



(86) Date de dépôt PCT/PCT Filing Date: 2008/07/16
(87) Date publication PCT/PCT Publication Date: 2009/01/29
(85) Entrée phase nationale/National Entry: 2010/01/18
(86) N° demande PCT/PCT Application No.: GB 2008/002406
(87) N° publication PCT/PCT Publication No.: 2009/013461
(30) Priorités/Priorities: 2007/07/20 (US607951,122);
2007/07/20 (US60/951,122); 2007/09/14 (GB0717985.6)

(51) Cl.Int./Int.Cl. *C07K 14/61* (2006.01),
C07K 14/71 (2006.01), *C12N 15/62* (2006.01)
(71) Demandeur/Applicant:
ASTERION LIMITED, GB
(72) Inventeurs/Inventors:
ROSS, RICHARD, GB;
ARTYMIUK, PETER, GB;
SAYERS, JON, GB
(74) Agent: RIDOUT & MAYBEE LLP

(54) Titre : PROTEINES DE FUSION DE L'HORMONE DE CROISSANCE
(54) Title: GROWTH HORMONE FUSION PROTEINS

(57) Abrégé/Abstract:

We disclose growth hormone fusion proteins that have increased in vivo stability and activity; nucleic acid molecules encoding said proteins and methods of treatment of growth hormone deficiency that use said proteins.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

CORRECTED VERSION

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
29 January 2009 (29.01.2009)

PCT

(10) International Publication Number
WO 2009/013461 A8

(51) International Patent Classification:

C07K 14/61 (2006.01) C12N 15/62 (2006.01)
C07K 14/71 (2006.01)

(21) International Application Number:

PCT/GB2008/002406

(22) International Filing Date:

16 July 2008 (16.07.2008)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

60/951,122 20 July 2007 (20.07.2007) US
0717985.6 14 September 2007 (14.09.2007) GB(71) Applicant (for all designated States except US): **ASTERION LIMITED** [GB/GB]; Western Bank, Firth Court, Sheffield S10 2TN (GB).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **ROSS, Richard** [GB/GB]; Asterion Limited, Western Bank, Firth Court, Sheffield S10 2TN (GB). **ARTYMIUK, Peter** [GB/GB]; Asterion Limited, Western Bank, Firth Court, Sheffield S10 2TN (GB). **SAYERS, Jon** [GB/GB]; Asterion Limited, Western Bank, Firth Court, Sheffield S10 2TN (GB).(74) Agent: **GILHOLM HARRISON**; Marlborough House, Westminster Place, York Business Park, Nether Poppleton, York YO26 6RW (GB).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

— with sequence listing part of description (Rule 5.2(a))

(48) Date of publication of this corrected version:

7 January 2010

(15) Information about Correction:

see Notice of 7 January 2010

(54) Title: GROWTH HORMONE FUSION PROTEINS

(57) Abstract: We disclose growth hormone fusion proteins that have increased in vivo stability and activity; nucleic acid molecules encoding said proteins and methods of treatment of growth hormone deficiency that use said proteins.

WO 2009/013461 A8

Growth Hormone Fusion Proteins

The invention relates to growth hormone fusion proteins; nucleic acid molecules encoding said proteins and methods of treatment that use said proteins.

5

Ligands that interact with receptors to bring about a biochemical response are known as agonists and those that prevent, or hinder, a biochemical response are known as antagonists. For example, cell specific growth factors are ligands that act as agonists and bind receptors located at the cell surface. Activation of the receptors by ligand-specific binding promotes cell proliferation via activation of intracellular signalling cascades that result in the expression of, amongst other things, cell-cycle specific genes and the activation of quiescent cells to proliferate.

15

A group of growth factors, referred to as cytokines, are involved in a number of diverse cellular functions. These include modulation of the immune system, regulation of energy metabolism and control of growth and development. Cytokines mediate their effects via receptors expressed at the cell surface on target cells. Cytokine receptors can be divided into three separate sub groups. Type 1 (growth hormone family) receptors are characterised by four conserved cysteine residues in the amino terminal part of their extracellular domain and the presence of a conserved Trp-Ser-Xaa-Trp-Ser motif in the C-terminal part. The repeated Cys motif is also present in Type 2 (interferon family) and Type III (tumour necrosis factor family).

20

Growth hormone (GH) is an anabolic cytokine hormone important for linear growth in childhood and normal body composition in adults¹. The current therapeutic regimen for GH replacement requires once-daily subcutaneous injections which is inconvenient and expensive. A number of approaches have been taken to create long-acting preparations, including pegylation² and sustained-release formulations³⁻⁵. Pegylation has the disadvantage that it reduces affinity of hormone for receptor², and chemical modification with subsequent purification is expensive. Sustained-release formulations have proven efficacy⁴⁻⁷ but such GH preparations are characterised by a dominant early-release profile, causing supraphysiological GH levels³, manufacture is expensive and injections may be painful⁴. There is a need for cytokine formulations that minimise manufacturing

30

costs, have good pharmacokinetic profiles, are easy to administer, and acceptable to patients.

5 GH acts through a cell-surface type 1 cytokine receptor (GHR). In common with other cytokine receptors, the extracellular domain of the GHR is proteolytically cleaved and circulates as a binding protein (GHBP)⁸. Under physiological conditions GH is in part bound in the circulation in a 1:1 molar ratio by GHBP and this complex appears to be biologically inactive, protected from clearance and degradation^{9,10}. A cross-linked complex of GH with GHBP has delayed clearance but no biological activity¹¹. Co-
10 administration of separately purified GHBP with GH in a 1:1 ratio can augment the anabolic actions of GH¹². Thus, like many hormonal systems, binding in the circulation provides an inactive circulating reservoir in equilibrium with active free hormone¹³.

15 Cytokine hormones like growth hormone have a short plasma half-life and require frequent administration. For example, growth hormone (GH) replacement involves daily injections. In common with other cytokines, extracellular domain GH receptor circulates as a binding protein and naturally prolongs GH's biological half-life.

20 This disclosure relates to the biological actions of a ligand-receptor fusion (LR-fusion) of GH with its extracellular domain receptor. Such a genetically engineered LR-fusion protein was purified from mammalian cell culture. In rats the LR-fusion had a 300-times reduced clearance compared to native GH and single administration promoted growth for 10 days far superior to that seen with native GH. The reduced clearance is reproducible in a primate model. The LR-fusion forms a reciprocal, head-to-tail dimer
25 that provides a reservoir of inactive hormone as occurs naturally with GH and its binding protein.

According to an aspect of the invention there is provided a nucleic acid molecule comprising a nucleic acid sequence selected from:

- 30
- i) a nucleic acid sequence as represented in SEQ ID NO:1;
 - ii) a nucleic acid sequence as represented in SEQ ID NO:2;
 - iii) a nucleic acid sequence as represented in SEQ ID NO:3;
 - iv) a nucleic acid sequence as represented in SEQ ID NO:4; or

- v) a nucleic acid molecule comprising a nucleic sequence that hybridizes under stringent hybridization conditions to SEQ ID NO:1, SEQ ID NO: 2; SEQ ID NO: 3 or SEQ ID NO: 4, and which encodes a polypeptide that has growth hormone receptor agonist activity.

5 Hybridization of a nucleic acid molecule occurs when two complementary nucleic acid molecules undergo an amount of hydrogen bonding to each other. The stringency of hybridization can vary according to the environmental conditions surrounding the nucleic acids, the nature of the hybridization method, and the composition and length of the nucleic acid molecules used. Calculations regarding hybridization conditions required for
 10 attaining particular degrees of stringency are discussed in Sambrook et al., Molecular Cloning: A Laboratory Manual (Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 2001); and Tijssen, Laboratory Techniques in Biochemistry and Molecular Biology—Hybridization with Nucleic Acid Probes Part I, Chapter 2 (Elsevier, New York, 1993). The T_m is the temperature at which 50% of a given strand of a nucleic acid
 15 molecule is hybridized to its complementary strand. The following is an exemplary set of hybridization conditions and is not limiting:

Very High Stringency (allows sequences that share at least 90% identity to hybridize)

	Hybridization:	5x SSC at 65°C for 16 hours
20	Wash twice:	2x SSC at room temperature (RT) for 15 minutes each
	Wash twice:	0.5x SSC at 65°C for 20 minutes each

High Stringency (allows sequences that share at least 80% identity to hybridize)

	Hybridization:	5x-6x SSC at 65°C-70°C for 16-20 hours
25	Wash twice:	2x SSC at RT for 5-20 minutes each
	Wash twice:	1x SSC at 55°C-70°C for 30 minutes each

Low Stringency (allows sequences that share at least 50% identity to hybridize)

	Hybridization:	6x SSC at RT to 55°C for 16-20 hours
30	Wash at least twice:	2x-3x SSC at RT to 55°C for 20-30 minutes each.

In a preferred embodiment of the invention said nucleic acid molecule comprises or consists of a nucleic acid sequence as represented in SEQ ID NO: 1.

In a preferred embodiment of the invention said nucleic acid molecule comprises or consists of a nucleic acid sequence as represented in SEQ ID NO: 2.

5 In a preferred embodiment of the invention said nucleic acid molecule comprises or consists of a nucleic acid sequence as represented in SEQ ID NO: 3.

In a preferred embodiment of the invention said nucleic acid molecule comprises or consists of a nucleic acid sequence as represented in SEQ ID NO: 4.

10

According to an aspect of the invention there is provided a polypeptide encoded by the nucleic acid according to the invention.

According to a further aspect of the invention there is provided a polypeptide comprising
15 an amino acid sequence selected from:

- i) an amino acid sequence as represented in SEQ ID NO:5;
- ii) an amino acid sequence as represented in SEQ ID NO:6;
- iii) an amino acid sequence as represented in SEQ ID NO:7;
- iv) an amino acid sequence as represented in SEQ ID NO:8;
- 20 v) an amino acid sequence as represented in SEQ ID NO:9;
- vi) an amino acid sequence as represented in SEQ ID NO:10;
- vii) an amino acid sequence as represented in SEQ ID NO:11;
- viii) an amino acid sequence as represented in SEQ ID NO:12; wherein said polypeptide has growth hormone receptor agonist activity.

25

In a preferred embodiment of the invention said polypeptide comprises or consists of an amino acid sequence as represented in SEQ ID NO: 5.

In a preferred embodiment of the invention said polypeptide comprises or consists of an
30 amino acid sequence as represented in SEQ ID NO: 6.

In a preferred embodiment of the invention said polypeptide comprises or consists of an amino acid sequence as represented in SEQ ID NO: 7.

In a preferred embodiment of the invention said polypeptide comprises or consists of an amino acid sequence as represented in SEQ ID NO: 8.

5 In a preferred embodiment of the invention said polypeptide comprises or consists of an amino acid sequence as represented in SEQ ID NO: 9.

In a preferred embodiment of the invention said polypeptide comprises or consists of an amino acid sequence as represented in SEQ ID NO: 10.

10 In a preferred embodiment of the invention said polypeptide comprises or consists of an amino acid sequence as represented in SEQ ID NO: 11.

In a preferred embodiment of the invention said polypeptide comprises or consists of an amino acid sequence as represented in SEQ ID NO: 12.

15

According to a further aspect of the invention there is provided a homodimer comprising two polypeptides comprising or consisting of SEQ ID NO: 5.

20 According to a further aspect of the invention there is provided a homodimer comprising two polypeptides comprising or consisting of SEQ ID NO: 6.

According to a further aspect of the invention there is provided a homodimer comprising two polypeptides comprising or consisting of SEQ ID NO: 7.

25 According to a further aspect of the invention there is provided a homodimer comprising two polypeptides comprising or consisting of SEQ ID NO: 8.

According to a further aspect of the invention there is provided a homodimer comprising two polypeptides comprising or consisting of SEQ ID NO: 9.

30

According to a further aspect of the invention there is provided a homodimer comprising two polypeptides comprising or consisting of SEQ ID NO: 10.

