

(19) AUSTRALIAN PATENT OFFICE

(54) Title
GMG-2 polynucleotides and polypeptides and uses thereof

(51)⁶ International Patent Classification(s)
C12N 15/09 (2006.01) 20060101ALI2006052
A61K 35/76 (2006.01) 1BMWO **A61P**
A61K 38/00 (2006.01) 3/06
A61K 38/17 (2006.01) 20060101ALI2006052
A61K 48/00 (2006.01) 1BMWO **A61P**
A61P 3/04 (2006.01) 3/10
A61P 3/06 (2006.01) 20060101ALI2006052
A61P 3/10 (2006.01) 1BMWO **A61P**
A61P 9/10 (2006.01) 9/10
A61P 9/12 (2006.01) 20060101ALI2006052
C07K 14/435 1BMWO **A61P**
(2006.01) 9/12
C07K 14/47 (2006.01) 20060101ALI2006052
C12N 1/15 (2006.01) 1BMWO **C07K**
C12N 1/19 (2006.01) 20060101ALI2005100
C12N 1/21 (2006.01) 8BMEP **C07K**
C12N 5/10 (2006.01) 14/47
C12N 15/09 20060101ALI2005122
20060101AFI2005122 0BMJP **C12N**
0BMJP **A61K** 1/15
35/76 20060101ALI2005122
20060101ALI2005122 0BMJP **C12N**
0BMJP **A61K** 1/19
38/00 20060101ALI2005122
20060101ALI2005122 0BMJP **C12N**
0BMJP **A61K** 1/21
38/17 20060101ALI2005122
20060101ALI2005100 0BMJP **C12N**
8BMEP **A61K** 5/10
48/00 20060101ALI2005122
20060101ALI2005122 0BMJP
0BMJP **A61P** PCT/IB02/03407
3/04

(21) Application No: 2002321768

(22) Application Date: 2002.07.25

(87) WIPO No: WO03/010314

(30) Priority Data

(31) Number	(32) Date	(33) Country
60/308,253	2001.07.26	US
60/315,277	2001.08.27	US
60/309,210	2001.07.31	US

(43) Publication Date: 2003.02.17

(43) Publication Journal Date: 2003.05.29

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(56) Related Art

WO 01/68848

WO 99/63088

WO 00/06698 (see SEQ ID NO: 82, 195)
WO 00/73454
WO 01/53312
WO 99/64629 (see page 15, lines 14-17; SEQ ID NO: 1-2; page 9, line 18 - page 11,
line 29)
WO 00/73446 (see page 3, line 19 - page 5, line 26; page 6, line 28 - page 8, line 19;
SEQ ID NO: 1-2, page 86, line 29-page 87, line 20)

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

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
6 February 2003 (06.02.2003)

PCT

(10) International Publication Number
WO 03/010314 A2

(51) International Patent Classification⁷: C12N 15/11, C07K 14/435, A61K 38/17, 31/713, A61P 3/04, 3/06, 3/10, 9/10, 9/12

(21) International Application Number: PCT/IB02/03407

(22) International Filing Date: 25 July 2002 (25.07.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/308,253 26 July 2001 (26.07.2001) US
60/309,210 31 July 2001 (31.07.2001) US
60/315,277 27 August 2001 (27.08.2001) US

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(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, ES, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 03/010314 A2

(54) Title: GMG-2 POLYNUCLEOTIDES AND POLYPEPTIDES AND USES THEREOF

(57) Abstract: The present invention relates to the field of obesity research. Obesity is a public health problem that is serious and widespread. A compound, homotrimer of GMG-2 polypeptide fragment comprising globular domain and all or part of GMG-2 collagen-like region, has been identified that has utility for reducing body mass, for maintaining weight loss, and for treating obesity-related diseases and disorders. These obesity-related diseases and disorders include hyperlipidemias, atherosclerosis, diabetes, and hypertension.

GMG-2 POLYNUCLEOTIDES AND POLYPEPTIDES AND USES THEREOF

FIELD OF THE INVENTION

The present invention relates to the field of metabolic research, in particular the discovery of compounds effective for treating obesity and obesity-related diseases and disorders. The 5 obesity-related diseases or disorders envisioned to be treated by the methods of the invention include, but are not limited to, hyperlipidemia, atherosclerosis, diabetes, and hypertension.

BACKGROUND OF THE INVENTION

The following discussion is intended to facilitate the understanding of the invention, but is 10 not intended nor admitted to be prior art to the invention.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

Obesity is a public health problem that is serious, widespread, and increasing. In the 15 United States, 20 percent of the population is obese; in Europe, a slightly lower percentage is obese [Friedman (2000) *Nature* 404:632-634]. Obesity is associated with increased risk of hypertension, cardiovascular disease, diabetes, and cancer as well as respiratory complications and osteoarthritis [Kopelman (2000) *Nature* 404:635-643]. Even modest weight loss ameliorates these associated conditions.

20 Maintenance of weight gain or loss is associated with compensatory changes in energy expenditure that oppose the maintenance of a body weight that is different from the usual weight [Leibel et al. (1995) *N Engl J Med* 332:621-8]. These changes may account, in part, for the poor long-term efficacy of obesity treatments [Wadden (1993) *Ann Intern Med* 229:688-93]. Further, the decreased insulin sensitivity after weight gain and the beneficial effects of even modest 25 amounts of weight reduction on carbohydrate metabolism and insulin sensitivity in some patients are well documented [Olefsky et al. (1974) *J Clin Invest* 53:64-76].

While still acknowledging that lifestyle factors including environment, diet, age and exercise play a role in obesity, twin studies, analyses of familial aggregation, and adoption studies 30 all indicate that obesity is largely the result of genetic factors [Barsh et al. (2000) *Nature* 404:644-651]. In agreement with these studies, is the fact that an increasing number of obesity-related genes are being identified. Some of the more extensively studied genes include those encoding leptin (ob) and its receptor (db), pro-opiomelanocortin (Pomc), melanocortin-4-receptor (Mc4r), agouti protein (Ay), carboxypeptidase E (fat), 5-hydroxytryptamine receptor 2C (Htr2c), nescient 35 basic helix-loop-helix 2 (Nhlh2), prohormone convertase 1 (PCSK1), and tubby protein (tubby) [rev'd in Barsh et al. (2000) *Nature* 404:644-651].

SUMMARY OF THE INVENTION

The instant invention is based on the discovery that fragments of the full-length GMG-2 polypeptide comprising the globular domain, termed gGMG-2 polypeptide fragments, form 5 homotrimers having unexpected effects in vitro and in vivo, including utility for weight reduction,

prevention of weight gain, and control of blood glucose levels in humans and other mammals. The invention is further based on the discovery that multimers of gGMG-2 homotrimer formed through disulfide linkage at the cysteine residue within the N-terminally disposed unique region have lower specific activity for the activities disclosed herein than does non-multimeric gGMG-2 homotrimer.

5 The instant invention is yet further based on the discovery that gGMG-2 polypeptide fragments comprising all or part of the collagen-like region form more stable gGMG-2 homotrimers having the activities disclosed herein.

These unexpected effects of homotrimeric gGMG-2 polypeptide fragment administration in mammals also include reduction of elevated free fatty acid levels caused by administration of

10 epinephrine, *i.v.* injection of "intralipid", or administration of a high fat test meal, as well as increased fatty acid oxidation in muscle cells, and weight reduction in mammals consuming a high fat/high sucrose diet. These effects are unexpected and surprising given that administration of multimers of gGMG-2 homotrimer typically has no effect or a significantly reduced effect *in vivo* or *in vitro* depending on the specific biological activity and the amount administered. To the extent

15 that any effect is observed following administration of multimers of gGMG-2 homotrimer, the levels of multimeric gGMG-2 homotrimer required for an effect render it unfeasible in most instances as a potential treatment for humans at this time. In contrast, non-multimeric gGMG-2 homotrimer of the invention is radically more effective and thus can be provided at levels that are feasible for treatments in humans.

20 Thus, the invention is drawn to gGMG-2 polypeptide fragments, polynucleotides encoding said gGMG-2 polypeptide fragments, vectors comprising said gGMG-2 polynucleotides, and cells recombinant for said gGMG-2 polynucleotides, as well as to pharmaceutical and physiologically acceptable compositions comprising said gGMG-2 polypeptide fragments and methods of administering said gGMG-2 pharmaceutical and physiologically acceptable compositions in order to

25 reduce body weight or to treat obesity-related diseases and disorders, wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region, and further wherein said gGMG-2 polypeptide fragment does not comprise the cysteine residue within the N-terminally disposed unique region either because said cysteine residue has been substituted with an amino acid other than cysteine or because said fragment does not span said cysteine residue. Assays for

30 identifying agonists and antagonists of obesity-related activity are also part of the invention.

Antagonists of homotrimeric gGMG-2 polypeptide fragment activity should be effective in the treatment of other metabolic-related diseases or disorders of the invention including cachexia, wasting, AIDS-related weight loss, cancer-related weight loss, anorexia, and bulimia. In preferred embodiments, said individual is a mammal, preferably a human.

35 In a first aspect, the invention features a purified, isolated, or recombinant gGMG-2 polypeptide fragment, wherein said gGMG-2 polypeptide fragment forms homotrimers having unexpected activity, wherein unexpected said activity is selected from the group consisting of lipid

partitioning, lipid metabolism, and insulin-like activity, wherein said gGMG-2 polypeptide comprises all or part of the collagen-like region, and wherein said gGMG-2 polypeptide fragment comprises a substitution of an amino acid other than cysteine for the cysteine within the N-terminally disposed unique region selected from the group consisting of alanine, aspartic acid, 5 glutamic acid, phenylalanine, glycine, histidine, isoleucine, lysine, leucine, methionine, asparagines, proline, glutamine, arginine, serine, threonine, valine, tryptophan, and tyrosine, preferably wherein said substituted amino acid is serine. In preferred embodiments, said polypeptide fragment comprises, consists essentially of, or consists of, at least 6 and not more than 288 consecutive amino acids of SEQ ID NO:2 wherein said polypeptide fragment comprises all or part of the collagen-like 10 region, and wherein the cysteines at positions 66, 69 or 70 are replaced by said substitute amino acid(s); or at least 6 and not more than 278 consecutive amino acids of SEQ ID NO:4 wherein said polypeptide comprises all or part of the collagen-like region, and wherein the cysteines at positions 56, 59 or 60 are replaced by said substitute amino acid(s); or at least 6 and not more than 259 consecutive amino acids of SEQ ID NO:6 wherein said polypeptide comprises all or part of the 15 collagen-like region, and wherein the cysteines at positions 37, 40 or 41 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161- 20 288 or 162-288 of SEQ ID NO:2 wherein the cysteines at positions 66, 69 or 70 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151- 25 278 or 152-278 of SEQ ID NO:4, wherein the cysteine at position 56, 59 or 60 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-259, 130-259, 131-259, 132- 30 259 or 133-259 of SEQ ID NO:6, wherein the cysteine at position 37, 40 or 41 are replaced by said substitute amino acid(s). In a further preferred embodiment, GMG-2 polypeptide fragments having unexpected activity are selected from amino acids about 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2; or 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4; 35 or 28-259, 29-259, 30-30-259, 31-259, 32-259, 114-259, 115-259, 123-259, 124-259, 132-259 or 133-259 of SEQ ID NO: 6. In most preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are human. In other further preferred embodiments, said polypeptide

fragment comprises an amino acid sequence at least 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identical to the corresponding consecutive amino acids of SEQ ID NOs:2, 4 or 6. Any gGMG-2 polypeptide fragment that forms homotrimers with activity, as described above, may be excluded.

5 In other highly preferred embodiments, the invention features an GMG-2 polypeptide fragment wherein said GMG-2 polypeptide fragment forms homotrimers having unexpected activity selected from the group consisting of lipid partitioning, lipid metabolism, and insulin-like activity, wherein said GMG-2 polypeptide fragment comprises, consists essentially of, or consists of a purified, isolated, or recombinant gGMG-2 polypeptide fragment, wherein said gGMG-2

10 polypeptide fragment comprises all or part of the collagen-like region, and wherein said gGMG-2 polypeptide fragment comprises a substitution of an amino acid other than cysteine for the cysteine within the N-terminally disposed unique region selected from the group consisting of alanine, aspartic acid, glutamic acid, phenylalanine, glycine, histidine, isoleucine, lysine, leucine, methionine, asparagines, proline, glutamine, arginine, serine, threonine, valine, tryptophan, and

15 tyrosine, preferably wherein said substituted amino acid is serine. In preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2 wherein the cysteines at

20 positions 66, 69 or 70 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 or 152-278 of SEQ ID NO:4, wherein the cysteine at

25 position 56, 59 or 60 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at

30 position 37, 40 or 41 are replaced by said substitute amino acid(s). In most preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are human. Alternatively, said gGMG-2 polypeptide fragment comprises, consists essentially of, or consists of, an amino acid sequence at least 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identical to the corresponding amino acids 57-288 of SEQ ID NO:2 or at least 75% identical to amino acids 47-278

35 of SEQ ID NO:4 or 28-259 of SEQ ID NO:6. Any gGMG-2 polypeptide fragment that forms homotrimers with activity, as described above, may be excluded.

In other highly preferred embodiments, the invention features a purified, isolated, or recombinant gGMG-2 polypeptide fragment, wherein said gGMG-2 polypeptide fragment forms homotrimers having unexpected activity, wherein unexpected said activity is selected from the group consisting of prevention of weight gain, weight reduction, and maintenance of weight loss, wherein

5 said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region, and wherein said gGMG-2 polypeptide fragment comprises a substitution of an amino acid other than cysteine for the cysteine within the N-terminally disposed unique region selected from the group consisting of alanine, aspartic acid, glutamic acid, phenylalanine, glycine, histidine, isoleucine, lysine, leucine, methionine, asparagine, proline, glutamine, arginine, serine, threonine, valine, tryptophan, and

10 tyrosine, preferably wherein said substituted amino acid is serine. In preferred embodiments, said polypeptide fragment comprises, consists essentially of, or consists of, at least 6 and not more than 288 consecutive amino acids of SEQ ID NO:2 wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region and wherein the cysteines at positions 66, 69 or 70 are replaced by said substitute amino acid(s), or at least 6 and not more than 278 consecutive amino

15 acids of SEQ ID NO:4 wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region and wherein the cysteines at positions 56, 59 or 60 are replaced by said substitute amino acid(s), or at least 6 and not more than 259 consecutive amino acids of SEQ ID NO:6 wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region and wherein the cysteines at position 37, 40 or 41 are replaced by said substitute amino acid(s). In

20 other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2 wherein the cysteines at positions 66, 69 or 70 are replaced by said substitute amino

25 acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 or 152-278 of SEQ ID NO:4, wherein the cysteine at position 56, 59 or 60 are replaced by said

30 substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at position 37, 40 or 41 are replaced by said

35 substitute amino acid(s). In most preferred embodiments, gGMG-2 polypeptide fragment having unexpected activity is human. In other further preferred embodiments, said polypeptide fragment comprises an amino acid sequence at least 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%,

98%, or 99% identical to the corresponding consecutive amino acids of SEQ ID NOs: 2, 4 or 6. Any gGMG-2 polypeptide fragment that forms homotrimers with activity, as described above, may be excluded.

In other highly preferred embodiments, the invention features an GMG-2 polypeptide fragment wherein said GMG-2 polypeptide fragment forms homotrimers having unexpected activity selected from the group consisting of prevention of weight gain, weight reduction, and maintenance of weight loss and wherein said polypeptide fragment comprises, consists essentially of, or consists of a purified, isolated, or recombinant gGMG-2 polypeptide fragment, wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region, and wherein said gGMG-2 polypeptide fragment comprises a substitution of an amino acid other than cysteine for the cysteine within the N-terminally disposed unique region selected from the group consisting of alanine, aspartic acid, glutamic acid, phenylalanine, glycine, histidine, isoleucine, lysine, leucine, methionine, asparagine, proline, glutamine, arginine, serine, threonine, valine, tryptophan, and tyrosine, preferably wherein said substituted amino acid is serine. Preferably, said gGMG-2 polypeptide fragment comprises, consists essentially of, or consists of, at least 6 consecutive amino acids of amino acids 57-288 of SEQ ID NO:2 wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region and wherein the cysteines at positions 66, 69 or 70 are replaced by said substitute amino acid(s), or at least 6 consecutive amino acids of amino acids 47-278 of SEQ ID NO:4 wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region wherein the cysteines at positions 56, 59 or 60 are replaced by said substitute amino acid(s), or at least 6 consecutive amino acids of amino acids 28-259 of SEQ ID NO:6 wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region wherein the cysteines at positions 37, 40 or 41 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2 wherein the cysteines at positions 66, 69 or 70 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 or 152-278 of SEQ ID NO:4, wherein the cysteine at position 56, 59 or 60 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ

ID NO:6, wherein the cysteine at position 37, 40 or 41 are replaced by said substitute amino acid(s). In most preferred embodiments, gGMG-2 polypeptide fragment having unexpected activity is human. Alternatively, said gGMG-2 fragment comprises, consists essentially of, or consists of, an amino acid sequence at least 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identical to the corresponding amino acids 57-288 of SEQ ID NO:2 or at least 75% identical to amino acids 47-278 of SEQ ID NO:4 or 28-259 of SEQ ID NO:6. Any gGMG-2 polypeptide fragment that forms homotrimers with activity, as described above, may be excluded.

In yet other highly preferred embodiments, the invention features a purified, isolated, or recombinant gGMG-2 polypeptide fragment, wherein said gGMG-2 polypeptide fragment forms homotrimers having unexpected activity, wherein unexpected said activity is selected from the group consisting of lipid partitioning, lipid metabolism, and insulin-like activity, wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region, and wherein said gGMG-2 polypeptide fragment does not span the cysteine residue within the N-terminally disposed unique region. In preferred embodiments, said polypeptide fragment comprises, consists essentially of, or consists of, at least 6 and not more than 288 consecutive amino acids of SEQ ID NO:2 or at least 6 and not more than 278 consecutive amino acids of SEQ ID NO:4, or at least 6 and not more than 259 consecutive amino acids of SEQ ID NO:6. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 114-259, 114-259, 115-259, 123-259, 124-259, 132-259 or 133-259 of SEQ ID NO: 6.

In most preferred embodiments, gGMG-2 polypeptide fragment having unexpected activity is human. In other further preferred embodiments, said polypeptide fragment comprises an amino acid sequence at least 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identical to the corresponding consecutive amino acids of SEQ ID NOs: 2, 4 or 6. Any gGMG-2 polypeptide fragment that forms homotrimers with activity, as described above, may be excluded.

In other highly preferred embodiments, the invention features an GMG-2 polypeptide fragment wherein said GMG-2 polypeptide fragment forms homotrimers having unexpected activity selected from the group consisting of lipid partitioning, lipid metabolism, and insulin-like activity, wherein said GMG-2 polypeptide fragment comprises, consists essentially of, or consists of a purified, isolated, or recombinant gGMG-2 polypeptide fragment, wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region and wherein said gGMG-2 polypeptide fragment does not span the cysteine residue within the N-terminally disposed unique region. In preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are

selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4.

5 In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 114-259, 114-259, 115-259, 123-259, 124-259, 132-259 or 133-259 of SEQ ID NO: 6. In most preferred embodiments, gGMG-2 polypeptide fragment having unexpected activity is human. Alternatively, said gGMG-2 polypeptide fragment comprises, consists essentially of, or consists of, an amino acid sequence at least 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identical to the corresponding amino acids 57-288 of SEQ ID NO:2 or at least 75% identical to amino acids 47-278 of SEQ ID NO:4, or at least 75% identical to amino acids 28-259 of SEQ ID NO:6. Any gGMG-2 polypeptide fragment that forms homotrimers with activity, as described above, may be excluded.

In other highly preferred embodiments, the invention features a purified, isolated, or recombinant gGMG-2 polypeptide fragment, wherein said gGMG-2 polypeptide fragment forms homotrimers having unexpected activity, wherein unexpected said activity is selected from the group consisting of prevention of weight gain, weight reduction, and maintenance of weight loss, wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region and wherein said gGMG-2 polypeptide fragment does not span the cysteine residue within the N-terminally disposed collagen region. In preferred embodiments, said polypeptide fragment comprises, consists essentially of, or consists of, at least 6 and not more than 288 consecutive amino acids of SEQ ID NO:2 or at least 6 and not more than 278 consecutive amino acids of SEQ ID NO:4 or at least 6 and not more than 259 consecutive amino acids of SEQ ID NO:6. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 114-259, 114-259, 115-259, 123-259, 124-259, 132-259 or 133-259 of SEQ ID NO: 6. In most preferred embodiments, gGMG-2 polypeptide fragment having unexpected activity is human. In other further preferred embodiments, said polypeptide fragment comprises an amino acid sequence at least 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identical to the corresponding consecutive amino acids of SEQ ID NOs: 2, 4 or 6. Any gGMG-2 polypeptide fragment that forms homotrimers with activity, as described above, may be excluded.

