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(74) Agents: **LOWEN, Gregory, T.** et al.; Morgan Lewis & Bockius LLP, 1111 Pennsylvania Avenue, NW, Washington, DC 20004 (US).

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(71) Applicant (for all designated States except US): **GENAERA CORPORATION** [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **MCLANE, Michael** [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US). **RUIZ-WHITE, Inez** [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US). **WOLFE, Henry** [US/US]; 5110 Campus Drive, Plymouth Meeting, PA 19462 (US).

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(54) Title: A METHOD FOR TREATING DIABETES

(57) Abstract: This application is directed to the use of steroid compounds for the selective inhibition of the enzyme PTP1B in a mammal for the treatment of diabetes.

A Method for Treating Diabetes

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 60/970,467, filed Sept. 6, 2007, which is incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] This application is directed to the use of steroid compounds for the selective inhibition of the enzyme PTP1B in a mammal for the treatment of diabetes.

BACKGROUND OF THE INVENTION

[0003] Several aminosterol compounds have been isolated from the liver of the dogfish shark, *Squalus acanthias*. One of these compounds has been designated as 1436, the structure of which is shown in FIG. 1. Compound 1436 has been previously described in, *e.g.*, U.S. Patent Nos. 5,763,430; 5,795,885; 5,847,172; 5,840,936 and 6,143,738, each of which is incorporated by reference in its entirety, and has been shown to inhibit weight gain and suppress appetite, which leads to weight loss in animal models.

[0004] Diabetes is a major medical problem in the United States and increasingly so in the rest of the developed world. Type II diabetes in particular is caused primarily by the effects of a sedentary life style and a fat-rich diet. The diabetic individual is susceptible to medical problems directly related to his disease such as elevated serum cholesterol, high blood pressure, congenital obesity syndromes (including congenital leptin, pro-opiomelanocortin (POMC) and melanocortin-4 receptor (MC4R) deficiencies), and sleep apnea, especially in pickwickian syndrome. In addition, the accumulation of fat in the liver can progress to nonalcoholic steatohepatitis and cirrhosis. Another problem for obese diabetic individuals is an increased risk in any surgery that must cut through thick layers of fatty tissue that are highly vascularized and therefore prone to hemorrhage. Necessary surgery is frequently postponed until this diabetic patient can lose sufficient weight to make the risk of the operation acceptable.

[0005] Insulin is an important regulator of different metabolic processes and plays a key role in the control of blood glucose. Defects related to insulin synthesis and signaling lead to diabetes mellitus. Binding of insulin to the insulin receptor (IR) causes rapid autophosphorylation of several tyrosine residues in the intracellular part of the beta-subunit. Three closely positioned tyrosine residues (the tyrosine-1150 domain) must be

phosphorylated to obtain maximum activity of the insulin receptor tyrosine kinase (IRTK), which transmits further signals via tyrosine phosphorylation of other cellular substrates, including insulin receptor substrate-1 (IRS-1) and insulin receptor substrate-2 (IRS-2).

[0006] Protein phosphorylation is a well-recognized cellular mechanism for transducing and regulating signals during different stages of cellular function (see, *e.g.*, Hunter, Phil, *Trans. R. Soc. Lond. B.* 353: 583-605 (1998); Chan *et al.*, *Annu. Rev. Immunol.* 12: 555-592 (1994); Zhang, *Curr. Top. Cell. Reg.* 35: 21-68 (1997); Matozaki and Kasuga, *Cell. Signal.* 8: 113-119 (1996)). There are at least two major recognized classes of phosphatases: (1) those that dephosphorylate proteins that contain a phosphate group(s) on a serine or threonine moiety (termed Ser/Thr phosphatases or dual specificity phosphatases or DSPs) and (2) those that remove a phosphate group(s) from the amino acid tyrosine (termed protein tyrosine phosphatases or PTPases or PTPs).

[0007] Several studies clearly indicate that the activity of the auto-phosphorylated IRTK can be reversed by dephosphorylation *in vitro* (reviewed in Goldstein, *Receptor* 3: 1-15 (1993)) with the tri-phosphorylated tyrosine-1150 domain being the most sensitive target for PTPases. This tri-phosphorylated tyrosine-1150 domain appears to function as a control switch of IRTK activity and the IRTK appears to be tightly regulated by PTP-mediated dephosphorylation *in vivo* (Faure *et al.*, *J. Biol. Chem.* 267: 11215-11221 (1992)).

[0008] PTP1B has been identified as at least one of the major phosphatases involved in IRTK regulation through studies conducted both *in vitro* (Seely *et al.*, *Diabetes* 45: 1379-1385 (1996)) and *in vivo* using PTP1B neutralizing antibodies (Ahmad *et al.*, *J. Biol. Chem.* 270: 20503-20508 (1995)). Three independent studies have indicated that PTP1B knock-out mice have increased glucose tolerance, increased insulin sensitivity and decreased weight gain when on a high fat diet (Elchebly *et al.*, *Science* 283: 1544-1548 (1999), Klamann *et al.*, *Mol. Cell. Biol.* 20: 5479-5489 (2000), and Bence *et al.*, *Nature Med* (2006)). Overexpression or altered activity of tyrosine phosphatase PTP1B can contribute to the progression of various disorders, including insulin resistance and diabetes (*Ann. Rev. Biochem.* 54: 897-930 (1985)). Furthermore, there is evidence which suggests that inhibition of protein tyrosine phosphatase PTP1B is therapeutically beneficial for the treatment of disorders such as type I and II diabetes, obesity, autoimmune disorders, acute and chronic inflammation, osteoporosis and various forms of cancer (Zhang Z Y *et al.*, *Expert Opin. Investig. Drugs* 2: 223-33 (2003); Taylor S D

et al., *Expert Opin. Investig. Drugs* 3:199-214 (2004); *J. Natl. Cancer Inst.* 86: 372-378 (1994); *Mol. Cell. Biol.* 14: 6674-6682 (1994); *The EMBO J.* 12: 1937-1946 (1993); *J. Biol. Chem.* 269: 30659-30667 (1994); and *Biochemical Pharmacology* 54: 703-711(1997)). Agents that inhibit phosphatase activity and thereby inhibit dephosphorylation of the insulin signaling pathway, increase whole-body insulin sensitivity. This is therapeutically beneficial in treatment of insulin resistance associated with Type II diabetes and obesity.

[0009] In addition, it has been shown (Bence KK et al., *Nat Med* 8:917-24 (2006)) that neuronal PTP1B in the brain regulates body weight, adiposity and leptin action.

Therefore, if a PTP1B inhibitor can cross the blood brain barrier it will not only sensitize the effect of insulin but also result in weight loss an added benefit in the treatment of type II diabetes and in addition the treatment of obesity and its complications.

[0010] There is also reported insulin resistance in Type I diabetes for which agents with PTP1B inhibitory activity would be a useful therapeutic. An insulin sensitizing agent in early type I diabetes or in a pre-diabetic statue might delay the onset of diabetes by increasing the sensitivity to insulin and thereby reducing the requirement for over-secretion of insulin from remaining insulin-producing beta-cells in the pancreas, i.e. sparing these cells from subsequent "burn-out" and death. It has also been shown (Jiang ZX and Zhang ZY, *Cancer Metastasis Rev.* 2:263-72 (2008)) that inhibitors of PTP1B can prevent the growth of tumors and therefore be useful for the treatment of cancer.

[0011] The PTPase family of enzymes can be classified into two subgroups: (1) intracellular or nontransmembrane PTPases and (2) receptor-type or transmembrane PTPases. Most known intracellular type PTPases contain a single conserved catalytic phosphatase domain consisting of 220-240 amino acid residues. The regions outside the PTPase domains are believed to play important roles in localizing the intracellular PTPases subcellularly (Mauro, L. J. and Dixon J. E., *TIBS* 19: 151-155 (1994)). The first of the intracellular PTPases to be purified and characterized was PTP1B (Tonks et al., *J. Biol. Chem.* 263: 6722-6730 (1988)). Other examples of intracellular PTPases include (1) T-cell PTPase (TCPTP) (Cool et al., *Proc. Natl. Acad. Sci. USA* 86: 5257-5261 (1989)), (2) neuronal phosphatases STEP (Lombroso et al., *Proc. Natl. Acad. Sci. USA* 88: 7242-7246 (1991)), (3) PTP1C/SH-PTP1/SHP-1 (Plutzky et al., *Proc. Natl. Acad. Sci. USA* 89: 1123-1127 (1992)), (4) PTP1D/Syp/SH-PPT2/SHP-2 (Vogel et al., *Science* 259: 1611-1614 (1993); Feng et al., *Science* 259: 1607-1611(1993)).

[0012] Receptor-type PTPases consist of (a) a putative ligand-binding extracellular domain, (b) a transmembrane segment, and (c) an intracellular catalytic region. The structure and sizes of the putative ligand-binding extracellular domains of receptor-type PTPases are quite divergent. In contrast, the intracellular catalytic regions of receptor-type PTPases are very homologous to each other and to the intracellular PTPases. Most receptor-type PTPases have two tandemly duplicated catalytic PTPase domains. The first PTPase receptor subtypes identified were (1) CD45 (Ralph, S. J., *EMBO J.* 6: 1251-1257 (1987)) and (2) LAR (Streuli et al., *J. Exp. Med.* 168:1523-1530 (1988)). Since then, many more receptor subtypes have been isolated and characterized, including, e.g., PTPalpha, PTPbeta, PTPdelta, PTPepsilon and PTPxi. (Krueger et al. *EMBO J.* 9: 3241-3252 (1990)).

