications associated with extended insulin monotherapy, which will serve to improve the long term prognosis and health of the patients.

[0204] Individuals diagnosed with T1D, or determined to be at high risk of developing T1D, are identified and randomized to a treatment group. Treatment groups include a placebo group and treatment groups to be treated with various dosages of REMD-477, and insulin supplementation. Examples of non-placebo treatment groups will include, e.g., patients who receive injections of either 0.01 mg/kg, 0.025 mg/kg, 0.05 mg/kg, 0.075 mg/kg, 0.1 mg/kg, 0.25 mg/kg, 0.5 mg/kg, 0.75 mg/kg, 1.0 mg/kg, 1.5 mg/kg, 2.0 mg/kg, 2.5 mg/kg, 5 mg/kg, 7.5 mg/kg, or 10 mg/kg REMD-477 per week, and patients who receive injections of either 0.01 mg/kg, 0.025 mg/kg, 0.05 mg/kg, 0.075 mg/kg, 0.1 mg/kg, 0.25 mg/kg, 0.5 mg/kg, 0.75 mg/kg, 1.0 mg/kg, 1.5 mg/kg, 2.0 mg/kg, 2.5 mg/kg, 5 mg/kg, 7.5 mg/kg, or 10 mg/kg REMD-477 bi-weekly. In various treatment groups, patients will also receive insulin injections (single or multiple injections) of 90-120 Units per day, 60-90 Units per day, 30-60 Units per day, or 15-30 Units per day, or 10-15 Units per day, or 5-10 Units per day or 1-5 Units per day.

[0205] All of the articles and methods disclosed and claimed herein can be made and executed without undue experimentation in light of the present disclosure. While the articles and methods of this disclosure have been described in terms of preferred embodiments, it will be apparent to those of skill in the art that variations may be applied to the articles and methods without departing from the spirit and scope of the disclosure. All such variations and equivalents apparent to those skilled in the art, whether now existing or later developed, are deemed to be within the spirit and scope of the disclosure as defined by the appended claims. All patents, patent applications, and publications mentioned in the specification are indicative of the levels of those of ordinary skill in the art to which the disclosure pertains. All patents, patent

applications, and publications are herein incorporated by reference in their entirety for all purposes and to the same extent as if each individual publication was specifically and individually indicated to be incorporated by reference in its entirety for any and all purposes. The disclosure illustratively described herein suitably may be practiced in the absence of any element(s) not specifically disclosed herein. Thus, for example, in each instance herein any of the terms “comprising”, “consisting essentially of”, and “consisting of” may be replaced with either of the other two terms. The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention that in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the disclosure claimed. Thus, it should be understood that although the present disclosure has been specifically disclosed by preferred embodiments and optional features, modification and variation of the concepts herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this disclosure as defined by the appended claims.

Sequence Listings

[0206] The amino acid sequences listed in the accompanying sequence listing are shown using standard three letter code for amino acids, as defined in 37 C.F.R. 1.822.

[0207] SEQ ID NO: 1 is the amino acid sequence of a human glucagon receptor (GCGR) molecule (Accession Number AA104855).

[0208] SEQ ID NO: 2 is the amino acid sequence encoding the heavy chain variable region of a fully human anti-GCGR antibody. SEQ ID NO: 3 is the amino acid sequence encoding the light chain variable region of a fully human anti-GCGR antibody.

[0209] SEQ ID NO: 4 is the amino acid sequence encoding the heavy chain variable region of a fully human anti-GCGR antibody. SEQ ID NO: 5 is the amino acid sequence encoding the light chain variable region of a fully human anti-GCGR antibody.

[0210] SEQ ID NO: 6 is the amino acid sequence encoding the heavy chain variable region of a fully human anti-GCGR antibody. SEQ ID NO: 7 is the amino acid sequence encoding the light chain variable region of a fully human anti-GCGR antibody.

[0211] SEQ ID NO: 8 is the amino acid sequence encoding the heavy chain of a chimeric anti-GCGR antibody. SEQ ID NO: 9 is the amino acid sequence encoding the light chain of a chimeric anti-GCGR antibody.

[0212] SEQ ID NOS: 10-28 are amino acid sequences encoding the heavy chain variable regions of various fully human anti-GCGR antibodies.

[0213] SEQ ID NOS: 29-47 are amino acid sequences encoding the light chain variable regions of various fully human anti-GCGR antibodies.

[0214] SEQ ID NO: 48 is the amino sequence encoding the kappa light chain constant region. SEQ ID NO: 49 is the amino sequence encoding the lambda light chain constant region.

[0215] SEQ ID NO: 50 is the amino sequence encoding the IgG2 heavy chain constant region.

[0216] SEQ ID NO: 51 is the amino acid sequence encoding the heavy chain of a human anti-GCGR antibody (REMD-477). SEQ ID NO: 52 is the amino acid sequence encoding the light chain of a human anti-GCGR antibody (REMD-477).

SEQUENCE LISTINGS

SEQ ID NO: 1 – Amino acid sequence of a human glucagon receptor (GCGR) molecule

MPPCQPQRPLLLLLLLACQPQVPSAQVMDFLFEKWKLYGDQCHHNLSELLPPPTLVCNRTFD
KYSCWPDTPANTTANISCPWYLPWHHKVQHRFVKRCGPDGQWVRGPRGQPWRDASQCQ
MDGEEIEVQKEVAKMYSSFQVMYTVGYSLSLGALLLAILGGLSKLHCTRNAIHANLFASFVLK
ASSVLVIDGLLRTRYSQLIGDDLSVSTWLSGDGAVAGCRVAAVFMQYGIVANYCWLLVEGLYLH
NLLGLATLPERSFFSLYLIGIWGAPMLFVVPWAVVKCLFENVQCWTSNDNMGFWWILRFPVFL
AILINFFIFVRIVQLLVAKLRARQMHTDYKFRLAKSTLTLLPLLGVHEVVFAFVTDEHAQGTLRSA
KLFFDLFLSSFQGLLVAVLYCFLNKEVQSELRRRWHRWRLGKVLWEERNTSNHRASSSPGHG
PPSKELQFGRGGGSQDSSAETPLAGGLPRLAESPF

SEQ ID NO: 2 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVAVMWYD
GSNKDYVDSVKGRFTISRDN SKNTLYLQMNRLRAEDTAVYYCAREKDHYDILTGYNY
YYGLDVWGQGTTTVTVSS

SEQ ID NO: 3 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVTITCRASQGIRNDLGWYQQKPGKAPKRLIYAASSLQSGV
PSRFSGSGSGTEFTLTISVQPEDFVITYYCLQHNSNPLTFGGGTKEIK

SEQ ID NO: 4 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWV
AVMWYDGSNKDYVDSVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCAREKDHYDI
LTGYNYYYGLDVWGQGTTTVTVSS

SEQ ID NO: 5 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVTITCRASQGIRNDLGWYQQKPGKAPKRLIYAASSLQSGV
PSRFSGSGSGTEFTLTISSLQPEDFVITYYCLQHNSNPLTFGGGGTKVEIK

SEQ ID NO: 6 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVAVMWYD
GSNKDYVDSVKGRFTISRDN SKNTLYLQMNRLRAEDTAVYYCAREKDHYDILTGYNY
YYGLDVWGQGTTTVTVSS

SEQ ID NO: 7 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVTITCRASQGIRNDLGWYQQKPGKAPKRLIYAASSLESGV
PSRFSGSGSGTEFTLTISVQPEDFVITYYCLQHNSNPLTFGGGGTKVEIK

SEQ ID NO: 8 – Amino acid sequence of a heavy chain of a chimeric antibody that binds GCGR

MEFGLSWVFLVALLRGVQCQVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPG
KGLEWVAVMWYDGSNKDYVDSVKGRFTISRDN SKNTLYLQMNRLRAEDTAVYYCAREKDHY
DILTGYNYYYYGLDVWGQGTTTVTVSSAKTTPPSVYPLAPGSAAQTNSMVTLGCLVKGYFPEPVT
VTWNSGSLSSGVHTFPAVLQSDLYTLSSSVTVPSSTWPSETVTCNVAHPASSTKVDKIVPRD
CGCKPCICTVPEVSSVFIFPPKPKDVLITLTPKVTCTVVDISKDDPEVQFSWFVDDVEVHTAQT
QPREEQFNSTFRSVSELPIMHQDWLNGKEFKCRVNSAAFPAPIEKTISKTKGRPKAPQVYTIPP
PKEQMAKDKVSLTCMITDFFPEDITVEWQWNGQPAENYKNTQPIMDTDGSYFVYSKLNQKS
NWEAGNTFTCSVLHEGLHNHHTKSLSHSPGK

SEQ ID NO: 9 – Amino acid sequence of a light chain of a chimeric antibody that binds GCGR

MDMRVPAQLLGLLLWFPGARCDIQMTQSPSSLSASVGDRVTITCRASQGIRNDLGWYQQK
GKAPKRLIYAASSLESGVPSRFSGSGSGTEFTLTISVQPEDFVITYYCLQHNSNPLTFGGGTKV
EIKRADAAPTVSIFPPSSEQLTSGGASVVCFLNNFYPKDINVKKIDGSRQNGVLNSWTDQDS
KDSTYSMSSTLTLTKEDEYERHNSYTCEATHKTSTSPIVKSFNREK

SEQ ID NO: 10 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSNYGMHWVRQAPGKGLEWVAVILSDGRNKYYA
DSVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCARDDEILTGYGYGMDVWGQGTTTVTV
SS

SEQ ID NO: 11 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVAVILNDGRNKYYA
DSVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCARDDEILTGYGYGMDVWGQGTTTVTV
SS

SEQ ID NO: 12 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLQQSGPGLVKPSQTLSTCAISGDSVSSNGAAWNWIRQSPSRGLEWLGRTYYRSKWYY
DYAGSVKSRININPDTSKNQFSLQVNSVTPEDTAVYYCTRDRSSGWNEGYYYYGMDVWGQG
TTTVTVSS

SEQ ID NO: 13 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYDIHWVRQAPGKGLEWVAVLSSDGNNKYCA
DSVKGRFTISRDN SKNTLYLQMNSLRTEDTAVYYCAREEVYYDILTGYDYDYGMDVWGQGTTV
TVSS