According to a further aspect of the invention there is provided a homodimer comprising two polypeptides comprising or consisting of SEQ ID NO: 11.

5 According to a further aspect of the invention there is provided a homodimer comprising two polypeptides comprising or consisting of SEQ ID NO: 12.

According to a further aspect of the invention there is provided a vector comprising a nucleic acid molecule according to the invention.

10 In a preferred embodiment of the invention said vector is an expression vector adapted to express the nucleic acid molecule according to the invention.

A vector including nucleic acid (s) according to the invention need not include a promoter or other regulatory sequence, particularly if the vector is to be used to introduce the
15 nucleic acid into cells for recombination into the genome for stable transfection. Preferably the nucleic acid in the vector is operably linked to an appropriate promoter or other regulatory elements for transcription in a host cell. The vector may be a bi-functional expression vector which functions in multiple hosts. By "promoter" is meant a nucleotide sequence upstream from the transcriptional initiation site and which contains
20 all the regulatory regions required for transcription. Suitable promoters include constitutive, tissue-specific, inducible, developmental or other promoters for expression in eukaryotic or prokaryotic cells. "Operably linked" means joined as part of the same nucleic acid molecule, suitably positioned and oriented for transcription to be initiated from the promoter. DNA operably linked to a promoter is "under transcriptional initiation
25 regulation" of the promoter.

In a preferred embodiment the promoter is a constitutive, an inducible or regulatable promoter.

30 According to a further aspect of the invention there is provided a cell transfected or transformed with a nucleic acid molecule or vector according to the invention.

Preferably said cell is a eukaryotic cell. Alternatively said cell is a prokaryotic cell.

In a preferred embodiment of the invention said cell is selected from the group consisting of; a fungal cell (e.g. *Pichia spp*, *Saccharomyces spp*, *Neurospora spp*); insect cell (e.g. *Spodoptera spp*); a mammalian cell (e.g. COS cell, CHO cell); a plant cell.

- 5 According to a further aspect of the invention there is provided a pharmaceutical composition comprising a polypeptide according to the invention including an excipient or carrier.

10 In a preferred embodiment of the invention said pharmaceutical composition is combined with a further therapeutic agent.

When administered the pharmaceutical composition of the present invention is administered in pharmaceutically acceptable preparations. Such preparations may routinely contain pharmaceutically acceptable concentrations of salt, buffering agents,
15 preservatives, compatible carriers, and optionally other therapeutic agents.

The pharmaceutical compositions of the invention can be administered by any conventional route, including injection. The administration and application may, for example, be oral, intravenous, intraperitoneal, intramuscular, intracavity, intra-articular,
20 subcutaneous, topical (eyes), dermal (e.g. a cream lipid soluble insert into skin or mucus membrane), transdermal, or intranasal.

Pharmaceutical compositions of the invention are administered in effective amounts. An "effective amount" is that amount of pharmaceuticals/compositions that alone, or
25 together with further doses or synergistic drugs, produces the desired response. This may involve only slowing the progression of the disease temporarily, although more preferably, it involves halting the progression of the disease permanently. This can be monitored by routine methods or can be monitored according to diagnostic methods.

30 The doses of the pharmaceuticals compositions administered to a subject can be chosen in accordance with different parameters, in particular in accordance with the mode of administration used and the state of the subject (i.e. age, sex). When administered, the pharmaceutical compositions of the invention are applied in pharmaceutically-acceptable amounts and in pharmaceutically-acceptable compositions. When used in medicine

salts should be pharmaceutically acceptable, but non-pharmaceutically acceptable salts may conveniently be used to prepare pharmaceutically-acceptable salts thereof and are not excluded from the scope of the invention. Such pharmacologically and pharmaceutically-acceptable salts include, but are not limited to, those prepared from the following acids: hydrochloric, hydrobromic, sulfuric, nitric, phosphoric, maleic, acetic, salicylic, citric, formic, malonic, succinic, and the like. Also, pharmaceutically-acceptable salts can be prepared as alkaline metal or alkaline earth salts, such as sodium, potassium or calcium salts.

10 The pharmaceutical compositions may be combined, if desired, with a pharmaceutically-acceptable carrier. The term "pharmaceutically-acceptable carrier" as used herein means one or more compatible solid or liquid fillers, diluents or encapsulating substances that are suitable for administration into a human. The term "carrier" denotes an organic or inorganic ingredient, natural or synthetic, with which the active ingredient is combined to facilitate the application. The components of the pharmaceutical compositions also are capable of being co-mingled with the molecules of the present invention, and with each other, in a manner such that there is no interaction that would substantially impair the desired pharmaceutical efficacy.

20 The pharmaceutical compositions may contain suitable buffering agents, including: acetic acid in a salt; citric acid in a salt; boric acid in a salt; and phosphoric acid in a salt.

The pharmaceutical compositions also may contain, optionally, suitable preservatives, such as: benzalkonium chloride; chlorobutanol; parabens and thimerosal.

25 The pharmaceutical compositions may conveniently be presented in unit dosage form and may be prepared by any of the methods well-known in the art of pharmacy. All methods include the step of bringing the active agent into association with a carrier that constitutes one or more accessory ingredients. In general, the compositions are prepared by uniformly and intimately bringing the active compound into association with a liquid carrier, a finely divided solid carrier, or both, and then, if necessary, shaping the product.

30 Compositions suitable for oral administration may be presented as discrete units, such

as capsules, tablets, lozenges, each containing a predetermined amount of the active compound. Other compositions include suspensions in aqueous liquids or non-aqueous liquids such as syrup, elixir or an emulsion.

5 Compositions suitable for parenteral administration conveniently comprise a sterile aqueous or non-aqueous preparation that is preferably isotonic with the blood of the recipient. This preparation may be formulated according to known methods using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation also may be a sterile injectable solution or suspension in a non-toxic
10 parenterally-acceptable diluent or solvent, for example, as a solution in 1, 3-butane diol. Among the acceptable solvents that may be employed are water, Ringer's solution, and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil may be employed including synthetic mono-or di-glycerides. In addition, fatty acids such as
15 oleic acid may be used in the preparation of injectables. Carrier formulation suitable for oral, subcutaneous, intravenous, intramuscular, etc. administrations can be found in Remington's Pharmaceutical Sciences, Mack Publishing Co., Easton, PA.

According to a further aspect of the invention there is provided a method to treat a human subject suffering from growth hormone deficiency comprising administering an
20 effective amount of at least one polypeptide according to the invention.

In a preferred method of the invention said polypeptide is administered intravenously.

In an alternative preferred method of the invention said polypeptide is administered
25 subcutaneously.

In a further preferred method of the invention said polypeptide is administered at two day intervals; preferably said polypeptide is administered at weekly, 2 weekly or monthly intervals.

30

In a preferred method of the invention said growth hormone deficiency is childhood growth hormone deficiency.

In a preferred method of the invention said growth hormone deficiency is adult growth hormone deficiency.

The treatment of growth hormone deficiency includes for example the treatment of
5 Turners Syndrome, Prader Willi Syndrome, Interuterine growth retardation, idiopathic short stature, renal failure, catabolic states for example during chemotherapy treatment and in the treatment of AIDS.

Throughout the description and claims of this specification, the words "comprise" and
10 "contain" and variations of the words, for example "comprising" and "comprises", means "including but not limited to", and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

Throughout the description and claims of this specification, the singular encompasses
15 the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers, characteristics, compounds, chemical moieties or groups described
20 in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

An embodiment of the invention will now be described by example only and with
25 reference to the following figures:

Figure 1 shows a schematic of relationship between GH, GH binding protein (GHBP), LR-fusion and the GHR based on published structures²⁷ (pdb3HHR): (a) The natural configuration of the GH binding to the GHBP in a 1:1 complex. (b) GH, released from the
30 GHBP complex, binds to the cell surface GH receptor. (c) The LR-fusion molecule in monomeric form with GH linked to exGHR. (d) Model for the LR-fusion forming a reciprocal head-to-tail dimer where GH in one molecule binds to exGHR in the other molecule. Finally in (e) the LR-fusion in monomeric form is capable of binding and activating the GH receptor;

Figure 2 shows the characterisation and bioactivity of LR-fusion: (a) shows LR-fusion separated by SDS-PAGE followed by Coomassie staining (CS) and western blotting (WB), using a GH specific antibody. The LR-fusion is approximately 75 kDa and separates into two bands approximately 5 kDa apart. (b) shows LR-fusion separated by native PAGE showing that there are two protein forms fast (F) and slow (S). (c) Individual bands (F and S) from the native PAGE were excised and separated further by SDS-PAGE under reducing conditions, followed by western blotting using a GH specific antibody. Both bands (F and S) run at approximately 75 kDa and separate as the doublet previously demonstrated. This suggests that the two distinct bands observed by native PAGE are both composed of the 75 kDa LR-fusion and may exist under native conditions in equilibrium as a monomers and dimers. (d) Shows the elution profile for LR-fusion following gel filtration. The separation of 2 distinct peaks is again indicative of the presence of the LR-fusion as a monomer and dimer in solution. (e) Cell based GHR signalling bioassay for GH and LR-fusion. The y-axis represents the fold induction of corrected luciferase from a Stat 5 luciferase-reporter assay. The standard curve for GH ranges from 0, 0.25, 0.5, 1.0, 2.0 and 5 nM: LR-fusion standard curve ranges from 0, 1, 2, 5, 10, 25, 50, 100 and 250 nM. The maximal response for GH is achieved with 5 nM, whereas the maximal response with the LR-fusion requires 50 to 250 nM;

20

Figure 3 shows profiles of GH and LR-fusion measured after subcutaneous (sc) and intravenous (iv) administration: (a) Shows early phase (5 hours) after sc administration; (b) Shows late phase (8 days) after iv; and (c) late phase after sc administration;

25

Figure 4 shows the body weight change after subcutaneous treatment with GH and LR-fusion: (a) after daily GH versus placebo (vehicle only); (b) alternate day injections; (c) two injections on days 1 and 5; (d) a single injection day 1; and (e) summary of changes in body weight after different treatment regimens. *** = $p < 0.0001$ GH vs LR-fusion;

30

Figure 5 illustrates the *in vivo* activity of 1B7v0, 1B7v1, 1B7v2, and 1B7v3;

Figure 6 illustrates a time course showing body weight increase in rats administered 1B7v0, 1B7v1, 1B7v2, and 1B7v3;

Figure 7 illustrates the pharmacokinetics of 1B7v0, 1B7v1, 1B7v2, and 1B7v3 after subcutaneous administration;

5 Figure 8 illustrates the pharmacokinetics of 1B7v0, 1B7v1, 1B7v2, and 1B7v3 after intravenous administration;

Figure 9 illustrates pharmacokinetic profiles for 1B7v2 and 1B7v3 following sequential s/c dosing of 1mg/kg in rhesus monkey. Red dotted line illustrates the minimum effective concentration for human growth hormone.

10

Table 1 shows results (mean \pm sem) after 10 days treatment with GH or LR-fusion in hypophysectomised rats.

15 **Materials and Methods**

15

Use of animals and human samples. The use of human samples was approved by the local ethics committee and patients gave informed consent. All the experiments have been conducted in compliance with the French laws (Council Directive N° 86/609/EEC of 24 November 1986) relating to the protection of animals used for experimental or other scientific purpose.

20

Materials. All the materials were purchased from Sigma (Poole, UK) unless otherwise stated. Recombinant GH was purchased from Pfizer, recombinant E. coli derived human GH binding protein used in binding assays was a gift from DSL (DSL Research Reagents, Oxfordshire, UK), and iodinated GH a gift from NovoNordisk (NovoNordisk Park, Denmark). GH and GHR mAbs used for purification and characterisation were in-house materials (CS) except mAbs B07b and B24a which were a gift from Dr. Skriver (NovoNordisk Park, Denmark) and mAb 263 (AbD Serotec, Kidlington, Oxford, UK).