In other highly preferred embodiments, the invention features an GMG-2 polypeptide fragment wherein said GMG-2 polypeptide fragment forms homotrimers having unexpected activity

selected from the group consisting of prevention of weight gain, weight reduction, and maintenance of weight loss and wherein said polypeptide fragment comprises, consists essentially of, or consists of a purified, isolated, or recombinant gGMG-2 polypeptide fragment, wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region and wherein said gGMG-2 polypeptide fragment does not span the cysteine residue within the N-terminally disposed unique region. Preferably, said gGMG-2 polypeptide fragment comprises, consists essentially of, or consists of, at least 6 consecutive amino acids of amino acids 57-288 of SEQ ID NO:2 comprising all or part of the collagen-like region, or at least 6 consecutive amino acids of amino acids 47-278 of SEQ ID NO:4 comprising all or part of the collagen-like region, or at least 6 consecutive amino acids of amino acids 28-259 of SEQ ID NO:6 comprising all or part of the collagen-like region. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4. In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 114-259, 114-259, 115-259, 123-259, 124-259, 132-259 or 133-259 of SEQ ID NO: 6. In most preferred embodiments, gGMG-2 polypeptide fragment having unexpected activity is human. Alternatively, said gGMG-2 fragment comprises, consists essentially of, or consists of, an amino acid sequence at least 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, or 99% identical to the corresponding amino acids 57-288 of SEQ ID NO:2 or at least 75% identical to amino acids 47-278 of SEQ ID NO:4, or at least 75% identical to amino acids 28-259 of SEQ ID NO:6. Any gGMG-2 polypeptide fragment that forms homotrimers with activity, as described above, may be excluded.

In other highly preferred embodiments, the invention features a purified, isolated, or recombinant gGMG-2 polypeptide fragment, wherein said gGMG-2 polypeptide fragment forms homotrimers having significantly greater activity than a monomeric gGMG-2 polypeptide fragment, wherein unexpected said activity is selected from the group consisting of inhibiting smooth muscle proliferation, inhibiting expression of proinflammatory cytokines, inhibiting expression of cell adhesion molecules, and inhibiting expression of tissue factor, wherein said gGMG-2 polypeptide fragment comprises all or part of the collagen-like region, and wherein said gGMG-2 polypeptide fragment comprises a substitution of an amino acid other than cysteine for the cysteine within the N-terminally disposed unique region selected from the group consisting of alanine, aspartic acid, glutamic acid, phenylalanine, glycine, histidine, isoleucine, lysine, leucine, methionine, asparagines, proline, glutamine, arginine, serine, threonine, valine, tryptophan, and tyrosine, preferably wherein said substituted amino acid is serine.

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In a further preferred embodiment, the gGMG-2 polypeptide fragment forms homotrimers able to lower circulating (either blood, serum or plasma) levels (concentration) of: (i) free fatty acids, (ii) glucose, and/or (iii) triglycerides. Further preferred gGMG-2 polypeptide fragments form homotrimers that demonstrate free fatty acid level lowering activity, glucose level lowering activity, and/or triglyceride level lowering activity, have an activity that is significantly greater than full-length GMG-2 at the same molar concentration, have a greater than transient activity and/or have a sustained activity.

5 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that maintain weight loss, preferably in individuals who were previously "obese" and are now "healthy" (as defined herein).

10 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that significantly stimulate muscle lipid or free fatty acid oxidation as compared to full-length GMG-2 polypeptides at the same molar concentration. Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that cause C2C12 cells differentiated in the presence of said fragments 15 to undergo at least 10%, 20%, 30%, 35%, or 40% more oleate oxidation as compared to untreated cells or cells treated with full-length GMG-2.

15 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that are at least 30% more efficient than full-length GMG-2 at increasing leptin uptake in a liver cell line (preferably BPRCL mouse liver cells (ATCC CRL-2217)).

20 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that significantly reduce the postprandial increase in plasma free fatty acids, particularly following a high fat meal.

25 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that significantly reduce or eliminate ketone body production, particularly following a high fat meal.

25 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that increase glucose uptake in skeletal muscle cells.

30 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that increase glucose uptake in adipose cells.

30 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that increase glucose uptake in neuronal cells.

35 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that increase glucose uptake in red blood cells.

35 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that increase glucose uptake in the brain.

35 Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that significantly reduce the postprandial increase in plasma glucose following a meal, particularly a high carbohydrate meal.

Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that significantly prevent the postprandial increase in plasma glucose following a meal, particularly a high fat or a high carbohydrate meal.

Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that 5 improve insulin sensitivity.

Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that inhibit the progression from impaired glucose tolerance to insulin resistance.

Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that 10 increase muscle mass, preferably those that increase muscle cell number, more preferably those that increase muscle fiber number.

Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that promote an increase in body girth, preferably fragments that promote an increase in muscle mass.

Further preferred gGMG-2 polypeptide fragments promote growth rate, preferably promoting an 15 increase in growth rate greater than an average growth rate in the absence of gGMG-2 polypeptide fragments.

Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that 20 promote growth rate in newborn mammals, preferably cow, goat, sheep, rabbit, mouse, rat, pig, dog, or human newborns, more preferably human newborns between the ages of 0-6 months of age, most preferably human newborn between the ages of 0-3 months. Further preferred gGMG-2 polypeptide fragments are those that form homotrimers that promote growth rate in newborn underweight or premature mammals, preferably cow, goat, sheep, rabbit, mouse, rat, pig, dog, or human underweight or premature newborns, more preferably human underweight or premature newborns between the ages of 0-6 months of age, most preferably human underweight or premature newborns between the ages of 0-3 months of age.

Further preferred gGMG-2 polypeptide fragments are those that form homotrimers *in vitro* 25 and/or *in vivo*. More preferred gGMG-2 polypeptide fragments are those that form homotrimers *in vitro* and/or *in vivo*, wherein at least 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55% 60%, 65%, 70%, 75%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or 100% of said gGMG-2 polypeptide fragment comprises said homotrimer. Most particularly preferred 30 gGMG-2 polypeptide fragments are those that form homotrimers *in vitro* and/or *in vivo* having activity selected from the group consisting of lipid partitioning, lipid metabolism, and insulin-like activity. Also most particularly preferred gGMG-2 polypeptide fragments are those that form homotrimers *in vitro* and/or *in vivo* having activity selected from the group consisting of prevention of weight gain, weight reduction, and maintenance of weight loss. Any gGMG-2 polypeptide 35 fragment that forms homotrimers with activity, as described above, may be excluded.

Further preferred embodiments include heterologous polypeptides comprising a gGMG-2 polypeptide fragment of the invention. More preferred is said heterologous polypeptide comprised

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of a signal peptide N-terminally fused to said gGMG-2 polypeptide of the invention. In yet more preferred embodiment, said signal peptide is human zinc-alpha 2-glycoprotein signal peptide of amino acid sequence MVRMVPVLLSLLLLLGPAVP, preferably encoded by the polynucleotide of sequence atggtaagaatggtgccctgtctgtctgtgtgtgtgtgtgggccccccccccc.

5 In a second aspect, the invention features a purified, isolated, or recombinant polynucleotide encoding said gGMG-2 polypeptide fragment or full-length GMG-2 polypeptide described in the first aspect, or the complement thereof. In further embodiments the polynucleotides are DNA, RNA, DNA/RNA hybrids, single-stranded, and double-stranded.

10 In a third aspect, the invention features a recombinant vector comprising, consisting essentially of, or consisting of, said polynucleotide described in the second aspect.

In a fourth aspect, the invention features a recombinant cell comprising, consisting essentially of, or consisting of, said recombinant vector described in the third aspect. Preferred said recombinant cell is prokaryotic or eukaryotic recombinant cell. Preferred said prokaryotic recombinant cell is E. coli recombinant cell. Preferred said eukaryotic recombinant cell is

15 mammalian recombinant cell. Particularly preferred mammalian recombinant cell is selected from the group consisting of COS recombinant cell, Chinese hamster ovary (CHO) recombinant cell, human embryonic kidney (HEK) recombinant cell, and 3T3-L1 adipocyte recombinant cell. A further embodiment includes a host cell recombinant for a polynucleotide of the invention. Preferred said host cell is prokaryotic or eukaryotic host cell. Preferred said prokaryotic host cell is E. coli host cell. Preferred said eukaryotic host cell is mammalian host cell. Particularly preferred mammalian host cell is selected from the group consisting of COS host cell, Chinese hamster ovary (CHO) host cell, human embryonic kidney (HEK) host cell, and 3T3-L1 adipocyte host cell.

20 In a fifth aspect, the invention features a pharmaceutical or physiologically acceptable composition comprising, consisting essentially of, or consisting of, said gGMG-2 polypeptide fragment described in the first aspect and, alternatively, a pharmaceutical or physiologically acceptable diluent. More preferred said pharmaceutical or physiologically acceptable composition comprises, consists essentially of, or consists of homotrimer of said gGMG-2 polypeptide fragment described in the first aspect and, alternatively, a pharmaceutical or physiologically acceptable diluent. In said pharmaceutical or physiologically acceptable composition, preferably at least 10%, 30, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 91%, 35, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or 100% of said gGMG-2 polypeptide fragment of the first aspect comprises homotrimer.

25 In a sixth aspect, the invention features a method of reducing body mass comprising providing or administering to individuals in need of reducing body mass said pharmaceutical or physiologically acceptable composition described in the fifth aspect. Further preferred is a method of reducing body fat mass comprising providing or administering to individuals in need thereof said pharmaceutical or physiologically acceptable composition described in the fifth aspect. Further

preferred is a method of increasing lean body mass comprising providing or administering to individuals in need thereof said pharmaceutical or physiologically acceptable composition described in the fifth aspect. Further preferred is a method of increasing the growth rate of body girth or length comprising providing or administering to individuals in need thereof said pharmaceutical or physiologically acceptable composition described in the fifth aspect.

In a further preferred embodiment, the present invention may be used in complementary therapy of obese patients to improve their weight in combination with a weight reducing agent. Examples of the weight reducing agent include lipase inhibitors, such as orlistat, and serotonin reuptake inhibitors (SSRI) and noradrenaline reuptake inhibitor, such as sibutramine.

10 In further preferred embodiments, the invention features a method of maintaining a reduced body mass comprising providing or administering to individuals in need of maintaining a reduced body mass said pharmaceutical or physiologically acceptable composition described in the fifth aspect. Further preferred is a method of maintaining a reduced body fat mass that comprises, providing or administering to individuals in need thereof said pharmaceutical or physiologically acceptable composition described in the fifth aspect, returning energy intake to a normal level in said individual, and maintaining increased energy expenditure in said individual. Preferably, said individual is able to maintain a stable weight that is 10–20% below their obese weight (as described herein).

20 In other preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used in combination with reduced energy intake and/or increased energy expenditure as a method of maintaining weight loss.

25 In yet further preferred embodiments, the identification of said individuals in need of reducing body mass to be treated with said pharmaceutical or physiologically acceptable composition comprises genotyping GMG-2 single nucleotide polymorphisms (SNPs) or measuring GMG-2 polypeptide or mRNA levels in clinical samples from said individuals. Preferably, said clinical samples are selected from the group consisting of plasma, urine, and saliva. Preferably, a gGMG-2 polypeptide fragment of the present invention is administered to an individual with at least a 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100% reduction in blood, serum or plasma levels of full-length GMG-2 or the naturally proteolytically cleaved GMG-2 fragment as compared

30 to healthy, non-obese patients.

35 In a seventh aspect, the invention features a method of preventing or treating an obesity-related disease or disorder comprising providing or administering to an individual in need of such treatment said pharmaceutical or physiologically acceptable composition described in the fifth aspect. In preferred embodiments, the identification of said individuals in need of such treatment to be treated with said pharmaceutical or physiologically acceptable composition comprises genotyping GMG-2 single nucleotide polymorphisms (SNPs) or measuring GMG-2 polypeptide or mRNA levels in clinical samples from said individuals. Preferably, said clinical samples are selected from

the group consisting of blood, serum, plasma, urine, and saliva. Preferably, said obesity-related disease or disorder is selected from the group consisting of obesity, impaired glucose tolerance, insulin resistance, atherosclerosis, atheromatous disease, heart disease, hypertension, stroke, Syndrome X, Noninsulin Dependent Diabetes Mellitus (NIDDM, or Type II diabetes) and Insulin Dependent Diabetes Mellitus (IDDM or Type I diabetes). Diabetes-related complications to be treated by the methods of the invention include microangiopathic lesions, ocular lesions, retinopathy, neuropathy, and renal lesions. Heart disease includes, but is not limited to, cardiac insufficiency, coronary insufficiency, and high blood pressure. Other obesity-related disorders to be treated by compounds of the invention include hyperlipidemia and hyperuricemia. Yet other metabolic-related diseases or disorders of the invention including cachexia, wasting, AIDS-related weight loss, cancer-related weight loss, anorexia, and bulimia. In preferred embodiments, said individual is a mammal, preferably a human.

In a related aspect, the invention features a method of preventing or treating an inflammation-related disease or disorder comprising providing or administering to an individual in need of such treatment said pharmaceutical or physiologically acceptable composition described in the fifth aspect. In preferred embodiments, the identification of said individuals in need of such treatment to be treated with said pharmaceutical or physiologically acceptable composition comprises genotyping GMG-2 single nucleotide polymorphisms (SNPs) or measuring GMG-2 polypeptide or mRNA levels in clinical samples from said individuals. Preferably, said clinical samples are selected from the group consisting of blood, serum, plasma, urine, and saliva. Preferably, said inflammation-related disease or disorder is selected from the group consisting of vascular disorders, diseases and injuries, particularly those caused by excessive inflammatory responses, such as atherosclerosis, angina pectoris, myocardial infarction, deep vein thrombosis, peripheral arterial occlusion, coronary heart disease (CDH), coronary artery disease (CAD), heart failure, transient ischemic attack, post-angioplasty restenosis, myelopoiesis, and disseminated intravascular coagulation (DIC). In preferred embodiments, said individual is a mammal, preferably a human.

In related aspects, embodiments of the present invention includes methods of causing or inducing a desired biological response in an individual comprising the steps of: providing or administering to an individual a composition comprising a polypeptide of the first aspect, wherein said biological response is selected from the group consisting of:

- (a) lowering circulating (either blood, serum, or plasma) levels (concentration) of free fatty acids;
- (b) lowering circulating (either blood, serum or plasma) levels (concentration) of glucose;
- (c) lowering circulating (either blood, serum or plasma) levels (concentration) of triglycerides;
- (d) stimulating muscle lipid or free fatty acid oxidation;

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- (c) increasing leptin uptake in the liver or liver cells;
- (e) reducing the postprandial increase in plasma free fatty acids, particularly following a high fat meal; and,
- (f) reducing or eliminating ketone body production, particularly following a high fat meal;
- 5 (g) increasing tissue sensitivity to insulin, particularly muscle, adipose, liver or brain;
- (h) inhibiting the progression from impaired glucose tolerance to insulin resistance;
- (i) increasing muscle cell protein synthesis;
- (j) reducing adipocyte triglyceride content;
- (k) increasing utilization of energy from foodstuffs or metabolic stores;
- 10 (l) increasing growth rate, preferably growth in girth or length;
- (m) increasing muscle growth; and
- (n) increasing skeletal growth;

and further wherein said biological response is significantly greater than, or at least 10%, 20%, 30%, 35%, or 40% greater than, the biological response caused or induced by a full-length

15 GMG-2 polypeptide at the same molar concentration; or alternatively wherein said biological response is greater than a transient response; or alternatively wherein said biological response is sustained. In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control blood glucose in some persons with Noninsulin Dependent Diabetes Mellitus (NIDDM, Type II diabetes) in combination

20 with insulin therapy.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control blood glucose in some persons with Insulin Dependent Diabetes Mellitus (IDDM, Type I diabetes) in combination with insulin therapy.

25 In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control body weight in some persons with Noninsulin Dependent Diabetes Mellitus (NIDDM, Type II diabetes) in combination with insulin therapy.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control body weight in some

30 persons with Insulin Dependent Diabetes Mellitus (IDDM, Type I diabetes) in combination with insulin therapy.

35 In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control blood glucose in some persons with Noninsulin Dependent Diabetes Mellitus (NIDDM, Type II diabetes) alone, without combination of insulin therapy.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control blood glucose in some persons with Insulin Dependent Diabetes Mellitus (IDDM, Type I diabetes) alone, without combination of insulin therapy.

5 In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control body weight in some persons with Noninsulin Dependent Diabetes Mellitus (NIDDM, Type II diabetes) alone, without combination of insulin therapy.

In further preferred embodiments, the present invention of said pharmaceutical or 10 physiologically acceptable composition can be used as a method to control body weight in some persons with Insulin Dependent Diabetes Mellitus (IDDM, Type I diabetes) alone, without combination of insulin therapy.

In a further preferred embodiment, the present invention may be used in complementary 15 therapy of NIDDM patients to improve their weight or glucose control in combination with an oral insulin secretagogue or an insulin sensitising agent. Preferably, the oral insulin secretagogue is 1,1-dimethyl-2-(2-morpholino phenyl)guanidine fumarate (BTS67582) or a sulphonylurea selected from tolbutamide, tolazamide, chlorpropamide, glibenclamide, glimepiride, glipizide and glidazide. Preferably, the insulin sensitising agent is selected from metformin, ciglitazone, troglitazone and pioglitazone.

20 The present invention further provides a method of improving the body weight or glucose control of NIDDM patients alone, without an oral insulin secretagogue or an insulin sensitising agent.

In a further preferred embodiment, the present invention may be used in complementary 25 therapy of IDDM patients to improve their weight or glucose control in combination with an oral insulin secretagogue or an insulin sensitising agent. Preferably, the oral insulin secretagogue is 1,1-dimethyl-2-(2-morpholino phenyl)guanidine fumarate (BTS67582) or a sulphonylurea selected from tolbutamide, tolazamide, chlorpropamide, glibenclamide, glimepiride, glipizide and glidazide. Preferably, the insulin sensitising agent is selected from metformin, ciglitazone, troglitazone and pioglitazone.

30 The present invention further provides a method of improving the body weight or glucose control of IDDM patients alone, without an oral insulin secretagogue or an insulin sensitising agent.

In a further preferred embodiment, the present invention may be administered either 35 concomitantly or concurrently, with the oral insulin secretagogue or insulin sensitising agent for example in the form of separate dosage units to be used simultaneously, separately or sequentially (either before or after the secretagogue or either before or after the sensitising agent). Accordingly, the present invention further provides for a composition of pharmaceutical or physiologically acceptable composition and an oral insulin secretagogue or insulin sensitising agent as a combined

preparation for simultaneous, separate or sequential use for the improvement of body weight or glucose control in NIDDM or IDDM patients.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition further provides a method for the use as an insulin sensitiser.

5 In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to improve insulin sensitivity in some persons with Noninsulin Dependent Diabetes Mellitus (NIDDM, Type II diabetes) in combination with insulin therapy.

10 In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to improve insulin sensitivity in some persons with Insulin Dependent Diabetes Mellitus (IDDM, Type I diabetes) in combination with insulin therapy.

15 In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to improve insulin sensitivity in some persons with Noninsulin Dependent Diabetes Mellitus (NIDDM, Type II diabetes) without insulin therapy.

In an eighth aspect, the invention features a method of making the gGMG-2 polypeptide fragment described in the first aspect, wherein said method is selected from the group consisting of: proteolytic cleavage, recombinant methodology and artificial synthesis.

20 In a ninth aspect, the present invention provides a method of making a recombinant gGMG-2 polypeptide fragment or a full-length GMG-2 polypeptide, the method comprising providing a transgenic, non-human mammal whose milk contains said recombinant gGMG-2 polypeptide fragment or full-length protein, and purifying said recombinant gGMG-2 polypeptide fragment or said full-length GMG-2 polypeptide from the milk of said non-human mammal. In one embodiment, said non-human mammal is a cow, goat, sheep, rabbit, or mouse. In another embodiment, the method comprises purifying a recombinant mature GMG-2 polypeptide absent the signal peptide from said milk, and further comprises cleaving said protein *in vitro* to obtain a desired gGMG-2 polypeptide fragment.

25 In a tenth aspect, the invention features a use of the polypeptide described in the first aspect for treatment of obesity-related diseases and disorders and/or reducing body mass. Preferably, said obesity-related diseases and disorders are selected from the group consisting of obesity, impaired glucose tolerance, insulin resistance, atherosclerosis, atheromatous disease, heart disease, hypertension, stroke, Syndrome X, Noninsulin Dependent Diabetes Mellitus (NIDDM, or Type II diabetes) and Insulin Dependent Diabetes Mellitus (IDDM or Type I diabetes). Diabetes-related complications to be treated by the methods of the invention include microangiopathic lesions, ocular lesions, retinopathy, neuropathy, and renal lesions. Heart disease includes, but is not limited to, cardiac insufficiency, coronary insufficiency, and high blood pressure. Other obesity-related

disorders to be treated by compounds of the invention include hyperlipidemia and hyperuricemia. In preferred embodiments, said individual is a mammal, preferably a human.

The invention further features a use of the polypeptide of the first aspect for prevention of weight gain, for weight reduction, and/or for maintenance of weight loss. In preferred embodiments, 5 said individual is a mammal, preferably a human.