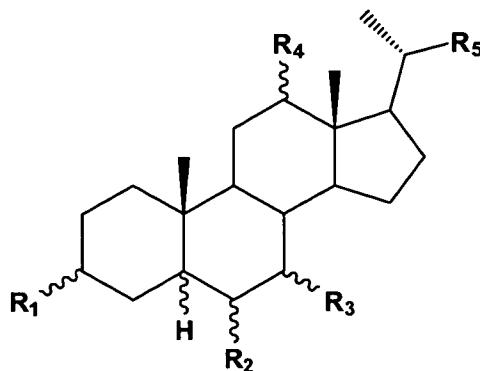
[0013] Although agents have been identified for use as PTP1B inhibitors, such as the heteroaryl- and aryl-amino acetic acids described in WO 01/19831, WO 01/19830, and WO 01/17516, these agents do not exhibit separation of the inhibitory activity between PTP1B and TCPTP. Furthermore, because of the potential immunosuppressive effects resulting from inhibiting TCPTP, selective inhibition of PTP1B over TCPTP would make such agents more suitable for drug development as they could diminish or eliminate undesired side effects resulting from such nonselectivity.

[0014] Therefore, there is a need for a drug that can safely treat diabetes by the selective inhibition of PTP1B. In addition, if neuronal PTP1B is inhibited rapid weight loss can be induced in obese individuals thus also treating the effects of obesity, prevent neurodegeneration or Alzheimer's. A drug of this type would also be useful for the treatment of complications due to obesity, obesity in type II diabetes, high serum cholesterol, sleep apnea (especially in pickwickian syndrome), nonalcoholic steatohepatitis and surgery for obese patients. Finally, a PTP1B inhibitor could also be useful for the treatment of cancer.

SUMMARY OF THE INVENTION

[0015] The present invention relates to various aminosteroids which inhibit protein phosphatase IB (PTPIB). The invention also relates to compositions which contain these aminosteroids, and methods of their use to treat diabetes in mammals, particularly humans.

[0016] One aspect of the invention relates to steroid compounds that are inhibitors of the enzyme PTP1B of the following formula, or a pharmaceutically acceptable salt thereof:



wherein:

$R_1 = -NH(CH_2)_{1-4}-NH-R_6$ or $-OH$ or $=O$ or H or piperazine or amino piperidine;

$R_6 = -(CH_2)_{1-4}-NH-R_7$ or C_1-C_5 alkyl or phenyl or H ;

$R_7 = -(CH_2)_{1-4}-N-R_8$;

$R_8 = C_1-C_5$ alkyl or benzyl or benzyl with 1-3 R_9 groups or H ;

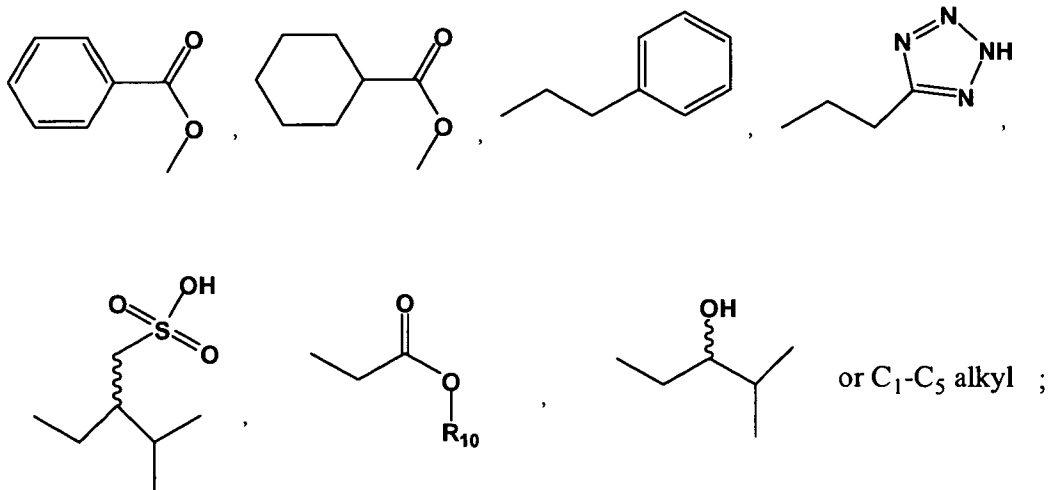
$R_9 = -OH$ or $-OCH_3$ or $-C_1-C_5$ alkyl;

$R_2 = -OH$ or H ;

$R_3 = -OH$ or H ;

$R_4 = -OH$ or H ;

$R_5 =$



$R_{10} = H$ or C_1-C_5 alkyl.

[0017] Another aspect of the invention is a compound selected from the compounds listed in Table 1, or a pharmaceutically acceptable salt thereof.

[0018] Another aspect of the invention is a pharmaceutical composition comprising a compound listed in Table 1 and a diluent or carrier.

[0019] Another aspect of the invention is a method of treating or preventing diabetes in a mammal, particularly a human, comprising administering to said mammal a therapeutically effective amount of a compound of the above formula or a compound listed in Table 1.

[0020] Another aspect of the invention is a method for treating a disorder in a mammal mediated by inhibition of protein tyrosine phosphatase PTP1B comprising administering to a mammal in need thereof a therapeutically effective amount of a compound of the above formula or a compound of Table 1.

[0021] In exemplary embodiments, the disorder treated by administration of a compound of the above formula or a compound of Table 1 includes, but is not limited to, obesity in type II diabetes, high serum cholesterol, sleep apnea and nonalcoholic steatohepatitis.

BRIEF DESCRIPTION OF THE FIGURES

[0022] Figure 1 shows that MSI-1701 and 1873 treated ob/ob mice have lower fasting blood glucose levels compared to saline treated controls.

[0023] Figure 2 shows a graph of the glucose tolerance test that produced the data in Figure 3.

[0024] Figure 3 shows that MSI-1701 and 1873 treated ob/ob mice respond significantly faster in a glucose tolerance test than the saline treated controls.

[0025] Figure 4 shows that MSI-1436 can increase the level of insulin stimulated tyrosine phosphorylation of IR β in the rat hypothalamus.

DETAILED DESCRIPTION OF THE INVENTION

[0026] The compounds listed in Table 1 are intended to include all pharmaceutically acceptable salts of the listed compounds. In addition, where the stereochemistry at any given carbon atom is undefined, it is intended that each individual stereoisomer is encompassed as well as the racemic mixture.

[0027] The aminosteroids of the invention may be administered alone or as part of a pharmaceutical composition. Pharmaceutical compositions for use *in vitro* or *in vivo* in accordance with the present invention may be formulated in a conventional manner using

one or more physiologically acceptable carriers comprising excipients and auxiliaries that facilitate processing of the active compounds into preparations which can be used pharmaceutically. Proper formulation is dependent upon the route of administration chosen. Examples of carriers or excipients include, but are not limited to, calcium carbonate, calcium phosphate, various sugars, starches, cellulose derivatives, gelatin and polymers such as polyethylene glycols.

[0028] In addition to carriers, the pharmaceutical compositions of the invention may also optionally include stabilizers, preservatives and/or adjuvants. For examples of typical carriers, stabilizers and adjuvants known to those of skill in the art, see Remington: The Science and Practice of Pharmacy, Lippincott, Williams & Wilkins, 21st ed. (2005), which is incorporated by reference in its entirety.

[0029] Optionally, other therapies known to those of skill in the art may be combined with the administration of the aminosteroids of the invention. More than one aminosteroid may be present in a single composition.

[0030] *In vivo* administration of the aminosteroids of the invention can be effected in one dose, multiple doses, continuously or intermittently throughout the course of treatment. Doses range from about 0.01 mg/kg to about 10 mg/kg, preferably between about 0.01 mg/kg to about 1 mg/kg, and most preferably between about 0.1 mg/kg to about 1 mg/kg in single or divided daily doses. Methods of determining the most effective means and dosages of administration are well known to those of skill in the art and will vary with the composition used for therapy, the purpose of the therapy, the target cell being treated and the subject being treated. Single or multiple administrations can be carried out with the dose level and pattern being selected by the treating physician.

[0031] Pharmaceutical compositions containing the aminosteroids of the invention can be administered by any suitable route, including oral, rectal, intranasal, topical (including transdermal, aerosol, ocular, buccal and sublingual), parenteral (including subcutaneous, intramuscular, intravenous), intraperitoneal and pulmonary. It will be appreciated that the preferred route will vary with the condition and age of the recipient, and the disease being treated.

[0032] For oral administration, the aminosteroids of the invention can be formulated readily by combining them with pharmaceutically acceptable carriers well known in the art. Such carriers enable the compounds of the invention to be formulated as tablets, pills, dragees, capsules, liquids, gels, syrups, slurries, suspensions and the like, for oral ingestion by a patient to be treated. Pharmaceutical preparations for oral use can be

obtained by combining the active compound with a solid excipient, optionally grinding a resulting mixture, and processing the mixture of granules, after adding suitable auxiliaries, if desired, to obtain tablets or dragee cores. Suitable excipients include, for example, fillers such as sugars, including lactose, sucrose, mannitol, or sorbitol; cellulose preparations such as maize starch, wheat starch, rice starch, potato starch, gelatin, gum tragacanth, methyl cellulose, hydroxypropylmethylcellulose, sodium carboxymethylcellulose and polyvinylpyrrolidone (PVP). If desired, disintegrating agents may be added, such as the cross-linked polyvinyl pyrrolidone, agar, alginic acid or a salt thereof, such as sodium alginate.

[0033] For administration by inhalation, the aminosteroids of the present invention are conveniently delivered in the form of an aerosol spray presentation from pressurized packs or a nebuliser, with the use of a suitable propellant, *e.g.*, dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, carbon dioxide or other suitable gas. In the case of pressurized aerosol the dosage unit may be determined by providing a valve to deliver a metered amount. Capsules and cartridges of *e.g.*, gelatin for use in an inhaler or insufflator may be formulated containing a powder mix of the compound and a suitable powder base such as lactose or starch.