SEQ ID NO: 14 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLQESGPGLVKPSETLSLTCTVSGGSISTYFWTWIRQFPKGLEWIGYIFYSGSTNYPNPSLK
SRVTISVDTSKNQFSLKLSSVTAADTAVYYCAREGYDILTGEDYSYGMDVWGQGTTVTVSS

SEQ ID NO: 15 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLQQSGPGLVKPSQILSLTCAISGDRVSSNGAAWNWIRQSPSRGLEWLGRTYYRSKWYYD
YAGSVKSRININPDTSKNQFSLQVNSVTPEDTAVYYCARDRSSGWNEGYYYYGMDVWGQGT
TVTSS

SEQ ID NO: 16 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLQESGPGLVKPSETLSLTCTVSGGSISTYFWTWIRQFPGEGLWIGYIFYSGNTNYPNPSLT
SRVTISVDTSKNQFSLKLSSVTAADTAVYYCAREGYDILTGEDYSYGIDVWGQGTTVTVSS

SEQ ID NO: 17 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFIFSSYGMHWVRQAPGKGLEWVAVISNDGSNKYYA
DFVKGRFTISRDN SKNTLYLQMNSLRAEDTAVYYCAREDYDILTGNNGVYGMDVWGQGTTVT
VSS

SEQ ID NO: 18 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

EVQLVESGGGLVQPGGSLRLSCAASGFTFSSYTMNWVRQAPGKGLEWVSYISGSSSLIYYAD
SVKGRFTISRDN AKNSLYLHMNSLRDEDTAVYYCARARYNWNDYYGMDVWGQGTTVTVSS

SEQ ID NO: 19 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFAFSSYGIHWVRQAPGKGLEWVAGIWDGSKNYYA
DSVKGRFTVSRDN SKNTLYLQMNSLRAEDTAVYYCARLFDADFIDWGQGTMTVSS

SEQ ID NO: 20 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

EVQLVESGGGLVQPGGSLRLSCAASGFIFSSYTMNWVRQAPGKGLEWVSYISSSSLIYYADS
VKGRFTISRDN AKNSLYLQMNSLRDEDTAVYYCARSDYYGSGSYKGNYYGMDVWGQGTTV
TVSS

SEQ ID NO: 21 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVTIISDGIN KYAD
SVKGRFTISRDN SKNTLNLQMNSLRAEDTAVYYCARERGLYDILTGYDYDYGIDVWGQGTTV
VSS

SEQ ID NO: 22 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVTIISDGIN KYAD
SVKGRFTISRDN SKNTLNLQMNSLRAEDTAVYYCARERGLYDILTGYDYDYGIDVWGQGTTV
VSS

SEQ ID NO: 23 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

EVQLVESGGGLVKPGGSLRLSCAASGITFRSYSMNWVRQAPGKGLEWVSAISSSSSYIYYADS
VKGRFTISRDNKNSVYLQMNSLRAEDTAVYYCARGRYGMDVWGQGTTVTVSS

SEQ ID NO: 24 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGSTFRSYDMHWVRQAPGKGLEWVAVISYDGSNKYYG
DSVKGRFTISRDNKNTLYLQMNSLRAEDTAVYYCARDQYDILTGYSSDAFDIWGQGTMTV
SS

SEQ ID NO: 25 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSRYGMHWVRQAPGKGLEWVAVIWDGSHKYY
EDSVKGRFTISRDNKNTLYLQMNSLRADDTGVIYCARVGYGSGWYEYHYHGMVWGQGT
TVTSS

SEQ ID NO: 26 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVAVMWYDGSNKDY
VDSVKGRFTISRDNKNTLYLQMNRLRAEDTAVYYCAREKDHIDYDILTGYNYYYGLDVWGQGT
TVTSS

SEQ ID NO: 27 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVAVMWYDGSNKDY
VDSVKGRFTISRDNKNTLYLQMNRLRAEDTAVYYCAREKDHIDYDILTGYNYYYGLDVWGQGT
TVTSS

SEQ ID NO: 28 – Amino acid sequence of a HCVR of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGITFSSYGMHWVRQAPGKGLEWVASIWDGSNKYYV
DSVKGRFTIFRDNKNTLYLQMNRLRAEDTAVYYCARLGGFDYWGGTLTVSS

SEQ ID NO: 29 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVTITCRASQDISNYLAWFQKKPGKAPKSLIYVSSLQSGVPSRFSG
SGSGTDFTLTINNLPEDFATYYCQYNYHYPLTFGGGTRVEIKR

SEQ ID NO: 30 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVTITCRASQDISNYLAWFQQRPKGKAPKSLIYVSSLQSGVPSRFSG
SGSGTDFTLTISNLPEDFATYFCQYNYHYPLTFGGGTRVEIKR

SEQ ID NO: 31 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQFPSSLSASIGDRVTITCQASQDISNFWFQQKPGKAPKLLIYDASDLETGVPSRFSGS
GAGTDFTFTISSLPEDIATYFCQYDDLPFTFGGGTRVDIKR

SEQ ID NO: 32 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVTITCRASQGIRNDLGWYQQKPGKAPKRLIYAASSLQSGVPSRFS
GSGSGTEFTLTISSLPEDFATYYCLQHNSNPLTFGGGTRVEIKR

SEQ ID NO: 33 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

QNVLTQSPGTLSSLSPGERVTLS CRASQSVSSSYLAWYQQKPGQAPRLLIFGVSSRATGIPDRF
SGSGSGTDFSLTISRLEPEDFAVYYCQQYGNSPFTFGPGTKVDIKR

SEQ ID NO: 34 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQFPSSLSASIGDRVTITCQASQDISNFLNWFQQKPGKAPKLLIYDASDLETGVPSRFSGS
GAGTDFTFTISLQPEDVATYFCQQYDNLPLTFGGGTKVDIKR

SEQ ID NO: 35 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

ENVLTQSPGTLSSLSPGERATLS CRASQSVTSSYLAWYQQKPGQAPRLLIFGVSSRATGIPDRF
SGSGSGTDFSLTISRLEPEDFAVYYCQQYGNSPFTFGPGTKVDIKR

SEQ ID NO: 36 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVTITCRASQGIDMYLAWFQQKPGKAPKSLIYAASSLQSGVPSKFS
GSGFGTDFTLTISLQPEDFATYYCQQYNIFPFTFGPGTKVDVKR

SEQ ID NO: 37 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVTITCRASQGIRNDLGWYQQKPGKAPKRLIYAASSLESQVPSRFS
GSGSGTEFTLTISLQPEDFATYYCLQHNSYPWTFGQGTKVEIKR

SEQ ID NO: 38 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

KIVMTQTPLALPVIPGEPASISCRSSQSLVSDDGDTYLDWYLQKPGQSPQVLIHRLSYRASGV
PDRFSGSGSGTDFTLKISRVEAEDVGIYYCMHRIEFPFTFGGGTKVEIKR

SEQ ID NO: 39 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVTITCRASQGIRNDLGWYQQRPKGKAPKRLIYAASSLQTVPSRFS
GSGSGTEFTLTISLQPEDFATYYCLQHNSYPWTFGQGTKVEIKR

SEQ ID NO: 40 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

GIVLTQSPLSLPVTTPGEPASISCRSSQSLLSNGYNYLDWYLQKPGQSPQLLIYLGSNRASGVP
DRFSGSGSGTDFTLKISRVEAEDVGVYYCMEALQTMCSFGQGTKLEIKR

SEQ ID NO: 41 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

GIVLTQSPLSLPVTTPGEPASISCRSSQSLLSNGYNYLDWYLQKPGQSPQLLIYLGSNRASGVP
DRFSGSGSGTDFTLKISRVEAEDVGVYYCMEALQTMSSFGQGTKLEIKR

SEQ ID NO: 42 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIVMTQTPLFLPVTTPGEPASISCRSSQTLSDDGNTYLDWYLQKPGQSPQRLIYTLISYRASGV
PDRFSGSGSGTDFTLKISRVEAEDVGIYYCMQHIEFPSTFGQGTRLEIKR

SEQ ID NO: 43 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

SYELTQPPSVSVSPGQTASITCSGDKLGDKYASWYQQKPGQSPVLVIYQSTKRPSGIPERFSG
NSGNTATLTISGTQAMDEADYYCQAWDSSTVVFGGGTKLTVLG

SEQ ID NO: 44 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

NIVMTQTPLSLSVTPGQPASISCKSSQSLLHSDGKNYLFWYLQKPGQSPQLLIYEVSYRFSGVP
DRFSGSGSGTDFSLKISRVEAEDVGVYYCMQNIQPPLTFGQGTRLEIKR

SEQ ID NO: 45 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVITICRASQGIRNDLGWYQQKPGKAPKRLIYAASSLQSGVPSRFS
GSGSGTEFTLTISVQPEDFVTYYCLQHNSNPLTFGGGTKVEIKR

SEQ ID NO: 46 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVITICRASQGIRNDLGWYQQKPGKAPKRLIYAASSLESQSGVPSRFS
GSGSGTEFTLTISVQPEDFVTYYCLQHNSNPLTFGGGTKVEIKR

SEQ ID NO: 47 – Amino acid sequence of a LCVR of a human antibody that binds GCGR

DIVLTQTPLSLPVTGPGEPAISCRSSQSLLDRDDGDTYLDWYLQKPGQSPQLLIYTLTYRASGV
PDRFSGSGSGTDFSLKISRVEAEDVGVYYCMQRIEFPFTFGPGTKVDIKR

SEQ ID NO: 48 – Amino acid sequence of the constant light chain kappa region

RTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD
STYLSLSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO: 49 – Amino acid sequence of the constant light chain lambda region

GQPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVTVAWKADSSPVKAGVETTTTPSKQSN
NKYAASSYLSTPEQWKSHRSYSCQVTHEGSTVEKTVAPTECS

SEQ ID NO: 50 – Amino sequence of the IgG2 heavy chain constant region

ASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLY
SLSSVTVTPSSNFGTQTYTCNVDHKPSNTKVDKTKVERKCCVECPPCPAPPVAGPSVFLFPPKP
KDTLMISRTPEVTCVVVDVSHEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTFRVSVLTVVH
QDWLNGKEYKCKVSNKGLPAPIEKTISKTKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFY
PSDIAVEWESNGQPENNYKTTTPMLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNH
YTQKSLSLSPGK