In an eleventh aspect, the invention features a use of the polypeptide described in the first aspect for the preparation of a medicament for the treatment of obesity-related diseases and disorders and/or for reducing body mass. Preferably, said obesity-related disease or disorder is selected from the group consisting of obesity, impaired glucose tolerance, insulin resistance, atherosclerosis,

10 atheromatous disease, heart disease, hypertension, stroke, Syndrome X, Noninsulin Dependent Diabetes Mellitus (NIDDM, or Type II diabetes) and Insulin Dependent Diabetes Mellitus (IDDM or Type I diabetes). Diabetes-related complications to be treated by the methods of the invention include microangiopathic lesions, ocular lesions, retinopathy, neuropathy, and renal lesions. Heart disease includes, but is not limited to, cardiac insufficiency, coronary insufficiency, and high blood

15 pressure. Other obesity-related disorders to be treated by compounds of the invention include hyperlipidemia and hyperuricemia. Yet other metabolic-related diseases or disorders of the invention including cachexia, wasting, AIDS-related weight loss, cancer-related weight loss, anorexia, and bulimia. In preferred embodiments, said individual is a mammal, preferably a human.

The invention further features a use of the polypeptide of the first aspect for the preparation 20 of a medicament for prevention of weight gain, for weight reduction, and/or for maintenance of weight loss. In preferred embodiments, said individual is a mammal, preferably a human.

In a twelfth aspect, the invention provides a polypeptide of the first aspect of the invention, or a composition of the fifth aspect of the invention, for use in a method of treatment of the human or animal body.

25 In a thirteenth aspect, the invention features methods of reducing body weight comprising providing to an individual said pharmaceutical or physiologically acceptable composition described in the fifth aspect, or the polypeptide described in the first aspect. Where the reduction of body weight is practiced for cosmetic purposes, the individual has a BMI of at least 20 and no more than 25. In embodiments for the treatment of obesity, the individual may have a BMI of at least 20. One 30 embodiment for the treatment of obesity provides for the treatment of individuals with BMI values of at least 25. Another embodiment for the treatment of obesity provides for the treatment of individuals with BMI values of at least 30. Yet another embodiment provides for the treatment of individuals with BMI values of at least 40. Alternatively, for increasing the body weight of an individual, the BMI value should be at least 15 and no more than 20.

35 In a related aspect, the invention features methods of maintaining weight loss comprising providing to an individual said pharmaceutical or physiologically acceptable composition described in the fifth aspect, or the polypeptide described in the first aspect. Where the maintenance of weight

loss is practiced for cosmetic purposes, the individual has a BMI of at least 20 and no more than 25.

In embodiments for the treatment of obesity by means of maintaining weight loss, the individual may have a BMI of at least 20. One embodiment for the treatment of obesity by means of maintaining weight loss provides for the treatment of individuals with BMI values of at least 25.

5 Another embodiment for the treatment of obesity by means of maintaining weight loss provides for the treatment of individuals with BMI values of at least 30.

In a fourteenth aspect, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect for reducing body mass and/or for treatment or prevention of obesity-related diseases or disorders. Preferably, said obesity-related disease or

10 disorder is selected from the group consisting of obesity, impaired glucose tolerance, insulin resistance, atherosclerosis, atheromatous disease, heart disease, hypertension, stroke, Syndrome X, Noninsulin Dependent Diabetes Mellitus (NIDDM, or Type II diabetes) and Insulin Dependent Diabetes Mellitus (IDDM or Type I diabetes). Diabetes-related complications to be treated by the methods of the invention include microangiopathic lesions, ocular lesions, retinopathy, neuropathy,

15 and renal lesions. Heart disease includes, but is not limited to, cardiac insufficiency, coronary insufficiency, and high blood pressure. Other obesity-related disorders to be treated by compounds of the invention include hyperlipidemia and hyperuricemia. Yet other obesity-related diseases or disorders of the invention include cachexia, wasting, AIDS-related weight loss, cancer-related weight loss, anorexia, and bulimia. In preferred embodiments, said individual is a mammal, preferably a human. In preferred embodiments, the identification of said individuals to be treated with said pharmaceutical or physiologically acceptable composition comprises genotyping GMG-2 single nucleotide polymorphisms (SNPs) or measuring GMG-2 polypeptide or mRNA levels in clinical samples from said individuals. Preferably, said clinical samples are selected from the group consisting of blood, serum, plasma, urine, and saliva.

25 In a related aspect, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect for reducing an inflammatory response, preferably an inflammatory response related to a vascular disorder or injury, and/or for treatment or prevention of inflammation-related diseases or disorders. Preferably, said inflammation-related disease or disorder is selected from the group consisting of vascular disorders, diseases and injuries, particularly those

30 caused by excessive inflammatory responses, such as atherosclerosis, angina pectoris, myocardial infarction, deep vein thrombosis, peripheral arterial occlusion, coronary heart disease (CDH), coronary artery disease (CAD), heart failure, transient ischemic attack, post-angioplasty restenoses, myelopoiesis, and disseminated intravascular coagulation (DIC). In preferred embodiments, said individual is a mammal, preferably a human. In preferred embodiments, the identification of said

35 individuals to be treated with said pharmaceutical or physiologically acceptable composition comprises genotyping GMG-2 single nucleotide polymorphisms (SNPs) or measuring GMG-2

20

polypeptide or mRNA levels in clinical samples from said individuals. Preferably, said clinical samples are selected from the group consisting of blood, serum, plasma, urine, and saliva.

In a fifteenth aspect, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect for reducing body weight for cosmetic reasons.

5 In a related aspect, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect for maintaining weight loss for cosmetic reasons.

In a sixteenth aspect, the invention features methods of treating insulin resistance comprising providing to an individual said pharmaceutical or physiologically acceptable composition described in the fifth aspect, or the polypeptide described in the first aspect.

10 In a seventeenth aspect, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect in a method of treating individuals with normal glucose tolerance (NGT) who are obese or who have fasting hyperinsulinemia, or who have both.

In further preferred embodiments, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect in a method of treating

15 individuals with gestational diabetes. Gestational diabetes refers to the development of diabetes in an individual during pregnancy, usually during the second or third trimester of pregnancy.

In further preferred embodiments, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect in a method of treating individuals with impaired fasting glucose (IFG). Impaired fasting glucose (IFG) is that condition in 20 which fasting plasma glucose levels in an individual are elevated but not diagnostic of overt diabetes, i.e. plasma glucose levels of less than 126 mg/dl and greater than or equal to 110 mg/dl.

In further preferred embodiments, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect in a method of treating impaired glucose tolerance (IGT) in an individual. In other further preferred embodiments, the invention 25 features the pharmaceutical or physiologically acceptable composition described in the fifth aspect in a method of preventing IGT in an individual. By providing therapeutics and methods for reducing or preventing IGT, i.e., for normalizing insulin resistance, the progression to NIDDM can be delayed or prevented. Furthermore, by providing therapeutics and methods for reducing or preventing insulin resistance, the invention provides methods for reducing and/or preventing the appearance of 30 Insulin-Resistance Syndrome.

In further preferred embodiments, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect in a method of treating a subject having polycystic ovary syndrome (PCOS). PCOS is among the most common disorders of premenopausal women. Insulin-sensitizing agents have been shown to be effective in PCOS.

35 Accordingly, the invention provides methods for reducing insulin resistance, normalizing blood glucose thus treating and/or preventing PCOS.

In further preferred embodiments, the invention features the pharmaceutical or physiologically acceptable composition described in the fifth aspect in a method of treating a subject having insulin resistance. In still further preferred embodiments, a subject having insulin resistance is treated according to the methods of the invention to reduce or cure the insulin-resistance. As insulin resistance is also often associated with infections and cancer, prevention or reducing insulin resistance according to the methods of the invention may prevent or reduce infections and cancer.

In further preferred embodiment, the methods of the invention are used to prevent the development of insulin resistance in a subject, e.g., those known to have an increased risk of developing insulin-resistance.

10 In an eighteenth aspect, the invention features a method of using homotrimeric gGMG-2 polypeptide fragment in a method of screening compounds for one or more antagonists of homotrimeric gGMG-2 polypeptide fragment activity, wherein said activity is selected from but not restricted to weight reduction, maintenance of weight loss, lipid partitioning, lipid metabolism, and insulin-like activity.

15 In preferred embodiment, said compound is selected from but is not restricted to small molecular weight organic or inorganic compound, protein, peptide, carbohydrate, or lipid.

In a nineteenth aspect, the present invention provides a mammal, preferably a newborn human, with a supplement to promote, improve, enhance or increase the assimilation, utilization or storage of energy and other nutrients present in foodstuffs consumed by newborn mammals, particularly newborn humans, and particularly energy and other nutrients in infant formula or breast milk. A further preferred embodiment of the present invention is to provide a mammal, preferably a newborn human, with a supplement to promote, improve, enhance, or increase growth rate.

Preferred methods of supplementation with a polypeptide of the first aspect include but are not limited to:

25 (a) direct addition of a polypeptide of the first aspect to synthetic infant formula or to breast milk;

(b) administration of the pharmaceutical or physiologically acceptable composition described in the fifth aspect prior to feeding, preferably 1-15 minutes prior to feeding, more preferably 1-5 minutes prior to feeding; and

30 (c) administration of the pharmaceutical or physiologically acceptable composition described in the fifth aspect following feeding, preferably 1-15 minutes following feeding, more preferably 1-5 minutes following feeding;

wherein routes of administration of a polypeptide of the first aspect or the pharmaceutical or physiologically acceptable composition described in the fifth aspect are selected from oral, buccal, nasal and intramuscular routes, preferably oral routes.

35 A further preferred embodiment is directed to using a polypeptide of the first aspect in methods to promote, improve, enhance or increase the assimilation, utilization or storage of energy

and other nutrients present in foodstuffs consumed by newborn mammals, particularly newborn humans, and particularly energy and other nutrients in infant formula or breast milk. A further preferred embodiment is directed to using a polypeptide of the first aspect in methods to promote, improve, enhance or increase the growth rate of a newborn mammal, preferably a human newborn.

- 5 Further preferred are compositions comprising a polypeptide of the first aspect which can be used in methods to promote, improve, enhance or increase the assimilation, utilization or storage of energy and other nutrients present in foodstuffs consumed by newborn mammals, particularly newborn humans, and particularly energy and other nutrients in infant formula or breast milk. Further preferred are compositions comprising a polypeptide of the first aspect which can be used in
- 10 methods to promote, improve, enhance or increase the growth rate of a newborn mammal, preferably a human newborn. A still further preferred embodiment of the present invention is directed to compositions comprising synthetic infant milk formula and a polypeptide of the first aspect.

Another embodiment of the invention is to provide compositions comprising a polypeptide of the first aspect useful for enhancing or improving the nutritional value of synthetic infant milk

- 15 formulas or breast milk. Further preferred are compositions useful for incorporation into the diet of a newborn mammal so as to enhance and improve the nutritional value of the diet. Still another embodiment of the invention is to provide techniques and routines for improving the diet and feeding of newborn mammals, particularly premature, underweight or very-low-birth-weight newborns, preferably human newborns.

- 20 In preferred aspects of the methods of the invention disclosed herein, the amount of gGMG-2 polypeptide fragment or polynucleotide administered to an individual is sufficient to bring circulating (blood, serum, or plasma) levels (concentration) of GMG-2 polypeptides to their normal levels (levels in non-obese individuals). "Normal levels" may be specified as the total concentration of all circulating GMG-2 polypeptides (full-length GMG-2 and fragments thereof) or the
- 25 concentration of all circulating proteolytically cleaved GMG-2 polypeptides only.

- 30 In preferred embodiments of the compositions of the invention disclosed herein, compositions of the invention may further comprise any combination of gGMG-2 polypeptide fragment of the first aspect, insulin, insulin secretagogues or insulin sensitising agents such that the composition produces a biological effect greater than the expected effect for said gGMG-2 polypeptide fragment administered alone rather than in combination with insulin, insulin secretagogues or insulin sensitising agents.

- 35 In a further embodiment, said biological function includes, but is not limited to, free fatty acid level lowering activity, glucose level lowering activity, triglyceride level lowering activity, stimulating adipose lipolysis, stimulating muscle lipid or free fatty acid oxidation, increasing leptin uptake in a liver cell line, significantly reducing the postprandial increase in plasma free fatty acids or glucose due to a high fat meal, significantly reducing or eliminate ketone body production as the result of a high fat meal, increasing glucose uptake in skeletal muscle cells, adipose cells, red blood

cells or the brain, increasing insulin sensitivity, inhibiting the progression from impaired glucose tolerance to insulin resistance, reducing body mass, decreasing fat mass, increasing lean muscle mass, preventing or treating an metabolic-related disease or disorder, controlling blood glucose in some persons with Noninsulin Dependent Diabetes Mellitus or Noninsulin Dependent Diabetes

5 Mellitus, treating insulin resistance or preventing the development of insulin resistance.

Any gGMG-2 polypeptide fragment that forms homotrimers with activity, as described above, may be excluded.

BRIEF DESCRIPTION OF SEQUENCE LISTING

10 SEQ ID NO:1 is the nucleotide sequence of cDNA with an open reading frame which location is indicated as featured.

SEQ ID NO:2 is the amino acid sequence of protein encoded by the cDNA of SEQ ID NO:1.

15 SEQ ID NO:3 is the nucleotide sequence of cDNA with an open reading frame which location is indicated as featured.

SEQ ID NO:4 is the amino acid sequence of protein encoded by the cDNA of SEQ ID NO:3.

SEQ ID NO:5 is the nucleotide sequence of cDNA with an open reading frame which location is indicated as featured.

20 SEQ ID NO:6 is the amino acid sequence of protein encoded by the cDNA of SEQ ID NO:5.

The appended Sequence Listing is hereby incorporated by reference in its entirety.

DETAILED DISCLOSURE OF THE INVENTION

25 Before describing the invention in greater detail, the following definitions are set forth to illustrate and define the meaning and scope of the terms used to describe the invention herein.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to 30 specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

As used interchangeably herein, the terms "oligonucleotides", and "polynucleotides" and 35 nucleic acid include RNA, DNA, or RNA/DNA hybrid sequences of more than one nucleotide in either single chain or duplex form. The terms encompass "modified nucleotides" which comprise at least one modification, including by way of example and not limitation: (a) an alternative linking

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group, (b) an analogous form of purine, (c) an analogous form of pyrimidine, or (d) an analogous sugar. For examples of analogous linking groups, purines, pyrimidines, and sugars see for example PCT publication No. WO 95/04064. The polynucleotide sequences of the invention may be prepared by any known method, including synthetic, recombinant, *ex vivo* generation, or a combination thereof, as well as utilizing any purification methods known in the art.

5 The terms polynucleotide construct, recombinant polynucleotide and recombinant polypeptide are used herein consistently with their use in the art. The terms "upstream" and

"downstream" are also used herein consistently with their use in the art. The terms "base paired" and "Watson & Crick base paired" are used interchangeably herein and consistently with their use in the art. Similarly, the terms "complementary", "complement thereof", "complement", "complementary polynucleotide", "complementary nucleic acid" and "complementary nucleotide sequence" are used interchangeably herein and consistently with their use in the art.

5 The term "purified" is used herein to describe a polynucleotide or polynucleotide vector of the invention that has been separated from other compounds including, but not limited to, other nucleic acids, carbohydrates, lipids and proteins (such as the enzymes used in the synthesis of the polynucleotide). Purified can also refer to the separation of covalently closed polynucleotides from 10 linear polynucleotides, or vice versa, for example. A polynucleotide is substantially pure when at least about 50%, 60%, 75%, or 90% of a sample contains a single polynucleotide sequence. In some cases this involves a determination between conformations (linear versus covalently closed). A substantially pure polynucleotide typically comprises about 50, 60, 70, 80, 90, 95, 99% weight/weight of a nucleic acid sample. Polynucleotide purity or homogeneity may be indicated by 15 a number of means well known in the art, such as agarose or polyacrylamide gel electrophoresis of a sample, followed by visualizing a single polynucleotide band upon staining the gel. For certain purposes, higher resolution can be achieved by using HPLC or other means well known in the art.

Similarly, the term "purified" is used herein to describe a polypeptide of the invention that has been separated from other compounds including, but not limited to, nucleic acids, lipids, 20 carbohydrates and other proteins. In some preferred embodiments, a polypeptide is substantially pure when at least about 50%, 60%, 75%, 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 99.5% of the polypeptide molecules of a sample have a single amino acid sequence. In some preferred embodiments, a substantially pure polypeptide typically comprises about 50%, 60%, 70%, 80%, 90%, 95%, 96%, 97%, 98%, 99% or 99.5% weight/weight of a protein sample. Polypeptide purity or 25 homogeneity is indicated by a number of methods well known in the art, such as agarose or polyacrylamide gel electrophoresis of a sample, followed by visualizing a single polypeptide band upon staining the gel. For certain purposes, higher resolution can be achieved by using HPLC or other methods well known in the art.

Further, as used herein, the term "purified" does not require absolute purity; rather, it is 30 intended as a relative definition. Purification of starting material or natural material to at least one order of magnitude, preferably two or three orders, and more preferably four or five orders of magnitude is expressly contemplated. Alternatively, purification may be expressed as "at least" a percent purity relative to heterologous polynucleotides (DNA, RNA or both) or polypeptides. As a preferred embodiment, the polynucleotides or polypeptides of the present invention are at least; 10%, 20%, 30%, 35% 40%, 50%, 60%, 70%, 80%, 90%, 95%, 96%, 98%, 99%, 99.5% or 100% pure relative to heterologous polynucleotides or polypeptides. As a further preferred embodiment the polynucleotides or polypeptides have an "at least" purity ranging from any number, to the thousandth

position, between 90% and 100% (e.g., at least 99.995% pure) relative to heterologous polynucleotides or polypeptides. Additionally, purity of the polynucleotides or polypeptides may be expressed as a percentage (as described above) relative to all materials and compounds other than the carrier solution. Each number, to the thousandth position, may be claimed as individual species of purity.

5 The term "isolated" requires that the material be removed from its original environment (e.g., the natural environment if it is naturally occurring). For example, a naturally occurring polynucleotide or polypeptide present in a living animal is not isolated, but the same polynucleotide or DNA or polypeptide, separated from some or all of the coexisting materials in the natural system, is isolated. Such polynucleotide could be part of a vector and/or such polynucleotide or polypeptide 10 could be part of a composition, and still be isolated in that the vector or composition is not part of its natural environment.

Specifically excluded from the definition of "isolated" are: naturally occurring chromosomes (e.g., chromosome spreads), artificial chromosome libraries, genomic libraries, and cDNA libraries that exist either as an *in vitro* nucleic acid preparation or as a transfected/transformed host cell preparation,

15 wherein the host cells are either an *in vitro* heterogeneous preparation or plated as a heterogeneous population of single colonies. Also specifically excluded are the above libraries wherein a 5' EST makes up less than 5% (or alternatively 1%, 2%, 3%, 4%, 10%, 25%, 50%, 75%, or 90%, 95%, or 99%) of the number of nucleic acid inserts in the vector molecules. Further specifically excluded are whole cell genomic DNA or whole cell RNA preparations (including said whole cell preparations which 20 are mechanically sheared or enzymatically digested). Further specifically excluded are the above whole cell preparations as either an *in vitro* preparation or as a heterogeneous mixture separated by electrophoresis (including blot transfers of the same) wherein the polynucleotide of the invention have not been further separated from the heterologous polynucleotides in the electrophoresis medium (e.g., further separating by excising a single band from a heterogeneous band population in an agarose gel or 25 nylon blot).

The term "primer" denotes a specific oligonucleotide sequence that is complementary to a target nucleotide sequence and used to hybridize to the target nucleotide sequence. A primer serves as an initiation point for nucleotide polymerization catalyzed by DNA polymerase, RNA polymerase, or reverse transcriptase.

30 The term "probe" denotes a defined nucleic acid segment (or nucleotide analog segment, e.g., PNA as defined hereinbelow) which can be used to identify a specific polynucleotide sequence present in a sample, said nucleic acid segment comprising a nucleotide sequence complementary to the specific polynucleotide sequence to be identified.

The term "polypeptide" refers to a polymer of amino acids without regard to the length of 35 the polymer. Thus, peptides, oligopeptides, and proteins are included within the definition of polypeptide. This term also does not specify or exclude post-expression modifications of polypeptides. For example, polypeptides that include the covalent attachment of glycosyl groups,

acetyl groups, phosphate groups, lipid groups and the like are expressly encompassed by the term polypeptide. Also included within the definition are polypeptides which contain one or more analogs of an amino acid (including, for example, non-naturally occurring amino acids, amino acids which only occur naturally in an unrelated biological system, modified amino acids from 5 mammalian systems etc.), polypeptides with substituted linkages, as well as other modifications known in the art, both naturally occurring and non-naturally occurring. As used herein, the term "GMG-2" refers generically to the murine or human GMG-2, unless otherwise specified.