[0034] The aminosteroids can be formulated for parenteral administration by injection, *e.g.*, bolus injection or continuous infusion. Formulations for injection may be presented in unit dosage form, *e.g.*, in ampoules or in multi-dose containers, with an added preservative. The compositions may take such forms as suspensions, solutions or emulsions in oily or aqueous vehicles, and may contain formulatory agents such as buffers, bacteriostats, suspending agents, stabilizing agents, thickening agents, dispersing agents or mixtures thereof.

[0035] Pharmaceutical formulations for parenteral administration include aqueous solutions of the active compounds in water-soluble form. Additionally, suspensions of the active compounds may be prepared as appropriate oily injection suspensions. Suitable lipophilic solvents or vehicles include fatty oils such as sesame oil, or synthetic fatty acid esters, such as ethyl oleate or triglycerides or liposomes. Aqueous injection suspensions may contain substances that increase the viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol or dextran. Optionally, the suspension may also contain suitable stabilizers or agents that increase the solubility of the compounds to allow for the preparation of highly concentrated solutions. In a preferred embodiment,

the aminosteroids of the invention are dissolved in a 5% sugar solution, such as dextrose, before being administered parenterally.

[0036] For injection, the aminosteroids of the invention may be formulated in aqueous solutions, preferably in physiologically compatible buffers such as Hanks's solution, Ringer's solution or physiological saline buffer. For transmucosal administration, penetrants appropriate to the barrier to be permeated are used in the formulation. Such penetrants are generally known in the art.

[0037] The aminosteroids may also be formulated in rectal compositions such as suppositories or retention enemas, *e.g.*, containing conventional suppository bases such as cocoa butter or other glycerides.

[0038] The aminosteroids may also be combined with at least one additional therapeutic agent.

[0039] Without further description, it is believed that one of ordinary skill in the art can, using the preceding description and the following illustrative examples, make and utilize the compounds of the present invention and practice the claimed methods. The following working examples therefore, specifically point out preferred embodiments of the present invention, and are not to be construed as limiting in any way the remainder of the disclosure.

EXAMPLES

[0040] Example 1-Inhibition of PTP1B by steroid analogues

[0041] The steroid analogues were tested for inhibition against the commercially available full length tyrosine phosphatase PTP1B. The ability of each analogue to inhibit the activity of PTP1B was measured in the presence of 10 μ M of the steroid analogue. The assay uses para-nitro-phenyl phosphate (pNPP), a non-specific substrate to assess phosphatase activity. Phosphatase activity was based on the ability of PTP1B to catalyze the hydrolysis of pNPP to p-nitrophenol (pNP). The activity was measured using a single point spectrophometric absorbance at 405 nm (the absorbance of the chromogenic product, para-nitrophenol (pNP)). The percent inhibition of tyrosine phosphatase activity by the steroid analogues was determined by the fractional response of pNP formation in the presence of inhibitor over the maximal response pNP formation observed in the absence of inhibitor. The results of these assays are shown in Table 1, column C and show many analogues that cause greater than 50 % inhibition at 5 μ M concentration.

[0042] Example 2- Inhibition of TCPTP by steroid analogues

[0043] The steroid analogues were also tested for their ability to inhibit the tyrosine phosphatase TCPTP as an indication of their potential toxicity by the inhibition of the immune response. The TCPTP inhibition assay was done in the same manner as the PTP1B assay except full length TCPTP was used as the enzyme and the inhibitor was at a concentration of 200 μ M. The results of the TCPTP inhibition assays are shown in Table 1, column D and show three compounds that inhibit TCPTP less than 50 % even at a 20 fold greater concentration.

[0044] Example 3- Effect of steroid analogues on body weight, blood glucose levels and the oral glucose tolerance test (OGTT) in the diabetic mouse

[0045] To determine in vivo efficacy of the steroid analogues a Db/db (*Lepr^{db}*) mouse model was used. Db/db mice are extensively used for screening of antidiabetic agents. Db/db mice were treated with either saline or 5 or 10 mg/kg steroid analogue every 3 days for a total of 4 doses via ip injection. Body weight, glucose tolerance and fasting blood glucose levels were measured for each group during the study. Each group had at least an N of 4 animals. All reagents and lab animals are commercially available.

[0046] Starting at study day 0, body weight measurements were taken every day for each group for up to 30 days. Percent change in body weight was calculated as the fractional response of body weight on study day X over the original body weight on study day 0. Animals displaying a reduction in body weight suggest that the steroid analogue inhibits neuronal PTP1B as is shown for MSI-1436 in Example 4 below. Table 1, column G shows % change in body weight for some 1436 analogues. MSI-1431 is seen to produce weight loss similar to 1436 but 1701 and 1873 able to inhibit PTP1B but do not produce weight loss.

[0047] On study day 13, all animal groups were fasted overnight. On study day 14, 25 μ L of whole blood was collected and analyzed for the glucose level (mg/dL) using a glucose analyzer. A significant reduction of FBG levels compared to saline control is shown for MSI-1431, 1436, 1701, 1814 and 1873 in Figure 1 and Table 1, column D.

[0048] Also on study day 14, an OGTT was performed to assess glucose tolerance. At time 0, an oral glucose challenge (1.5 g/kg) was administered by oral gavage. At timepoints 0, 15, 30, 60, 90, 120 min post glucose load, 25 μ l of whole blood was withdrawn from the tail vein of the animal and the glucose level was measured using a glucose analyzer. The glucose concentration vs time was plotted (Figure 2). Above

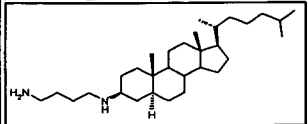
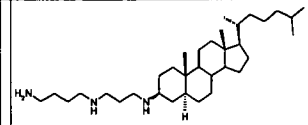
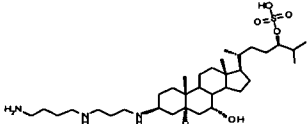
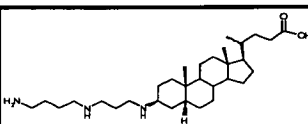
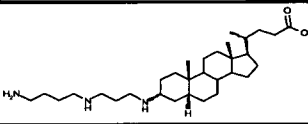
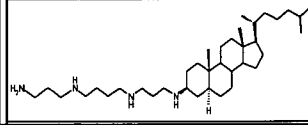
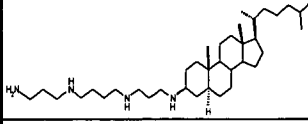
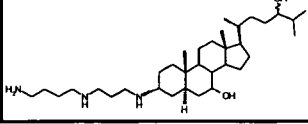
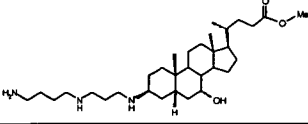
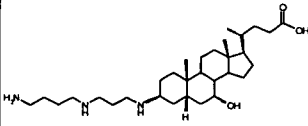
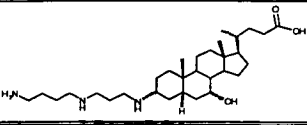
baseline area under the curve (ABAUC) of the glucose excursion time curve was determined using trapezoidal rule analyses. A significant reduction ($p < 0.05$) in ABAUC compared to saline control is shown for MSI-1431, 1436, 1701, 1814 and 1873 in Figure 3 and Table 1, column F.

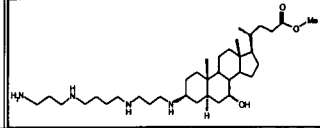
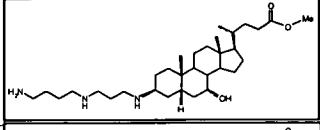
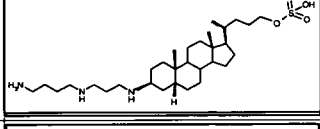
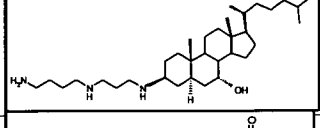
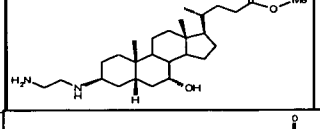
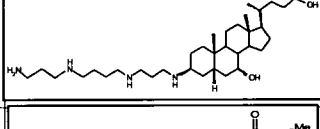
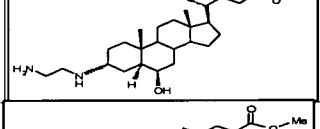
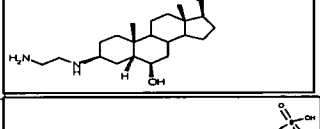
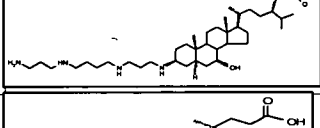
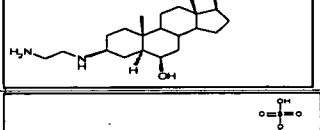
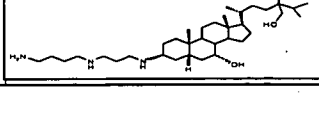
[0049] Example 4 Effect of MSI-1436 on the phosphorylation of IR- β in the rat hypothalamus