SEQ ID NO: 51 – Amino acid sequence of a HC of a human antibody that binds GCGR

QVQLVESGGGVVQPGRSLRLSCAASGFTFSSYGMHWVRQAPGKGLEWVAVMWYD
GSNKDYVDSVKGRFTISRDN SKNTLYLQMNRLRAEDTAVYYCAREKDHYDILTGYN
YYYGLDVWGQGTTVTVSSASTKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWN
SGALTSGVHTFPAVLQSSGLYSLSSVTVTPSSNFGTQTYTCNVDHKPSNTKVDKTKVERKCCVE
CPPCPAPPVAGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVQFNWYVDGVEVHNAKT
KPREEQFNSTFRVSVLTVVHQDWLNGKEYKCKVSNKGLPAPIEKTISKTKGQPREPQVYTL
PSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPMLDSDGSFFLYSKLTVDKS
RWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

SEQ ID NO: 52 – Amino acid sequence of a LC of a human antibody that binds GCGR

DIQMTQSPSSLSASVGDRVITICRASQGIRNDLGWYQQKPGKAPKRLIYAASSLQSGV
PSRFSGSGSGTEFTLTISVQPEDFVTYYCLQHNSNPLTFGGGTKVEIKRTVAAPSVFIF
PPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDESTYLSLSTLT
SKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

What is claimed is:

1. A method of treating a patient diagnosed with type 1 diabetes (T1D) comprising administering to the patient: (a) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (b) insulin supplementation.
2. A method of reducing, suppressing, attenuating, or inhibiting one or more symptoms associated with T1D, comprising administering to a patient diagnosed with T1D: (a) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (b) insulin supplementation.
3. A method of claim 2, wherein the one or more symptoms is selected from the group consisting of excess gluconeogenesis, excess glycogenolysis, hyperglycemia, hyperglucagonemia, ketosis, diabetic ketoacidosis, hypertriglyceridemia, elevated plasma free fatty acid, weight loss, catabolic syndrome, terminal illness, hypertension, diabetic nephropathy, renal insufficiency, renal failure, hyperphagia, muscle wasting, diabetic neuropathy, diabetic retinopathy, or diabetic coma, excess HbA1c levels, polydipsia (increased thirst), xerostomia (dry mouth), polyphagia (increased hunger), polyuria (frequent urination), and fatigue.
4. A method of treating a patient who is at risk of developing T1D comprising (a) identifying a patient who is at risk of developing T1D and (b) administering to the patient (i) a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor; and (ii) insulin supplementation.
5. A method according to claim 4, wherein the patient who is at risk of developing T1D is identified as having impaired glucose tolerance and evidence of pancreatic β cell loss or functional insufficiency.
6. A method according to any one of claims 1 to 5, wherein the insulin supplementation comprises 90% to 70% of a normal daily dosage of insulin supplementation.
7. A method according to any one of claims 1 to 5, wherein the insulin supplementation comprises 70% to 50% of a normal daily dosage of insulin supplementation.

8. A method according to any one of claims 1 to 5, wherein the insulin supplementation comprises 50% to 30% of a normal daily dosage of insulin supplementation.
9. A method according to any one of claims 1 to 5, wherein the insulin supplementation comprises 30% to 15% of a normal daily dosage of insulin supplementation.
10. A method according to any one of claims 1 to 5, wherein the insulin supplementation comprises 15% to 10% of a normal daily dosage of insulin supplementation.
11. A method according to any one of claims 1 to 5, wherein the insulin supplementation comprises 10% to 5% of a normal daily dosage of insulin supplementation.
12. A method according to any one of claims 1 to 5, wherein the insulin supplementation comprises 5% to 1% of a normal daily dosage of insulin supplementation.
13. A method according to any one of claims 1 to 5, wherein the insulin supplementation comprises 1% to .1% of a normal daily dosage of insulin supplementation.
14. A method for treating a patient diagnosed with type 1 diabetes (T1D) comprising administering to the patient a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation.
15. A method for reducing, suppressing, attenuating, or inhibiting one or more symptoms associated with T1D, comprising administering to a patient diagnosed with T1D a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation.
16. A method of claim 14, wherein the one or more symptoms is selected from the group consisting of excess gluconeogenesis, excess glycogenolysis, hyperglycemia, hyperglucagonemia, ketosis, diabetic ketoacidosis, hypertriglyceridemia, elevated plasma free fatty acid, weight loss, catabolic syndrome, terminal illness, hypertension, diabetic nephropathy, renal insufficiency, renal failure, hyperphagia, muscle wasting, diabetic neuropathy, diabetic retinopathy, or diabetic coma, excess HbA1c levels, polydipsia (increased thirst), xerostomia (dry mouth), polyphagia (increased hunger), polyuria (frequent urination), and fatigue.

17. A method of treating a patient who is at risk of developing T1D comprising (a) identifying a patient who is at risk of developing T1D and (b) administering to the patient a therapeutically effective amount of an isolated antagonistic antigen binding protein that specifically binds to the human glucagon receptor, without insulin supplementation.
18. A method according to claim 17, wherein the patient who is at risk of developing T1D is identified as having impaired glucose tolerance and evidence of pancreatic β cell loss or functional insufficiency.
19. A method according to any one of claims 1 to 18, wherein the isolated antagonistic antigen binding protein comprises an isolated antibody selected from the group consisting of a fully human antibody, a humanized antibody, a chimeric antibody, a monoclonal antibody, a polyclonal antibody, a recombinant antibody, an antigen-binding antibody fragment, a Fab, a Fab', a Fab₂, a Fab'₂, a IgG, a IgM, a IgA, a IgE, a scFv, a dsFv, a dAb, a nanobody, a unibody, a diabody, and a hemibody.
20. A method according to claim 19, wherein the isolated antagonistic antibody or antigen-binding antibody fragment specifically binds to a human glucagon receptor with a dissociation constant (K_D) of at least about 1×10^{-7} M, at least about 1×10^{-8} M, at least about 1×10^{-9} M, at least about 1×10^{-10} M, at least about 1×10^{-11} M, or at least about 1×10^{-12} M.
21. A method according to claim 19, wherein the isolated antagonistic antibody is a fully human antibody.
22. A method according to claim 19, wherein the fully human antibody comprises a human anti-GCGR antibody which comprises the amino acid sequence encoding the heavy chain variable region of SEQ ID NO: 2 and the amino acid sequence encoding the light chain variable region of SEQ ID NO: 3.
23. A method according to claim 19, wherein the fully human antibody comprises a human anti-GCGR antibody which comprises the amino acid sequence encoding the heavy chain variable region of SEQ ID NO: 4 and the amino acid sequence encoding the light chain variable region of SEQ ID NO: 5.

24. A method according to claim 19, wherein the fully human antibody comprises a human anti-GCGR antibody which comprises the amino acid sequence encoding the heavy chain variable region of SEQ ID NO: 6 and the amino acid sequence encoding the light chain variable region of SEQ ID NO: 7.

25. A method according to claim 19, wherein the fully human antibody comprises a human anti-GCGR antibody which comprises the amino acid sequence encoding the heavy chain variable region of SEQ ID NO: 28 and the amino acid sequence encoding the light chain variable region of SEQ ID NO: 47.

26. A method according to claim 19, wherein the chimeric antibody comprises a human anti-GCGR antibody which comprises the amino acid sequence encoding the heavy chain of SEQ ID NO: 8 and the amino acid sequence encoding the light chain of SEQ ID NO: 9.

27. A method according to claim 19, wherein the chimeric antibody comprises a human anti-GCGR antibody which comprises the amino acid sequence encoding the heavy chain of SEQ ID NO: 51 and the amino acid sequence encoding the light chain of SEQ ID NO: 52.

28. A method according to any one of claims 1-27, wherein the therapeutically effective amount of the isolated antagonistic antigen binding protein is selected from the group consisting of 0.001 to 100 mg/kg, 0.001 to 90 mg/kg, 0.001 to 80 mg/kg, 0.001 to 70 mg/kg, 0.001 to 60 mg/kg, 0.001 to 50 mg/kg, 0.001 to 40 mg/kg, 0.001 to 30 mg/kg, 0.001 to 20 mg/kg, 0.001 to 10 mg/kg, 0.001 to 5 mg/kg, 0.001 to 4 mg/kg, 0.001 to 3 mg/kg, 0.001 to 2 mg/kg, 0.001 to 1 mg/kg, 0.010 to 50 mg/kg, 0.010 to 40 mg/kg, 0.010 to 30 mg/kg, 0.010 to 20 mg/kg, 0.010 to 10 mg/kg, 0.010 to 5 mg/kg, 0.010 to 4 mg/kg, 0.010 to 3 mg/kg, 0.010 to 2 mg/kg, 0.010 to 1 mg/kg, 0.1 to 50 mg/kg, 0.1 to 40 mg/kg, 0.1 to 30 mg/kg, 0.1 to 20 mg/kg, 0.1 to 10 mg/kg, 0.1 to 5 mg/kg, 0.1 to 4 mg/kg, 0.1 to 3 mg/kg, 0.1 to 2 mg/kg, 0.1 to 1 mg/kg, 0.5 to 50 mg/kg, 0.5 to 40 mg/kg, 0.5 to 30 mg/kg, 0.5 to 20 mg/kg, 0.5 to 10 mg/kg, 0.5 to 5 mg/kg, 0.5 to 4 mg/kg, 0.5 to 3 mg/kg, 0.5 to 2 mg/kg, 0.5 to 1 mg/kg, 1 to 50 mg/kg, 1 to 40 mg/kg, 1 to 30 mg/kg, 1 to 20 mg/kg, 1 to 10 mg/kg, 1 to 5 mg/kg, 1 to 4 mg/kg, 1 to 3 mg/kg, 1 to 2 mg/kg, and 0.1 mg/kg to 1 mg/kg body weight per week.

29. A method according to claim 28, wherein the therapeutically effective amount of the isolated antagonistic antigen binding protein is 0.01 to 10 mg/kg body weight per week.