Without being limited by theory, the compounds/polypeptides of the invention are capable of modulating the partitioning of dietary lipids between the liver and peripheral tissues, and are thus 10 believed to treat "diseases involving the partitioning of dietary lipids between the liver and peripheral tissues." The term "peripheral tissues" is meant to include muscle and adipose tissue. In preferred embodiments, the compounds/polypeptides of the invention partition the dietary lipids toward the muscle. In alternative preferred embodiments, the dietary lipids are partitioned toward the 15 adipose tissue. In other preferred embodiments, the dietary lipids are partitioned toward the liver. In yet other preferred embodiments, the compounds/polypeptides of the invention increase or decrease the oxidation of dietary lipids, preferably free fatty acids (FFA) by the muscle. Dietary lipids include, but are not limited to triglycerides and free fatty acids.

Preferred diseases believed to involve the partitioning of dietary lipids include obesity and 20 obesity-related diseases and disorders such as obesity, impaired glucose tolerance, insulin resistance, atherosclerosis, atheromatous disease, heart disease, hypertension, stroke, Syndrome X, Noninsulin Dependent Diabetes Mellitus (NIDDM, or Type II diabetes) and Insulin Dependent Diabetes Mellitus (IDDM or Type I diabetes). Diabetes-related complications to be treated by the methods of the invention include microangiopathic lesions, ocular lesions, retinopathy, neuropathy, and renal 25 lesions. Heart disease includes, but is not limited to, cardiac insufficiency, coronary insufficiency, and high blood pressure. Other obesity-related disorders to be treated by compounds of the invention include hyperlipidemia and hyperuricemia. Yet other metabolic-related diseases or disorders of the invention including cachexia, wasting, AIDS-related weight loss, cancer-related weight loss, anorexia, and bulimia.

The term "heterologous", when used herein, is intended to designate any polypeptide or 30 polynucleotide other than an GMG-2 or GMG-2 polypeptide or a polynucleotide encoding a gGMG-2 polypeptide of the present invention.

The terms "comprising", "consisting of" and "consisting essentially of" are defined according to their standard meaning. A defined meaning set forth in the M.P.E.P. controls over a 35 defined meaning in the art and a defined meaning set forth in controlling Federal Circuit case law controls over a meaning set forth in the M.P.E.P. With this in mind, the terms may be substituted for one another throughout the instant application in order to attach the specific meaning associated with each term.

The term "host cell recombinant for" a particular polynucleotide of the present invention, means a host cell that has been altered by the hands of man to contain said polynucleotide in a way not naturally found in said cell. For example, said host cell may be transiently or stably transfected or transduced with said polynucleotide of the present invention.

5 The term "obesity" as used herein is defined in the WHO classifications of weight (Kopelman (2000) *Nature* 404:635643). Underweight is less than 18.5 (thin); Healthy is 18.5-24.9 (normal); grade 1 overweight is 25.0-29.9 (overweight); grade 2 overweight is 30.0-39.0 (obesity); grade 3 overweight is greater than or equal to 40.0 BMI. BMI is body mass index (morbid obesity) and is kg/m². Waist circumference can also be used to indicate a risk of metabolic complications 10 where in men a circumference of greater than or equal to 94 cm indicates an increased risk, and greater than or equal to 102 cm indicates a substantially increased risk. Similarly for women, greater than or equal to 88 cm indicates an increased risk, and greater than or equal to 88 cm indicates a substantially increased risk. The waist circumference is measured in cm at midpoint between lower border of ribs and upper border of the pelvis. Other measures of obesity include, but are not limited 15 to, skinfold thickness which is a measurement in cm of skinfold thickness using calipers, and bioimpedance, which is based on the principle that lean mass conducts current better than fat mass because it is primarily an electrolyte solution; measurement of resistance to a weak current (impedance) applied across extremities provides an estimate of body fat using an empirically derived equation.

20 The term "energy intake" as used herein is defined as the energy introduced into an individual from total caloric intake, i.e., the total energy from food and liquid diet.

The term "energy expenditure" as used herein is defined as total energy expenditure (TEE), which includes resting energy expenditure (REE), the thermic effect of feeding (TEF), and activities such as exercise. Both "energy intake" and "energy expenditure" are defined by Rosenbaum et al.

25 [Am J Clin Nutr (2000) Jun;71(6):1421-32], which is hereby incorporated by reference in its entirety].

The term "maintenance of weight loss" as used herein is defined as sustaining a stable weight in an individual that is 10-20% below the initial, obese weight of the individual. Preferably, the new maintained weight after weight loss is a healthy weight (as defined herein). When the 30 maintenance of weight loss is practiced for cosmetic purposes, the individual has a BMI of at least 20 and no more than 25. As defined for the treatment of obesity by means of maintaining weight loss, the individual may have a BMI of at least 20.

The term "diabetes" as used herein is intended to encompass the usual diagnosis of diabetes made from any of the methods included, but not limited to, the following list: symptoms of diabetes 35 (e.g. polyuria, polydipsia, polyphagia) plus casual plasma glucose levels of greater than or equal to 200 mg/dl, wherein casual plasma glucose is defined any time of the day regardless of the timing of meal or drink consumption; 8 hour fasting plasma glucose levels of less than or equal to 126 mg/dl;

and plasma glucose levels of greater than or equal to 200 mg/dl 2 hours following oral administration of 75 g anhydrous glucose dissolved in water.

The term "impaired glucose tolerance (IGT)" as used herein is intended to indicate that condition associated with insulin-resistance that is intermediate between frank, NIDDM and normal glucose tolerance (NGT). A high percentage of the IGT population is known to progress to NIDDM relative to persons with normal glucose tolerance (Sad et al., New Engl J Med 1988; 319:1500-6 which disclosure is hereby incorporated by reference in its entirety). Thus, by providing 5 therapeutics and methods for reducing or preventing IGT, i.e., for normalizing insulin resistance, the progression to NIDDM can be delayed or prevented. IGT is diagnosed by a procedure wherein an 10 affected person's postprandial glucose response is determined to be abnormal as assessed by 2-hour postprandial plasma glucose levels. In this test, a measured amount of glucose is given to the patient and blood glucose levels measured regular intervals, usually every half hour for the first two hours and every hour thereafter. In a "normal" or non-IGT individual, glucose levels rise during the first two hours to a level less than 140 mg/dl and then drop rapidly. In an IGT individual, the blood 15 glucose levels are higher and the drop-off level is at a slower rate.

The term "Insulin-Resistance Syndrome" as used herein is intended to encompass the cluster of abnormalities resulting from an attempt to compensate for insulin resistance that sets in motion a series of events that play an important role in the development of both hypertension and coronary artery disease (CAD), such as premature atherosclerotic vascular disease. Increased plasma 20 triglyceride and decreased HDL-cholesterol concentrations, conditions that are known to be associated with CAD, have also been reported to be associated with insulin resistance. Thus, by providing therapeutics and methods for reducing or preventing insulin resistance, the invention provides methods for reducing and/or preventing the appearance of insulin-resistance syndrome.

The term "polycystic ovary syndrome (PCOS)" as used herein is intended to designate that 25 etiologically unassigned disorder of premenopausal women, affecting 5-10% of this population, characterized by hyperandrogenism, chronic anovulation, defects in insulin action, insulin secretion, ovarian steroidogenesis and fibrinolysis. Women with PCOS frequently are insulin resistant and at increased risk to develop glucose intolerance or NIDDM in the third and fourth decades of life (Dunaif et al. (1996) J Clin Endocrinol Metab 81:3299 which disclosure is hereby incorporated by 30 reference in its entirety). Hyperandrogenism also is a feature of a variety of diverse insulin-resistant states, from the type A syndrome, through leprechaunism and lipoatrophic diabetes, to the type B syndrome, when these conditions occur in premenopausal women. It has been suggested that hyperinsulinemia per se causes hyperandrogenism. Insulin-sensitizing agents, e.g., troglitazone, have been shown to be effective in PCOS and that, in particular, the defects in insulin action, insulin 35 secretion, ovarian steroidogenesis and fibrinolysis are improved (Ehrman et al. (1997) J Clin Invest 100:1230 which disclosure is hereby incorporated by reference in its entirety), such as in insulin-resistant humans.

The term "insulin resistance" as used herein is intended to encompass the usual diagnosis of insulin resistance made by any of a number of methods, such as the intravenous glucose tolerance test or measurement of the fasting insulin level. It is well known that there is an excellent correlation between the height of the fasting insulin level and the degree of insulin resistance.

- 5 Therefore, one could use elevated fasting insulin levels as a surrogate marker for insulin resistance for the purpose of identifying which normal glucose tolerance (NGT) individuals have insulin resistance. Another way to do this is to follow the approach as disclosed in The New England Journal of Medicine, No. 3, pp. 1188 (1995) (which disclosure is hereby incorporated by reference in its entirety), i.e. to select obese subjects as an initial criterion for entry into the treatment group.
- 10 Some obese subjects have impaired glucose tolerance (IGT) while others have normal glucose tolerance (NGT). Since essentially all obese subjects are insulin resistant, i.e. even the NGT obese subjects are insulin resistant and have fasting hyperinsulinemia. Therefore, the target of the treatment according to the present invention can be defined as NGT individuals who are obese or who have fasting hyperinsulinemia, or who have both.

15 A diagnosis of insulin resistance can also be made using the euglycemic glucose clamp test. This test involves the simultaneous administration of a constant insulin infusion and a variable rate glucose infusion. During the test, which lasts 3-4 hours, the plasma glucose concentration is kept constant at euglycemic levels by measuring the glucose level every 5-10 minutes and then adjusting the variable rate glucose infusion to keep the plasma glucose level unchanged. Under these 20 circumstances, the rate of glucose entry into the bloodstream is equal to the overall rate of glucose disposal in the body. The difference between the rate of glucose disposal in the basal state (no insulin infusion) and the insulin infused state, represents insulin mediated glucose uptake. In normal individuals, insulin causes brisk and large increase in overall body glucose disposal, whereas in NIDDM subjects, this effect of insulin is greatly blunted, and is only 20-30% of normal. In insulin 25 resistant subjects with either IGT or NGT, the rate of insulin stimulated glucose disposal is about half way between normal and NIDDM. For example, at a steady state plasma insulin concentration of about 100 μ U/ml (a physiologic level) the glucose disposal rate in normal subjects is about 7 mg/kg/min. In NIDDM subjects, it is about 2.5mg/kg/min., and in patients with IGT (or insulin resistant subjects with NGT) it is about 4-5 mg/kg/min. This is a highly reproducible and precise 30 test, and can distinguish patients within these categories. It is also known that as subjects become more insulin resistant, the fasting insulin level rises. There is an excellent positive correlation between the height of the fasting insulin level and the magnitude of the insulin resistance as measured by euglycemic glucose clamp tests and, therefore, this provides the rationale for using fasting insulin levels as a surrogate measure of insulin resistance.

35 The term "agent acting on the partitioning of dietary lipids between the liver and peripheral tissues" refers to a compound or polypeptide of the invention that modulates the partitioning of dietary lipids between the liver and the peripheral tissues as previously described. Preferably, the

agent increases or decreases the oxidation of dietary lipids, preferably free fatty acids (FFA) by the muscle. Preferably the agent decreases or increases the body weight of individuals or is used to treat or prevent an obesity-related disease or disorder such as obesity, impaired glucose tolerance, insulin resistance, atherosclerosis, atheromatous disease, heart disease, hypertension, stroke, Syndrome X, 5 Noninsulin Dependent Diabetes Mellitus (NIDDM, or Type II diabetes) and Insulin Dependent Diabetes Mellitus (IDDM or Type I diabetes). Diabetes-related complications to be treated by the methods of the invention include microangiopathic lesions, ocular lesions, retinopathy, neuropathy, and renal lesions. Heart disease includes, but is not limited to, cardiac insufficiency, coronary insufficiency, and high blood pressure. Other obesity-related disorders to be treated by compounds 10 of the invention include hyperlipidemia and hyperuricemia. Yet other obesity-related diseases or disorders of the invention include cachexia, wasting, AIDS-related weight loss, cancer-related weight loss, anorexia, and bulimia.

The terms "response to an agent acting on the partitioning of dietary lipids between the liver and peripheral tissues" refer to drug efficacy, including but not limited to, ability to metabolize a 15 compound, ability to convert a pro-drug to an active drug, and the pharmacokinetics (absorption, distribution, elimination) and the pharmacodynamics (receptor-related) of a drug in an individual.

The terms "side effects to an agent acting on the partitioning of dietary lipids between the liver and peripheral tissues" refer to adverse effects of therapy resulting from extensions of the 20 principal pharmacological action of the drug or to idiosyncratic adverse reactions resulting from an interaction of the drug with unique host factors. "Side effects to an agent acting on the partitioning of dietary lipids between the liver and peripheral tissues" can include, but are not limited to, adverse reactions such as dermatologic, hematologic or hepatologic toxicities and further includes gastric and intestinal ulceration, disturbance in platelet function, renal injury, nephritis, vasomotor rhinitis with profuse watery secretions, angioneurotic edema, generalized urticaria, and bronchial asthma to 25 laryngeal edema and bronchoconstriction, hypotension, and shock.

The term "GMG-2-related diseases and disorders" as used herein refers to any disease or disorder comprising an aberrant functioning of GMG-2, or which could be treated or prevented by modulating GMG-2 levels or activity. "Aberrant functioning of GMG-2" includes, but is not limited to, aberrant levels of expression of GMG-2 (either increased or decreased, but preferably decreased), 30 aberrant activity of GMG-2 (either increased or decreased), and aberrant interactions with ligands or binding partners (either increased or decreased). By "aberrant" is meant a change from the type, or level of activity seen in normal cells, tissues, or patients, or seen previously in the cell, tissue, or patient prior to the onset of the illness. In preferred embodiments, these GMG-2-related diseases and disorders include obesity and the obesity-related diseases and disorders described previously.

35 The term "cosmetic treatments" is meant to include treatments with compounds or polypeptides of the invention that increase or decrease the body mass of an individual where the individual is not clinically obese or clinically thin. Thus, these individuals have a body mass index

(BMI) below the cut-off for clinical obesity (e.g. below 25 kg/m²) and above the cut-off for clinical thinness (e.g. above 18.5 kg/m²). In addition, these individuals are preferably healthy (e.g. do not have an obesity-related disease or disorder of the invention). "Cosmetic treatments" are also meant to encompass, in some circumstances, more localized increases in adipose tissue, for example, gains 5 or losses specifically around the waist or hips, or around the hips and thighs, for example. These localized gains or losses of adipose tissue can be identified by increases or decreases in waist or hip size, for example.

The term "preventing" as used herein refers to administering a compound prior to the onset of clinical symptoms of a disease or condition so as to prevent a physical manifestation of 10 aberrations associated with obesity or GMG-2. Alternatively, the term "preventing" can also be used to signify the reduction, or severity, of clinical symptoms associated with a disease or condition.

The term "treating" as used herein refers to administering a compound after the onset of clinical symptoms.

15 The term "in need of treatment" as used herein refers to a judgment made by a caregiver (e.g. physician, nurse, nurse practitioner, etc in the case of humans; veterinarian in the case of animals, including non-human mammals) that an individual or animal requires or will benefit from treatment. This judgment is made based on a variety of factors that are in the realm of a caregiver's expertise, but that include the knowledge that the individual or animal is ill, or will be ill, as the 20 result of a condition that is treatable by the compounds of the invention.

The term "perceives a need for treatment" refers to a sub-clinical determination that an individual desires to reduce weight for cosmetic reasons as discussed under "cosmetic treatment" above. The term "perceives a need for treatment" in other embodiments can refer to the decision that an owner of an animal makes for cosmetic treatment of the animal.

25 The term "individual" or "patient" as used herein refers to any animal, including mammals, preferably mice, rats, other rodents, rabbits, dogs, cats, swine, cattle, sheep, horses, or primates, and most preferably humans. The term may specify male or female or both, or exclude male or female.

The term "non-human animal" refers to any non-human vertebrate, including birds and more 30 usually mammals, preferably primates, animals such as swine, goats, sheep, donkeys, horses, cats, dogs, rabbits or rodents, more preferably rats or mice. Both the terms "animal" and "mammal" expressly embrace human subjects unless preceded with the term "non-human".

The inventors have found that a fragment of GMG-2, called gGMG-2, is able to 35 significantly reduce the postprandial response of plasma free fatty acids, glucose, and triglycerides in mice fed a high fat/sucrose meal. There was no significant effect on leptin, insulin or glucagon levels. In addition, gGMG-2 was found to increase muscle free fatty acid oxidation *in vitro* and *ex vivo*. Further, gGMG-2 was shown to decrease and then to prevent an increase in weight gain in mice that had been fed a high fat/sucrose diet for 19 days. In mice that had been maintained on the

same high fat/sucrose diet for 6 months, gGMG-2 treatment resulted in a sustained weight loss over 16 days that was significant, despite being maintained on the high fat/sucrose diet.

The instant invention encompasses the use of GMG-2 polypeptide fragments in the partitioning of free fatty acid (FFA) and as an important new tool to control energy homeostasis. Of 5 the tissues that can significantly remove lipids from circulation and cause FFA oxidation, muscle is quantitatively the most important. Globular GMG-2 is a unique and novel pharmacological tool that controls body weight without interfering with food intake.

PREFERRED EMBODIMENTS OF THE INVENTION

10

I. GMG-2 Polypeptide Fragments of the Invention

GMG-2 polypeptide fragments that have measurable activity *in vitro* and *in vivo* have been identified. These activities include, but are not limited to, reduction of the postprandial response of 15 plasma free fatty acids, glucose, and triglycerides in mice fed a high fat/sucrose meal (Examples 8 or 11), increase in muscle free fatty acid oxidation *in vitro* and *ex vivo* (Example 10), and sustained weight loss in mice on a high fat/sucrose diet (Example 2). Other assays for GMG-2 polypeptide fragment activity *in vitro* and *in vivo* are also provided throughout the Examples, and equivalent assays can be designed by those of ordinary skill in the art.

In contrast, the "intact" or "full-length" GMG-2 polypeptide does not have either the *in vivo* 20 or the *in vitro* activities that have been identified for gGMG-2 polypeptide fragments of the invention. In most cases, the activities are either not present or at a minimum are undetectable over control values in the assays used. In other cases, the activities can be measured, but are present either at extremely reduced levels and/or require significantly more protein on a molar basis compared with the gGMG-2 polypeptide fragments of the invention (see, e.g. Example 10). By 25 "intact" or "full-length" GMG-2 polypeptide as used herein is meant the full-length polypeptide sequence of any GMG-2 polypeptide, from the N-terminal methionine to the C-terminal stop codon. Examples of intact or full-length GMG-2 polypeptides are found in SEQ ID NOs:2, 4 and 6. The term "GMG-2 polypeptide fragments" as used herein refers to fragments of the "intact" or "full-length" GMG-2 polypeptide that have "obesity-related activity" or "insulin-like activity". The term 30 "gGMG-2 polypeptide fragments" refers to polypeptide fragments comprised of the globular domain and is thus a narrower term than "GMG-2 polypeptide fragments". The term "fragment" means a polypeptide having a sequence that is entirely the same as part, but not all, of an intact or full-length GMG-2 polypeptide. Such fragments may be "free-standing" (*i.e.* not part of or fused to other polypeptides), or one or more fragments may be present in a single polypeptide. gGMG-2 fragments 35 are contiguous fragments of the full-length GMG-2 polypeptide unless otherwise specified.

The term "obesity-related activity" as used herein refers to at least one, and preferably all, of the activities described herein for GMG-2 polypeptide fragments. Assays for the determination of

these activities are provided herein (e.g. Examples 4-16), and equivalent assays can be designed by those with ordinary skill in the art. Optionally, “obesity-related activity” can be selected from the group consisting of lipid partitioning, lipid metabolism, and insulin-like activity, or an activity within one of these categories. By “lipid partitioning” activity is meant the ability to effect the 5 location of dietary lipids among the major tissue groups including, adipose tissue, liver, and muscle. The inventors have shown that GMG-2 polypeptide fragments of the invention play a role in the partitioning of lipids to the muscle, liver or adipose tissue. By “lipid metabolism” activity is meant the ability to influence the metabolism of lipids. The inventors have shown that GMG-2 polypeptide fragments of the invention have the ability to affect the level of free fatty acids in the plasma as well 10 as to increase the metabolism of lipids in the muscle through free fatty acid oxidation experiments and to transiently affect the levels of triglycerides in the plasma and the muscle. By “insulin-like” activity is meant the ability of GMG-2 polypeptide fragments to modulate the levels of glucose in the plasma. The inventors have found that GMG-2 polypeptide fragments do not significantly impact insulin levels but do impact glucose levels similarly to the effects of insulin. These effects 15 are not seen in the presence of multimers of gGMG-2 polypeptide fragment homotrimer or are significantly greater in the presence of non-multimeric gGMG-2 polypeptide fragment trimer compared with multimers of gGMG-2 polypeptide fragment homotrimer.

The term “significantly greater” as used herein refers to a comparison of the activity of an 20 non-multimeric gGMG-2 polypeptide fragment homotrimer in an obesity-related assay compared with the activity of multimers of gGMG-2 polypeptide fragment homotrimer in the same assay. By 25 “significantly” as used herein is meant statistically significant as it is typically determined by those with ordinary skill in the art. For example, data are typically calculated as a mean \pm SEM, and a p-value ≤ 0.05 is considered statistically significant. Statistical analysis is typically done using either the unpaired Student’s t test or the paired Student’s t test, as appropriate in each study.