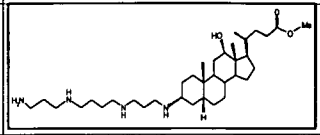
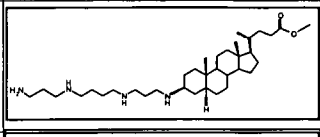
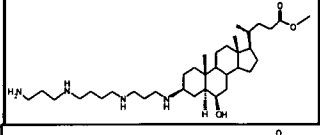
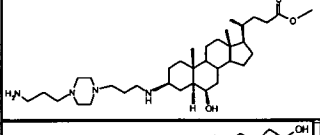
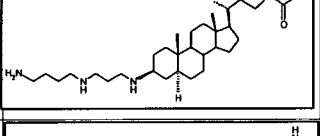
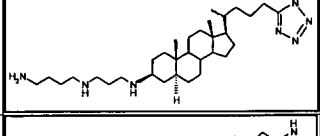
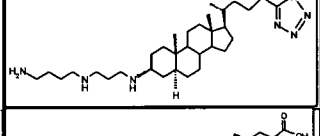
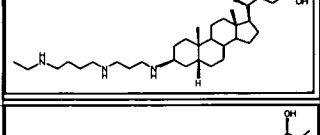
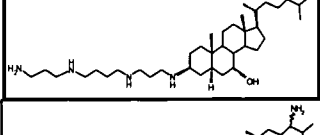
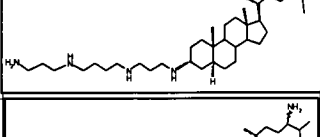
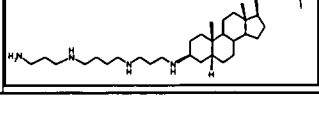
[0050] Male SD rats were divided into 8 groups with 4 rats per group. All rats were fed *ad libitum* normal rodent chow and regular tap water. On Day 0, rats were dosed via intraperitoneal (i.p.) injection with 10 mg/kg MSI-1436 or 0.9% saline. Rats were fasted overnight from Day 0 to Day 1. On Day 1, animals were dosed i.p. with 0.9% saline or 100 U/kg of insulin. At 15 or 30 minutes post-dose (Day 1), animals were sacrificed and the hypothalamuses were harvested, transferred to 1.5 mL eppendorf tubes, and frozen in liquid nitrogen. Samples were stored at -80°C until further analysis. Hypothalamuses were pooled (3-4 per group) and homogenized in 2-mL Wheaton vials and Dounce homogenizers in 1 mL of tissue extraction reagent plus phosphatase and protease inhibitors. Lysates were centrifuged for 10 minutes at 4°C (14,000 rpm) and the supernatants were transferred to new 1.5 mL eppendorf tubes. Lysates (500 μg) were immunoprecipitated for Insulin Receptor β overnight at 4°C . The samples were then bound to Protein A according to standard protocols for 4 hours at 4°C . Samples were then washed 4X with RIPA/Empigen buffer and eluted in 4X LDS sample buffer. After elution, the samples were boiled at 95°C for 5 min.

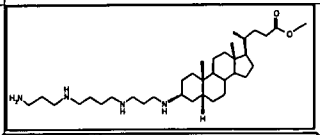
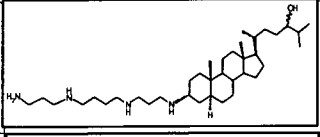
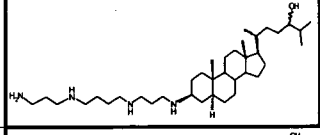
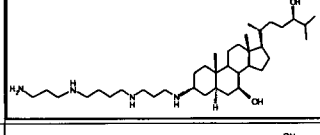
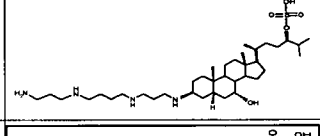
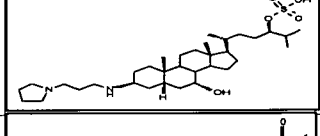
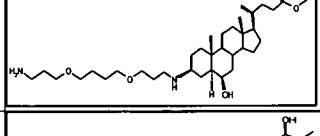
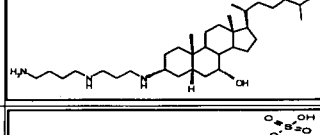
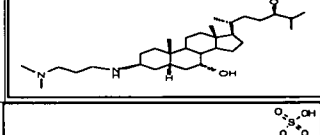
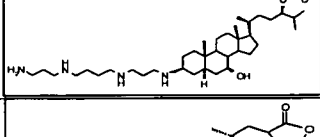
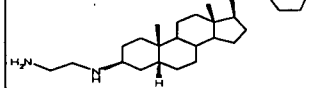
[0051] 500 μg of total protein from each sample was loaded onto a 1.5 mm 4-12% Bis-Tris Novex gel and run at 175V for approximately 1 hr in 1x MOPS buffer. The gel was transferred to nitrocellulose membrane overnight at 4°C and 10V in a Novex transfer blot apparatus and blocked the following morning in 5% BSA for 1 hr at room temperature. Next, the membrane was incubated in anti-pTyr 4G10 primary antibody diluted to 1 $\mu\text{g}/\mu\text{L}$ in 1%BSA at room temperature for 2 hours. After 3 ten-minute washes in TBST, the membrane was incubated at room temperature in goat anti-mouse secondary antibody diluted 1:80,000 in 1%BSA for 1 hr. Finally, the membrane was washed 3 x 10 min in TBST, 5 x 2 min in pico pure water, and developed using SuperSignal West Pico ECL reagent. The membrane was exposed to film for various time points. Densitometric analysis of the bands of interest was performed using ImageJ. The ratio of the pTyr-IR β band to the IR β band was computed in Excel and the fold change in IR phosphorylation

determined. The data indicates (Figure 4) that treatment with MSI-1436 nearly doubles the amount of phospho-Tyrosine found on insulin stimulated IR- β in the hypothalamus. The assumption in this case is that MSI-1436 has crossed the blood brain barrier into the hypothalamus and increased the amount of phosphor-Tyrosine on IR- β by the inhibition on PTP1B.

Table 1						
Compound	Structure	PTP1B Inhibition (5 μ M)	TCPTP Inhibition (200 μ M)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
1241		22				
1255		43				
1256		24				
1271		26				
1272		23				
1303		58	83			
1304		71				
1317		43				
1320		48	0			
1321		28				
1322		16				

Compound	Structure	PTP1B Inhibition (5 μ M)	TCPTP Inhibition (200 μ M)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
1336		67				
1352		38				
1370		66	44			
1371		90	0			
1409		7				
1413		53				
1431		49		55	47	-7
1432		22				
1436		72	0	64	83	-8
1433		27				
1437		40				

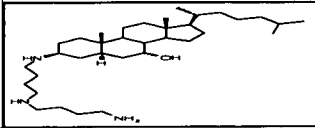
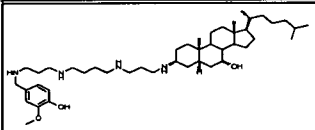
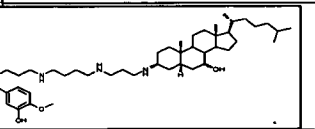
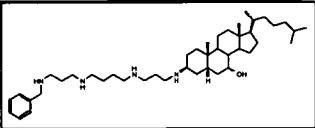
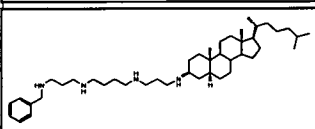
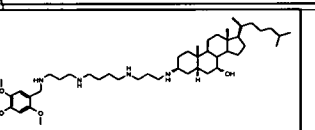
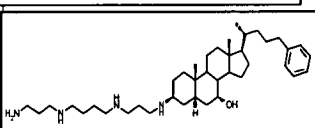
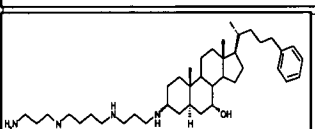
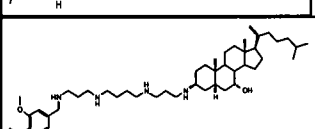
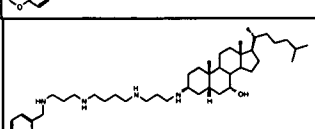
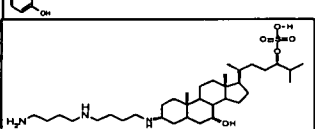
Compound	Structure	PTP1B Inhibition (5 μ M)	TCPTP Inhibition (200 μ M)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
1448		65				
1459		75				
1466		85				
1469		85				
1470		59				
1486		25				
1487		44				
1520		31				
1521		50				
1561		13				
1562		20				

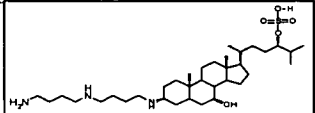
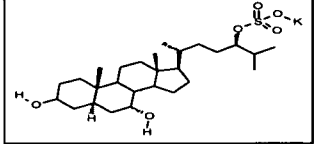
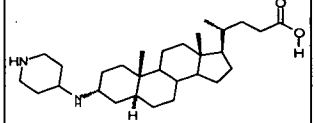
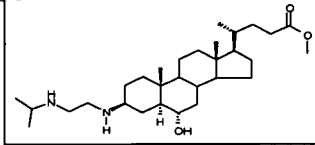
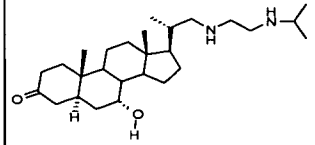
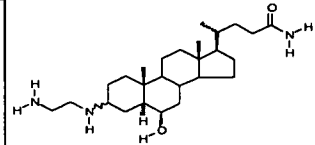
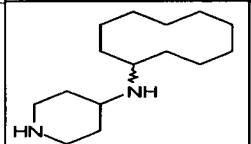
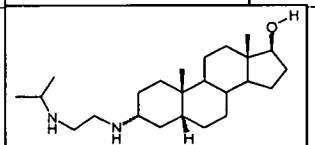
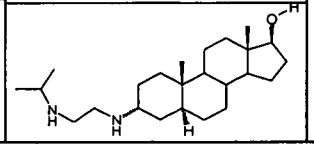
Compound	Structure	PTP1B Inhibition (5 μ M)	TCPTP Inhibition (200 μ M)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
1569		46				
1597		70				
1598		68				
1678		22				
1701		41		40	49	3
1718		19				
1751		6				
1755		24				
1768		13				
1777		37				
1783		36				