30. A method according to claim 28, wherein the therapeutically effective amount of the isolated antagonistic antigen binding protein is 0.01 to 10 mg/kg body weight bi-weekly.

31. A method according to any one of claims 1 to 30 wherein the isolated antagonistic antigen binding protein is admixed with a pharmaceutically acceptable carrier to form a pharmaceutical composition for systemic administration to the patient.

32. A method according to claim 31, wherein the systemic administration is selected from: intravenous injection, intramuscular injection, subcutaneous injection, intraperitoneal injection, transdermal injection, intraarterial injection, intrasternal injection, intrathecal injection, intraventricular injection, intraurethral injection, intracranial injection, intrasynovial injection or via infusions.

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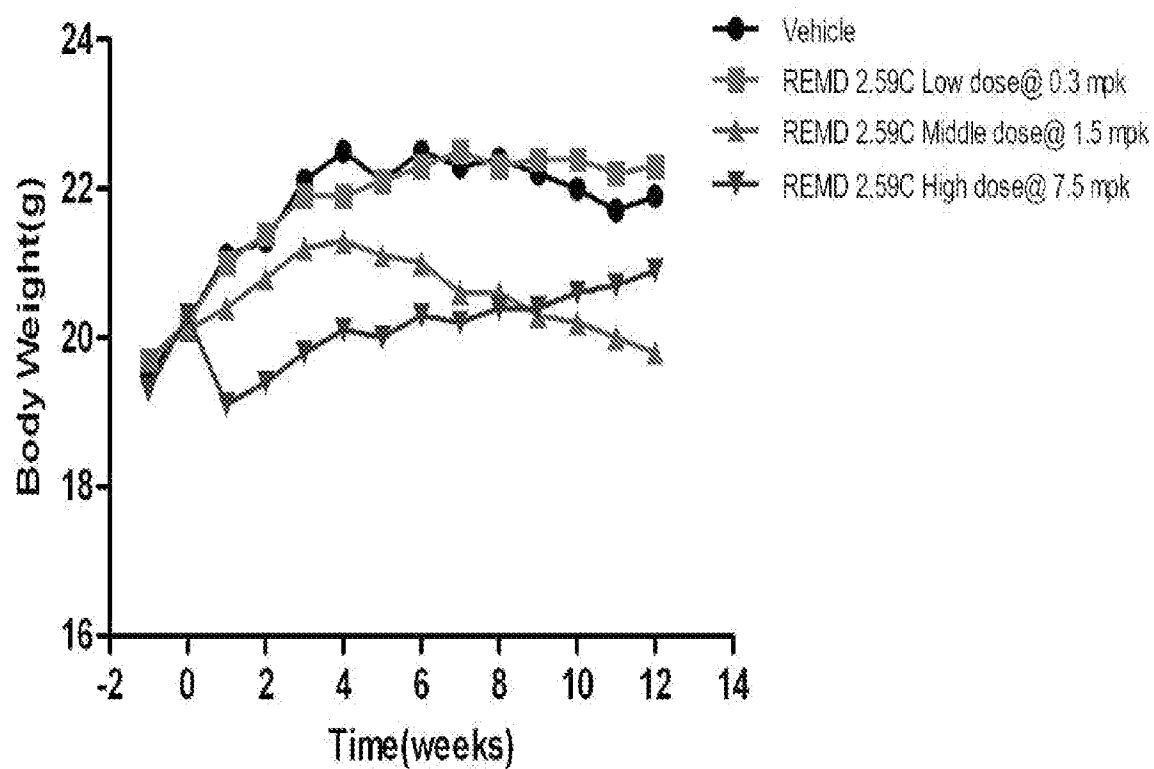


FIG. 1

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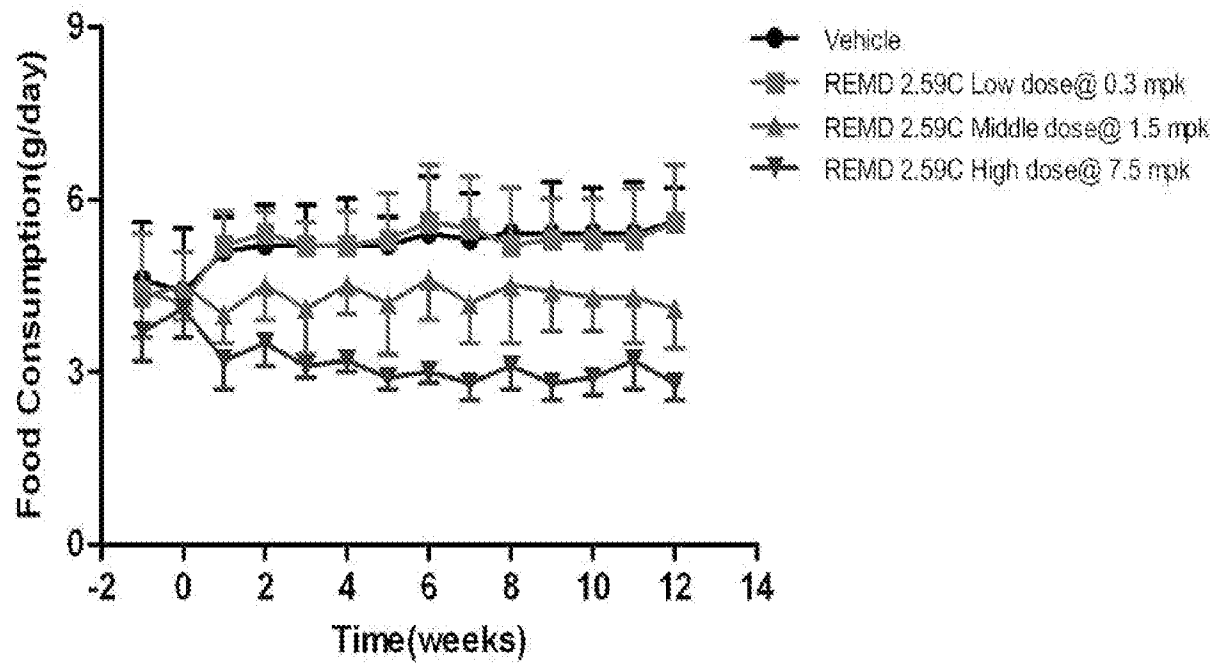


FIG. 2

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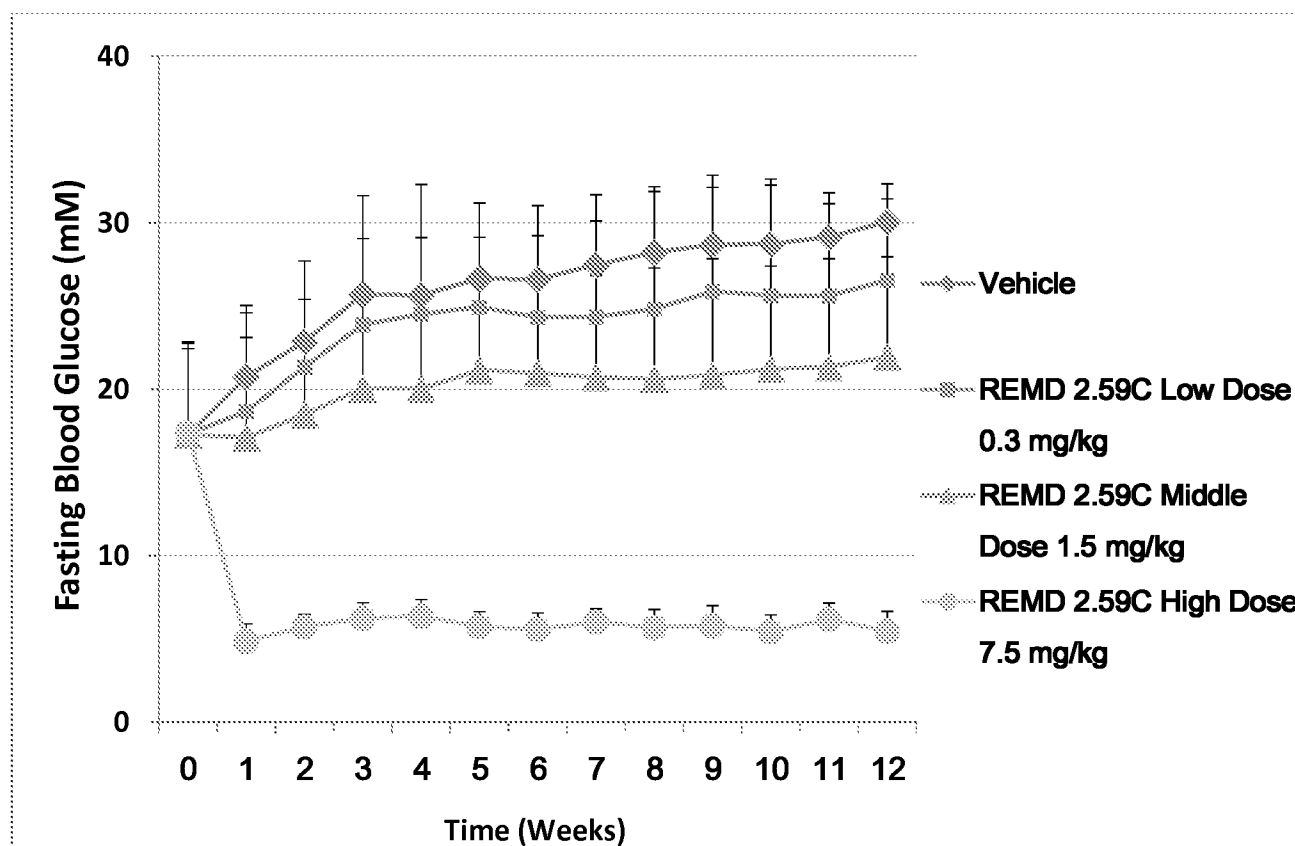