25 Examples of a significant change in activity as a result of the presence of an GMG-2 polypeptide fragment of the invention compared to the presence of a full-length GMG-2 polypeptide include an increase or a decrease in a given parameter of at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, or 75%. One or more, but not necessarily all, of the measurable 30 parameters will change significantly in the presence of GMG-2 polypeptide fragments as compared to in the presence of an intact GMG-2 polypeptide.

35 Representative “obesity-related assays” are provided in the Examples. These assays include, but are not limited to, methods of measuring the postprandial response, methods of measuring free fatty acid oxidation, and methods of measuring weight modulation. In preferred embodiments, the post-prandial response is measured in non-human animals, preferably mice. In preferred embodiments changes in dietary lipids are measured, preferably free fatty acids and/or triglycerides. In other embodiments, other physiologic parameters are measured including, but not limited to, levels of glucose, insulin, and leptin. In other preferred embodiments, free fatty acid oxidation is

measured in cells *in vitro* or *ex vivo*, preferably in muscle cells or tissue of non-human animals, preferably mice. In yet other preferred embodiments weight modulation is measured in human or non-human animals, preferably rodents (rats or mice), primates, canines, felines or procines on a high fat/sucrose diet. Optionally, "obesity-related activity" includes other activities not specifically identified herein. In general, "measurable parameters" relating to obesity and the field of metabolic research can be selected from the group consisting of free fatty acid levels, free fatty acid oxidation, triglyceride levels, glucose levels, insulin levels, leptin levels, food intake, weight, leptin and lipoprotein binding, uptake and degradation and lipolysis stimulated receptor (LSR) expression.

In these obesity-related assays, preferred GMG-2 polypeptide fragments of the invention, but not full-length GMG-2 polypeptides, would cause a significant change in at least one of the measurable parameters selected from the group consisting of post-prandial lipemia, free fatty acid levels, triglyceride levels, glucose levels, free fatty acid oxidation, and weight. Alternatively, preferred GMG-2 polypeptide fragments of the invention, but not full-length GMG-2 polypeptides, would have a significant change in at least one of the measurable parameters selected from the group consisting of an increase in LSR activity, an increase in leptin activity and an increase in lipoprotein activity. By "LSR" activity is meant expression of LSR on the surface of the cell, or in a particular conformation, as well as its ability to bind, uptake, and degrade leptin and lipoprotein. By "leptin" activity is meant its binding, uptake and degradation by LSR, as well as its transport across a blood brain barrier, and potentially these occurrences where LSR is not necessarily the mediating factor or the only mediating factor. Similarly, by "lipoprotein" activity is meant its binding, uptake and degradation by LSR, as well as these occurrences where LSR is not necessarily the mediating factor or the only mediating factor.

The invention is drawn, *inter alia*, to isolated, purified or recombinant GMG-2 polypeptides. GMG-2 polypeptides of the invention are useful for reducing or increasing (using antagonists of GMG-2 polypeptides) body weight either as a cosmetic treatment or for treatment or prevention of metabolic-related diseases and disorders. GMG-2 polypeptides are also useful *inter alia* in screening assays for agonists or antagonists of GMG-2 polypeptide activity; in screening assays for antagonists of N-terminal dipeptidyl peptidase cleavage of GMG-2 fragments, preferably cleavage of the N-terminal SP dipeptide of GMG-2 polypeptide fragment 144-288 of SEQ ID NO: 2, or cleavage of the N-terminal SP dipeptide of GMG-2 polypeptide fragment 134-278 of SEQ ID NO: 4, or cleavage of the N-terminal SP dipeptide of GMG-2 polypeptide fragment 115-259 of SEQ ID NO: 6, or cleavage of the N-terminal TA dipeptide of GMG-2 fragment 162-288 of SEQ ID NO: 2, or cleavage of the N-terminal TA dipeptide of GMG-2 fragment 152-278 of SEQ ID NO: 2, or cleavage of the N-terminal TA dipeptide of GMG-2 fragment 133-259 of SEQ ID NO: 6; for raising GMG-2 polypeptide-specific antibodies; and in diagnostic assays. When used for cosmetic treatments, or for the treatment or prevention of metabolic-related diseases, disorders or conditions, one or more GMG-2 polypeptide fragments can be provided to a subject. Thus, various fragments of

the full-length protein can be combined into a "cocktail" for use in the various treatment regimens.

The full-length GMG-2 polypeptide is comprised of at least four distinct regions including:

1. an N-terminal putative signal sequence about from amino acids 1-56 of SEQ ID NO: 2, or 1-46 of SEQ ID NO: 4, or 1-27 of SEQ ID NO: 6;
- 5 2. a unique region about from amino acids 57-106 of SEQ ID NO: 2, or 47-96 of SEQ ID NO: 4, or 28-77 of SEQ ID NO: 6;
3. a collagen-like region about from amino acids 107-148 of SEQ ID NO: 2, or 97-138 of SEQ ID NO: 4, or 78-119 of SEQ ID NO: 6; and
- 10 4. a globular region of C1q homology about from amino acids 155-288 of SEQ ID NO: 2, or 145-278 of SEQ ID NO: 4, or 126-259 of SEQ ID NO: 6.

The term "collagen residues" is used in the manner standard in the art to mean the amino acid triplet glycine, X, Y, where X and Y can be any amino acid.

The GMG-2 polypeptide fragments of the present invention are preferably provided in an isolated form, and may be partially or substantially purified. A recombinant produced version of 15 an GMG-2 polypeptide fragment can be substantially purified by the one-step method described by Smith et al. ((1988) Gene 67(1):31-40) or by the methods described herein or known in the art.

Fragments of the invention also can be purified from natural or recombinant sources using antibodies directed against the polypeptide fragments of the invention by methods known in the art of protein purification.

20 Preparations of GMG-2 polypeptide fragments of the invention involving a partial purification of or selection for the GMG-2 polypeptide fragments are also specifically contemplated. These crude preparations are envisioned to be the result of the concentration of cells expressing GMG-2 polypeptide fragments with perhaps a few additional purification steps, but prior to complete purification of the fragment. The cells expressing GMG-2 polypeptide fragments are present in a 25 pellet, they are lysed, or the crude polypeptide is lyophilized, for example.

GMG-2 polypeptide fragments can be any integer in length from at least 6 consecutive amino acids to one amino acid less than a full length GMG-2 polypeptide. Thus, for the polypeptides of SEQ ID NOs: 2, a GMG-2 polypeptide can be any integer of consecutive amino acids from 6 to 287, for example. The term "integer" is used herein in its mathematical sense and 30 thus representative integers include, but are not limited to: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 35 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178,

179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198,
199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218,
219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 234, 235, 236, 237, 238, 239,
240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259,
5 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279,
280, 281, 282, 283, 284, 285, 286 or 287.

Each GMG-2 polypeptide fragment as described above can be further specified in terms of its N-terminal and C-terminal positions. For example, every combination of a N-terminal and C-terminal position that fragments of from 6 contiguous amino acids to 1 amino acid less than the 10 full length polypeptide of SEQ ID NO: 2 could occupy, on any given intact and contiguous full length polypeptide sequence of SEQ ID NO: 2 are included in the present invention. Thus, a 6 consecutive amino acid fragment could occupy positions selected from the group consisting of 1-6, 2-7, 3-8, 4-9, 5-10, 6-11, 7-12, 8-13, 9-14, 10-15, 11-16, 12-17, 13-18, 14-19, 15-20, 16-21, 17-22, 18-23, 19-24, 20-25, 21-26, 22-27, 23-28, 24-29, 25-30, 26-31, 27-32, 28-33, 29-34, 30-35, 31-36, 15 32-37, 33-38, 34-39, 35-40, 36-41, 37-42, 38-43, 39-44, 40-45, 41-46, 42-47, 43-48, 44-49, 45-50, 46-51, 47-52, 48-53, 49-54, 50-55, 51-56, 52-57, 53-58, 54-59, 55-60, 56-61, 57-62, 58-63, 59-64, 60-65, 61-66, 62-67, 63-68, 64-69, 65-70, 66-71, 67-72, 68-73, 69-74, 70-75, 71-76, 72-77, 73-78, 74-79, 75-80, 76-81, 77-82, 78-83, 79-84, 80-85, 81-86, 82-87, 83-88, 84-89, 85-90, 86-91, 87-92, 88-93, 89-94, 90-95, 91-96, 92-97, 93-98, 94-99, 95-100, 96-101, 97-102, 98-103, 99-104, 100-105, 20 101-106, 102-107, 103-108, 104-109, 105-110, 106-111, 107-112, 108-113, 109-114, 110-115, 111-116, 112-117, 113-118, 114-119, 115-120, 116-121, 117-122, 118-123, 119-124, 120-125, 121-126, 122-127, 123-128, 124-129, 125-130, 126-131, 127-132, 128-133, 129-134, 130-135, 131-136, 132-137, 133-138, 134-139, 135-140, 136-141, 137-142, 138-143, 139-144, 140-145, 141-146, 142-147, 143-148, 144-149, 145-150, 146-151, 147-152, 148-153, 149-154, 150-155, 151-156, 152-157, 153-158, 154-159, 155-160, 156-161, 157-162, 158-163, 159-164, 160-165, 161-166, 162-167, 163-168, 164-169, 165-170, 166-171, 167-172, 168-173, 169-174, 170-175, 171-176, 172-177, 173-178, 174-179, 175-180, 176-181, 177-182, 178-183, 179-184, 180-185, 181-186, 182-187, 183-188, 184-189, 185-190, 186-191, 187-192, 188-193, 189-194, 190-195, 191-196, 192-197, 193-198, 194-199, 195-200, 196-201, 197-202, 198-203, 199-204, 200-205, 201-206, 202-207, 203-208, 204-209, 205-210, 30 206-211, 207-212, 208-213, 209-214, 210-215, 211-216, 212-217, 213-218, 214-219, 215-220, 216-221, 217-222, 218-223, 219-224, 220-225, 221-226, 222-227, 223-228, 224-229, 225-230, 226-231, 227-232, 228-233, 229-234, 230-235, 231-236, 232-237, 233-238, 234-239, 235-240, 236-241, 237-242, 238-243, and 239-244 of a 244 consecutive amino acid fragment. A 238 consecutive amino acid fragment could occupy positions selected from the group consisting of 1-238, 2-239, 3-240, 4-35 241, 5-242, 6-243 and 7-244. Similarly, the positions occupied by all the other fragments of sizes between 6 amino acids and 287 amino acids in SEQ ID NO: 2, and by all the other fragments of sizes between 6 amino acids and 277 amino acids in SEQ ID NO: 4, and by all the other fragments of sizes

between 6 amino acids and 258 amino acids in SEQ ID NO: 6 are included in the present invention and can also be immediately envisaged based on these two examples and therefore, are not individually listed solely for the purpose of not unnecessarily lengthening the specification.

Furthermore, the positions occupied by fragments of 6 to next to the last amino acid consecutive

5 amino acids in SEQ ID NOs: 2, 4 or 6 are included in the present invention and can also be immediately envisaged based on these two examples and therefore are not individually listed solely for the purpose of not unnecessarily lengthening the specification. In addition, the positions occupied by fragments of 6 consecutive amino acids to 1 amino acid less than any other full length GMG-2 polypeptide can also be envisaged based on these two examples and therefore are not

10 individually listed solely for the purpose of not unnecessarily lengthening the specification.

A 238 consecutive amino acid fragment could occupy positions selected from the group consisting of 1-238, 2-239, 3-240, 4-241, 5-242, 6-243 and 7-244 of SEQ ID NO:2. Similarly, the positions occupied by all the other fragments of sizes between 6 amino acids and 284 amino acids on SEQ ID NO:2 are included in the present invention and can also be immediately envisaged based on

15 the examples for fragments of 6, 50, 100 or 284 consecutive amino acids listed above, and therefore, are not individually listed solely for the purpose of not unnecessarily lengthening the specification.

Furthermore, the positions occupied by fragments of 6 to 217 consecutive amino acids on SEQ ID NO:4 are included in the present invention and can also be immediately envisaged based on these two examples and therefore are not individually listed solely for the purpose of not unnecessarily

20 lengthening the specification. In preferred embodiments, gGMG-2 polypeptide fragments, and polynucleotides encoding the same, having unexpected activity are selected from amino acids numbered from 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2

25 wherein the cysteines at positions 66, 69 or 70 are replaced by said substitute amino acid(s). In preferred embodiments, gGMG-2 polypeptide fragments, and polynucleotides encoding the same, having unexpected activity are selected from amino acids numbered from 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278,

138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-

30 278, 149-278, 150-278, 151-278 or 152-278 of SEQ ID NO:4, wherein the cysteine at position 56, 59 or 60 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments having unexpected activity are selected from amino acids 28-259, 29-259, 30-

259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-

259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259,

35 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at position 37, 40 or 41 are replaced by said substitute amino acid(s). In other preferred embodiments, gGMG-2 polypeptide fragments, and polynucleotides encoding the same, having unexpected activity are

selected from amino acids numbered from 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2. In other preferred embodiments, gGMG-2 polypeptide fragments, and polynucleotides encoding the same, having unexpected activity are selected from amino acids numbered from 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 5 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4, or 28-259, 29-259, 30-259, 31-259, 32-259, 114-259, 114-259, 115-259, 123-259, 124-259, 132-259 or 133-259 of SEQ ID NO: 6.

The gGMG-2 polypeptide fragments of the present invention may alternatively be described by the formula "n to c" (inclusive); where "n" equals the N-terminal most amino acid position (as defined by the sequence listing) and "c" equals the C-terminal most amino acid position (as defined

10 by the sequence listing) of the polypeptide; and further where "n" equals an integer between 1 and the number of amino acids of the full length polypeptide sequence of the present invention minus 5 (283 for SEQ ID NO:2 and 273 for SEQ ID NO:4 and 254 for SEQ ID NO:6); and where "c" equals an integer between 6 and the number of amino acids of the full-length polypeptide sequence (288 for SEQ ID NO:2 and 278 for SEQ ID NO:4 and 259 for SEQ ID NO:6); and where "n" is an integer 15 smaller than "c" by at least 6. Therefore, for SEQ ID NO:2, "n" is any integer selected from the list consisting of: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 20 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 25 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, or 283; and "c" is any integer selected from the group consisting of: 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 30 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 35 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200,

201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220,
221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 234, 235, 236, 237, 238, 239, 240, 241,
242, 243, 244 ... (every integer between 245 and 288, inclusive). Every combination of "n" and "c"
5 may be modified as "n1 - n2" to "c1 - c2", wherein "n1 - n2" and "c1 - c2" represent positional
ranges selected from any two integers above which represent amino acid positions of the sequence
listing. Alternative formulas include "n1 - n2" to "c" and "n" to "c1 - c2". In a preferred
embodiment, GMG-2 polypeptide fragments of the invention may be described by the formula
where n1=57, n2=155, and c=288 of SEQ ID NO:2; or by the formula n1=47, n2=145, and c=278 of
10 SEQ ID NO:4, or by the formula n1=28, n2=126, and c=259 of SEQ ID NO:6.

These specific embodiments, and other polypeptide and polynucleotide fragment
embodiments described herein may be modified as being "at least", "equal to", "equal to or less
than", "less than", "at least ___ but not greater than ___" or "from ___ to ___" a specified size or
specified N-terminal and/or C-terminal positions. It is noted that all ranges used to describe any
15 embodiment of the present invention are inclusive unless specifically set forth otherwise.

The present invention also provides for the exclusion of any individual fragment specified
by N-terminal and C-terminal positions or of any fragment specified by size in amino acid residues
as described above. In addition, any number of fragments specified by N-terminal and C-terminal
positions or by size in amino acid residues as described above may be excluded as individual species.
20 Further, any number of fragments specified by N-terminal and C-terminal positions or by size in
amino acid residues as described above may make up a polypeptide fragment in any combination and
may optionally include non-GMG-2 polypeptide sequence as well.

gGMG-2 polypeptide fragments of the invention include variants, fragments, fragments, analogs and
derivatives of the gGMG-2 polypeptide fragments described above, including modified gGMG-2
25 polypeptide fragments.

Proteolytic cleavage of full length GMG-2 polypeptides of the invention *in vivo* is believed
to be subject to complex regulation that facilitates the appropriate and effective generation of GMG-
2 polypeptide fragments of the invention comprised of all or part of the globular C-terminal C1q
homology region and having unexpected lipid partitioning, lipid metabolism, and insulin-like
30 activity. Said proteolytic cleavage is regulated in part by selective presentation of protease cleavage
sites through alternative splicing. Said proteolytic cleavage is further regulated at the level of the
protease, for example at the level of tissue distribution of the protease and at the level of amount of
the protease, which itself can be regulated by physiological signals such as those associated with
inflammation. Particularly preferred GMG-2 polypeptide fragments of the invention comprised of
35 all or part of the globular C-terminal C1q homology region and having unexpected lipid partitioning,
lipid metabolism, and insulin-like activity are said GMG-2 polypeptide fragments of SEQ ID NOs:
2, 4, or 6 believed to be generated proteolytically *in vivo*. Particularly preferred is GMG-2 fragment

of about amino acids 144-288 of SEQ ID NO: 2 made by collagenase cleavage of SEQ ID NO: 2 at about position 144. Particularly preferred is GMG-2 fragment of about amino acids 134-278 of SEQ ID NO: 4 made by collagenase cleavage of SEQ ID NO: 2 at about position 134. Particularly preferred is GMG-2 fragment of about amino acids 115-259 of SEQ ID NO: 6, made by collagenase cleavage of SEQ ID NO: 6 at about position 115. Particularly preferred is GMG-2 fragment of about amino acids 144-288 of SEQ ID NO: 2 made by matrix metalloproteinase-1 (MMP-1) cleavage of SEQ ID NO: 2 at about position 144. Particularly preferred is GMG-2 fragment of about amino acids 134-278 of SEQ ID NO: 4 made by matrix metalloproteinase-1 (MMP-1) cleavage of SEQ ID NO: 4 at about position 134. Particularly preferred is GMG-2 fragment of about amino acids 115-259 of SEQ ID NO: 6, made by matrix metalloproteinase-1 (MMP-1) cleavage of SEQ ID NO: 6 at about position 115. Particularly preferred is GMG-2 fragment of about amino acids 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2 made by plasmin cleavage of SEQ ID NO: 2 at about position 152, 153, 161 or 162. Particularly preferred is GMG-2 fragment of about amino acids 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4, made by plasmin cleavage of SEQ ID NO: 4 at about positions 142, 143, 151 or 152. Particularly preferred is GMG-2 fragment of about amino acids 123-259, 124-259, 132-259 or 133-259 of SEQ ID NO: 6 made by plasmin cleavage of SEQ ID NO: 6 at about position 123, 124, 132 or 133.

GMG-2 polypeptides of the invention include variants, fragments, analogs and derivatives of the GMG-2 polypeptides described above, including modified GMG-2 polypeptides.

20

Variants

It will be recognized by one of ordinary skill in the art that some amino acids of the gGMG-2 fragment sequences of the present invention can be varied without significant effect on the structure or function of the protein; there will be critical amino acids in the fragment sequence that determine activity. Thus, the invention further includes variants of gGMG-2 polypeptide fragments that have obesity-related activity as described above. Such variants include GMG-2 fragment sequences with one or more amino acid deletions, insertions, inversions, repeats, and substitutions either from natural mutations or human manipulation selected according to general rules known in the art so as to have little effect on activity. Guidance concerning how to make phenotypically silent amino acid substitutions is provided below.

There are two main approaches for studying the tolerance of an amino acid sequence to change (see, Bowie, et al. (1990) *Science*, 247, 1306-10). The first method relies on the process of evolution, in which mutations are either accepted or rejected by natural selection. The second approach uses genetic engineering to introduce amino acid changes at specific positions of a cloned gene and selections or screens to identify sequences that maintain functionality.

These studies have revealed that proteins are surprisingly tolerant of amino acid substitutions and indicate which amino acid changes are likely to be permissive at a certain position

of the protein. For example, most buried amino acid residues require nonpolar side chains, whereas few features of surface side chains are generally conserved. Other such phenotypically silent substitutions are described by Bowie et al. (supra) and the references cited therein.

Typically seen as conservative substitutions are the replacements, one for another, among the aliphatic amino acids Ala, Val, Leu and Phe; interchange of the hydroxyl residues Ser and Thr; exchange of the acidic residues Asp and Glu; substitution between the amide residues Asn and Gln; exchange of the basic residues Lys and Arg; and replacements among the aromatic residues Phe, Tyr. In addition, the following groups of amino acids generally represent equivalent changes: (1) Ala, Pro, Gly, Glu, Asp, Gln, Asn, Ser, Thr; (2) Cys, Ser, Tyr, Thr; (3) Val, Ile, Leu, Met, Ala, Phe; (4) Lys, Arg, His; (5) Phe, Tyr, Trp, His.