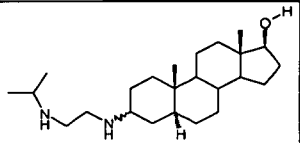
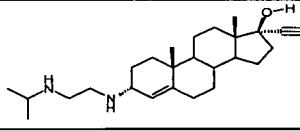
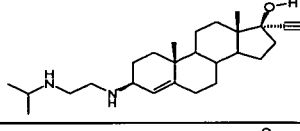
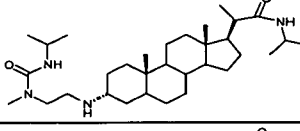
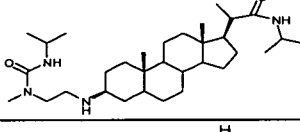
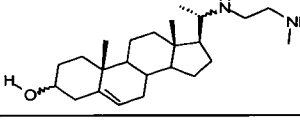
Compound	Structure	PTP1B Inhibition (5 μ M)	TCPTP Inhibition (200 μ M)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
1804		10				
1805		17				
1810		30				
1811		8				
1812		37				
1814		58		46	60	
1830		18				
1839		27				
1873		63		41	47	4
1875		71				
1876		43				

Compound	Structure	PTP1B Inhibition (5 μ M)	TCPTP Inhibition (200 μ M)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
1877		47				
1888		81				
1892		28				
1893		16				
1894		77				
1909		41				
1911		37				
1913		38				
1920		22				
2347		27				
2348		34				

Compound	Structure	PTP1B Inhibition (5 μ M)	TCPTP Inhibition (200 μ M)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
2349		27				
2351		88				
2352		76				
2353		76				
2354		43				
2355		35				
2356		23				
2357		29				
2358		24				
2360		81				
2361		82				

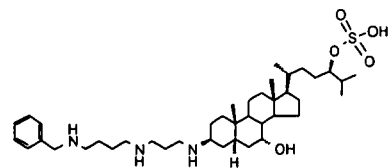
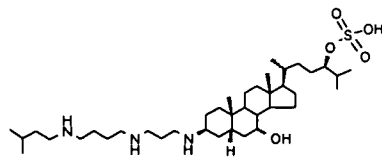
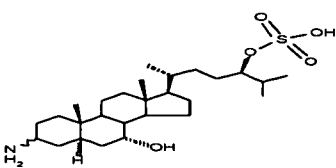
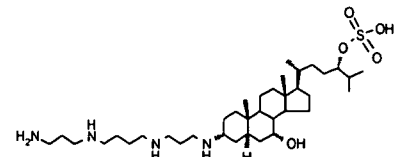
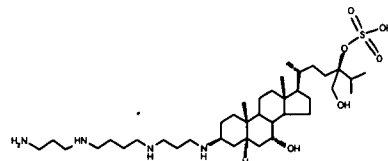
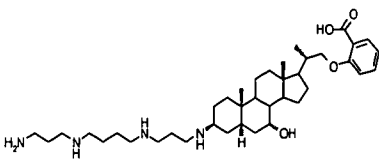
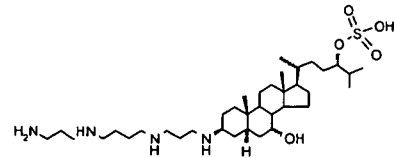
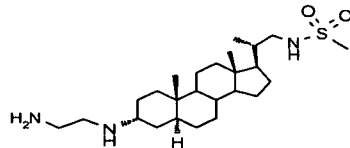
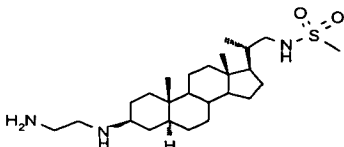
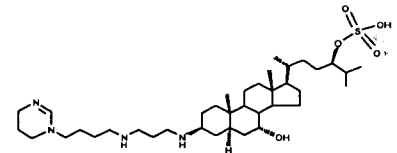
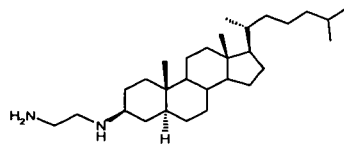
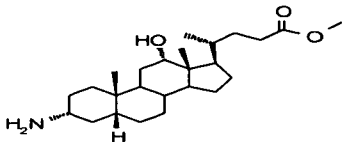
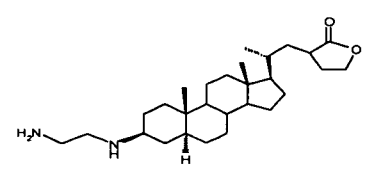
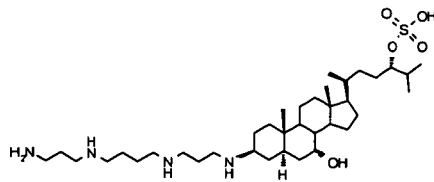
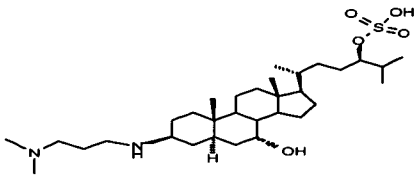
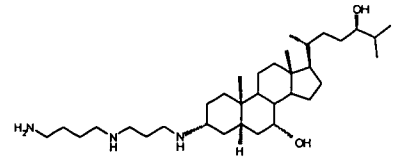
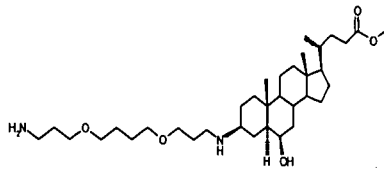
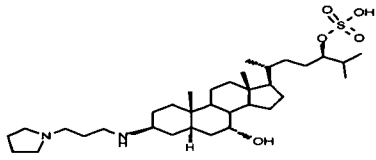
Compound	Structure	PTP1B Inhibition (5 μ M)	TCPTP Inhibition (200 μ M)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
2363		63				
2364		61				
2365		73				
2367		78				
2368		37				
2369		93				
2370		77				
2371		55				
2374		37				
2375		59				
2450		28				

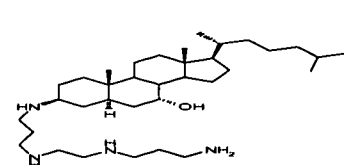
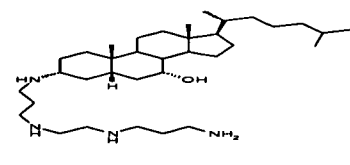
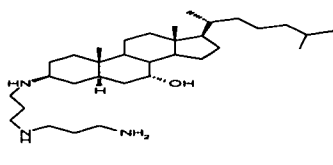
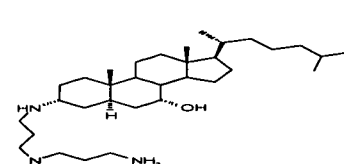
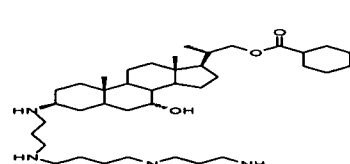
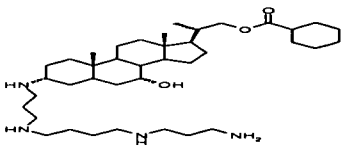
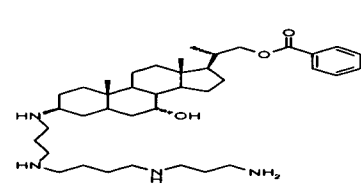
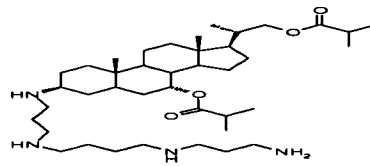
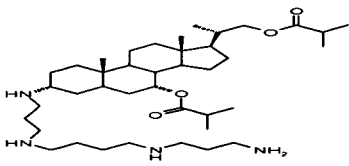
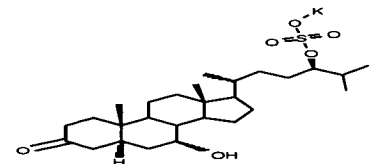
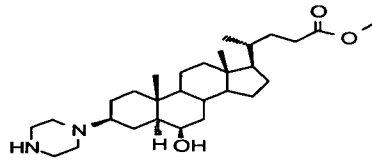
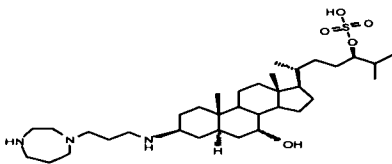
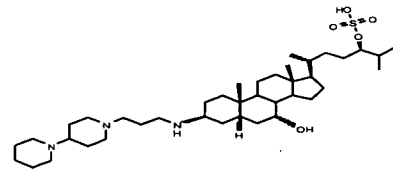
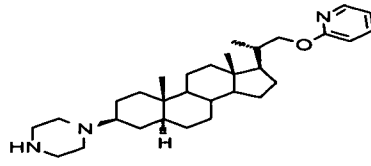
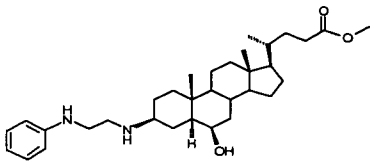
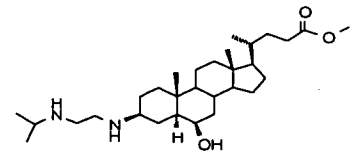
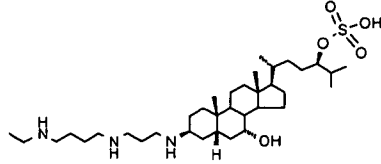
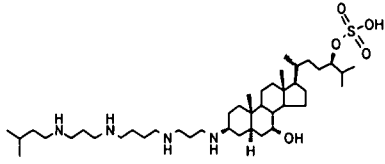
Compound	Structure	PTP1B Inhibition (5 μ M)	TCPTP Inhibition (200 μ M)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
2451		7				
2459		17				
2464		38				
2465		10				
2484		5				
2490		7				
2491		9				
2492		10				
2492		10				