FIG. 3

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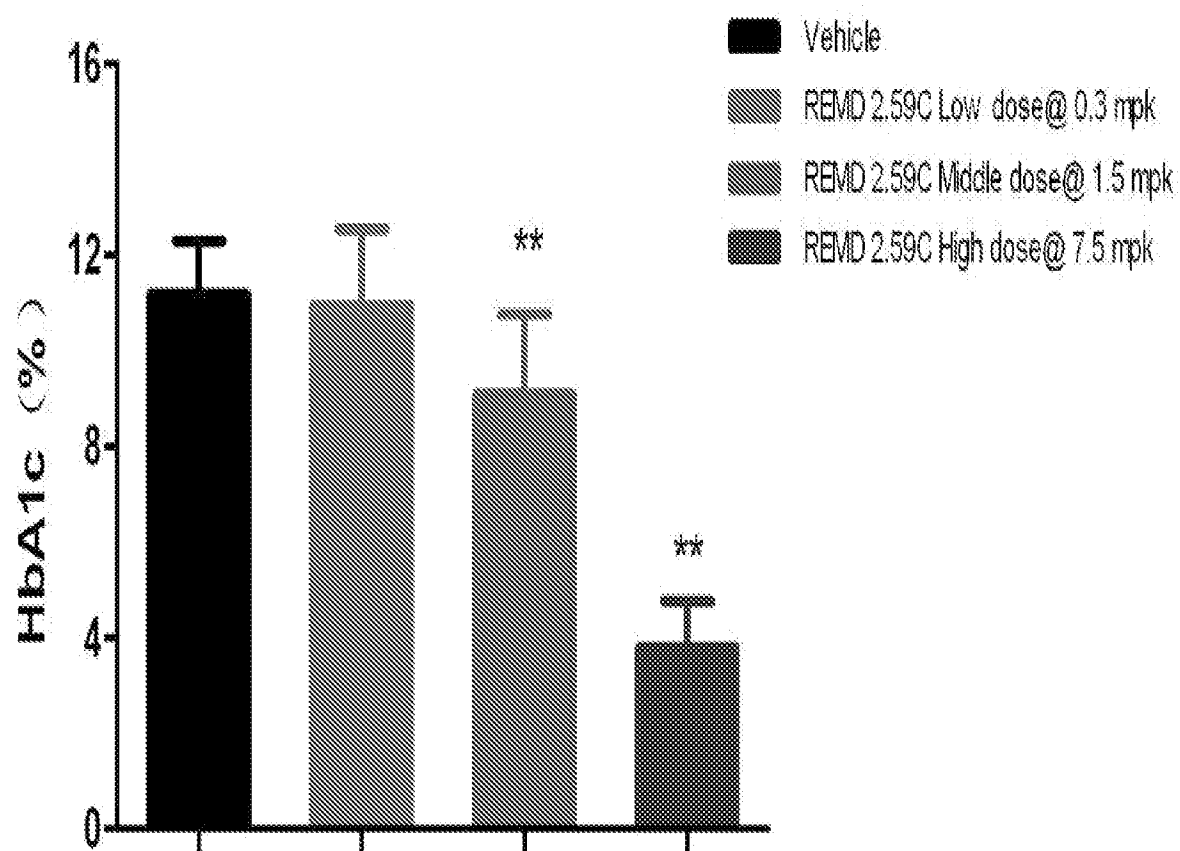


FIG. 4

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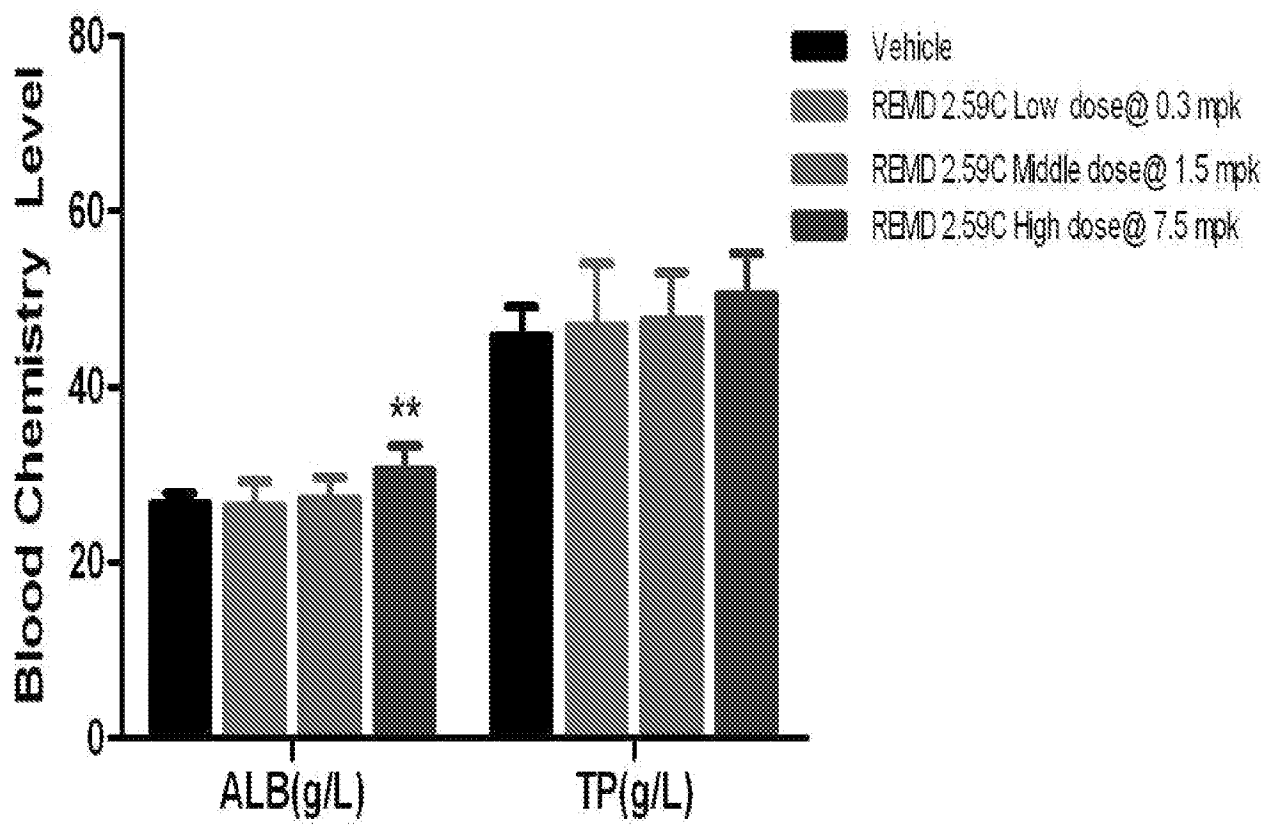


FIG. 5

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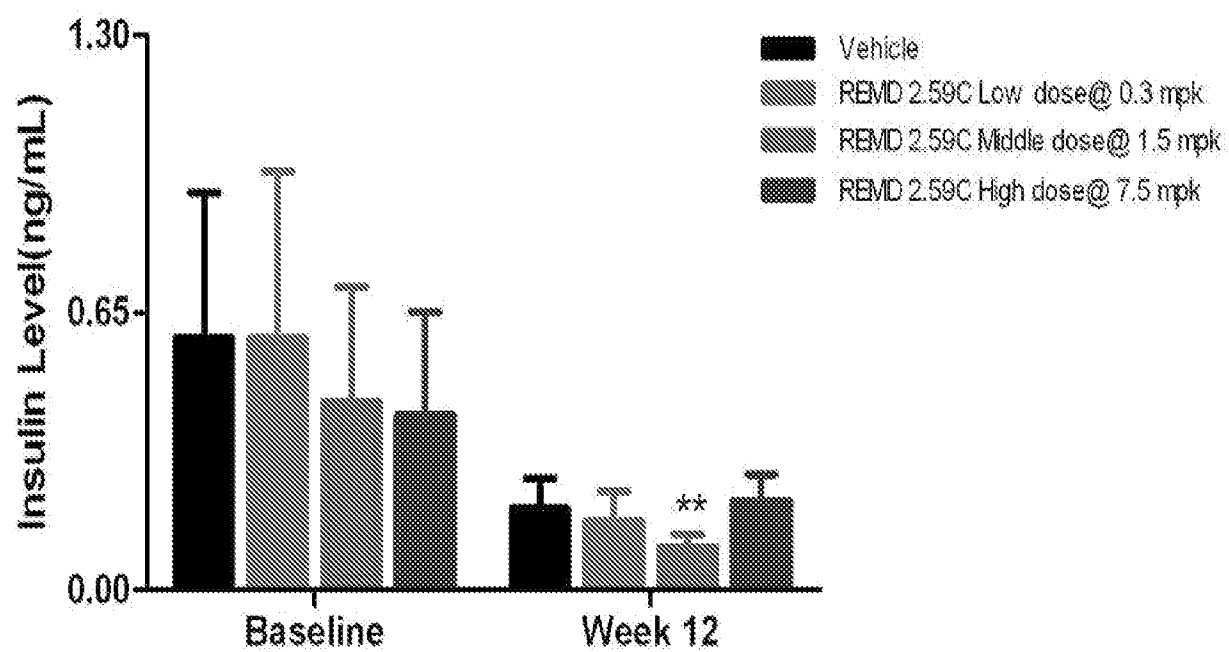