Similarly, amino acids in the gGMG-2 polypeptide fragment sequences of the invention that are essential for function can also be identified by methods known in the art, such as site-directed mutagenesis or alanine-scanning mutagenesis (see, e.g., Cunningham, et al. (1989) *Science* 244(4908):1081-5). The latter procedure introduces single alanine mutations at every residue in the molecule. The resulting mutant molecules are then tested for obesity-related activity using assays as described above. Of special interest are substitutions of charged amino acids with other charged or neutral amino acids that may produce proteins with highly desirable improved characteristics, such as less aggregation. Aggregation may not only reduce activity but also be problematic when preparing pharmaceutical or physiologically acceptable formulations, because aggregates can be immunogenic (see, e.g., Pinckard, et al., (1967) *Clin. Exp. Immunol.* 2:331-340; Robbins, et al., (1987) *Diabetes Jul*;36(7):838-41; and Cleland, et al., (1993) *Crit Rev Ther Drug Carrier Syst.* 10(4):307-77).

Thus, the fragment, derivative, analog, or homolog of the gGMG-2 fragment of the present invention may be, for example: (i) one in which one or more of the amino acid residues are substituted with a conserved or non-conserved amino acid residue (preferably a conserved amino acid residue) and such substituted amino acid residue may or may not be one encoded by the genetic code (i.e. may be a non-naturally occurring amino acid); or (ii) one in which one or more of the amino acid residues includes a substituent group; or (iii) one in which the gGMG-2 fragment is fused with another compound, such as a compound to increase the half-life of the fragment (for example, polyethylene glycol); or (iv) one in which the additional amino acids are fused to the above form of the fragment, such as an IgG Fc fusion region peptide or leader or secretory sequence or a sequence which is employed for purification of the above form of the fragment or a pro-protein sequence. Such fragments, derivatives and analogs are deemed to be within the scope of those skilled in the art from the teachings herein.

35 A further embodiment of the invention relates to a polypeptide which comprises the amino acid sequence of a gGMG-2 polypeptide fragment having an amino acid sequence which contains at least one conservative amino acid substitution, but not more than 50 conservative amino acid

substitutions, not more than 40 conservative amino acid substitutions, not more than 30 conservative amino acid substitutions, and not more than 20 conservative amino acid substitutions. Also provided are polypeptides which comprise the amino acid sequence of a gGMG-2 fragment, having at least one, but not more than 10, 9, 8, 7, 6, 5, 4, 3, 2 or 1 conservative amino acid substitutions.

5 A further embodiment of the invention relates to a GMG-2 polypeptide fragment made resistant to dipeptidyl peptidase cleavage through N-terminal modification of said polypeptide fragment. In a preferred embodiment, said GMG-2 polypeptide fragment is selected from amino acids 144-288 or 162-288 of SEQ ID NO: 2, or amino acids 134-278 or 152-278 of SEQ ID NO: 4, or amino acids 115-259 or 133-259 of SEQ ID NO: 6. In a preferred embodiment, said dipeptidyl peptidase cleavage leads to removal of the N-terminal dipeptide SP or TA by dipeptidyl peptidase from said preferred fragment. In another preferred embodiment, said dipeptidyl peptidase is human plasma comprised of dipeptidyl peptidase. In another preferred embodiment, said dipeptidyl peptidase is selected from but not restricted to human CD26 and human Attractin. In a further preferred embodiment, said dipeptidyl peptidase is selected from soluble human CD26 or soluble human Attractin. In preferred embodiment, said N-terminal modification is selected from but not restricted to glycation [Harte (2001) Regulatory Peptides 96:95-104 which disclosure is hereby incorporated by reference in its entirety], N-methylation, alpha-methylation, desamidation [Gallwitz (2000) Regulatory Peptides 86:103-111 which disclosure is hereby incorporated by reference in its entirety], or alternation of the chirality of one or more N-terminal amino acids [Siegel (1999)]

10 European Journal of Clinical Investigation 29:610-614 which disclosure is hereby incorporated by reference in its entirety]. Thus, the invention also encompasses a GMG-2 polypeptide fragment or a variant thereof that has been made resistant to dipeptidyl peptidase cleavage through N-terminal modification of said polypeptide fragment.

15 Another specific embodiment of a modified gGMG-2 fragment of the invention is a polypeptide that is resistant to proteolysis, for example a gGMG-2 fragment in which a -CONH-peptide bond is modified and replaced by one or more of the following: a (CH₂NH) reduced bond; a (NHCO) retro inverso bond; a (CH₂-O) methylene-oxy bond; a (CH₂-S) thiomethylene bond; a (CH₂CH₂) carba bond; a (CO-CH₂) cetomethylene bond; a (CHOH-CH₂) hydroxyethylene bond; a (N-N) bound; a E-alcene bond; or a -CH=CH- bond. Thus, the invention also encompasses a

20 gGMG-2 fragment or a variant thereof in which at least one peptide bond has been modified as described above.

25 In addition, amino acids have chirality within the body of either L or D. In some embodiments it is preferable to alter the chirality of the amino acids in the gGMG-2 polypeptide fragments of the invention in order to extend half-life within the body. Thus, in some embodiments, one or more of the amino acids are preferably in the L configuration. In other embodiments, one or more of the amino acids are preferably in the D configuration.

Percent Identity

The polypeptides of the present invention also include polypeptides having an amino acid sequence at least 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98% or 99% identical to a gGMG-2 fragment as described above. By a polypeptide having an amino acid sequence at least, for example, 95% "identical" to a gGMG-2 fragment amino acid sequence is meant that the amino acid sequence is identical to the gGMG-2 polypeptide fragment sequence except that it may include up to five amino acid alterations per each 100 amino acids of the gGMG-2 polypeptide fragment amino acid sequence. The reference sequence is the gGMG-2 polypeptide fragment with a sequence corresponding to the sequence of the sequence listing. Thus, to obtain a polypeptide having an amino acid sequence at least 95% identical to a gGMG-2 fragment amino acid sequence, up to 5% (5 of 100) of the amino acid residues in the sequence may be inserted, deleted, or substituted with another amino acid compared with the gGMG-2 polypeptide fragment sequence. These alterations may occur at the amino or carboxy termini or anywhere between those terminal positions, interspersed either individually among residues in the sequence or in one or more contiguous groups within the sequence.

As a practical matter, whether any particular polypeptide is a percentage identical to a gGMG-2 fragment can be determined conventionally using known computer programs. Such algorithms and programs include, but are by no means limited to, TBLASTN, BLASTP, FASTA, TFASTA, and CLUSTALW (Pearson and Lipman, (1988) Proc Natl Acad Sci USA 85(8):2444-8; Altschul et al., (1990) J Mol Biol 215(3):403-410; Thompson et al., (1994) Nucleic Acids Res 22(2):4673-4680; Higgins et al., (1996) Meth Enzymol 266:383-402; Altschul et al., (1997) Nuc Acids Res 25:3389-3402; Altschul et al., (1993) Nature Genetics 3:266-272). In a particularly preferred embodiment, protein and nucleic acid sequence homologies are evaluated using the Basic Local Alignment Search Tool ("BLAST"), which is well known in the art (See, e.g., Karlin and Altschul (1990) Proc Natl Acad Sci USA 87(6):2264-8; Altschul et al., 1990, 1993, 1997, all *supra*). In particular, five specific BLAST programs are used to perform the following tasks:

- (1) BLASTP and BLAST3 compare an amino acid query sequence against a protein sequence database;
- (2) BLASTN compares a nucleotide query sequence against a nucleotide sequence database;
- (3) BLASTX compares the six-frame conceptual translation products of a query nucleotide sequence (both strands) against a protein sequence database;
- (4) TBLASTN compares a query protein sequence against a nucleotide sequence database translated in all six reading frames (both strands); and
- (5) TBLASTX compares the six-frame translations of a nucleotide query sequence against the six-frame translations of a nucleotide sequence database.

The BLAST programs identify homologous sequences by identifying similar segments, which are referred to herein as "high-scoring segment pairs," between a query amino or nucleic acid

sequence and a test sequence which is preferably obtained from a protein or nucleic acid sequence database. High-scoring segment pairs are preferably identified (*i.e.*, aligned) by means of a scoring matrix, many of which are known in the art. Preferably, the scoring matrix used is the BLOSUM62 matrix (see, Gonnet et al., (1992) *Science* 256(5062):1443-5; Henikoff and Henikoff (1993) *Proteins* 17(1):49-61). Less preferably, the PAM or PAM250 matrices may also be used (See, *e.g.*, Schwartz and Dayhoff, eds, (1978) *Matrices for Detecting Distance Relationships: Atlas of Protein Sequence and Structure*, Washington: National Biomedical Research Foundation). The BLAST programs evaluate the statistical significance of all high-scoring segment pairs identified, and preferably selects those segments which satisfy a user-specified threshold of significance, such as a user-specified percent homology. Preferably, the statistical significance of a high-scoring segment pair is evaluated using the statistical significance formula of Karlin (See, *e.g.*, Karlin and Altschul, (1990) *Proc Natl Acad Sci USA* 87(6):2264-8). The BLAST programs may be used with the default parameters or with modified parameters provided by the user. Preferably, the parameters are default parameters.

15 A preferred method for determining the best overall match between a query sequence (a sequence of the present invention) and a subject sequence, also referred to as a global sequence alignment, can be determined using the FASTDB computer program based on the algorithm of Brutlag et al. (1990) *Comp. App. Biosci.* 6:237-245. In a sequence alignment the query and subject sequences are both amino acid sequences. The result of said global sequence alignment is in percent identity. Preferred parameters used in a FASTDB amino acid alignment are: Matrix=PAM 0, k-tuple=2, Mismatch Penalty=1, Joining Penalty=20, Randomization Group=25 Length=0, Cutoff Score=1, Window Size=sequence length, Gap Penalty=5, Gap Size Penalty=0.05, Window Size=247 or the length of the subject amino acid sequence, whichever is shorter.

20 If the subject sequence is shorter than the query sequence due to N- or C-terminal deletions, not because of internal deletions, the results, in percent identity, must be manually corrected because the FASTDB program does not account for N- and C-terminal truncations of the subject sequence when calculating global percent identity. For subject sequences truncated at the N- and C-termini, relative to the query sequence, the percent identity is corrected by calculating the number of residues of the query sequence that are N- and C-terminal of the subject sequence, that are not 25 matched/aligned with a corresponding subject residue, as a percent of the total bases of the query sequence. Whether a residue is matched/aligned is determined by results of the FASTDB sequence alignment. This percentage is then subtracted from the percent identity, calculated by the above FASTDB program using the specified parameters, to arrive at a final percent identity score. This final percent identity score is what is used for the purposes of the present invention. Only residues to 30 the N- and C-termini of the subject sequence, which are not matched/aligned with the query sequence, are considered for the purposes of manually adjusting the percent identity score. That is, 35

only query amino acid residues outside the farthest N- and C-terminal residues of the subject sequence.

For example, a 90 amino acid residue subject sequence is aligned with a 100-residue query sequence to determine percent identity. The deletion occurs at the N-terminus of the subject

5 sequence and therefore, the FASTDB alignment does not match/align with the first residues at the N-terminus. The 10 unpaired residues represent 10% of the sequence (number of residues at the N- and C- termini not matched/total number of residues in the query sequence) so 10% is subtracted from the percent identity score calculated by the FASTDB program. If the remaining 90 residues were perfectly matched the final percent identity would be 90%.

10 In another example, a 90-residue subject sequence is compared with a 100-residue query sequence. This time the deletions are internal so there are no residues at the N- or C-termini of the subject sequence, which are not matched/aligned with the query. In this case, the percent identity calculated by FASTDB is not manually corrected. Once again, only residue positions outside the N- and C-terminal ends of the subject sequence, as displayed in the FASTDB alignment, which are not 15 matched/aligned with the query sequence are manually corrected. No other manual corrections are made for the purposes of the present invention.

Production

Note, throughout the disclosure, wherever GMG-2 polypeptide fragments are discussed, gGMG-2 fragments are specifically intended to be included as a preferred subset of GMG-2 20 polypeptide fragments.

GMG-2 polypeptide fragments are preferably isolated from human or mammalian tissue samples or expressed from human or mammalian genes in human or mammalian cells. The GMG-2 polypeptide fragments of the invention can be made using routine expression methods known in the art. The polynucleotide encoding the desired polypeptide fragments is ligated into an expression 25 vector suitable for any convenient host. Both eukaryotic and prokaryotic host systems are used in forming recombinant polypeptide fragments. The polypeptide fragment is then isolated from lysed cells or from the culture medium and purified to the extent needed for its intended use. Purification is by any technique known in the art, for example, differential extraction, salt fractionation, chromatography, centrifugation, and the like. See, for example, *Methods in Enzymology* for a 30 variety of methods for purifying proteins. Also, see Examples 1-3 for methods previously used for GMG-2 polypeptide fragments.

In an alternative embodiment, the polypeptides of the invention are isolated from milk. The polypeptides can be purified as full-length GMG-2 polypeptides, which can then be cleaved, if appropriate, *in vitro* to generate an GMG-2 fragment, or, alternatively, GMG-2 fragments themselves 35 can be purified from the milk. Any of a large number of methods can be used to purify the present polypeptides from milk, including those taught in *Protein Purification Applications, A Practical Approach* (New Edition), Edited by Simon Roe, AEA Technology Products and Systems,

Biosciences, Harwell; Clark (1998) J Mammary Gland Biol Neoplasia 3:337-50; Wilkins and Velander (1992) 49:333-8; U.S. Patent Nos. 6,140,552; 6,025,540; Hennighausen, Protein Expression and Purification, vol. 1, pp. 3-8 (1990); Harris et al. (1997) Bioseparation 7:31-7; Degener et al. (1998) J Chromatog 799:125-37; Wilkins (1993) J Cell Biochem Suppl. 0 (17 part A):39; the entire disclosures of each of which are herein incorporated by reference. In a typical embodiment, milk is centrifuged, e.g. at a relatively low speed, to separate the lipid fraction, and the aqueous supernatant is then centrifuged at a higher speed to separate the casein in the milk from the remaining, "whey" fraction. Often, biomedical proteins are found in this whey fraction, and can be isolated from this fraction using standard chromatographic or other procedures commonly used for protein purification, e.g. as described elsewhere in the present application. In one preferred embodiment, GMG-2 polypeptides are purified using antibodies specific to GMG-2 polypeptides, e.g. using affinity chromatography. In addition, methods can be used to isolate particular GMG-2 fragments, e.g. electrophoretic or other methods for isolating proteins of a particular size. The GMG-2 polypeptides isolating these methods can be naturally occurring, as GMG-2 polypeptides have been discovered to be naturally present in the milk of mammals (see, e.g. Example 18), or can be the result of the recombinant production of the protein in the mammary glands of a non-human mammal, as described infra. In one such embodiment, the GMG-2 fragment is produced as a fusion protein with a heterologous, antigenic polypeptide sequence, which antigenic sequence can be used to purify the protein, e.g., using standard immuno-affinity methodology.

In addition, shorter protein fragments may be produced by chemical synthesis. Alternatively, the proteins of the invention are extracted from cells or tissues of humans or non-human animals. Methods for purifying proteins are known in the art, and include the use of detergents or chaotropic agents to disrupt particles followed by differential extraction and separation of the polypeptides by ion exchange chromatography, affinity chromatography, sedimentation according to density, and gel electrophoresis.

Any GMG-2 fragment cDNA can be used to express GMG-2 polypeptide fragments. The nucleic acid encoding the GMG-2 fragment to be expressed is operably linked to a promoter in an expression vector using conventional cloning technology. The GMG-2 fragment cDNA insert in the expression vector may comprise the coding sequence for: the full-length GMG-2 polypeptide (to be later modified); from 6 amino acids to 1 amino acid less than the full-length GMG-2 polypeptide; a gGMG-2 fragment; or variants and % similar polypeptides.

The expression vector is any of the mammalian, yeast, insect or bacterial expression systems known in the art, some of which are described herein, and examples of which are given in the Examples (Examples 1-3). Commercially available vectors and expression systems are available from a variety of suppliers including Genetics Institute (Cambridge, MA), Stratagene (La Jolla, California), Promega (Madison, Wisconsin), and Invitrogen (San Diego, California). If desired, to enhance expression and facilitate proper protein folding, the codon context and codon pairing of the sequence can be optimized

for the particular expression organism into which the expression vector is introduced, as explained by Hatfield, et al., US Patent Number 5,082,767, the disclosures of which are incorporated by reference herein in their entirety.

If the nucleic acid encoding GMG-2 polypeptide fragments lacks a methionine to serve as the initiation site, an initiating methionine can be introduced next to the first codon of the nucleic acid using conventional techniques. Similarly, if the insert from the GMG-2 polypeptide fragment cDNA lacks a poly A signal, this sequence can be added to the construct by, for example, splicing out the Poly A signal from pSG5 (Stratagene) using BglII and SalI restriction endonuclease enzymes and incorporating it into the mammalian expression vector pXT1 (Stratagene). pXT1 contains the LTRs and a portion of the gag gene from Moloney Murine Leukemia Virus. The position of the LTRs in the construct allow efficient stable transfection. The vector includes the Herpes Simplex Thymidine Kinase promoter and the selectable neomycin gene.

The nucleic acid encoding an GMG-2 fragment can be obtained by PCR from a vector containing the GMG-2 nucleotide sequence using oligonucleotide primers complementary to the desired GMG-2 cDNA and containing restriction endonuclease sequences for Pst I incorporated into the 5' primer and BglII at the 5' end of the corresponding cDNA 3' primer, taking care to ensure that the sequence encoding the GMG-2 fragment is positioned properly with respect to the poly A signal. The purified fragment obtained from the resulting PCR reaction is digested with PstI, blunt ended with an exonuclease, digested with Bgl II, purified and ligated to pXT1, now containing a poly A signal and digested with BglIII. Alternative methods are presented in Examples 1-3.

Transfection of an GMG-2 fragment-expressing vector into mouse NIH 3T3 cells is one embodiment of introducing polynucleotides into host cells. Introduction of a polynucleotide encoding a polypeptide into a host cell can be effected by calcium phosphate transfection, DEAE-dextran mediated transfection, cationic lipid-mediated transfection, electroporation, transduction, infection, or other methods. Such methods are described in many standard laboratory manuals, such as Davis et al. ((1986) Methods in Molecular Biology, Elsevier Science Publishing Co., Inc., Amsterdam). It is specifically contemplated that the polypeptides of the present invention may in fact be expressed by a host cell lacking a recombinant vector. Methods of expressing GMG-2 fragment of the invention in cells are described in Examples 1-3.

A polypeptide of this invention (i.e. a gGMG-2 fragment) can be recovered and purified from recombinant cell cultures by well-known methods including ammonium sulfate or ethanol precipitation, acid extraction, anion or cation exchange chromatography, phosphocellulose chromatography, hydrophobic interaction chromatography, affinity chromatography, hydroxylapatite chromatography and lectin chromatography. Most preferably, high performance liquid chromatography ("HPLC") is employed for purification. Polypeptides of the present invention, and preferably the secreted form, can also be recovered from: products purified from natural sources, including bodily fluids, tissues and cells, whether directly isolated or cultured; products of chemical

synthetic procedures; and products produced by recombinant techniques from a prokaryotic or eukaryotic host, including, for example, bacterial, yeast, higher plant, insect, and mammalian cells.

Depending upon the host employed in a recombinant production procedure, the polypeptides of the present invention may be glycosylated or may be non-glycosylated. Preferably GMG-2 5 globular domain comprising the polypeptides of the invention is non-glycosylated. In addition, polypeptides of the invention may also include an initial modified methionine residue, in some cases as a result of host-mediated processes. Thus, it is well known in the art that the N-terminal methionine encoded by the translation initiation codon generally is removed with high efficiency from any protein after translation in all eukaryotic cells. While the N-terminal methionine on most 10 proteins also is efficiently removed in most prokaryotes, for some proteins, this prokaryotic removal process is inefficient, depending on the nature of the amino acid to which the N-terminal methionine is covalently linked.

In addition to encompassing host cells containing the vector constructs discussed herein, the invention also encompasses primary, secondary, and immortalized host cells of vertebrate origin, 15 particularly mammalian origin, that have been engineered to delete or replace endogenous genetic material (e.g., coding sequence), and/or to include genetic material (e.g., heterologous polynucleotide sequences) that is operably associated with the polynucleotides of the invention, and which activates, alters, and/or amplifies endogenous polynucleotides. For example, techniques known in the art may be used to operably associate heterologous control regions (e.g., promoter 20 and/or enhancer) and endogenous polynucleotide sequences via homologous recombination, see, e.g., US Patent Number 5,641,670, issued June 24, 1997; International Publication No. WO 96/29411, published September 26, 1996; International Publication No. WO 94/12650, published August 4, 1994; Koller et al., (1989) Proc Natl Acad Sci USA 86(22):8932-5; Koller et al., (1989) Proc Natl Acad Sci USA 86(22):8927-31; and Zijlstra et al. (1989) Nature 342(6248):435-8; the 25 disclosures of each of which are incorporated by reference in their entireties).