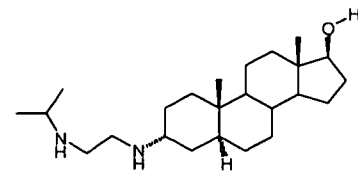
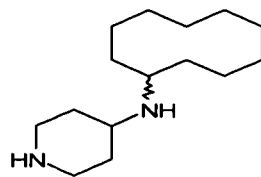
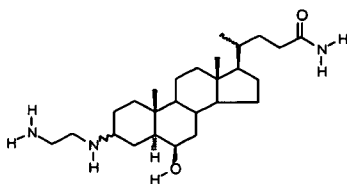
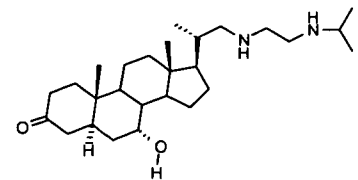
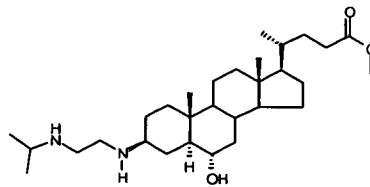
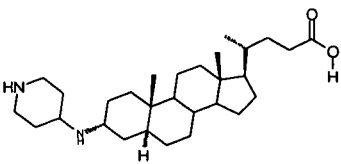
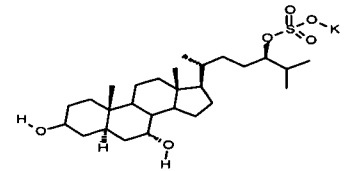
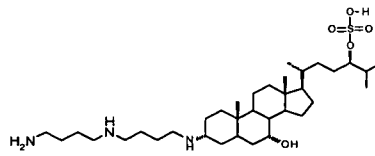
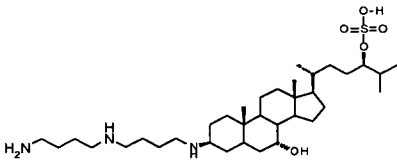
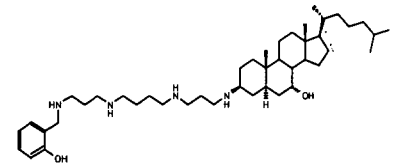
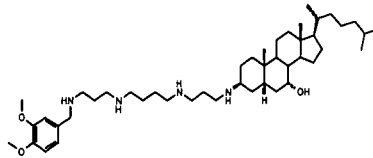
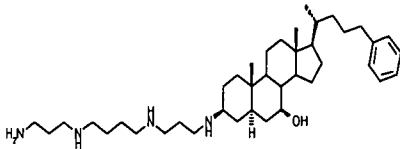
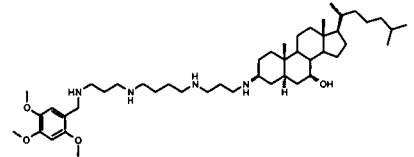
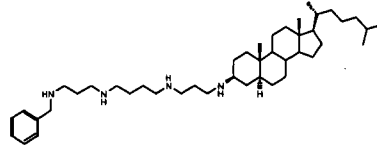
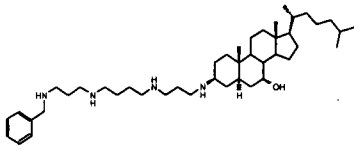
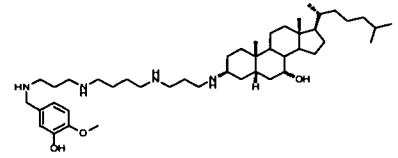
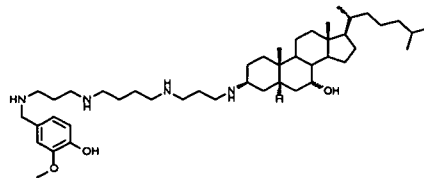
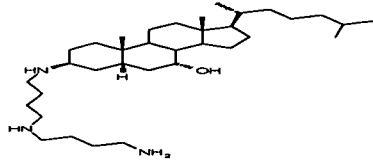
Compound	Structure	PTP1B Inhibition (5 μM)	TCPTP Inhibition (200 μM)	% Reduction in FBG	% Reduction in OGTT Above Baseline AUC	% Change in Body Weight
2493		10				
2494		9				
2495		7				
2496		10				
2497		15				
2498		13				

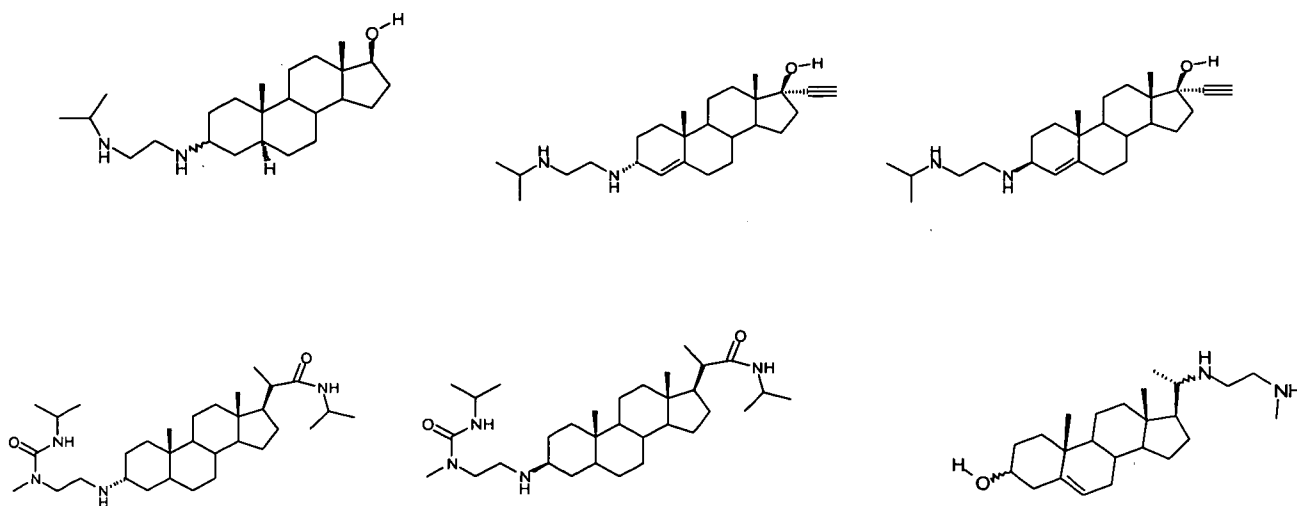
CLAIMS

Claim 1. A compound or pharmaceutically acceptable salt thereof selected from the group consisting of



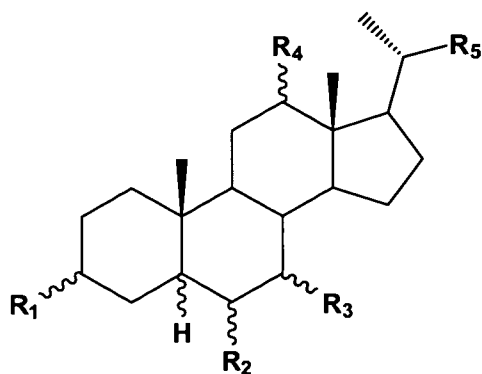






Claim 2. A pharmaceutical composition comprising the compound of claim 1 and a pharmaceutically acceptable diluent or carrier.

Claim 3. A method for treating diabetes in a mammal comprising administering to a mammal in need thereof a therapeutically effective amount of a compound of formula



or a pharmaceutically acceptable salt thereof,

wherein:

R₁ = -NH(CH₂)₁₋₄-NH-R₆ or -OH or =O or H or piperazine or amino piperidine;

R₆ = -(CH₂)₁₋₄-NH-R₇ or C₁-C₅ alkyl or phenyl or H;

R₇ = -(CH₂)₁₋₄-N-R₈;

R₈ = C₁-C₅ alkyl or benzyl or benzyl with 1-3 R₉ groups or H;

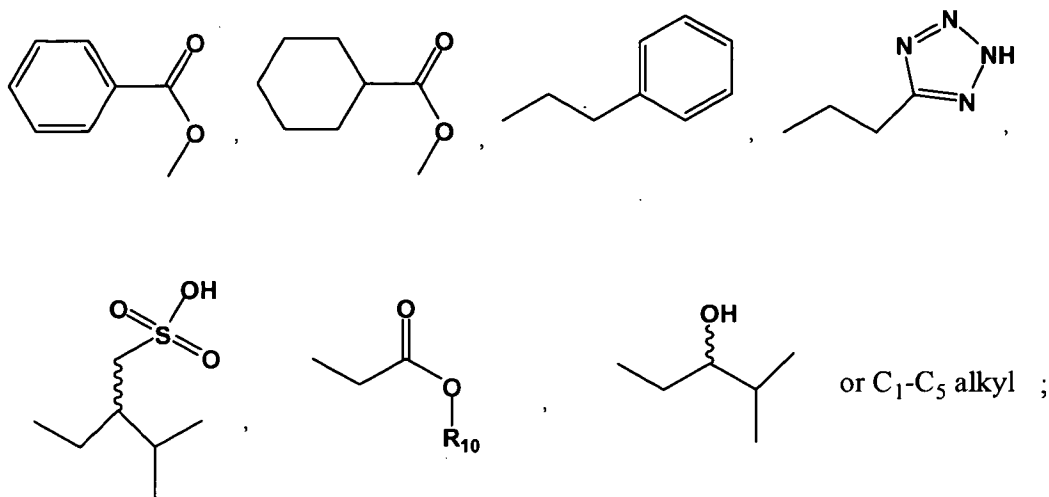
R₉ = -OH or -OCH₃ or -C₁-C₅ alkyl;

R₂ = -OH or H;

R₃= -OH or H;

R₄= -OH or H;

R₅=



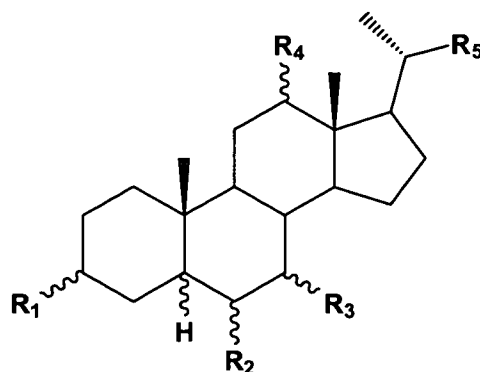
R₁₀= H or C₁-C₅ alkyl.