25

Purification of GH-exGHR LR-fusions. Human GH and GH receptor were amplified by RT-PCR from human pituitary and liver respectively and cloned into the vector, pSecTag-V5/FRT/Hist-TOPO (Invitrogen, Paisley, UK) under the human GH secretion signal sequence. Four repeats of a Gly₄Ser linker were used to link the native C-terminus of human GH to the native N-terminus of the human GHR. Stable clones were

30

made in CHO Flp-In cells (Invitrogen, Paisley, UK), adapted to protein free media and grown in suspension culture. LR-fusion expression was confirmed by an in-house ELISA. Affinity purification was performed using a GH mAb column.

- 5 **Transcription bioassays.** These were performed as previously described in human 293 cells stably expressing the human GHR¹⁶.

10 ELISA. An in house GH and LR-fusion ELISA has been established based on the sandwich ELISA format. In the assay, standards (GH or LR-fusion), controls and unknowns are incubated with biotin-labelled mouse antibody to human GH (mAb 7F8) in wells pre-coated with a mouse antibody to human GH antibody (mAb 10A7). The detection limit for the assay is 2.5 pg and the intra and inter assay CV is <10%. The IGF-I ELISA was purchased from DSL (DSL-10-2900 ACTIVE mouse/rat IGF-I kit; DSL Research Reagents, Oxfordshire, UK).

15

Pharmacokinetic studies. Seven weeks old normal Sprague Dawley rats from Janvier (Le Genest Saint Isle, France) were used for pharmacokinetic studies. Sc or iv administration (penile vein) and blood withdrawal (orbital sinus) were conducted under isoflurane anaesthesia. The rats (n=4-6/group) were injected iv or sc with of 0.1 mg/kg rhGH or LR-fusion. Blood samples were collected from the retro-orbital plexus. Serum was harvested and stored at -70°C until assays. Pharmacokinetic parameters were estimated by fitting values of hormone concentration versus time to compartmental models using non-linear least-squares regression analysis. Clearance values were normalized to animal weight. Clearance rate per animal weight and terminal half lives (t_{1/2}) were calculated using the coefficient and exponents obtained from the iv bolus model fits.

25

Primate Pharmacokinetic Study

30 The test substances IB7v2 and IB7v3 were formulated in solutions containing 11.9 mM sodium and potassium phosphates, 137 mM sodium chloride, 2.7 mM potassium chloride, 0.01 % polysorbate 80; pH of the solution was adjusted to 7.4.

35

Study design

The animals were assigned to 4 treatment groups (1 vehicle, 1 IB7v2 test group, 1 IB7v3 test group), comprising 3 males in the vehicle group and 4 males per group in the 2 treatment groups. The dose levels and volumes administered were as outlined in the table below:

Group	Treatment	# Monkeys (male)	Dose (mg/kg/dose)	Dose Volume
1	Vehicle (control)	3	0	0.2 mL/kg, on days 1, 15
2	IB7v2	4	1	0.2 mL/kg, on days 1, 15
3	IB7v3	4	1	0.2 mL/kg, on days 1, 15

Blood samples were obtained from all animals throughout the study in order to determine the concentration of the appropriate test material in serum. These samples were taken at a number of time points throughout the study.

Clinical endpoints and measurements

15

The serum concentration of IB7v2 and IB7v3 was determined using a validated ELISA method. The pharmacokinetic profile for each of the protein was determined by plotting the concentration for each of the protein in serum versus time using WinNonlin Pro (v4.0.1) software.

20

Growth studies. The growth studies used hypophysectomized rats and were performed on Sprague Dawley rats from Charles River Laboratories (Larbresle, France). Rats were hypophysectomized under isoflurane anaesthesia at 4 weeks of age by the breeder and delivered one week after selection on body weight criteria for successful surgery.

25

Animals were individually caged and allowed another week of rest before entering the experimental phase. The injection solutions of excipient, rhGH and LR-fusion never exceeded 2 ml/kg. The rats were weighed daily and depending on the administration protocol, received injections of the test substances for 10 days.

Characterisation of LR-fusions. Conformation of the LR-fusion was examined using a panel of 16 conformationally sensitive hGH receptor mAbs. Denaturing, native gels and western blotting were used to analyse the LR-fusion and western blotting performed with non-conformationally sensitive to GH. The form of the LR-fusion protein in solution was defined by gel filtration using a Superose G200 analytical column and analytical ultracentrifugation. Analytical ultracentrifugation (AUC) was performed by sedimentation velocity (Analytical service, Dr Andy Barry, Astbury, Leeds University, Leeds, UK).

Statistics. Two groups were compared with a Student's test if their variance was normally distributed or by a Student-Satterthwaite's test if not normally distributed. Distribution was tested with an F test. One-way ANOVA was used to compare the means of 3 or more groups and if the level of significance was $p < 0.05$ individual comparisons were performed with Dunnett's tests. All statistical tests were two-sided at the 5% level of significance and no imputation was made for missing values.

15

Examples

Design and characterisation of LR-fusion

A recombinant gene encoding human GH linked to the A & B domains of the GHR extracellular domain (exGHR1-238) via a flexible $(\text{Gly}_4\text{Ser})_4$ linker, was generated (Fig. 1c). This LR-fusion was expressed in CHO cells and purified using mAb antibody to GH affinity media to >95% purity (Fig. 2a). The LR-fusion was screened by ELISA using 16 conformationally-sensitive mAbs. All these mAbs bound the LR-fusion with affinity comparable to that for GHBP derived from human serum. Coomassie staining and western blotting of SDS-PAGE gels showed the LR-fusion protein to separate as a doublet of approximately 75 kDa with an approximate 5 kDa difference between the two bands. Native PAGE gel analysis (Fig. 2b) showed no evidence of aggregation. The LR-fusion appeared as two distinct forms. These distinct protein forms, fast (F) and slow (S), were excised from the native PAGE gel and then re-analysed by SDS-PAGE under reducing conditions. Both F & S forms from the native PAGE consisted of the 75 kDa doublet (Fig. 2c). The evidence for the existence of two forms of LR-fusion in solution was confirmed by analytical gel filtration (Fig. 2d). These results are consistent with the LR-fusion existing as a dimer in solution. This was confirmed by analytical ultracentrifugation where the size of the monomer was confirmed at 75 kDa.

In vitro bioassay and pharmacokinetics

The *in vitro* bioactivity of the LR-fusion was tested using a GH-specific luciferase reporter assay¹⁶. The LR-fusion had approximately 10% of the bioactivity compared to GH in this static assay system, although the LR-fusion was capable of stimulating maximal response albeit at a higher concentration than GH (Fig. 2e). The LR-fusion's pharmacokinetic profile was examined in normal rats after single subcutaneous (sc) or intravenous (iv) injection (Fig. 3). The LR-fusion demonstrated delayed clearance irrespective of the route of administration and delayed absorption after sc administration. After an iv bolus the terminal half-life of the LR-fusion was 21 ± 2 h, and clearance 3.3 ± 0.9 ml·h⁻¹·kg⁻¹. The clearance of the LR-fusion was 300-times slower than GH^{2,12}. After single sc administration the LR-fusion had a delayed peak compared to GH (30 vs 1 hour). The LR-fusion was still detectable at 8 days whilst GH was undetectable at 6 hours. We examined whether the exceptional pharmacokinetics of the LR-fusion were related to size. Two variant LR-fusion molecules with identical linkers were tested: one an LR-fusion of GH to only the B domain exGHR (55 kDa) and the other a tandem (GH linked to GH) linked to exGHR (100 kDa). Both the 55 kDa and 100 kDa proteins showed increased agonist activity in the bioassay compared to the original 75 kDa LR-fusion but for both the circulating half-life was <4 hours after iv administration (precise half-life determination was not possible as the sampling protocol used expected a longer half-life). The results confirm that the exceptional pharmacokinetics of the original 75 kDa LR-fusion was not solely related to molecular weight.

The pharmacokinetic profiles in the primate study for IB7v2 and IB7v3 following two sequential s/c doses of 1mg/kg at t-0 and t-336 hours (14-days) are shown in Figure 9. It can be noted that the levels reach a maximum rapidly and declines over a significantly extended period of time as compared to native human growth human which has a half-life of <1-hour. The levels are also maintained well above the minimum effective concentration, as defined by the dotted line over the duration of the sequential dosing.

30

Superiority of LR-fusion growth promotion over GH

To test biological activity, the LR-fusion and GH were administered to hypophysectomised (GH-deficient) rats. Daily administration of GH induced continuous

growth over 10 days. The LR-fusion was then compared to GH with either alternate day sc injections, or two injections over 10 days, or a single injection. For all experiments equimolar doses of GH and LR-fusion were used with the same total dose being given over the 10 day period: 220 $\mu\text{g}/\text{kg}/\text{day}$, approximately 10 nmol over 10 days similar to the dose previously used to obtain a maximal growth response¹². The LR-fusion promoted an increase in weight gain which was greater than GH under the same injection protocol and similar to that seen after daily GH injections (Fig. 4 and Table). GH appeared only to promote weight gain in the 24 hours post injection. In contrast, the LR-fusion produced continuous weight gain over 10 days even when given as a single injection. A similar pattern of growth was seen in femur, tibia, thymus, liver and kidney (Table). The 10-day terminal bleed from all animals was analysed for the GH-dependent biomarker, insulin-like growth factor-I (IGF-I), and GH and LR-fusion levels (Table). IGF-I levels were significantly elevated after LR-fusion administration even after single injection and were significantly greater than those seen after daily injection of GH. Levels of GH were undetectable in the terminal bleed after all injection regimens whereas LR-fusion levels were detectable 10 days after a single injection.

We have demonstrated that an LR-fusion of GH generates a potent agonist. We propose that the ability of the molecule to form a head-to-tail reciprocal dimers (Fig. 1d) is responsible for its enhanced in vivo bioactivity.

The design of the LR-fusion was based on the known crystal structure of the GHR¹⁷. We used a flexible Gly₄Ser linker with 4 repeats (predicted length of 80 Å). This long linker was chosen as a relatively flexible tether between GH and the GHR such that the GH moiety could still interact with the cell surface GHR (Fig. 1e). Similar Gly₄Ser linkers have been used in recombinant single chain Fv antibody production because of stability and lack of immunogenicity¹⁸.

The LR-fusion was appropriately folded, appearing on both native PAGE gels and in gel filtration as two distinct species, i.e. potentially monomer and dimer. The presence of dimers was confirmed by analytical ultracentrifugation. We propose that the LR-fusion forms a reciprocal head-to-tail dimer through intermolecular binding of the GH moiety in each LR-fusion molecule to the receptor moiety in the other (Fig. 1d). The LR-fusion

appeared as two bands on SDS-PAGE, with a molecular weight difference of 5 kDa, presumably due to glycosylation^{19,20}.

The LR-fusion was more potent in vivo compared to GH but in vitro bioactivity was 10-
5 times less. This discrepancy can be attributed to dimerisation of the LR-fusion. In a static in vitro bioassay the dimer would be biologically inactive as seen with the native GH/GHBP complex^{21,22}. However, in vivo the dimer provides a reservoir of inactive hormone in equilibrium with biologically active monomer.

10 After iv administration to rats our LR-fusion had a 300-times reduced clearance compared to GH and a 10 to 30-times reduced clearance compared to that previously reported for a GH/GHBP complex or conjugate^{11,12}. We tested two other LR-fusion variants one of 55 kDa and the other 100kDa. Neither protein showed the same delayed
15 clearance. We therefore conclude that it is not monomeric size alone that is responsible for LR-fusion delayed clearance. The renal contribution to GH clearance has been estimated to be 25-53% in humans²³ and 67% in rats²⁴. Therefore reducing renal clearance alone can only be predicted to approximately halve GH clearance². As GH clearance is relatively independent of a GH receptor mechanism²⁵ it is presumed that proteolysis is a major contributor. We propose that the greatly reduced clearance of our
20 LR-fusion is attributable to both reduced renal clearance and a conformation that prevents proteolysis.