FIG. 6

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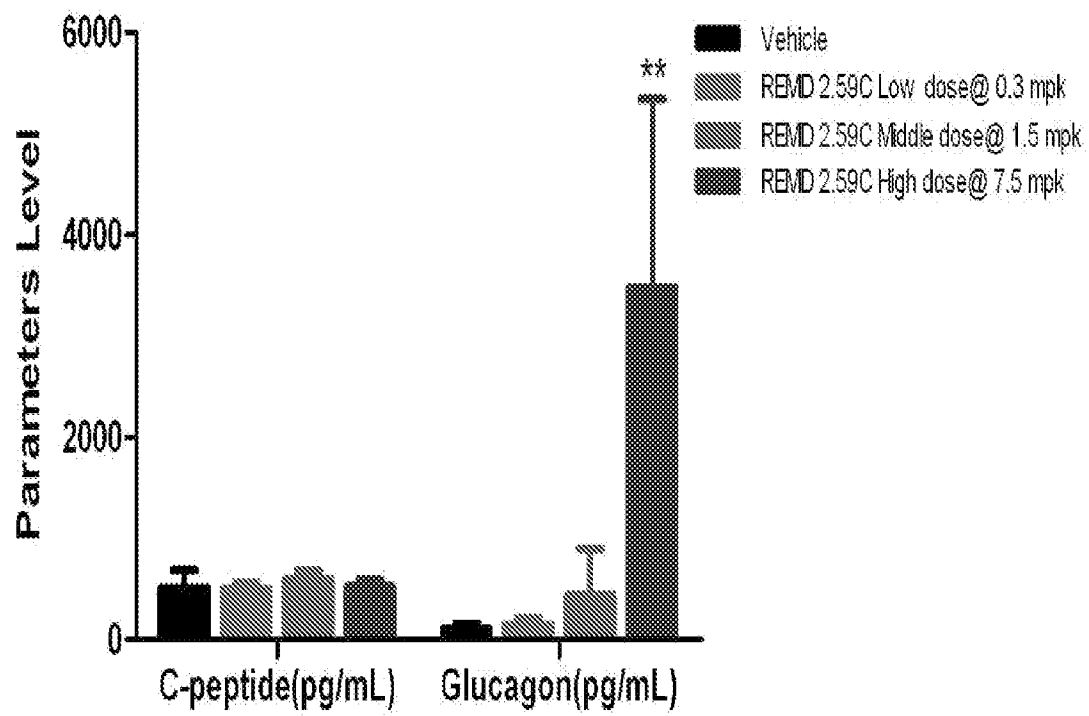


FIG. 7

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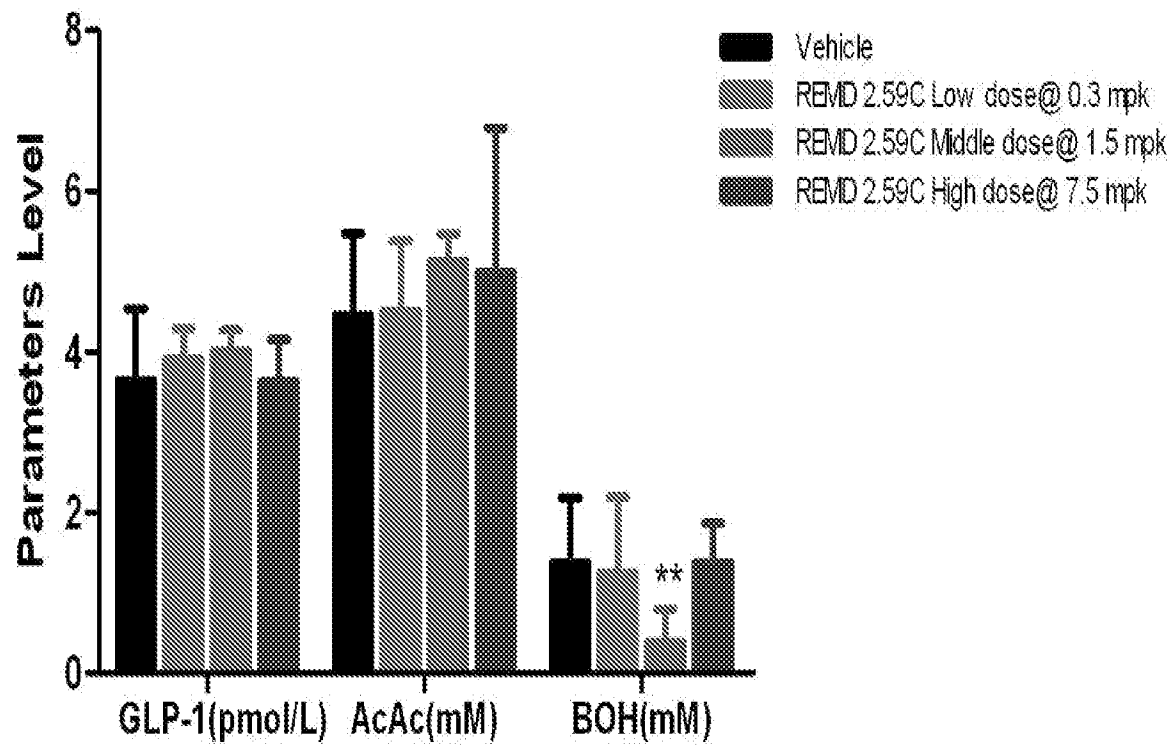


FIG. 8

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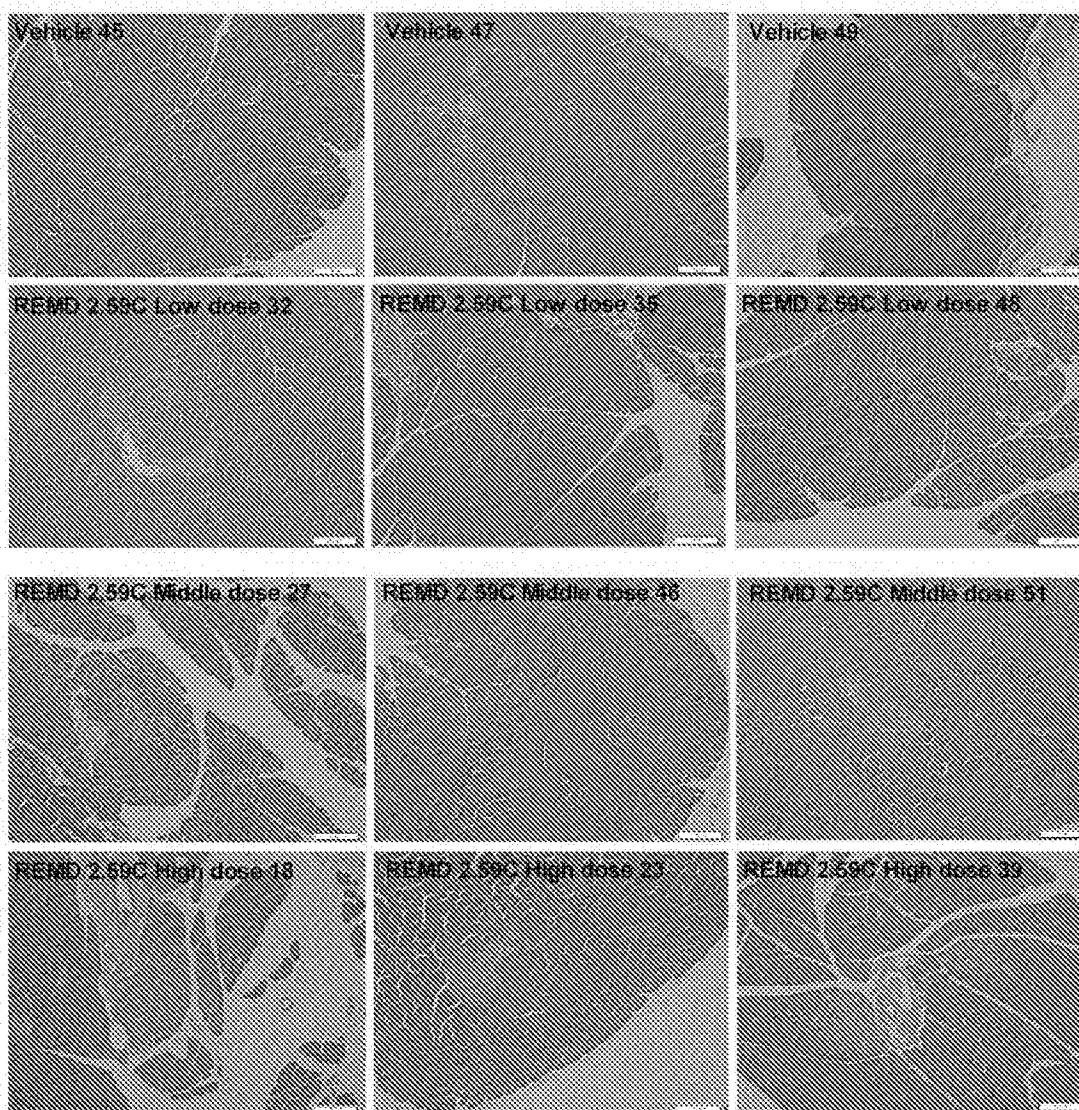


FIG. 9

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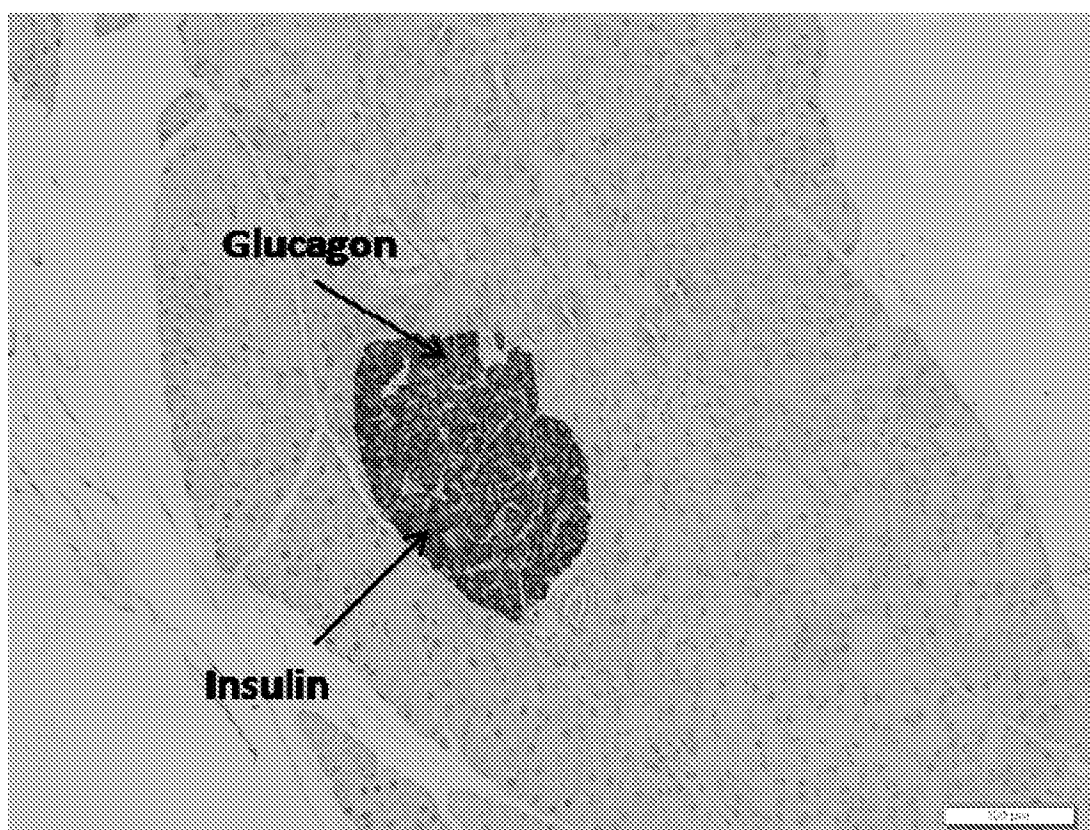