Modifications

In addition, polypeptides of the invention can be chemically synthesized using techniques known in the art (See, e.g., Creighton, 1983 *Proteins*. New York, New York: W.H. Freeman and Company; and Hunkapiller et al., (1984) *Nature* 310(5973):105-11). For example, a relative short 30 fragment of the invention can be synthesized by use of a peptide synthesizer. Furthermore, if desired, nonclassical amino acids or chemical amino acid analogs can be introduced as a substitution or addition into the fragment sequence. Non-classical amino acids include, but are not limited to, to the D-isomers of the common amino acids, 2,4-diaminobutyric acid, a-amino isobutyric acid, 4-aminobutyric acid, Abu, 2-amino butyric acid, g-Abu, e-Ahx, 6-amino hexanoic acid, Aib, 2-amino 35 isobutyric acid, 3-amino propionic acid, ornithine, norlucine, norvaline, hydroxyproline, sarcosine, citrulline, homocitrulline, cysteic acid, t-butylglycine, t-butylalanine, phenylglycine, cyclohexylalanine, b-alanine, fluoroamino acids, designer amino acids such as b-methyl amino acids,

Ca-methyl amino acids, Na-methyl amino acids, and amino acid analogs in general. Furthermore, the amino acid can be D (dextrorotary) or L (levorotary).

The invention encompasses polypeptide fragments which are differentially modified during or after translation, e.g., by glycosylation, acetylation, phosphorylation, amidation, derivatization by known protecting/blocking groups, proteolytic cleavage, linkage to an antibody molecule or other cellular ligand, etc. Any of numerous chemical modifications may be carried out by known techniques, including but not limited, to specific chemical cleavage by cyanogen bromide, trypsin, chymotrypsin, papain, V8 protease, NaBH4; acetylation, formylation, oxidation, reduction; metabolic synthesis in the presence of tunicamycin; etc.

10 Additional post-translational modifications encompassed by the invention include, for example, N-linked or O-linked carbohydrate chains, processing of N-terminal or C-terminal ends), attachment of chemical moieties to the amino acid backbone, chemical modifications of N-linked or O-linked carbohydrate chains, and addition or deletion of an N-terminal methionine residue as a result of prokaryotic host cell expression. The polypeptide fragments may also be modified with a 15 detectable label, such as an enzymatic, fluorescent, isotopic or affinity label to allow for detection and isolation of the polypeptide.

Also provided by the invention are chemically modified derivatives of the polypeptides of the invention that may provide additional advantages such as increased solubility, stability and circulating time of the polypeptide, or decreased immunogenicity. See U.S. Patent No: 4,179,337.

20 The chemical moieties for derivitization may be selected from water soluble polymers such as polyethylene glycol, ethylene glycol/propylene glycol copolymers, carboxymethylcellulose, dextran, polyvinyl alcohol and the like. The polypeptides may be modified at random positions within the molecule, or at predetermined positions within the molecule and may include one, two, three or more attached chemical moieties.

25 The polymer may be of any molecular weight, and may be branched or unbranched. For polyethylene glycol, the preferred molecular weight is between about 1 kDa and about 100 kDa (the term "about" indicating that in preparations of polyethylene glycol, some molecules will weigh more, some less, than the stated molecular weight) for ease in handling and manufacturing. Other sizes may be used, depending on the desired therapeutic profile (e.g., the duration of sustained release desired, 30 the effects, if any on biological activity, the ease in handling, the degree or lack of antigenicity and other known effects of the polyethylene glycol to a therapeutic protein or analog).

The polyethylene glycol molecules (or other chemical moieties) should be attached to the polypeptide with consideration of effects on functional or antigenic domains of the polypeptide. There are a number of attachment methods available to those skilled in the art, e.g., EP 0 401 384, 35 herein incorporated by reference (coupling PEG to G-CSF), see also Malik et al. (1992) *Exp Hematol* 20(8):1028-35, reporting pegylation of GM-CSF using tresyl chloride). For example, polyethylene glycol may be covalently bound through amino acid residues via a reactive group, such

as, a free amino or carboxyl group. Reactive groups are those to which an activated polyethylene glycol molecule may be bound. The amino acid residues having a free amino group may include lysine residues and the N-terminal amino acid residues; those having a free carboxyl group may include aspartic acid residues, glutamic acid residues and the C-terminal amino acid residue.

5 Sulfhydryl groups may also be used as a reactive group for attaching the polyethylene glycol molecules. Preferred for therapeutic purposes is attachment at an amino group, such as attachment at the N-terminus or lysine group.

One may specifically desire proteins chemically modified at the N-terminus. Using polyethylene glycol as an illustration of the present composition, one may select from a variety of 10 polyethylene glycol molecules (by molecular weight, branching, etc.), the proportion of polyethylene glycol molecules to protein (polypeptide) molecules in the reaction mix, the type of pegylation reaction to be performed, and the method of obtaining the selected N-terminally pegylated protein. The method of obtaining the N-terminally pegylated preparation (i.e., separating this moiety from other monopegylated moieties if necessary) may be by purification of the N-terminally pegylated 15 material from a population of pegylated protein molecules. Selective proteins chemically modified at the N-terminus may be accomplished by reductive alkylation, which exploits differential reactivity of different types of primary amino groups (lysine versus the N-terminal) available for derivatization in a particular protein. Under the appropriate reaction conditions, substantially selective derivatization of the protein at the N-terminus with a carbonyl group containing polymer is achieved.

20 In further preferred embodiment, the invention features a method of reducing body mass comprising providing or administering to individuals in need of reducing body mass said pharmaceutical or physiologically acceptable composition described in the fifth aspect in combination with provision or administration of an antagonist of dipeptidyl peptidase cleavage of GMG-2 polypeptide fragment of the first aspect.

25 Preferred said antagonist is a peptidyl derivative of a diester of alpha-aminoalkylphosphonic acid (US Patent Number 5,543,396 which disclosure is hereby incorporated by reference in its entirety). More preferred said peptidyl derivative is selected from Ala-Pro^P(OZ)₂, AcOH.Ala-Pip^P(Oph)₂, HCl.Ala-Pro^P(Oph-4Cl)₂, HCl.Ala-Pip^P(Oph-4Cl)₂, or 2HCl.Lys-Pip^P(Oph-4Cl)₂, where Z represents an aryl group, a substituted aryl group or a highly fluorinated alkyl group, 30 Pro^P represents a proline phosphonate derivative, and Pip^P represents piperidyl phosphonate (US Patent Number 5,543,396 which disclosure is hereby incorporated by reference in its entirety).

Other preferred said antagonist is a compound of the general formula Z-Xaa-Y', in which Xaa is an amino acid, Z is a protecting group, and Y' is one of various types of ring structures (US Patent Number 6,090,786 which disclosure is hereby incorporated by reference in its entirety). More 35 preferred is said compound wherein Z may or may not be present and represents a protecting group, such as benzyloxycarbonyl; Xaa represents alanine, methionine, arginine, phenylalanine, aspartic acid, proline, asparagine, serine, cysteine, threonine, glycine, tyrosine, glutamic acid, tryptophan,

glutamine, valine, isoleucine, lysine, leucine, L-thioproline, L-homoproline, L-1,2,3,4-tetrahydroisoquinoline-3-carboxylic acid (Tic), L-2,3-dihydroindol-2-carboxylic acid, L-naphthylglycine, L-phenylglycine, L-4-phenylproline, O-benzyl tyrosine, omega-Z lysine, or omega-acetyl lysine; and Y' represents a pyrrolidine, a phosphonate or phosphinate derivative, or reduced peptide; or pharmaceutically acceptable salts thereof (US Patent Number 6,090,786 which disclosure is hereby incorporated by reference in its entirety).

Other preferred said antagonist is sulphostin (US Patent Number 6,214,340 which disclosure is hereby incorporated by reference in its entirety).

Other preferred said antagonist is N-(substituted glycyl)-2-cyanopyrrolidine (US Patent Number 6,166,063). More preferred said N-(substituted glycyl)-2-cyanopyrrolidine is selected from pyrrolidine, 1-[(3,5-dimethyl-1-adamantyl)amino]-acetyl]-2-cyano-, (S)-; pyrrolidine, 1-[(3-ethyl-1-adamantyl)amino]-acetyl]-2-cyano-, (S)-; pyrrolidine, 1-[[3-[(t-butylamino)carbonyl]oxy]-1-adamantyl]amino]-acetyl]-2-cyano-, (S)-; pyrrolidine, 1-[[3-[(4-methoxyphenyl)amino]-carbonyl]oxy]-1-adamantyl]amino]-acetyl]-2-cyano-, (S)-; pyrrolidine, 1-[[3-[(4-methoxyphenyl)amino]-carbonyl]oxy]-1-adamantyl]amino]-acetyl]-2-cyano-, (S)-; pyrrolidine, 1-[[3-[(phenylamino)carbonyl]oxy]-1-adamantyl]amino]-acetyl]-2-cyano-, (S)-; pyrrolidine, 1-[(5-hydroxy-2-adamantyl)amino]-acetyl]-2-cyano-, (S)-; pyrrolidine, 1-[[3-[(2-[(diisopropyl)amino]carbonyl]oxy]-1-adamantyl]amino]-acetyl]-2-cyano-, (S)-; pyrrolidine, 1-[[3-[(cyclohexyl)amino]carbonyl]oxy]-1-adamantyl]amino]-acetyl]-2-cyano-, (S)-; pyrrolidine, 1-[[3-[(3-ethoxy-1-adamantyl)amino]-acetyl]-2-cyano-, (S)-; or, in each case, a pharmaceutically acceptable acid addition salt thereof (US Patent Number 6,166,063).

Other preferred said antagonist is tetrahydroisoquinoline 3-carboxamide derivative of formula ##STR1## (US Patent Number 6,172,081). More preferred is said derivative and pharmaceutically acceptable salts thereof wherein X is CH₂, S, O, or C(CH₃)₂; R₁ and R₂ are independently hydrogen, hydroxy, alkyl, alkoxy, aralkoxy, or halogen (US Patent Number 6,172,081).

Other preferred said antagonist is valine-pyrrolidine [Deacon (2001) Diabetes 50:1588-1597 which disclosure is hereby incorporated by reference in its entirety].

30 Multimers

The polypeptide fragments of the invention may be in monomers or multimers. Most preferably, the polypeptide fragments of the invention are in homotrimers. Accordingly, the present invention relates to monomers and multimers of the polypeptide fragments of the invention, their preparation, and compositions (preferably, pharmaceutical or physiologically acceptable compositions) containing them. In specific embodiments, the polypeptides of the invention are homotrimers. In additional embodiments, the multimers of the invention comprise, consist essentially of, or consist of homotrimers.

Multimers encompassed by the invention may be homomers or heteromers. As used herein, the term homomer refers to a multimer containing only polypeptides corresponding to the GMG-2 polypeptide fragments of the invention (including polypeptide fragments, variants, splice variants, and fusion proteins corresponding to these polypeptide fragments as described herein). These

5 homomers may contain polypeptide fragments having identical or different amino acid sequences. In a specific embodiment, a homomer of the invention is a multimer containing only polypeptide fragments having an identical amino acid sequence. In another specific embodiment, a homomer of the invention is a multimer containing polypeptide fragments having different amino acid sequences. In specific embodiments, the multimer of the invention is a homodimer (e.g., containing polypeptide
10 fragments having identical or different amino acid sequences) or a homotrimer (e.g., containing polypeptide fragments having identical and/or different amino acid sequences). In additional embodiments, the homomeric multimer of the invention is at least a homodimer, at least a homotrimer, or at least a homotetramer. More preferably, the homomeric multimer of the invention is a homotrimer. Further more preferably, said homotrimer of the invention is gGMG-2 polypeptide
15 fragment homotrimer. Most preferably, said gGMG-2 polypeptide fragment homotrimer of the invention has activity selected from the group consisting of lipid partitioning, lipid metabolism, and insulin-like activity. Also most preferably, said gGMG-2 polypeptide fragment homotrimer of the invention has activity selected from the group consisting of prevention of weight gain, weight reduction, and maintenance of weight loss.

20 As used herein, the term heteromer refers to a multimer containing one or more heterologous polypeptides (i.e., corresponding to different proteins or polypeptide fragments thereof) in addition to the polypeptides of the invention. In a specific embodiment, the multimer of the invention is a heterodimer, a heterotrimer, or a heterotetramer. In additional embodiments, the heteromeric multimer of the invention is at least a heterodimer, at least a heterotrimer, or at least a
25 heterotetramer.

Multimers of the invention may be the result of hydrophobic, hydrophilic, ionic and/or covalent associations and/or may be indirectly linked, by for example, liposome formation. Thus, in most preferred embodiment, homotrimers of the invention are formed when polypeptides of the invention contact one another in solution. In another embodiment, heteromultimers of the invention, such as, for example, heterotrimers or heterotetramers, are formed when polypeptides of the invention contact antibodies to the polypeptides of the invention (including antibodies to the heterologous polypeptide sequence in a fusion protein of the invention) in solution. In other embodiments, multimers of the invention are formed by covalent associations with and/or between the polypeptides of the invention. Such covalent associations may involve one or more amino acid
30 residues contained in the polypeptide sequence (e.g., that recited in the sequence listing, or contained in the polypeptide encoded by a deposited clone). In one instance, the covalent associations are
35 cross-linking between cysteine residues located within the polypeptide sequences, which interact in

the native (*i.e.*, naturally occurring) polypeptide. In another instance, the covalent associations are the consequence of chemical or recombinant manipulation. Alternatively, such covalent associations may involve one or more amino acid residues contained in the heterologous polypeptide sequence in a fusion protein of the invention.

5 In particularly preferred embodiment of the invention, said multimers of the invention are gGMG-2 polypeptide fragment homotrimers. Most preferably, said gGMG-2 polypeptide fragment homotrimer of the invention has activity selected from the group consisting of lipid partitioning, lipid metabolism, and insulin-like activity. Also most preferably, said gGMG-2 polypeptide fragment homotrimer of the invention has activity selected from the group consisting of prevention of weight
10 gain, weight reduction, and maintenance of weight loss.

In one example, covalent associations are between the heterologous sequence contained in a fusion protein of the invention (see, e.g., US Patent Number 5,478,925). In a specific example, the covalent associations are between the heterologous sequence contained in an Fc fusion protein of the invention (as described herein). In another specific example, covalent associations of fusion proteins
15 of the invention are between heterologous polypeptide sequence from another protein that is capable of forming covalently associated multimers, such as for example, osetcoprotegerin (see, e.g., International Publication NO: WO 98/49305, the contents of which are herein incorporated by reference in its entirety). In another embodiment, two or more polypeptides of the invention are joined through peptide linkers. Examples include those peptide linkers described in U.S. Pat. No.
20 5,073,627 (hereby incorporated by reference). Proteins comprising multiple polypeptides of the invention separated by peptide linkers may be produced using conventional recombinant DNA technology.

Another method for preparing multimer polypeptides of the invention involves use of polypeptides of the invention fused to a leucine zipper or isoleucine zipper polypeptide sequence.

25 Leucine zipper and isoleucine zipper domains are polypeptides that promote multimerization of the proteins in which they are found. Leucine zippers were originally identified in several DNA-binding proteins, and have since been found in a variety of different proteins (Landschulz et al., (1988) Genes Dev. Jul;2(7):786-800). Among the known leucine zippers are naturally occurring peptides and derivatives thereof that dimerize or trimerize. Examples of leucine zipper domains suitable for
30 producing soluble multimeric proteins of the invention are those described in PCT application WO 94/10308, hereby incorporated by reference. Recombinant fusion proteins comprising a polypeptide of the invention fused to a polypeptide sequence that dimerizes or trimerizes in solution are expressed in suitable host cells, and the resulting soluble multimeric fusion protein is recovered from the culture supernatant using techniques known in the art.

35 Trimeric polypeptides of the invention may offer the advantage of enhanced biological activity. Preferred leucine zipper moieties and isoleucine moieties are those that preferentially form trimers. One example is a leucine zipper derived from lung surfactant protein D (SPD), as described

in Hoppe et al. FEBS Letters (1994) 344(2-3):191-5 and in U.S. patent application Ser. No. 08/446,922, hereby incorporated by reference. Other peptides derived from naturally occurring trimeric proteins may be employed in preparing trimeric polypeptides of the invention. In another example, proteins of the invention are associated by interactions between Flag® & polypeptide sequence contained in fusion proteins of the invention containing Flag® polypeptide sequence. In a further embodiment, proteins of the invention are associated by interactions between heterologous polypeptide sequence contained in Flag® fusion proteins of the invention and anti Flag® antibody.

5 The multimers of the invention may be generated using chemical techniques known in the art. For example, polypeptides desired to be contained in the multimers of the invention may be 10 chemically cross-linked using linker molecules and linker molecule length optimization techniques known in the art (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety). Additionally, multimers of the invention may be generated using techniques known in the art to form one or more inter-molecule cross-links between the cysteine residues located within the sequence of the polypeptides desired to be contained in the multimer (see, e.g., US Patent 15 Number 5,478,925, which is herein incorporated by reference in its entirety). Further, polypeptides of the invention may be routinely modified by the addition of cysteine or biotin to the C-terminus or N-terminus of the polypeptide and techniques known in the art may be applied to generate multimers containing one or more of these modified polypeptides (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety). Additionally, at least 30 techniques known 20 in the art may be applied to generate liposomes containing the polypeptide components desired to be contained in the multimer of the invention (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety).

25 Alternatively, multimers of the invention may be generated using genetic engineering techniques known in the art. In one embodiment, polypeptides contained in multimers of the invention are produced recombinantly using fusion protein technology described herein or otherwise known in the art (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety). In a specific embodiment, polynucleotides coding for a homodimer of the invention are generated by ligating a polynucleotide sequence encoding a polypeptide of the invention to a sequence encoding a linker polypeptide and then further to a synthetic polynucleotide encoding the 30 translated product of the polypeptide in the reverse orientation from the original C-terminus to the N-terminus (lacking the leader sequence) (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety). In another embodiment, recombinant techniques described herein or otherwise known in the art are applied to generate recombinant polypeptides of the invention which contain a transmembrane domain (or hydrophobic or signal peptide) and which can 35 be incorporated by membrane reconstitution techniques into liposomes (See, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety).

II. GMG-2 Polynucleotides of the Invention

Preferred polynucleotides are those that encode full-length GMG-2 and gGMG-2 polypeptide fragments of the invention. The recombinant polynucleotides encoding full-length GMG-2 and gGMG-2 polypeptide fragments can be used in a variety of ways, including, but not limited to, expressing the polypeptide in recombinant cells for use in screening assays for antagonists and agonists of its activity as well as to facilitate its purification for use in a variety of ways including, but not limited to screening assays for agonists and antagonists of its activity, diagnostic screens, and raising antibodies, as well as treatment and/or prevention of obesity-related diseases and disorders and/or to reduce body mass.

The invention relates to the polynucleotides encoding full-length GMG-2 and gGMG-2 polypeptide fragments and variant polypeptide fragments thereof as described herein. These polynucleotides may be purified, isolated, and/or recombinant. In all cases, the desired GMG-2 and gGMG-2 polynucleotides of the invention are those that encode gGMG-2 polypeptide fragments of the invention having obesity-related activity as described and discussed herein.

Fragments

A polynucleotide fragment is a polynucleotide having a sequence that entirely is the same as part, but not all, of the full-length GMG-2 polypeptide or a specified gGMG-2 polypeptide nucleotide sequence. Such fragments may be "free-standing", *i.e.* not part of or fused to other polynucleotides, or they may be comprised within another non-GMG-2 or non-gGMG-2 (heterologous) polynucleotide of which they form a part or region. However, several gGMG-2 polynucleotide fragments may be comprised within a single polynucleotide.

The GMG-2 polynucleotides of the invention comprise from 18 consecutive bases to 18 consecutive bases less than the full-length polynucleotide sequence encoding the intact GMG-2 polypeptide, for example the full-length GMG-2 polypeptide polynucleotide sequences in SEQ ID NOs:1, 3 or 5. In one aspect of this embodiment, the polynucleotide comprises at least 18, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, 300, 305, 310, 315, 320, 325, 330, 335, 340, 345, 350, 355, 360, 365, 370, 375, 380, 385, 390, 395, 400, 405, 410, 415, 420, 425, 430, 435, 440, 445, 450, 455, 460, 465, 470, 475, 480, 485, 490, 495, 500, 505, 510, 515, 520, 525, 530, 535, 540, 545, 550, 555, 560, 565, 570, 575, 580, 585, 590, 595, 600, 605, 610, 615, 620, 625, 630, 635, 640, 645, 650, 655, 660, 665, 670, 675, 680, 685, 690, 695, 700, 705, 710, 715, 720, 725, 740, 770, 800, 850, 900, 950, 1000, 1100, 1200, 1300, 1400, 1500, 1600 or 1621 consecutive nucleotides of a polynucleotide of the present invention.

In addition to the above preferred nucleic acid sizes, further preferred nucleic acids comprise at least 18 nucleotides, wherein "at least 18" is defined as any integer between 18 and the integer

representing 18 nucleotides less than the 3' most nucleotide position of the intact GMG-2 polypeptides cDNA as set forth in SEQ ID NOS: 1, 3 or 5 or elsewhere herein.