Claim 4. A method for treating diabetes in a mammal comprising administering to a mammal in need thereof a therapeutically effective amount of a compound of claim 1 or a pharmaceutically acceptable salt thereof.

Claim 5. The method according to claim 3 or claim 4, wherein the diabetes is type I diabetes.

Claim 6. The method according to claim 3 or claim 4, wherein the diabetes is type II diabetes.

Claim 7. A method of treating a disorder in a mammal mediated by inhibition of protein tyrosine phosphatase PTP1B comprising administering to a mammal in need thereof a therapeutically effective amount of a compound of formula



or a pharmaceutically acceptable salt thereof,

wherein:

R₁ = -NH(CH₂)₁₋₄-NH-R₆ or -OH or =O or H or piperazine or amino piperidine;

R₆ = -(CH₂)₁₋₄-NH-R₇ or C₁-C₅ alkyl or phenyl or H;

R₇ = -(CH₂)₁₋₄-N-R₈;

R₈ = C₁-C₅ alkyl or benzyl or benzyl with 1-3 R₉ groups or H;

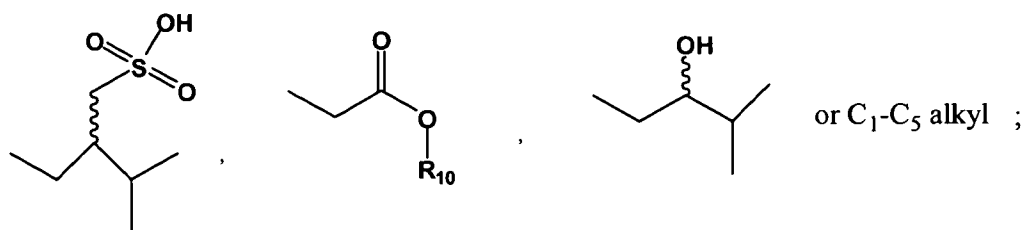
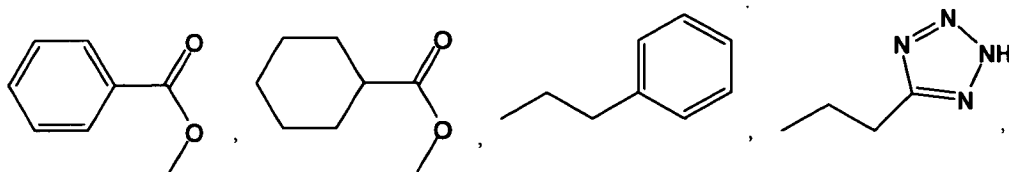
R₉ = -OH or -OCH₃ or -C₁-C₅ alkyl;

R₂ = -OH or H;

R₃ = -OH or H;

R₄ = -OH or H;

R₅ =



R₁₀ = H or C₁-C₅ alkyl.

Claim 8. A method of treating a disorder in a mammal mediated by inhibition of protein tyrosine phosphatase PTP1B comprising administering to a mammal in need thereof a therapeutically effective amount of a compound of claim 1.

Claim 9. The method of claim 7 or claim 8, wherein the disorder is selected from obesity, high serum cholesterol, sleep apnea and nonalcoholic steatohepatitis.

Claim 10. The method of claim 9, wherein the obesity is associated with type II diabetes.