In hypophysectomised rats our LR-fusion given only once during 10 days produced a similar increase in weight to that seen with daily injections of GH. It has previously been
25 shown that GHBP co-administered as 1:1 molar complex with GH augments growth¹². Using the same protocol our LR-fusion protein promoted growth over 10 days after a single injection whereas the GH/GHBP complex required daily injections and our LR-fusion generated a higher IGF-I level than that seen after GH/GHBP co-administration. GH is biologically inactive when conjugated to GHBP and the non-covalently linked
30 complex lacks the stability of the LR-fusion^{11,12}. The greater biological action of the LR-fusion may relate to its increased stability and its ability to activate the GHR in monomeric form.

In humans IGF-I levels are generally a good biomarker of GH activity. However, in hypophysectomised rats IGF-I levels do not always reflect the growth response to GH^{2,12}. LR-fusion administration resulted in clearly elevated IGF-I levels compared to GH injection. We suggest that the dose-response to GH of growth and IGF-I differs in hypophysectomised rats. Thus, the dose of LR-fusion used in our study was in excess of that required to promote a maximal growth response, but still capable of stimulating IGF-I generation. Rats display more rapid renal clearance than humans making it difficult to predict the dosing regimen that will be required in man. One might expect that the LR-fusion could be used at lower doses and much less frequently than GH.

Fusions of cytokine hormones with serum albumin and pegylation have been used to prolong circulating half-life^{2,26}. Our LR-fusion molecule has major advantages over these two approaches. Pegylation is highly effective at delaying the clearance of proteins, but requires chemical modification and reduces the affinity of ligand for its receptor². Thus, with pegylation a greater dose is required whereas with our LR-fusion a similar dose has a greater effect than native GH. Regarding the GH fusion with albumen, Albutropin, relatively little is known as it is understood that this was withdrawn from clinical studies. In the one PK study²⁶ Albutropin had 6-times longer terminal half-life when given s.c. compared to GH whereas our LR-fusion protein has a 100-times longer terminal half-life given i.v. compared to that published for GH¹² (For native human GH: clearance value of 18.6 ml/min.kg = 1116 ml/hr.kg and Vd = 336 ml/kg thus T1/2 = 0.693x336/1116 = 0.21 hrs.). GH naturally binds to circulating exGHR and therefore our LR-fusion is unlikely to be immunogenic compared to fusions with other proteins and extensive in silico T cell epitope screening showed no sites in the LR-fusion molecule (data not shown).

References:

1. Woodhouse, L.J., Mukherjee, A., Shalet, S.M. & Ezzat, S. The influence of growth hormone status on physical impairments, functional limitations, and health-related quality of life in adults. *Endocr Rev.* 27, 287317 (2006).
2. Clark, R. et al. Long-acting growth hormones produced by conjugation with polyethylene glycol. *Journal of Biological Chemistry.* 271, 2196921977 (1996).

3. Cook, D.M. et al. The pharmacokinetic and pharmacodynamic characteristics of a long-acting growth hormone (GH) preparation (nutropin depot) in GH-deficient adults. *J Clin Endocrinol Metab.* 87, 450814 (2002).
4. Reiter, E.O. et al. A multicenter study of the efficacy and safety of sustained
5 release GH in the treatment of naive pediatric patients with GH deficiency. *J Clin Endocrinol Metab.* 86, 47006 (2001).
5. Jostel, A., Mukherjee, A., Alenfall, J., Smethurst, L. & Shalet, S.M. A new sustained-release preparation of human growth hormone and its pharmacokinetic, pharmacodynamic and safety profile. *Clin Endocrinol (Oxf).* 62,
10 6237 (2005).
6. Laursen, T. et al. Long-term effects of continuous subcutaneous infusion versus daily subcutaneous injections of growth hormone (GH) on the insulin-like growth factor system, insulin sensitivity, body composition, and bone and lipoprotein metabolism in GH-deficient adults. *J Clin Endocrinol Metab.* 86, 12228 (2001).
- 15 7. Laursen, T., Jorgensen, J.O., Jakobsen, G., Hansen, B.L. & Christiansen, J.S. Continuous infusion versus daily injections of growth hormone (GH) for 4 weeks in GH-deficient patients. *J Clin Endocrinol Metab.* 80, 24108 (1995).
8. Muller-Newen, G., Kohne, C. & Heinrich, P.C. Soluble receptors for cytokines and growth factors. [Review] [58 refs]. *International Archives of Allergy & Immunology.* 111, 99106 (1996).
- 20 9. Baumann, G., Amburn, K.D. & Buchanan, T.A. The effect of circulating growth hormone-binding protein on metabolic clearance, distribution, and degradation of human growth hormone. *J Clin Endocrinol Metab.* 64, 65760 (1987).
10. Baumann, G. Growth hormone heterogeneity: genes, isohormones, variants, and
25 binding proteins. *Endocrine Reviews* 12, 424449 (1991).
11. Baumann, G., Shaw, M.A. & Buchanan, T.A. In vivo kinetics of a covalent growth hormone-binding protein complex. *Metabolism.* 38, 3303 (1989).
12. Clark, R.G. et al. Recombinant human growth hormone (GH)-binding protein enhances the growth-promoting activity of human GH in the rat. *Endocrinology.*
30 137, 43084315 (1996).
13. Baumann, G. Growth hormone binding protein--errant receptor or active player? [editorial]. *Endocrinology.* 136, 377378 (1995).
14. Ayling, R.M. et al. A dominant-negative mutation of the growth hormone receptor causes familial short stature. *Nature Genetics.* 16, 1314 (1997).

15. Ross, R.J. et al. A short isoform of the human growth hormone receptor functions as a dominant negative inhibitor of the full-length receptor and generates large amounts of binding protein. *Molecular Endocrinology*. 11, 265273 (1997).
- 5 16. Ross, R.J.M. et al. Binding and functional studies with the growth hormone receptor antagonist, B2036-PEG (pegvisomant), reveal effects of pegylation and evidence that it binds to a receptor dimer. *Journal of Clinical Endocrinology & Metabolism*. 86, 17161723 (2001).
- 10 17. Cunningham, B.C. et al. Dimerization of the extracellular domain of the human growth hormone receptor by a single hormone molecule. *Science*. 254, 821825 (1991).
18. Huston, J.S., Tai, M.S., McCartney, J., Keck, P. & Oppermann, H. Antigen recognition and targeted delivery by the single-chain Fv. *Cell Biophys*. 22, 189-224 (1993).
- 15 19. Herington, A.C., Smith, A.I., Wallace, C. & Stevenson, J.L. Partial purification from human serum of a specific binding protein for human growth hormone. *Mol Cell Endocrinol*. 53, 2039 (1987).
- 20 20. Frick, G.P., Tai, L.R., Baumbach, W.R. & Goodman, H.M. Tissue distribution, turnover, and glycosylation of the long and short growth hormone receptor isoforms in rat tissues. *Endocrinology*. 139, 282430 (1998).
- 20 21. Mannor, D.A., Winer, L.M., Shaw, M.A. & Baumann, G. Plasma growth hormone (GH)-binding proteins: effect on GH binding to receptors and GH action. *J Clin Endocrinol Metab*. 73, 304 (1991).
- 25 22. Lim, L., Spencer, S.A., McKay, P. & Waters, M.J. Regulation of growth hormone (GH) bioactivity by a recombinant human GH-binding protein. *Endocrinology*. 127, 128791 (1990).
23. Haffner, D., Schaefer, F., Girard, J., Ritz, E. & Mehls, O. Metabolic clearance of recombinant human growth hormone in health and chronic renal failure. *J Clin Invest*. 93, 116371 (1994).
24. Johnson, V. & Maack, T. Renal extraction, filtration, absorption, and catabolism of growth hormone. *American Journal of Physiology* 233, F185F196 (1977).
- 30 25. Veldhuis, J.D. et al. Impact of experimental blockade of peripheral growth hormone (GH) receptors on the kinetics of endogenous and exogenous GH removal in healthy women and men. *Journal of Clinical Endocrinology & Metabolism* 87, 57375745 (2002).

26. Osborn, B.L. et al. Albutropin: a growth hormone-albumin fusion with improved pharmacokinetics and pharmacodynamics in rats and monkeys. *Eur J Pharmacol* 456, 14958 (2002).
27. de Vos, A.M., Ultsch, M. & Kossiakoff, A.A. Human growth hormone and extracellular domain of its receptor: crystal structure of the complex. *Science* 255, 306312 (1992)

10

15

20

25

30

Claims

- 1 A nucleic acid molecule comprising a nucleic acid sequence selected from:
- 5 i) a nucleic acid sequence as represented in SEQ ID NO:1;
ii) a nucleic acid sequence as represented in SEQ ID NO:2;
iii) a nucleic acid sequence as represented in SEQ ID NO:3;
iv) a nucleic acid sequence as represented in SEQ ID NO:4; or
v) a nucleic acid molecule comprising a nucleic sequence that hybridizes
10 under stringent hybridization conditions to SEQ ID NO:1, SEQ ID NO: 2;
SEQ ID NO: 3 or SEQ ID NO: 4, and which encodes a polypeptide that
has growth hormone receptor agonist activity.
2. A nucleic acid molecule according to claim 1, comprising a nucleic acid sequence
as represented in SEQ ID NO: 1.
- 15 3. A nucleic acid molecule according to claim 1, comprising a nucleic acid sequence
as represented in SEQ ID NO: 2.
4. A nucleic acid molecule according to claim 1, comprising a nucleic acid sequence
20 as represented in SEQ ID NO: 3.
5. A nucleic acid molecule according to claim 1, comprising a nucleic acid sequence
as represented in SEQ ID NO: 4.
- 25 6. A polypeptide encoded by the nucleic acid molecule according to claim 1.
7. A polypeptide comprising an amino acid sequence selected from:
- 30 i) an amino acid sequence as represented in SEQ ID NO:5;
ii) an amino acid sequence as represented in SEQ ID NO:6;
iii) an amino acid sequence as represented in SEQ ID NO:7;
iv) an amino acid sequence as represented in SEQ ID NO:8;
v) an amino acid sequence as represented in SEQ ID NO:9;
vi) an amino acid sequence as represented in SEQ ID NO:10;
vii) an amino acid sequence as represented in SEQ ID NO:11;

viii) an amino acid sequence as represented in SEQ ID NO:12; wherein said polypeptide has growth hormone receptor agonist activity.

5 8. A polypeptide according to claim 7 wherein said polypeptide comprises an amino acid sequence as represented in SEQ ID NO: 5.

9. A polypeptide according to claim 7 wherein said polypeptide comprises an amino acid sequence as represented in SEQ ID NO: 6.

10 10. A polypeptide according to claim 7 wherein said polypeptide comprises an amino acid sequence as represented in SEQ ID NO: 7.

11. A polypeptide according to claim 7 wherein said polypeptide comprises an amino acid sequence as represented in SEQ ID NO: 8.

15

12. A polypeptide according to claim 7 wherein said polypeptide comprises an amino acid sequence as represented in SEQ ID NO: 9.

13 20 A polypeptide according to claim 7 wherein said polypeptide comprises an amino acid sequence as represented in SEQ ID NO: 10.

14. A polypeptide according to claim 7 wherein said polypeptide comprises an amino acid sequence as represented in SEQ ID NO: 11.

25 15. A polypeptide according to claim 7 wherein said polypeptide comprises an amino acid sequence as represented in SEQ ID NO: 12.

16. A homodimer comprising two polypeptides comprising SEQ ID NO: 5.

30 17. A homodimer comprising two polypeptides comprising SEQ ID NO: 6.