FIG. 10

FIG. 11A

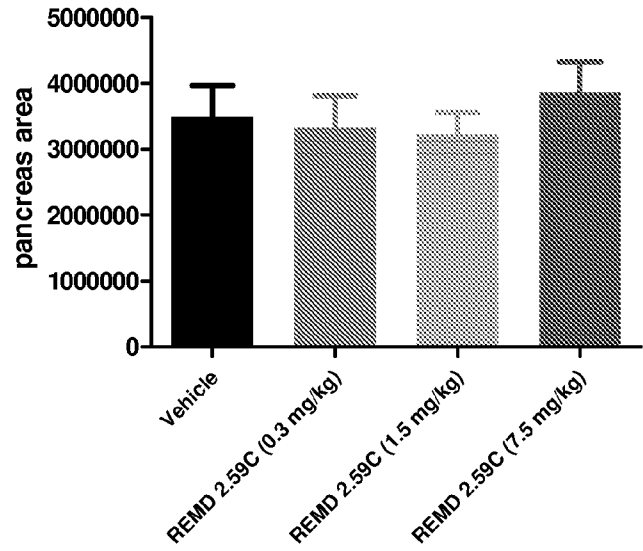


FIG. 11B

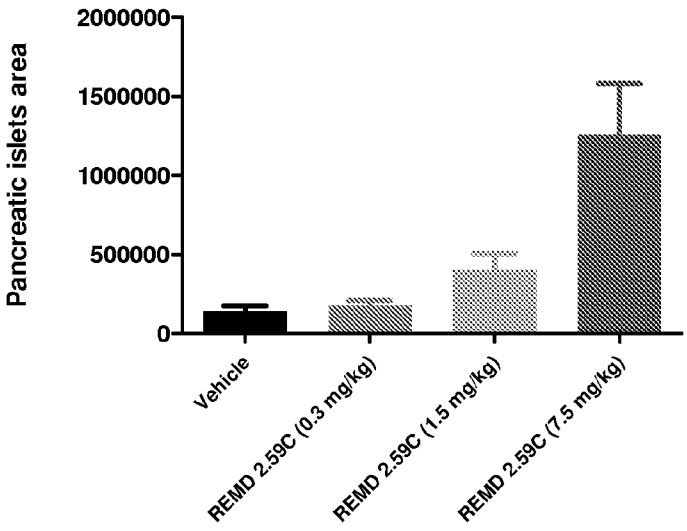
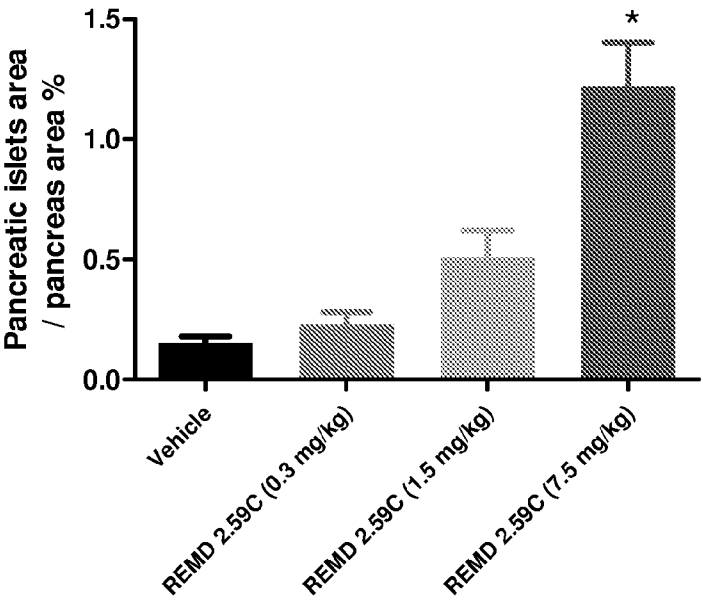


FIG. 11C



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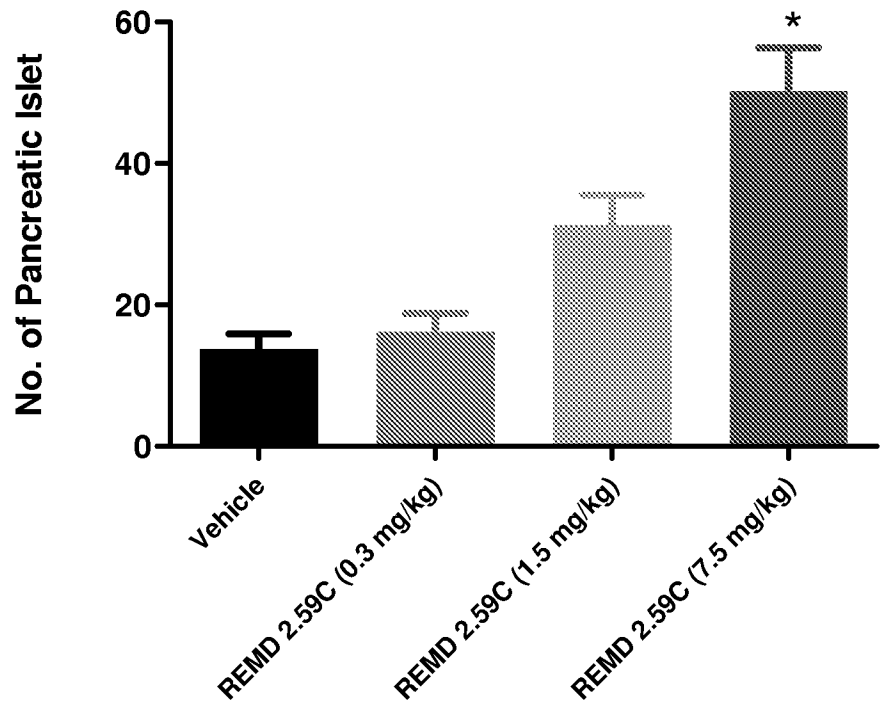


FIG. 12A

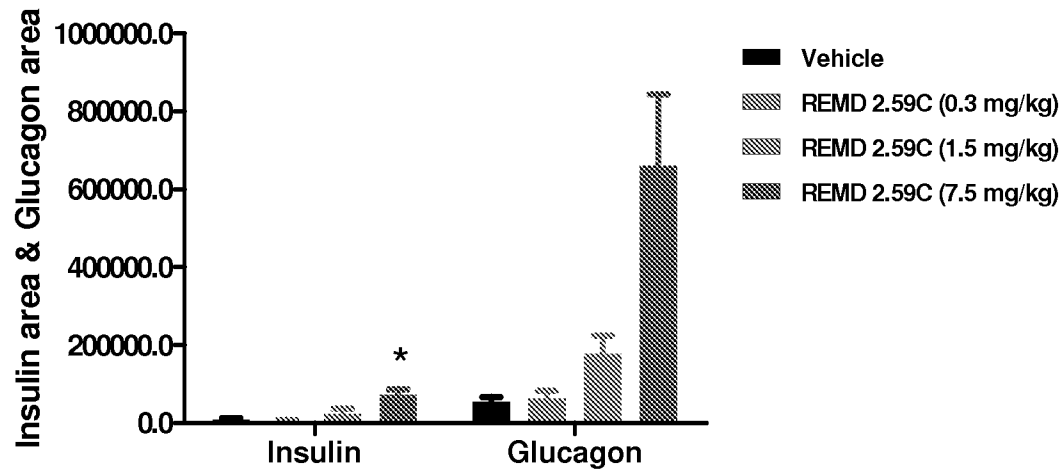


FIG. 12B

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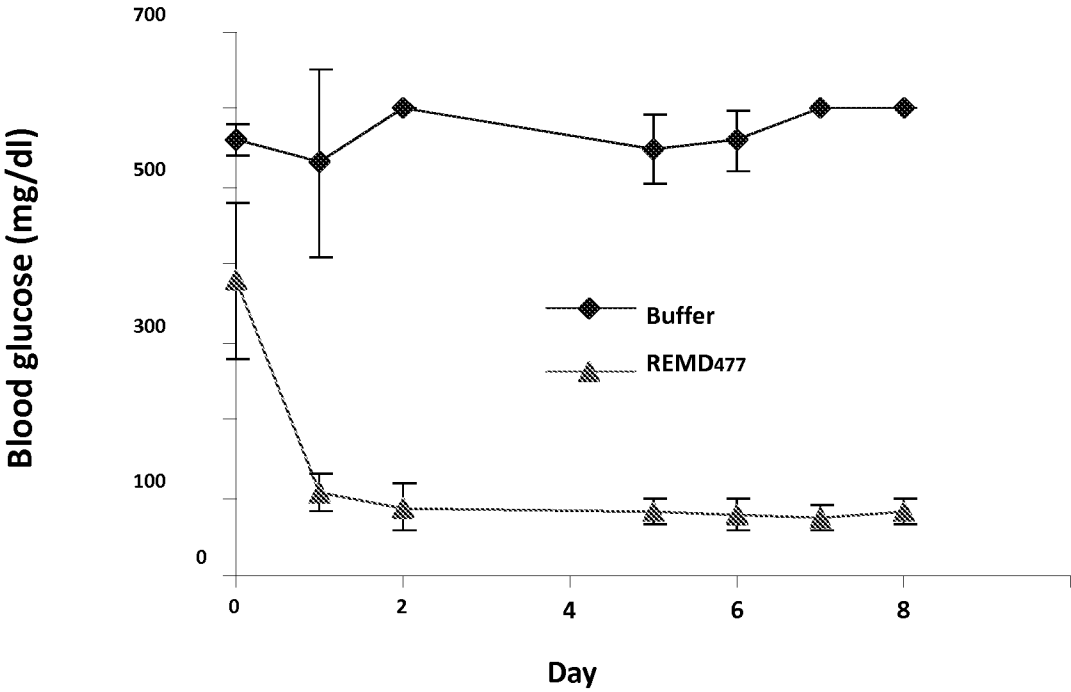