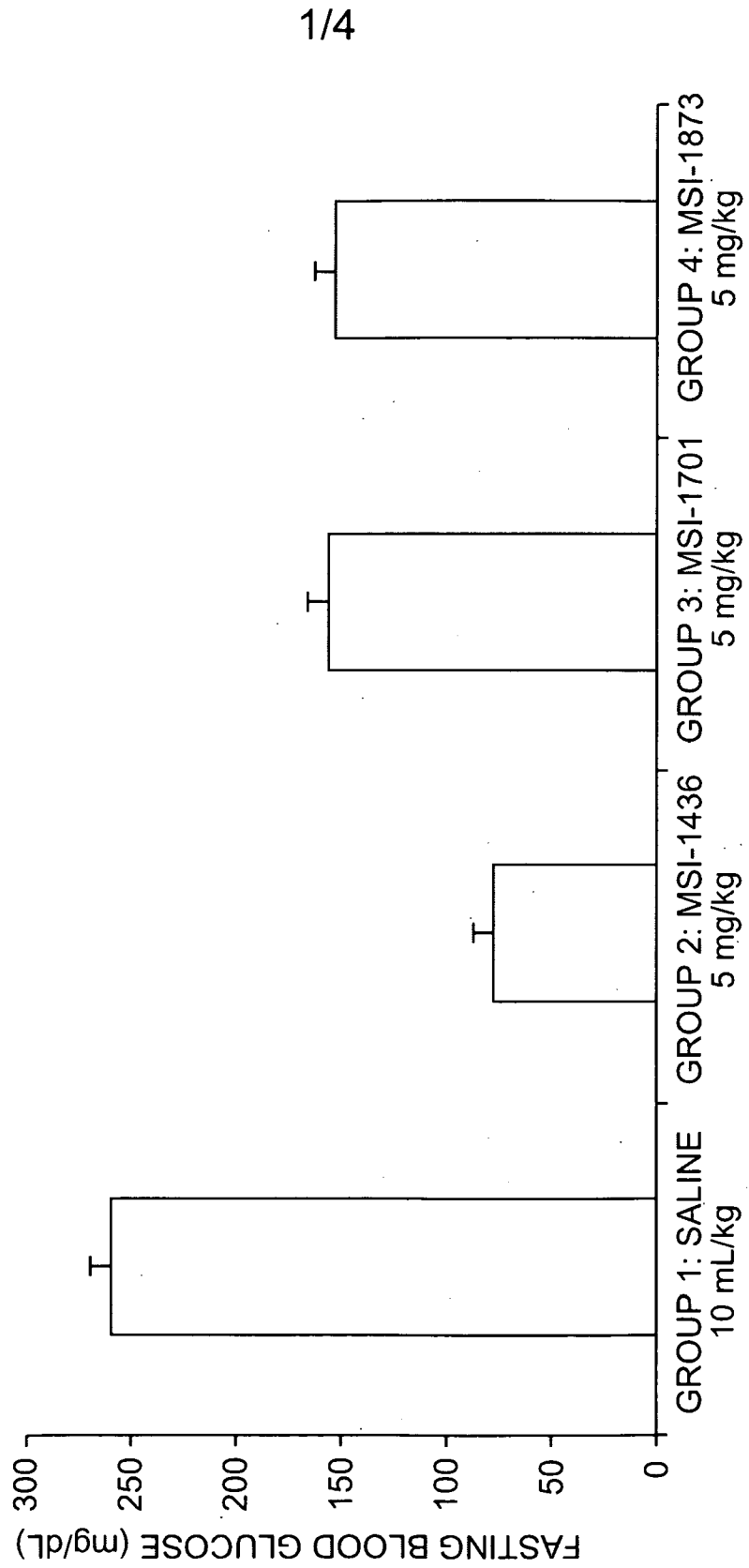


FIG. 1

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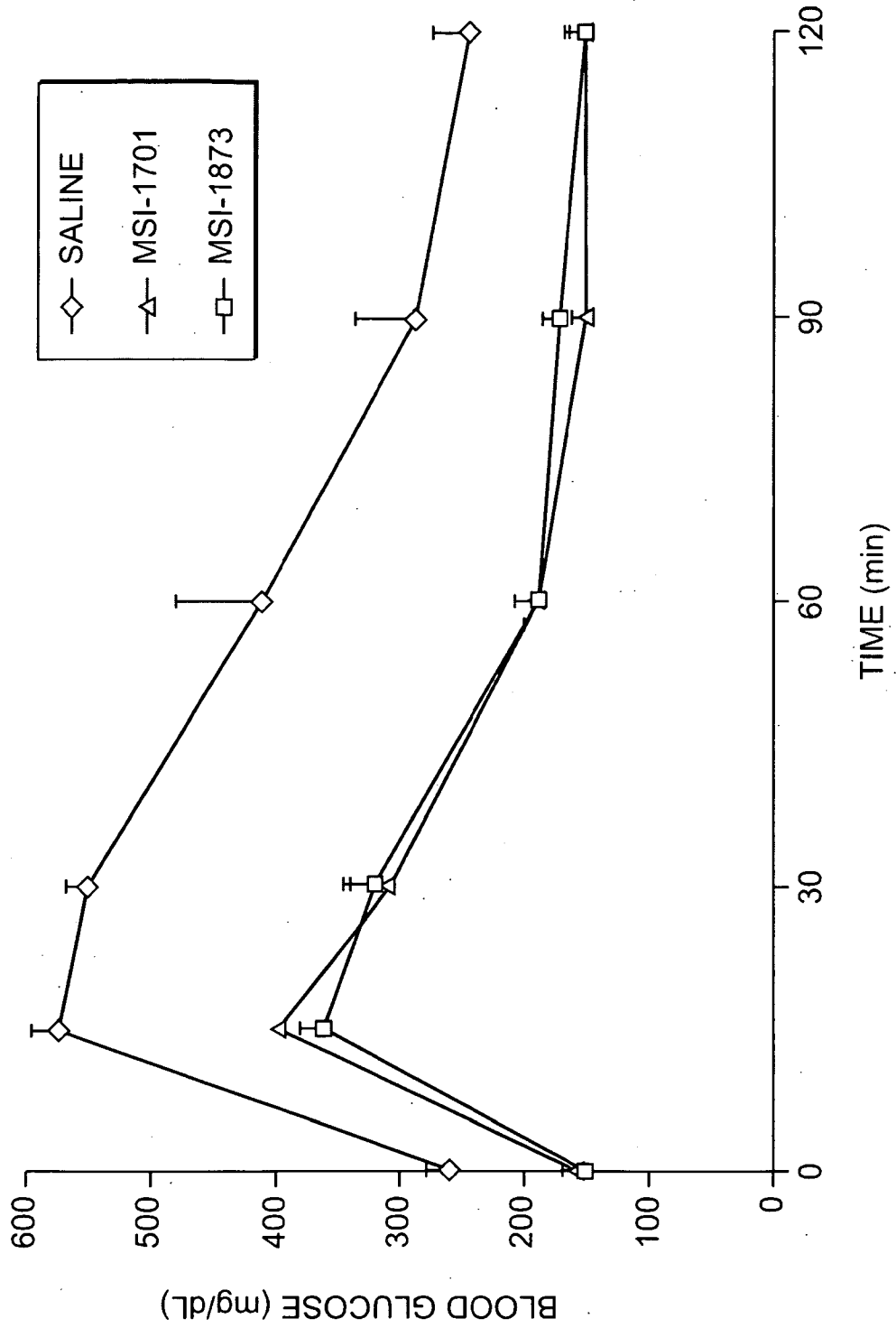


FIG. 2

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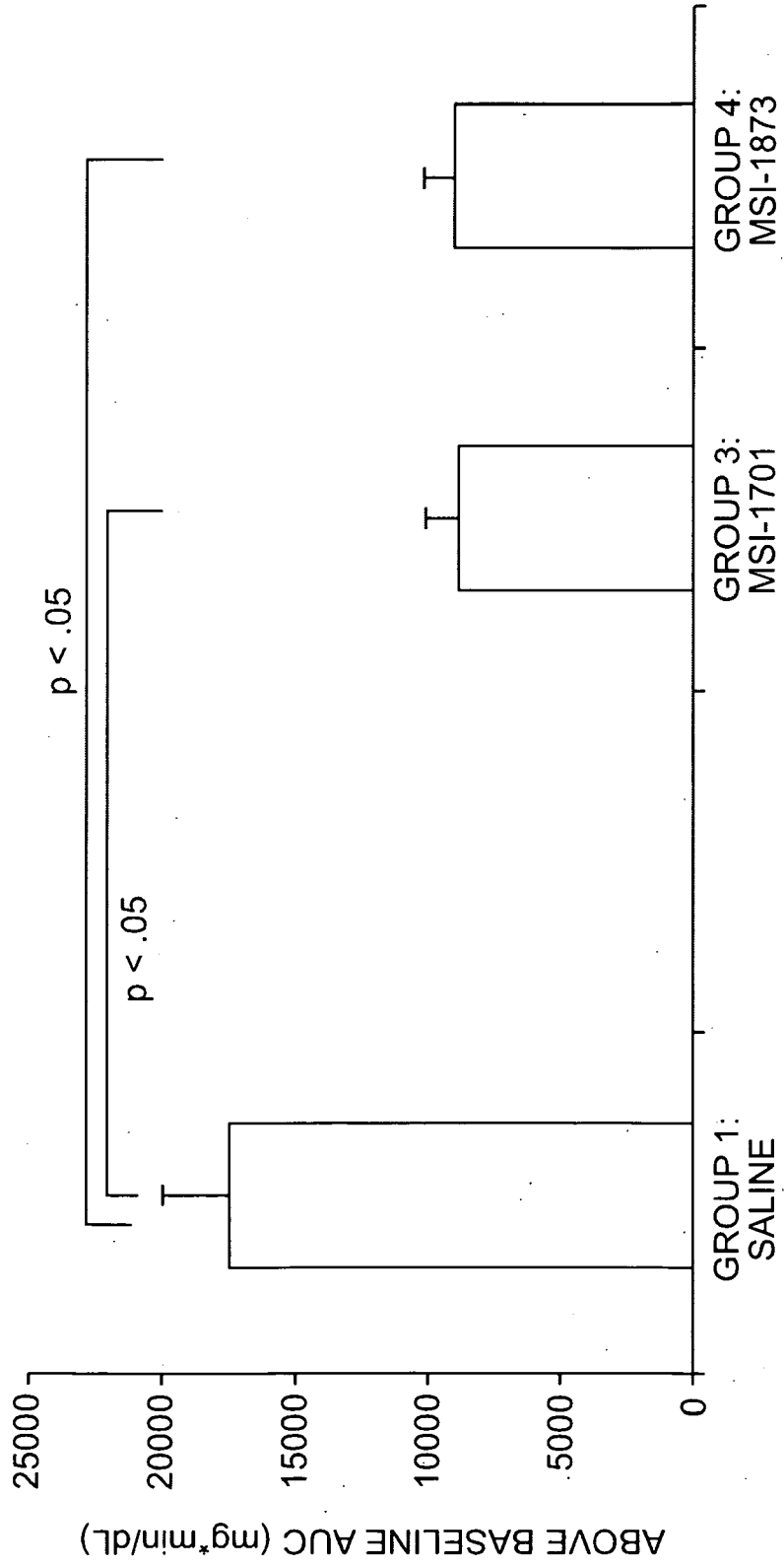


FIG. 3

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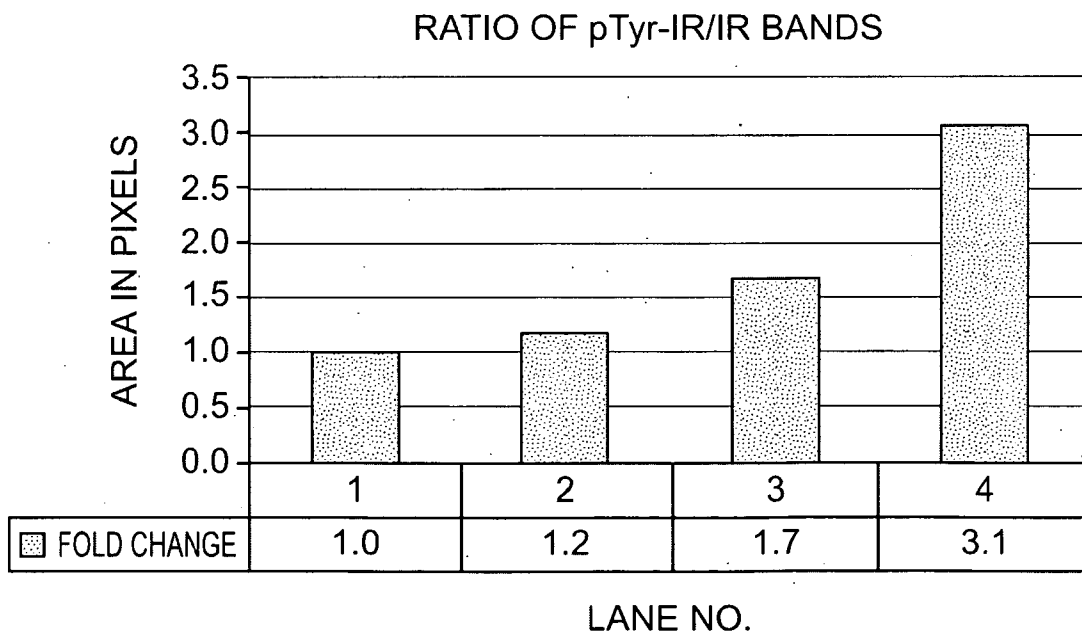
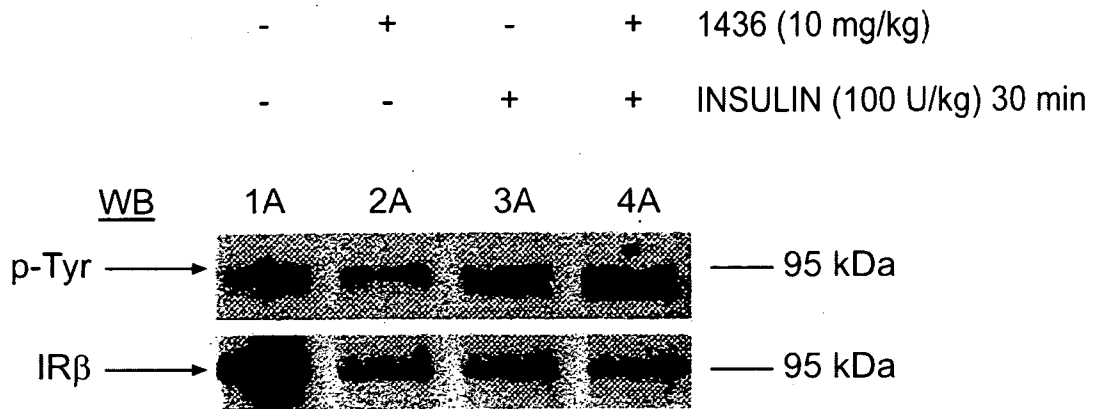


FIG. 4