18. A homodimer comprising two polypeptides comprising SEQ ID NO: 7.

19. A homodimer comprising two polypeptides comprising SEQ ID NO: 8.

20. A homodimer comprising two polypeptides comprising SEQ ID NO: 9.
21. A homodimer comprising two polypeptides comprising SEQ ID NO: 10.
- 5 22. A homodimer comprising two polypeptides comprising SEQ ID NO: 11.
23. A homodimer comprising two polypeptides comprising SEQ ID NO: 12.
- 10 24. A vector comprising a nucleic acid molecule according to claim 1.
25. A vector according to claim 24 wherein said vector is an expression vector.
26. A cell transfected or transformed with a vector according to claim 25.
- 15 27. A cell according to claim 26 wherein said cell is a eukaryotic cell.
28. A cell according to claim 26 wherein said cell is a prokaryotic cell.
- 20 29. A pharmaceutical composition comprising a polypeptide according to claim 7 including an excipient or carrier.
- 25 30. A method to treat a human subject suffering from growth hormone deficiency comprising administering an effective amount of at least one polypeptide according to claim 7.
31. A method according to claim 30 wherein said polypeptide is administered intravenously.
- 30 32. A method according to claim 30 wherein said polypeptide is administered subcutaneously.
33. A method according to claim 30 wherein said polypeptide is administered at two day intervals.

34. A method according to claim 30 wherein said polypeptide is administered at weekly intervals.

5 35. A method according to claim 30 wherein said polypeptide is administered at 2 weekly intervals.

36. A method according to claim 30 wherein said polypeptide is administered at monthly intervals.

10

37. A method according to claim 30 wherein said growth hormone deficiency is childhood growth hormone deficiency.

15 38. A method according to claim 30 wherein said growth hormone deficiency is adult growth hormone deficiency.

20

25

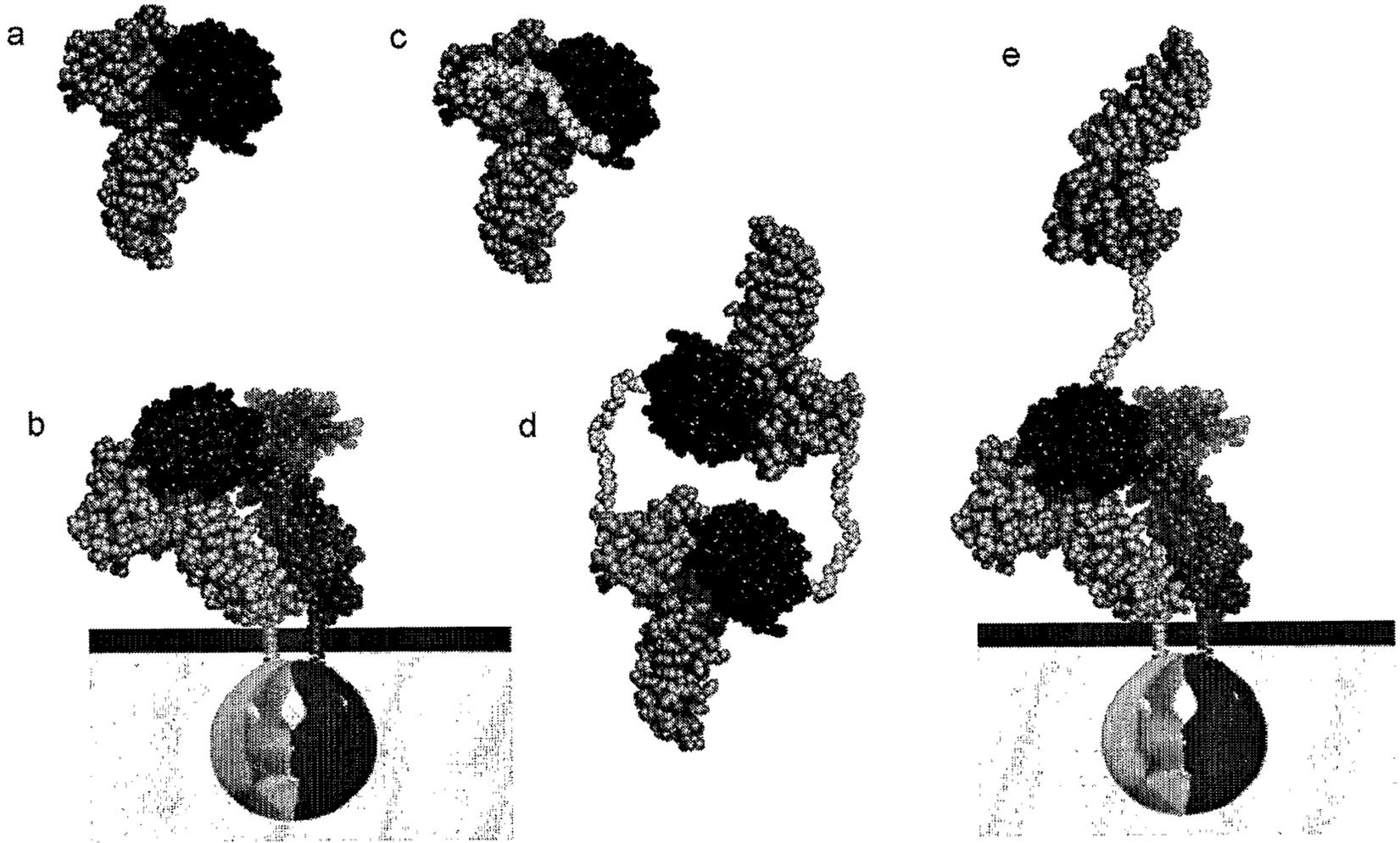
30

Table 1

Variable at 10 days	Placebo	Treatment	GH	LR-fusion	t-test p GH vs LR
Weight (g)	86.3 ± 1.6	Daily injections	103.3 ± 1.4	na	na
		Injections every 2 days	95.9 ± 0.8	102.2 ± 1.6	<0.0001
		Injections every 5 days	88.4 ± 2.1	101.1 ± 0.7	<0.0001
		Single injection	93.2 ± 2.9	108.3 ± 1.5	<0.0001
Change in weight from baseline (g)	1.43 ± 0.96	Daily injections	16.4 ± 0.8	na	na
		Injections every 2 days	9.9 ± 0.5	17 ± 1.5	0.0003
		Injections every 5 days	4.5 ± 1.3	14.8 ± 0.9	<0.0001
		Single injection	5.0 ± 0.1	17.2 ± 1.1	<0.0001
Change in Femur Length (mM)	0.00 ± 0.25	Daily injections	0.83 ± 0.26	na	na
		Injections every 2 days	0.99 ± 0.18	1.08 ± 0.07	0.667
		Injections every 5 days	0.44 ± 0.21	1.29 ± 0.22	0.0194
		Single injection	na	na	na
Change in Tibia weight (g)	0.00 ± 0.02	Daily injections	0.03 ± 0.01	na	na
		Injections every 2 days	0.06 ± 0.02	0.05 ± 0.01	0.52
		Injections every 5 days	0.01 ± 0.01	0.07 ± 0.02	0.027
		Single injection	na	na	na
Change in Thymus weight (mg)	0.00 ± 21	Daily injections	79 ± 20	na	na
		Injections every 2 days	43 ± 6	142 ± 22	0.0054
		Injections every 5 days	35 ± 12	120 ± 15	0.0132
		Single injection	-13 ± 22	117 ± 21	0.0017
Change in Liver weight (mg)	0 ± 167	Daily injections	123 ± 170	na	na
		Injections every 2 days	362 ± 74	587 ± 206	0.056
		Injections every 5 days	402 ± 236	407 ± 116	0.073
		Single injection	na	na	na
Change in Kidney weight (mg)	0 ± 11	Daily injections	51 ± 22	na	na
		Injections every 2 days	45 ± 26	75 ± 21	0.0053
		Injections every 5 days	5 ± 26	67 ± 12	0.0273
		Single injection	7 ± 22	78 ± 15	0.0062
IGF-I (ng.ml ⁻¹)	51 ± 12	Daily injections	92 ± 30	na	na
		Injections every 2 days	92 ± 30	329 ± 35	0.0005
		Injections every 5 days	55 ± 15	205 ± 5	<0.0001
		Single injection	18 ± 2.5	198 ± 66	0.0146
GH or Chimera by ELISA (nM)	nd	Daily injections	nd	na	na
		Injections every 2 days	nd	44 ± 15	0.015
		Injections every 5 days	nd	23 ± 5	0.0015
		Single injection	nd	3.2 ± 1.2	0.0193