FIG. 13

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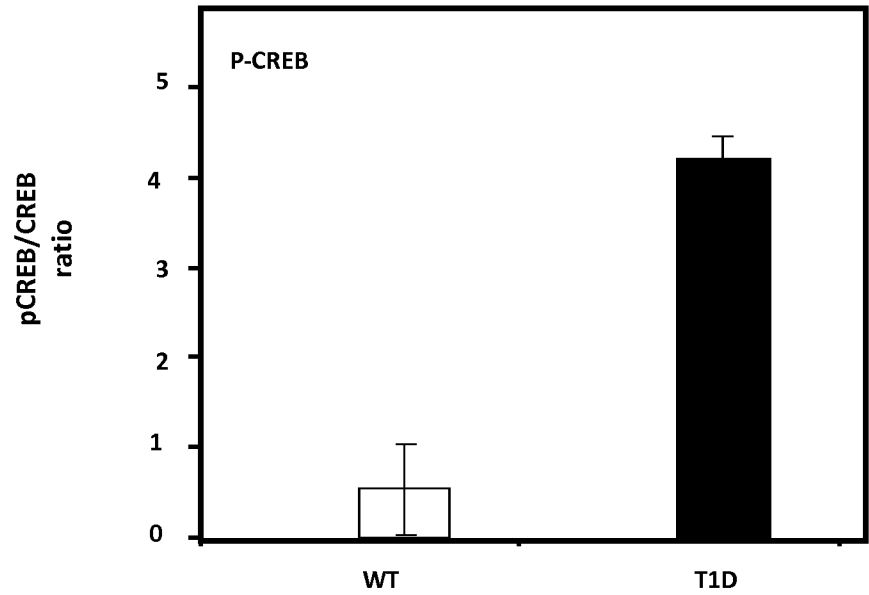


FIG. 14A

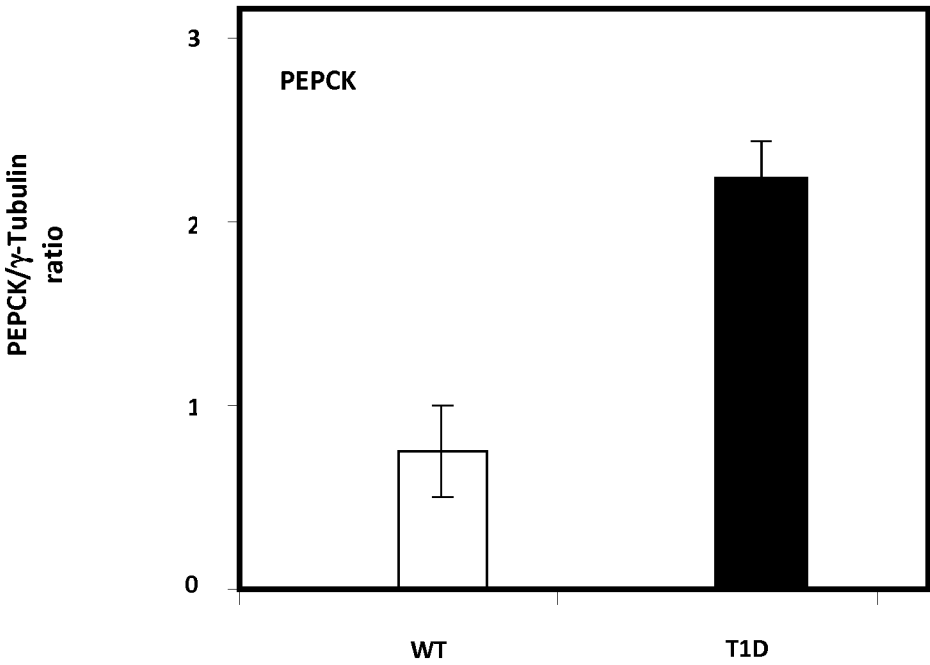


FIG. 14B

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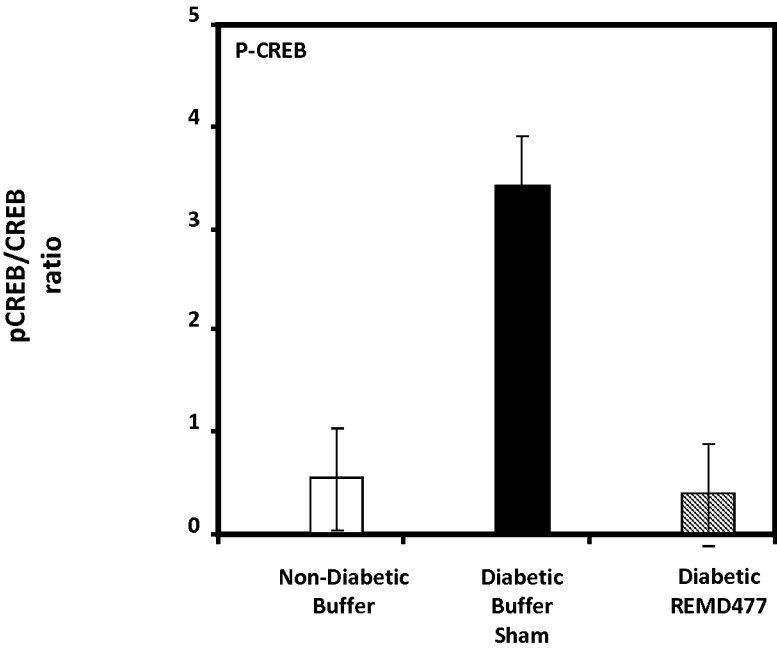


FIG. 15A

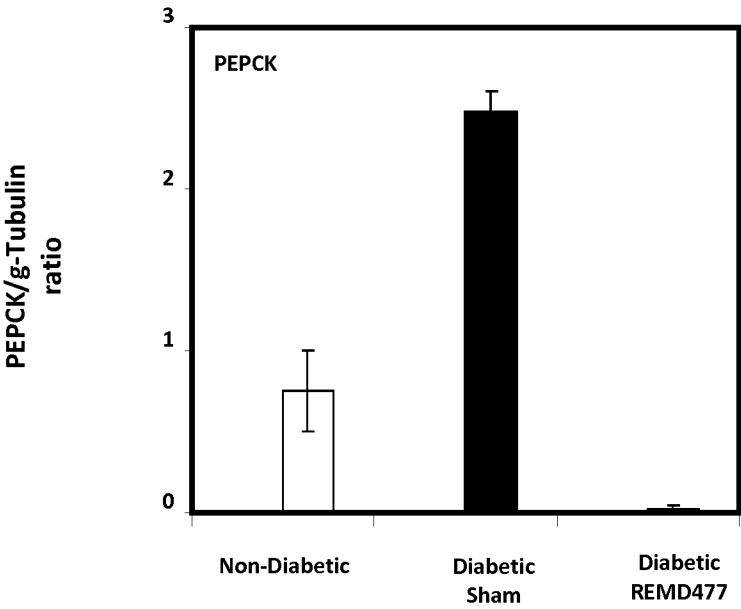


FIG. 15B

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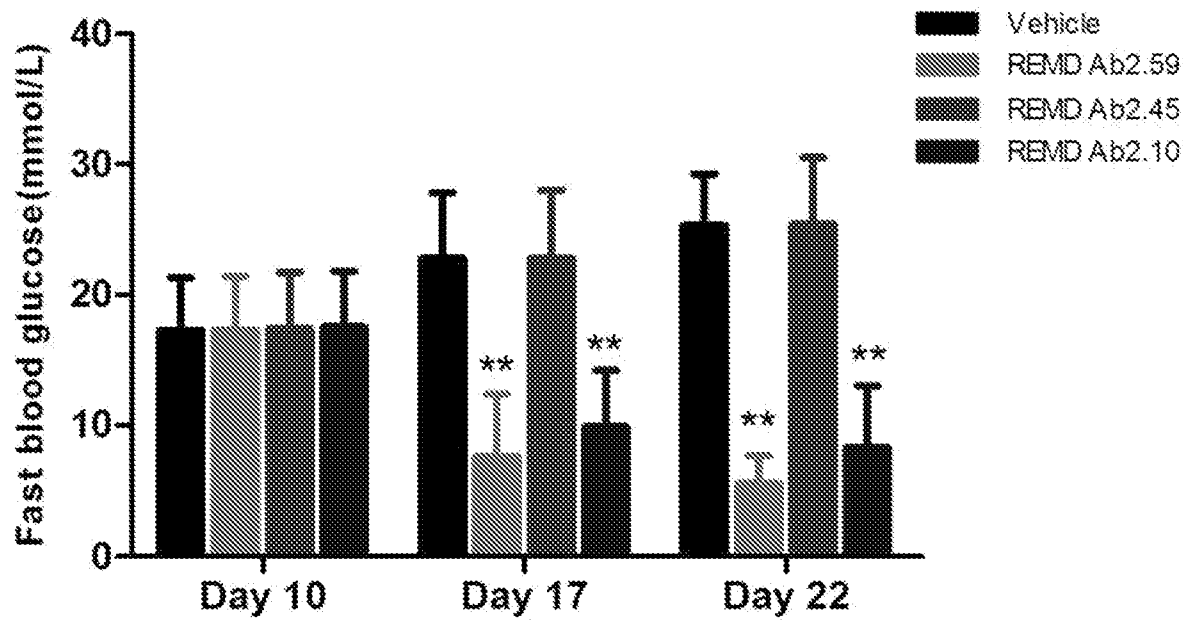


FIG. 16