nd = Not Detectable

na = Not Analyzed



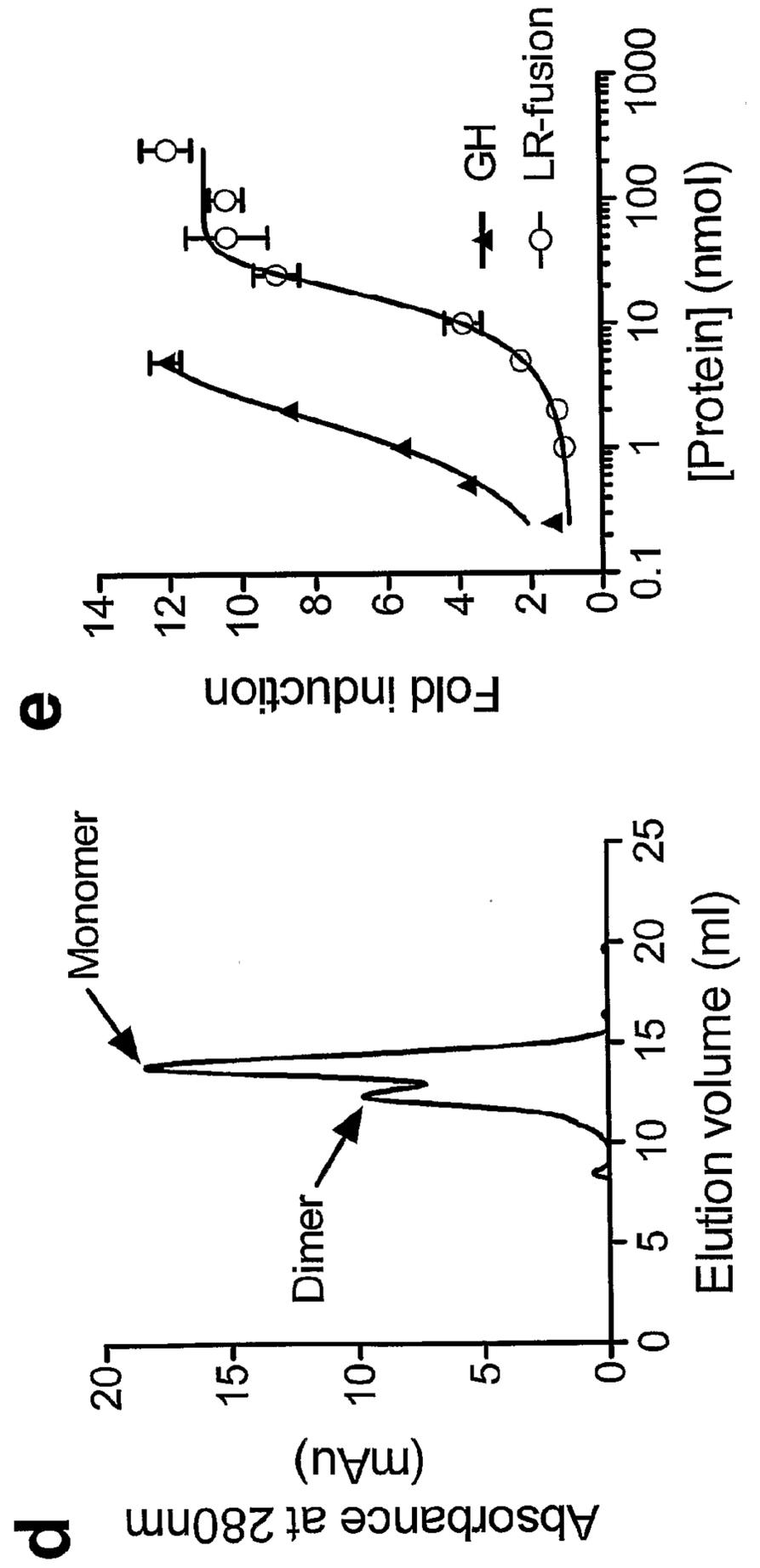
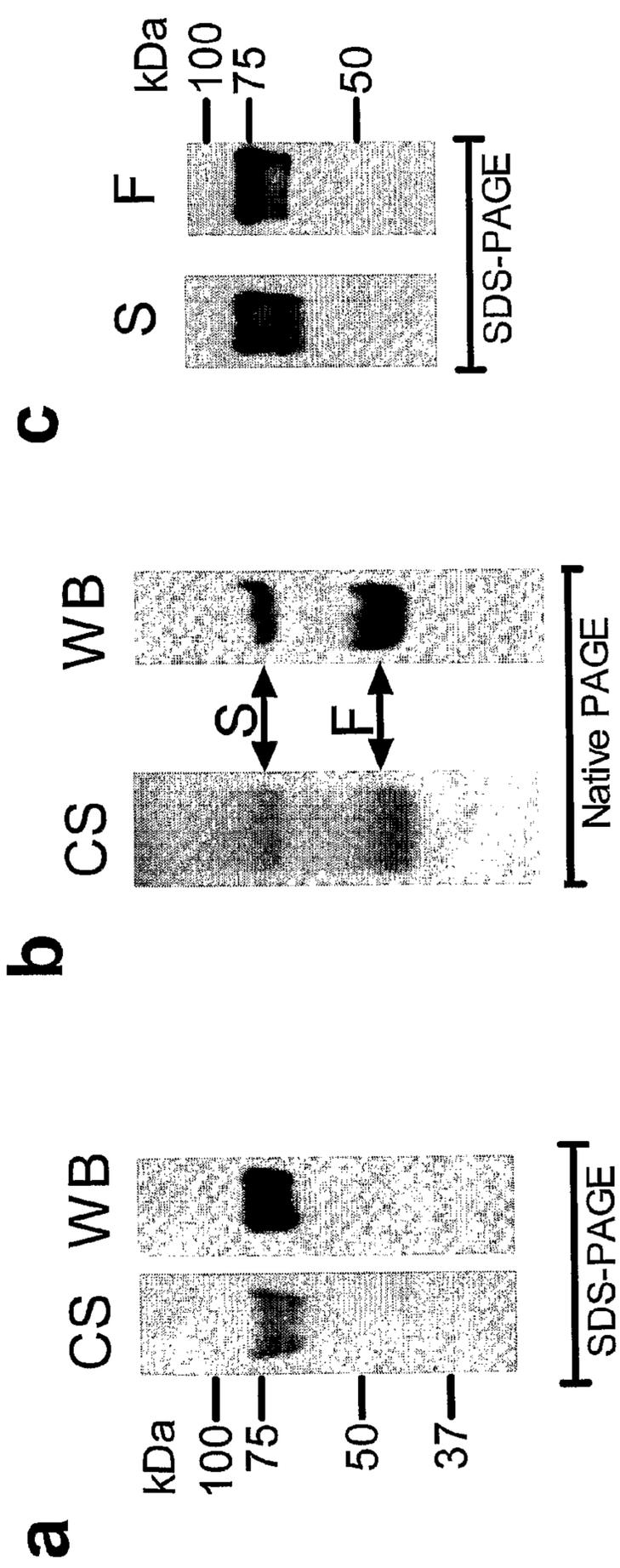
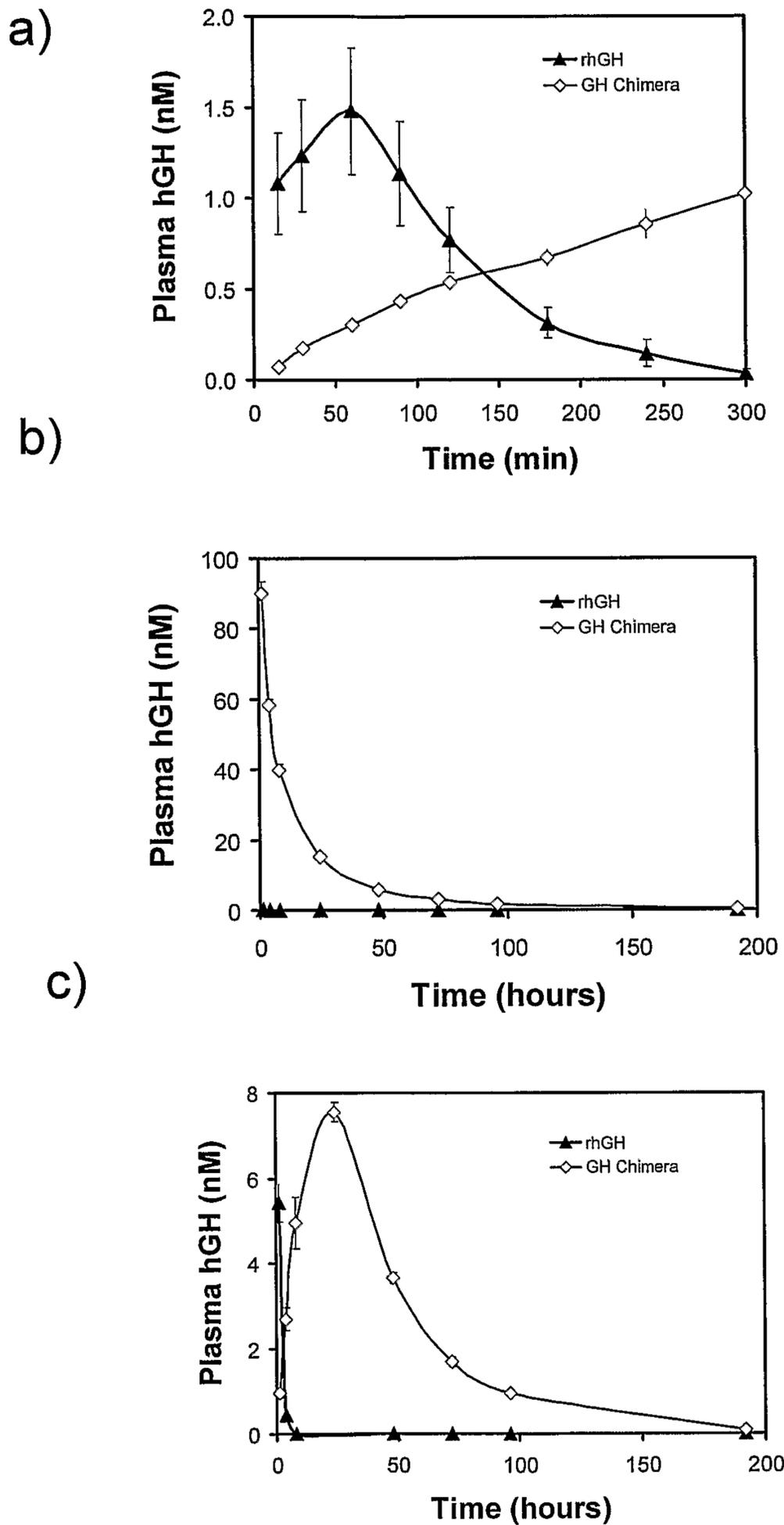
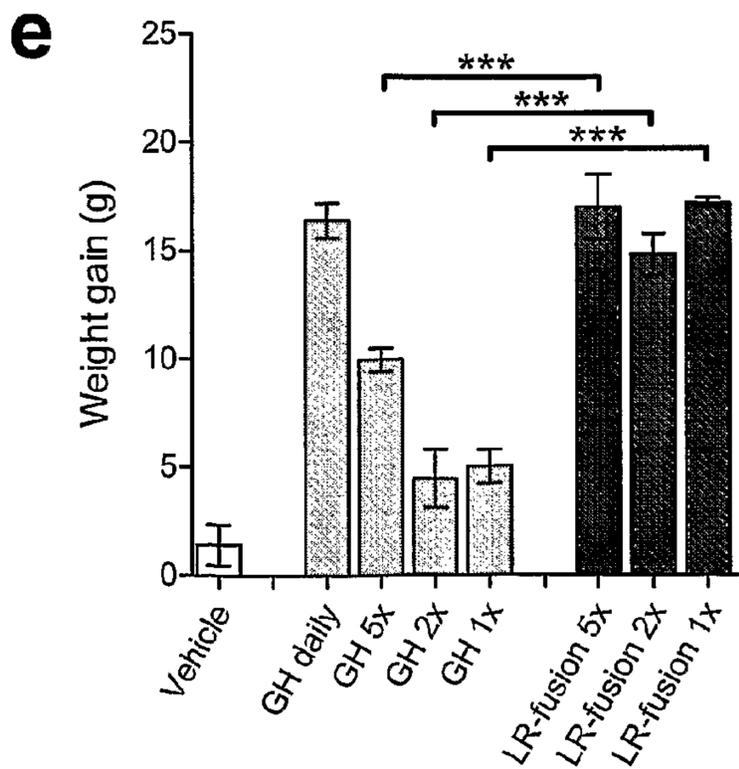
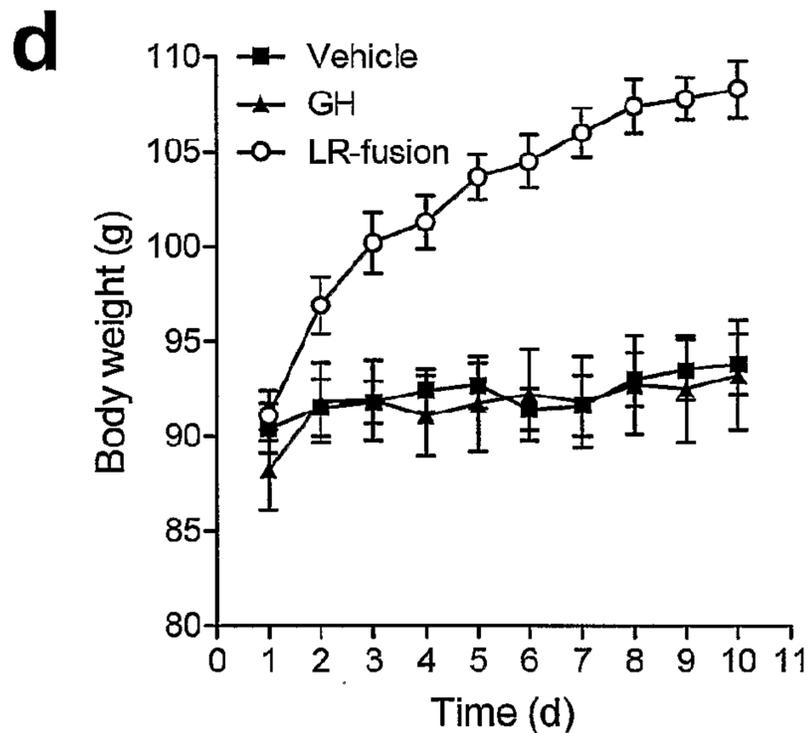
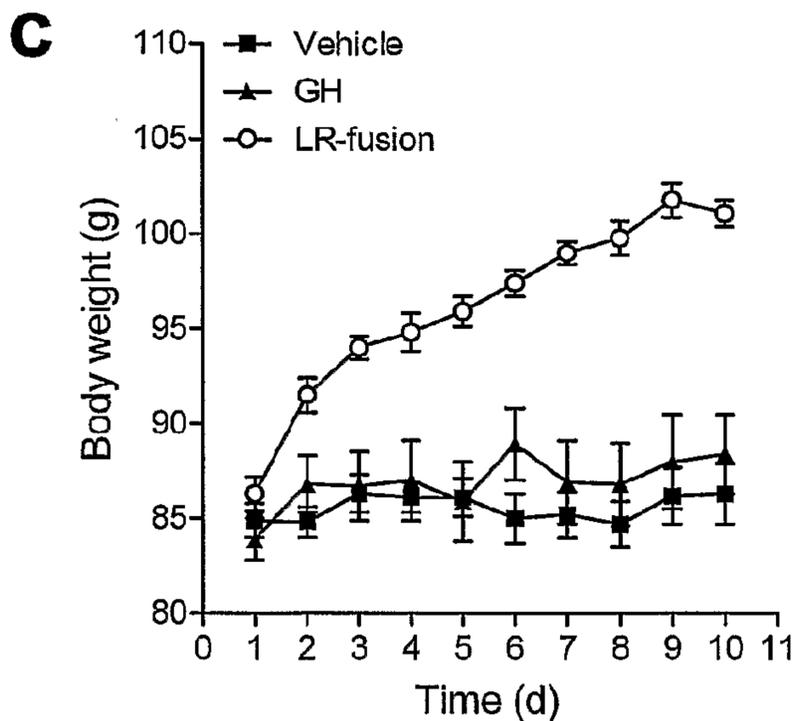
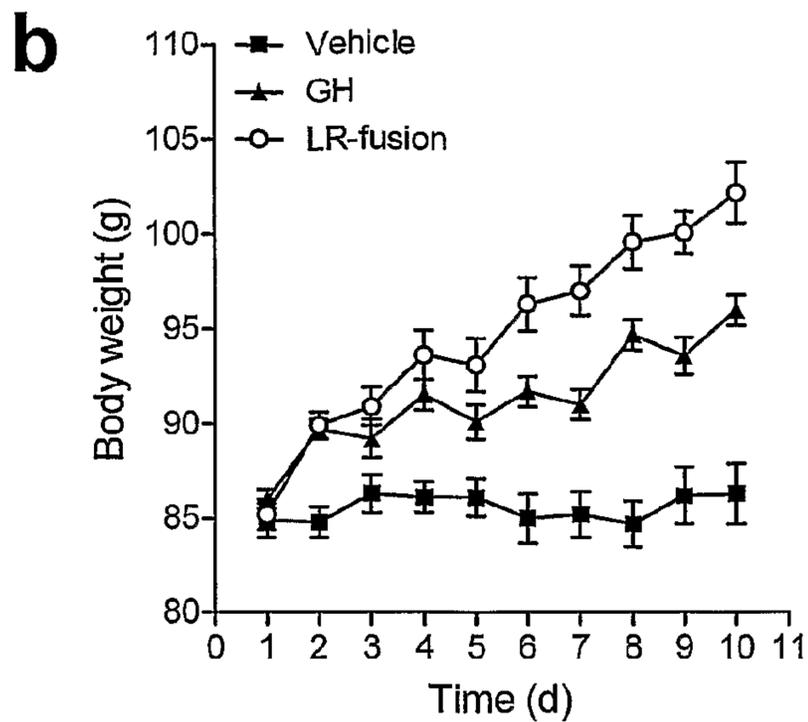
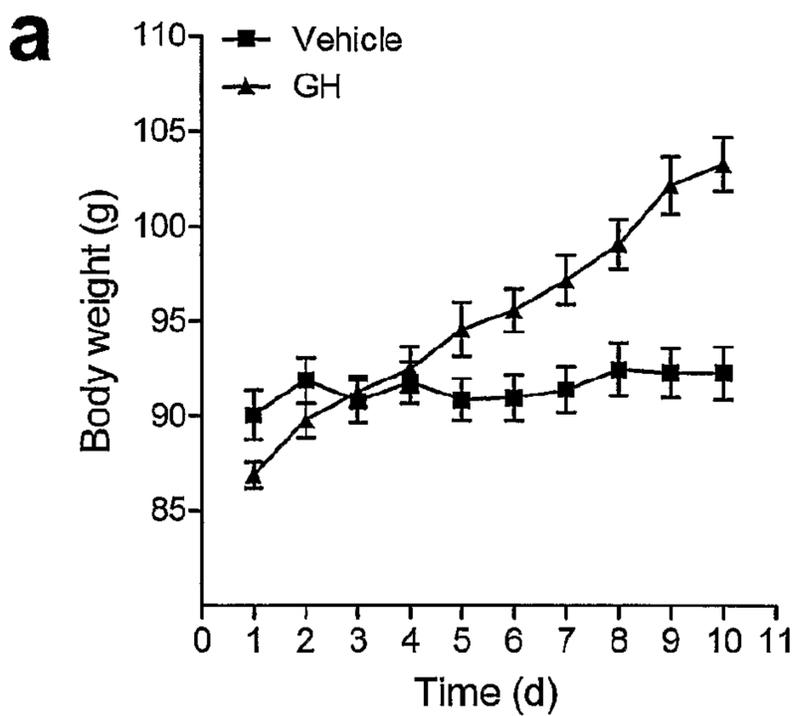


Figure 3





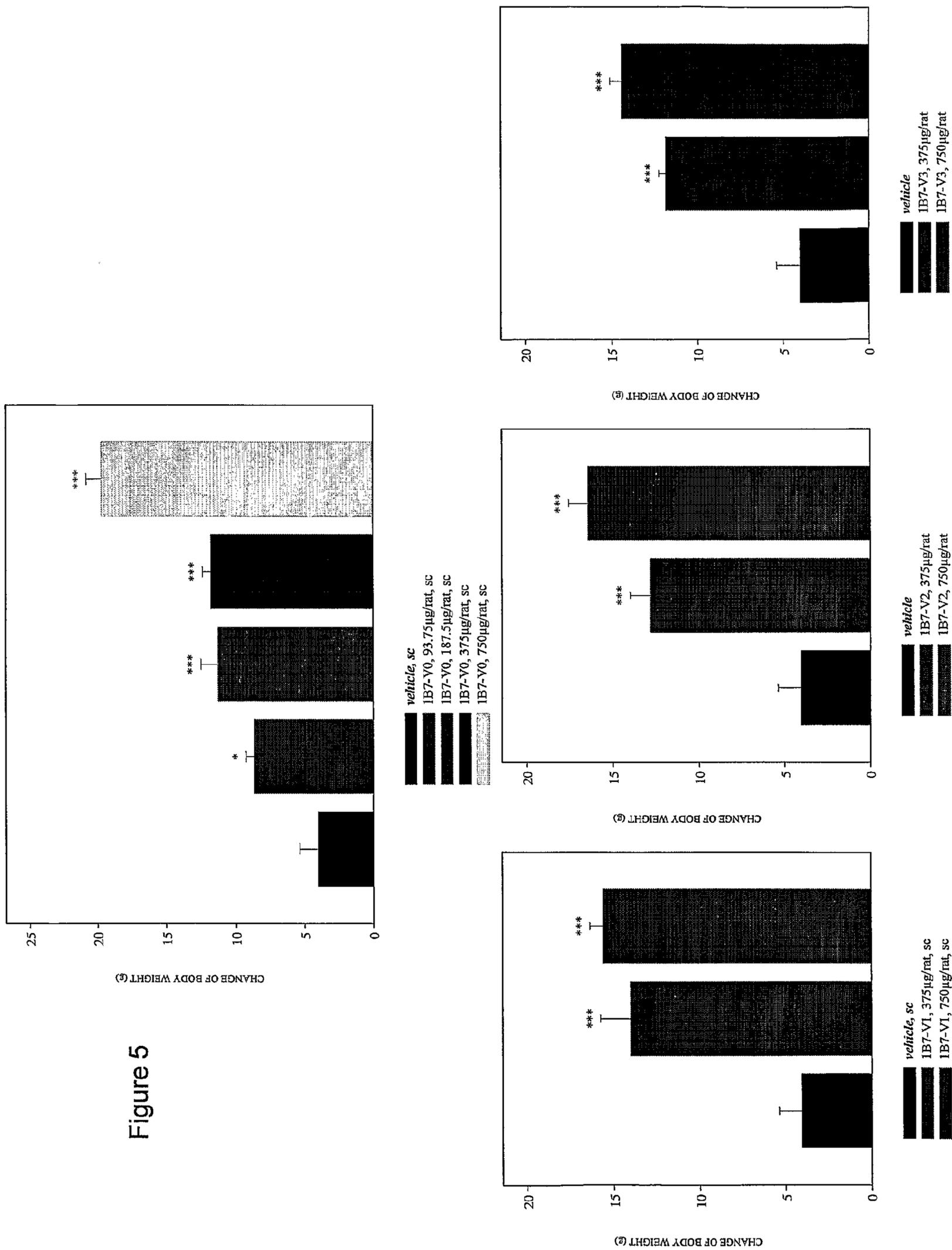
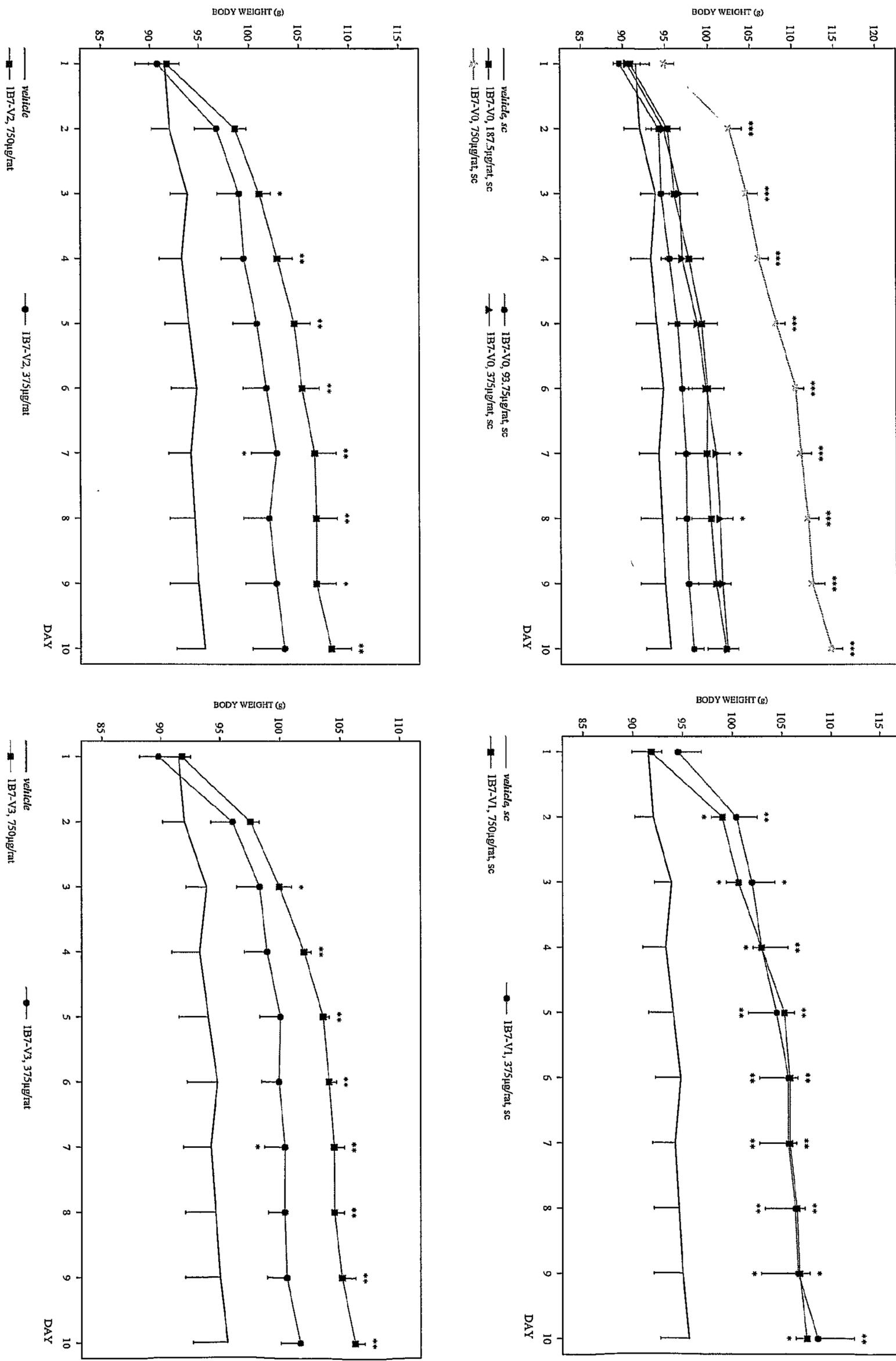


Figure 6



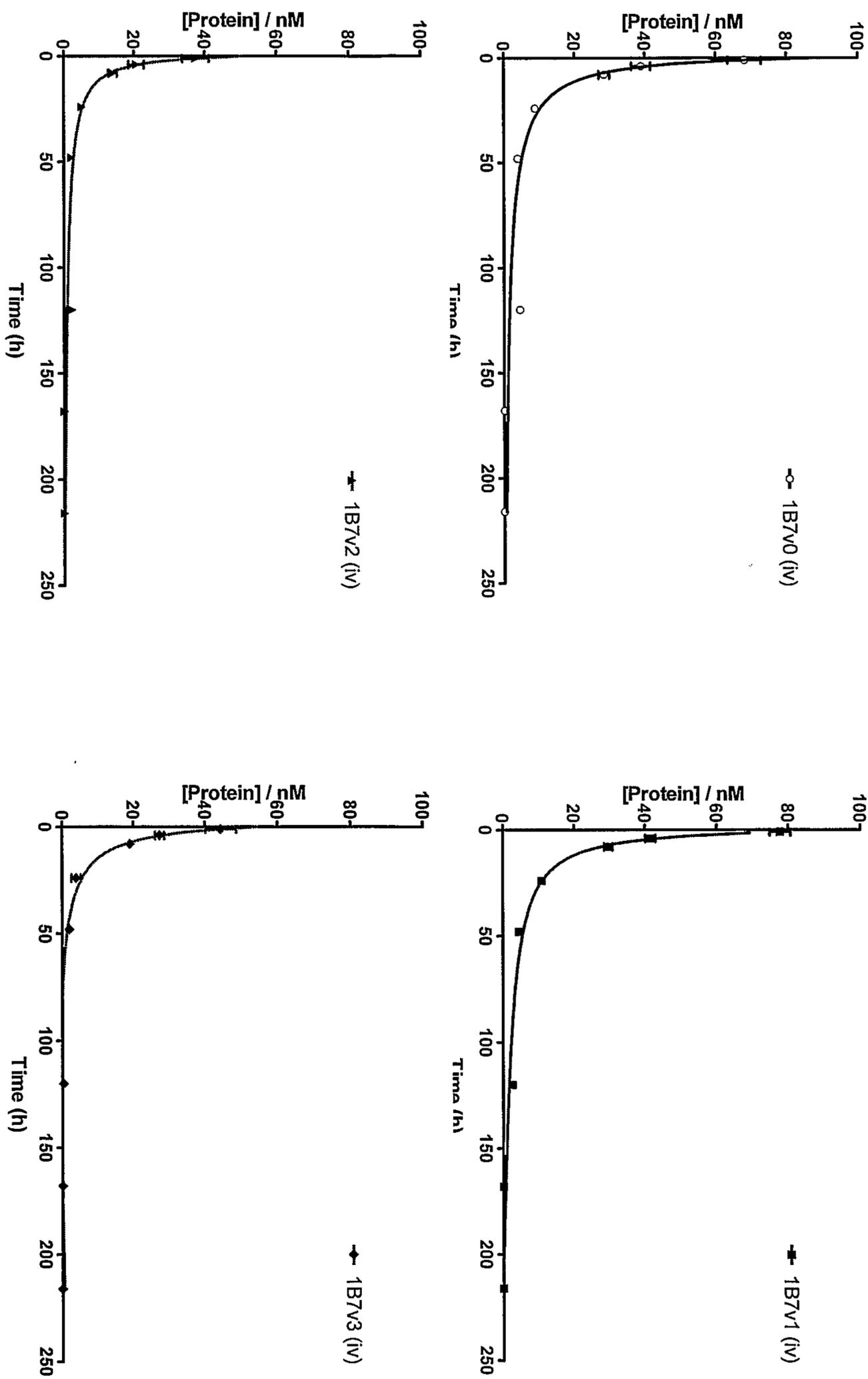


Figure 7

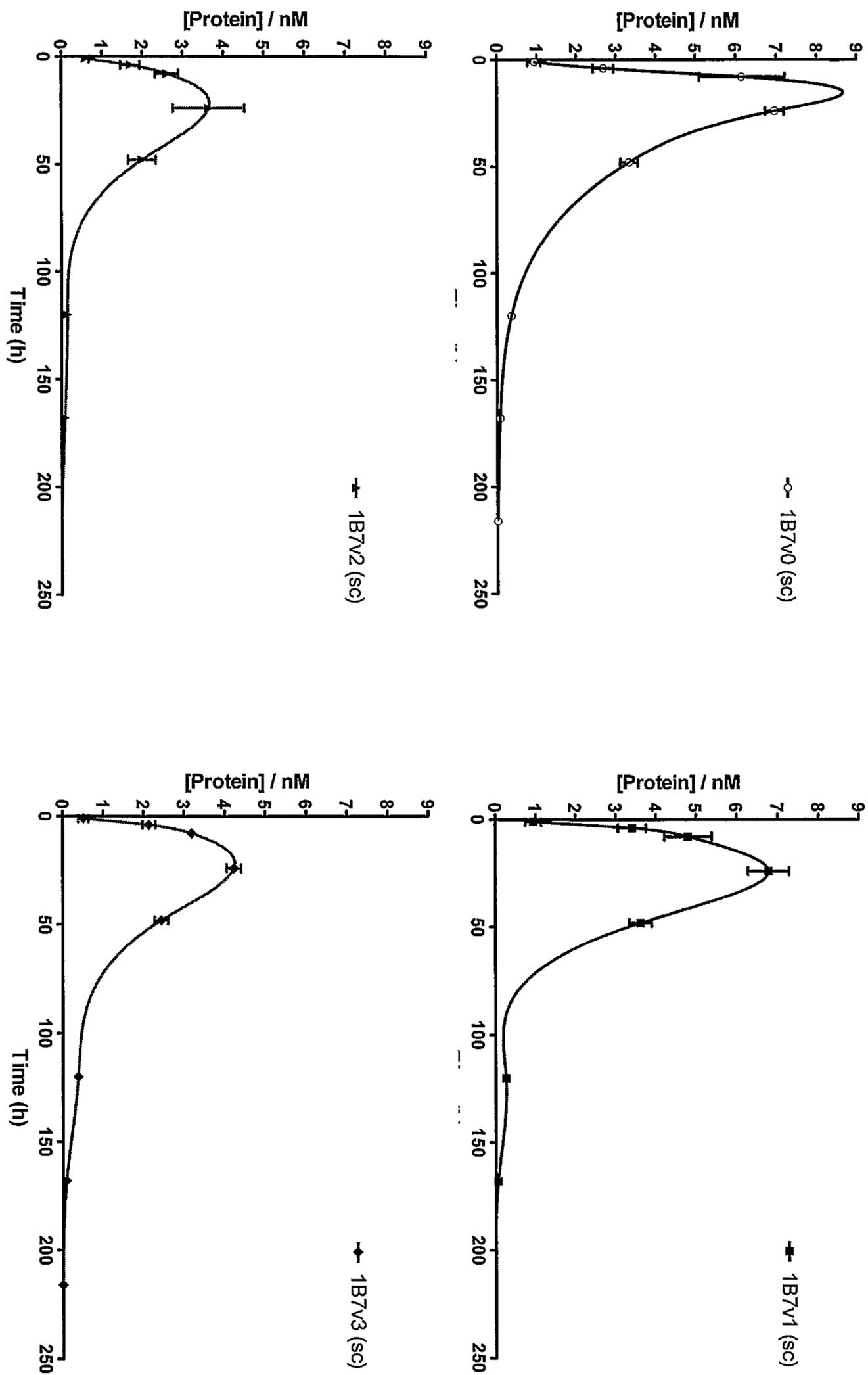


Figure 8

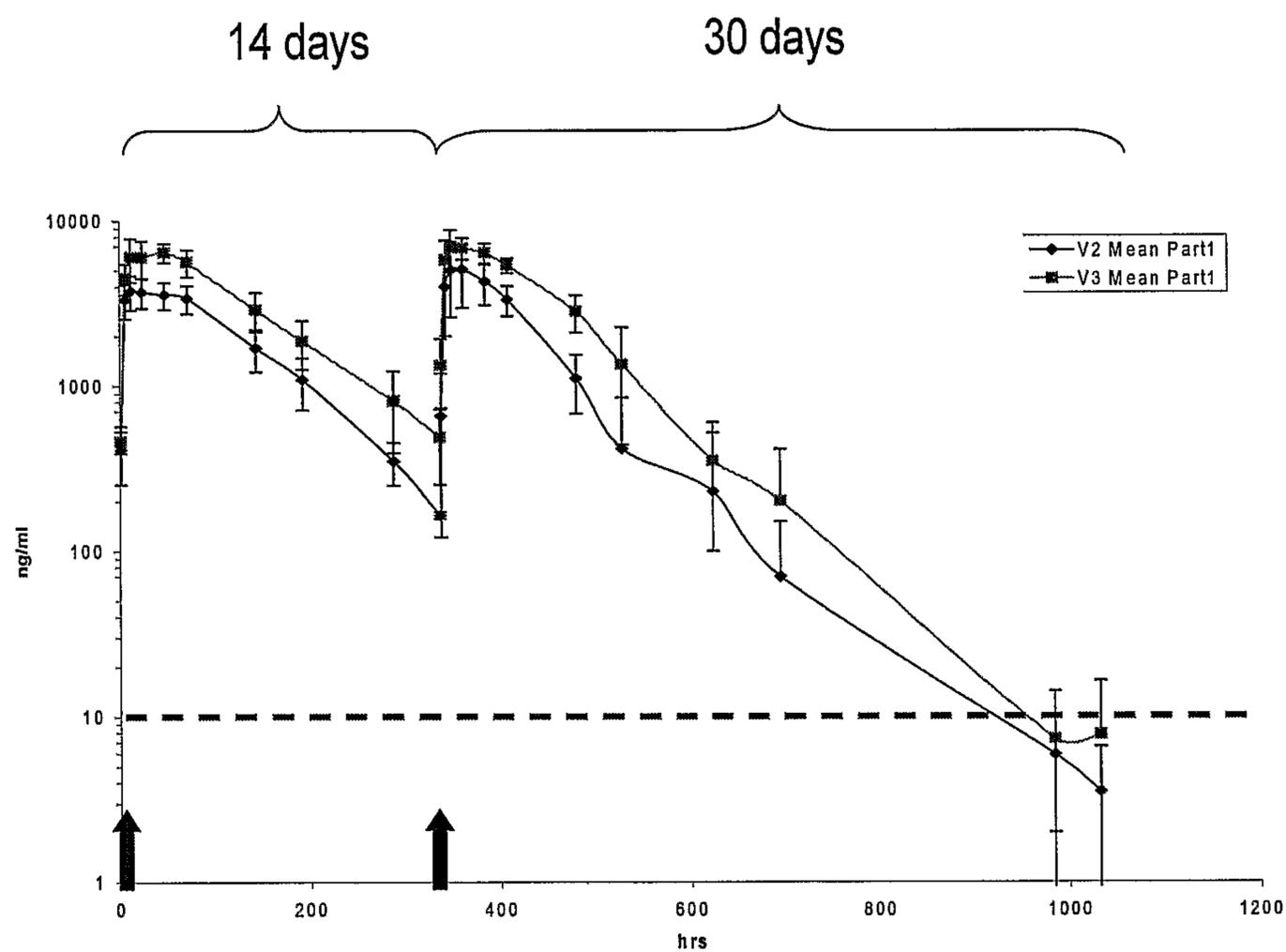


Figure 9