Further included as preferred polynucleotides of the present invention are nucleic acid fragments at least 18 nucleotides in length, as described above, that are further specified in terms of 5 their 5' and 3' position. The 5' and 3' positions are represented by the position numbers set forth in the sequence listing below. For allelic and degenerate and other variants, position 1 is defined as the 5' most nucleotide of the ORF, i.e., the nucleotide "A" of the start codon (ATG) with the remaining nucleotides numbered consecutively. Therefore, every combination of a 5' and 3' nucleotide position that a polynucleotide fragment invention, at least 18 contiguous nucleotides in length, could occupy 10 on an intact GMG-2 polypeptide polynucleotide of the present invention is included in the invention as an individual species. The polynucleotide fragments specified by 5' and 3' positions can be immediately envisaged and are therefore not individually listed solely for the purpose of not unnecessarily lengthening the specification.

It is noted that the above species of polynucleotide fragments of the present invention may 15 alternatively be described by the formula "x to y"; where "x" equals the 5' most nucleotide position and "y" equals the 3' most nucleotide position of the polynucleotide; and further where "x" equals an integer between 1 and the number of nucleotides of the polynucleotide sequence of the present invention minus 18, and where "y" equals an integer between 19 and the number of nucleotides of the polynucleotide sequence of the present invention; and where "x" is an integer smaller than "y" by 20 at least 18.

The present invention also provides for the exclusion of any species of polynucleotide fragments of the present invention specified by 5' and 3' positions or polynucleotides specified by size in nucleotides as described above. Any number of fragments specified by 5' and 3' positions or by size in nucleotides, as described above, may be excluded.

25 The GMG-2 polynucleotide fragments of the invention comprise from 18 consecutive bases to the full length polynucleotide sequence encoding the GMG-2 fragments described herein. In one aspect of this embodiment, the polynucleotide comprises at least 18, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 255, 30 260, 265, 270, 275, 280, 285, 290, 295, 300, 305, 310, 315, 320, 325, 330, 335, 340, 345, 350, 355, 360, 365, 370, 375, 380, 385, 390, 395, 400, 405, 410, 415, 420, 425, 430, 435, 440, 445, 450, 455, 460, 465, 470, 475, 480, 485, 490, 495, 500, 505, 510, 515, 520, 525, 530, 535, 540, 545, 550, 555, 560, 565, 570, 575, 580, 585, 590, 595, 600, 605, 610, 615, 620, 625, 630, 635, 640, 645, 650, 655, 660, 665, 670, 675, 680, 685, 690, 695, 700, 705, 710, 715, 720, 725, 740, 770, 800, 850, 900, 950, 35 1000, 1100, 1200, 1300, 1400, 1500, 1600 or 1621 consecutive nucleotides of a polynucleotide of the present invention.

In addition to the above preferred nucleic acid sizes, further preferred nucleic acids comprise at least 18 nucleotides, wherein "at least 18" is defined as any integer between 18 and the integer corresponding to the 3' most nucleotide position of a gGMG-2 fragment cDNA herein.

Further included as preferred polynucleotides of the present invention are nucleic acid fragments at least 18 nucleotides in length, as described above, that are further specified in terms of their 5' and 3' position. The 5' and 3' positions are represented by the position numbers set forth in the sequence listing below. For allelic and degenerate and other variants, position 1 is defined as the 5' most nucleotide of the open reading frame (ORF), i.e., the nucleotide "A" of the start codon (ATG) with the remaining nucleotides numbered consecutively. Therefore, every combination of a 5' and 3' nucleotide position that a polynucleotide fragment invention, at least 18 contiguous nucleotides in length, could occupy on a gGMG-2 fragment polynucleotide of the present invention is included in the invention as an individual species. The polynucleotide fragments specified by 5' and 3' positions can be immediately envisaged and are therefore not individually listed solely for the purpose of not unnecessarily lengthening the specification.

It is noted that the above species of polynucleotide fragments of the present invention may alternatively be described by the formula "x to y"; where "x" equals the 5' most nucleotide position and "y" equals the 3' most nucleotide position of the polynucleotide; and further where "x" equals an integer between 1 and the number of nucleotides of the gGMG-2 polynucleotide sequence of the present invention minus 18, and where "y" equals an integer between 9 and the number of nucleotides of the gGMG-2 polynucleotide sequence of the present invention; and where "x" is an integer smaller than "y" by at least 18. Every combination of "x" and "y" positions are included as specific embodiments of the invention. Moreover, the formula "x" to "y" may be modified as "x1 - x2" to "y1 - y2", wherein "x1 - x2" and "y1 - y2" represent positional ranges selected from any two nucleotide positions of the sequence listing. Alternative formulas include "x1 - x2" to "y" and "x" to "y1 - y2".

These specific embodiments, and other polynucleotide fragment embodiments described herein may be modified as being "at least", "equal to", "equal to or less than", "less than", "at least ____ but not greater than ____" or "from ____ to ____" a specified size or specified 5' and/or 3' positions. The present invention also provides for the exclusion of any species of polynucleotide fragments of the present invention specified by 5' and 3' positions or polynucleotides specified by size in nucleotides as described above. Any number of fragments specified by 5' and 3' positions or by size in nucleotides, as described above, may be excluded.

Variants

In other preferred embodiments, variants of gGMG-2 polynucleotides encoding gGMG-2 polypeptide fragments are envisioned. Variants of polynucleotides, as the term is used herein, are polynucleotides whose sequence differs from a reference polynucleotide. A variant of a polynucleotide may be a naturally occurring variant such as a naturally occurring allelic variant, or

it may be a variant that is not known to occur naturally. Such non-naturally occurring variants of the polynucleotide may be made by mutagenesis techniques, including those applied to polynucleotides, cells or organisms. Generally, differences are limited so that the nucleotide sequences of the reference and the variant are closely similar overall and, in many regions,

5 identical.

Polynucleotide variants that comprise a sequence substantially different from those described above but that, due to the degeneracy of the genetic code, still encode gGMG-2 polypeptide fragments of the present invention are also specifically envisioned. It would also be routine for one skilled in the art to generate the degenerate variants described above, for instance, to

10 optimize codon expression for a particular host (e.g., change codons in the human mRNA to those preferred by other mammalian or bacterial host cells).

As stated above, variant polynucleotides may occur naturally, such as a natural allelic variant, or by recombinant methods. By an "allelic variant" is intended one of several alternate forms of a gene occupying a given locus on a chromosome of an organism (See, e.g., B. Lewin, 15 (1990) *Genes IV*, Oxford University Press, New York). Non-naturally occurring variants may be produced using art-known mutagenesis techniques. Such nucleic acid variants include those produced by nucleotide substitutions, deletions, or additions. The substitutions, deletions, or additions may involve one or more nucleotides. Alterations in the coding regions may produce conservative or non-conservative amino acid substitutions, deletions or additions. Especially 20 preferred among these are silent substitutions, additions and deletions, which do not alter the properties and activities of a gGMG-2 polypeptide fragment of the invention. Also preferred in this regard are conservative substitutions.

Nucleotide changes present in a variant polynucleotide are preferably silent, which means that they do not alter the amino acids encoded by the polynucleotide. However, nucleotide changes 25 may also result in amino acid substitutions, additions, deletions, fusions and truncations in the polypeptide encoded by the reference sequence.

In cases where the nucleotide substitutions result in one or more amino acid changes, preferred gGMG-2 polypeptide fragments include those that retain one or more obesity-related activity as described in Section I of the Preferred Embodiments of the Invention.

30 By "retain the same activities" is meant that the activity measured using the polypeptide encoded by the variant gGMG-2 polynucleotide in assays is at least 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100%, and not more than 101%, 102%, 103%, 104%, 105%, 110%, 115%, 120% or 125% of the activity measured using a gGMG-2 fragment described in the Examples Section herein.

35 By the activity being "increased" is meant that the activity measured using the polypeptide encoded by the variant gGMG-2 polynucleotide in assays is at least 125%, 130%, 135%, 140%, 145%, 150%, 155%, 160%, 170%, 180%, 190%, 200%, 225%, 250%, 275%, 300%, 325%, 350%,

375%, 400%, 450%, or 500% of the activity measured using a gGMG-2 fragment described in the Examples Section herein.

By the activity being "decreased" is meant that the activity measured using the polypeptide encoded by the variant gGMG-2 polynucleotide in assays is decreased by at least 25%, 30%, 35%, 40%,

5 45%, or 50% of the activity measured using a gGMG-2 fragment described in the Examples Section herein.

Percent Identity

The present invention is further directed to nucleic acid molecules having sequences at least 50%, 60%, 70%, 80%, 90%, 95%, 96%, 97%, 98% or 99% identical to the polynucleotide sequences

10 of SEQ ID NO:1 or SEQ ID NO:3 or SEQ ID NO:5 or fragments thereof that encode a polypeptide having obesity-related activity as described in Section I of the Preferred Embodiments of the Invention. Of course, due to the degeneracy of the genetic code, one of ordinary skill in the art will immediately recognize that a large number of the nucleic acid molecules at least 50%, 60%, 70%, 80%, 90%, 95%, 96%, 97%, 98%, or 99% identical to the nucleic acid sequences shown in SEQ ID
15 NOs:1, 3 or 5 or fragments thereof will encode a polypeptide having biological activity. In fact, since degenerate variants of these nucleotide sequences all encode the same polypeptide, this will be clear to the skilled artisan even without performing the above described comparison assay. It will be further recognized in the art that, for such nucleic acid molecules that are not degenerate variants, a reasonable number will also encode a polypeptide having biological activity. This is because the
20 skilled artisan is fully aware of amino acid substitutions that are either less likely or not likely to significantly affect protein function (e.g., replacing one aliphatic amino acid with a second aliphatic amino acid), as further described previously in Section I of the Preferred Embodiments of the Invention.

By a polynucleotide having a nucleotide sequence at least, for example, 95% "identical" to a
25 reference nucleotide sequence of the present invention, it is intended that the nucleotide sequence of the polynucleotide is identical to the reference sequence except that the polynucleotide sequence may include up to five point mutations per each 100 nucleotides of the reference nucleotide sequence encoding the gGMG-2 fragment. In other words, to obtain a polynucleotide having a nucleotide sequence at least 95% identical to a reference nucleotide sequence, up to 5% of the nucleotides in the
30 reference sequence may be deleted, inserted, or substituted with another nucleotide. The query sequence may be an entire sequence or any fragment specified as described herein.

The methods of determining and defining whether any particular nucleic acid molecule or polypeptide is at least 50%, 60%, 70%, 80%, 90%, 95%, 96%, 97%, 98% or 99% identical to a nucleotide sequence of the present invention can be done by using known computer programs. A
35 preferred method for determining the best overall match between a query sequence (a sequence of the present invention) and a subject sequence, also referred to as a global sequence alignment, can be determined using the FASTDB computer program based on the algorithm of Brutlag et al., ((1990)

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Comput Appl Biosci 6(3):237-45). In a sequence alignment the query and subject sequences are both DNA sequences. An RNA sequence can be compared by first converting U's to T's. The result of said global sequence alignment is in percent identity. Preferred parameters used in a FASTDB alignment of DNA sequences to calculate percent identity are: Matrix=Unitary, k-tuple=4, Mismatch Penalty=1, Joining Penalty=30, Randomization Group Length=0, Cutoff Score=1, Gap Penalty=5, Gap Size Penalty 0.05, Window Size=500 or the length of the subject nucleotide sequence, whichever is shorter.

If the subject sequence is shorter than the query sequence because of 5' or 3' deletions, not because of internal deletions, a manual correction must be made to the results. This is because the FASTDB program does not account for 5' and 3' truncations of the subject sequence when calculating percent identity. For subject sequences truncated at the 5' or 3' ends, relative to the query sequence, the percent identity is corrected by calculating the number of bases of the query sequence that are 5' and 3' of the subject sequence, which are not matched/aligned, as a percent of the total bases of the query sequence. Whether a nucleotide is matched/aligned is determined by results of the FASTDB sequence alignment. This percentage is then subtracted from the percent identity, calculated by the above FASTDB program using the specified parameters, to arrive at a final percent identity score. This corrected score is what is used for the purposes of the present invention. Only nucleotides outside the 5' and 3' nucleotides of the subject sequence, as displayed by the FASTDB alignment, which are not matched/aligned with the query sequence, are calculated for the purposes of manually adjusting the percent identity score.

For example, a 90-nucleotide subject sequence is aligned to a 100-nucleotide query sequence to determine percent identity. The deletions occur at the 5' end of the subject sequence and therefore, the FASTDB alignment does not show a matched/alignment of the first 10 nucleotides at 5' end. The 10 unpaired nucleotides represent 10% of the sequence (number of nucleotides at the 5' and 3' ends not matched/total number of nucleotides in the query sequence) so 10% is subtracted from the percent identity score calculated by the FASTDB program. If the remaining 90 nucleotides were perfectly matched the final percent identity would be 90%.

In another example, a 90 nucleotide subject sequence is compared with a 100 nucleotide query sequence. This time the deletions are internal deletions so that there are no nucleotides on the 5' or 3' of the subject sequence which are not matched/aligned with the query. In this case the percent identity calculated by FASTDB is not manually corrected. Once again, only nucleotides 5' and 3' of the subject sequence which are not matched/aligned with the query sequence are manually corrected for. No other manual corrections are made for the purposes of the present invention.

Fusions

Further included in the present invention are polynucleotides encoding the polypeptides of the present invention that are fused in frame to the coding sequences for additional heterologous amino acid sequences. Also included in the present invention are nucleic acids encoding

polypeptides of the present invention together with additional, non-coding sequences, including for example, but not limited to non-coding 5' and 3' sequences, vector sequence, sequences used for purification, probing, or priming. For example, heterologous sequences include transcribed, non-translated sequences that may play a role in transcription, and mRNA processing, for example, 5 ribosome binding and stability of mRNA. The heterologous sequences may alternatively comprise additional coding sequences that provide additional functionalities. Thus, a nucleotide sequence encoding a polypeptide may be fused to a tag sequence, such as a sequence encoding a peptide that facilitates purification of the fused polypeptide. In certain preferred embodiments of this aspect of the invention, the tag amino acid sequence is a hexa-histidine peptide, such as the tag provided in a 10 pQE vector (QIAGEN, Inc., 9259 Eton Avenue, Chatsworth, CA, 91311), among others, many of which are commercially available. For instance, hexa-histidine provides for convenient purification of the fusion protein (See, Gentz et al., (1989) Proc Natl Acad Sci USA 86(3):821-4). The "HA" tag is another peptide useful for purification which corresponds to an epitope derived from the influenza hemagglutinin protein (See, Wilson et al., (1984) Cell 37(3):767-78). As discussed above, other 15 such fusion proteins include gGMG-2 fragment cDNA fused to Fc at the N- or C-terminus.

III. Recombinant Vectors of the Invention

The term "vector" is used herein to designate either a circular or a linear DNA or RNA molecule, that is either double-stranded or single-stranded, and that comprises at least one 20 polynucleotide of interest that is sought to be transferred in a cell host or in a unicellular or multicellular host organism.

The present invention relates to recombinant vectors comprising any one of the polynucleotides described herein.

The present invention encompasses a family of recombinant vectors that comprise 25 polynucleotides encoding GMG-2 polypeptide fragments of the invention.

In a first preferred embodiment, a recombinant vector of the invention is used to amplify the inserted polynucleotide in a suitable cell host, this polynucleotide being amplified every time that the recombinant vector replicates. The inserted polynucleotide can be one that encodes gGMG-2 polypeptide fragments of the invention.

30 A second preferred embodiment of the recombinant vectors according to the invention consists of expression vectors comprising polynucleotides encoding GMG-2 polypeptide fragments of the invention. Within certain embodiments, expression vectors are employed to express an GMG-2 fragment of the invention, preferably a modified GMG-2 fragment described in the present invention, which can be then purified and, for example, be used as a treatment for obesity-related 35 diseases, or simply to reduce body mass of individuals.

Expression requires that appropriate signals are provided in the vectors, said signals including various regulatory elements, such as enhancers/promoters from both viral and mammalian sources, that drive expression of the genes of interest in host cells. Dominant drug selection markers

for establishing permanent, stable, cell clones expressing the products are generally included in the expression vectors of the invention, as they are elements that link expression of the drug selection markers to expression of the polypeptide.

More particularly, the present invention relates to expression vectors which include nucleic acids encoding an GMG-2 fragment of the invention, or a modified GMG-2 fragment as described herein, or variants or fragments thereof, under the control of a regulatory sequence selected among GMG-2 polypeptide fragments, or alternatively under the control of an exogenous regulatory sequence.

Consequently, preferred expression vectors of the invention are selected from the group consisting of: (a) an GMG-2 fragment regulatory sequence and driving the expression of a coding polynucleotide operably linked thereto; and (b) an GMG-2 fragment coding sequence of the invention, operably linked to regulatory sequences allowing its expression in a suitable cell host and/or host organism.

Some of the elements that can be found in the vectors of the present invention are described in further detail in the following sections.

1) General features of the expression vectors of the invention:

A recombinant vector according to the invention comprises, but is not limited to, a YAC (Yeast Artificial Chromosome), a BAC (Bacterial Artificial Chromosome), a phage, a phagemid, a cosmid, a plasmid, or even a linear DNA molecule which may consist of a chromosomal, non-chromosomal, semi-synthetic or synthetic DNA. Such a recombinant vector can comprise a transcriptional unit comprising an assembly of:

- (1) a genetic element or elements having a regulatory role in gene expression, for example promoters or enhancers. Enhancers are *cis*-acting elements of DNA, usually from about 10 to 300 bp in length that act on the promoter to increase the transcription;
- (2) a structural or coding sequence which is transcribed into mRNA and eventually translated into a polypeptide, said structural or coding sequence being operably linked to the regulatory elements described in (1); and
- (3) appropriate transcription initiation and termination sequences. Structural units intended for use in yeast or eukaryotic expression systems preferably include a leader sequence enabling extracellular secretion of translated protein by a host cell. Alternatively, when a recombinant protein is expressed without a leader or transport sequence, it may include a N-terminal residue. This residue may or may not be subsequently cleaved from the expressed recombinant protein to provide a final product.

Generally, recombinant expression vectors will include origins of replication, selectable markers permitting transformation of the host cell, and a promoter derived from a highly expressed gene to direct transcription of a downstream structural sequence. The heterologous structural sequence is assembled in appropriate phase with translation initiation and termination sequences, and preferably

a leader sequence capable of directing secretion of the translated protein into the periplasmic space or the extracellular medium. In a specific embodiment wherein the vector is adapted for transfecting and expressing desired sequences in mammalian host cells, preferred vectors will comprise an origin of replication in the desired host, a suitable promoter and enhancer, and also any necessary ribosome binding sites, polyadenylation sites, splice donor and acceptor sites, transcriptional termination sequences, and 5'-flanking non-transcribed sequences. DNA sequences derived from the SV40 viral genome, for example SV40 origin, early promoter, enhancer, splice and polyadenylation sites may be used to provide the required non-transcribed genetic elements.

2) Regulatory elements

10 Promoters

The suitable promoter regions used in the expression vectors of the present invention are chosen taking into account the cell host in which the heterologous gene is expressed. The particular promoter employed to control the expression of a nucleic acid sequence of interest is not believed to be important, so long as it is capable of directing the expression of the nucleic acid in the targeted 15 cell. Thus, where a human cell is targeted, it is preferable to position the nucleic acid coding region adjacent to and under the control of a promoter that is capable of being expressed in a human cell, such as, for example, a human or a viral promoter. The promoter used may be constitutive or inducible.

A suitable promoter may be heterologous with respect to the nucleic acid for which it 20 controls the expression or alternatively can be endogenous to the native polynucleotide containing the coding sequence to be expressed. Additionally, the promoter is generally heterologous with respect to the recombinant vector sequences within which the construct promoter/coding sequence has been inserted.

Promoter regions can be selected from any desired gene using, for example, CAT 25 (chloramphenicol transferase) vectors and more preferably pKK232-8 and pCM7 vectors. Preferred bacterial promoters are the LacI, LacZ, the T3 or T7 bacteriophage RNA polymerase promoters, the gpt, lambda PR, PL and trp promoters (EP 0036776), the polyhedrin promoter, or the p10 protein promoter from baculovirus (Kit Novagen) (Smith et al., (1983) Mol Cell Biol 3(12):2156-65; O'Reilly et al., 1992), the lambda PR promoter or also the trc promoter.

30 Eukaryotic promoters include CMV immediate early, HSV thymidine kinase, early and late SV40, LTRs from retrovirus, and mouse metallothionein-L. In addition, promoters specific for a particular cell type may be chosen, such as those facilitating expression in adipose tissue, muscle tissue, or liver. Selection of a convenient vector and promoter is well within the level of ordinary skill in the art.

35 The choice of a promoter is well within the ability of a person skilled in the field of genetic engineering. For example, one may refer to Sambrook et al. (1989) Molecular Cloning: A

Laboratory Manual, Cold Spring Harbor Laboratory Press, NY, Vol. 1, 2, 3 (1989), or also to the procedures described by Fuller et al. (1996) Immunology in Current Protocols in Molecular Biology.

Other regulatory elements

Where a cDNA insert is employed, one will typically desire to include a polyadenylation signal to effect proper polyadenylation of the gene transcript. The nature of the polyadenylation signal is not believed to be crucial to the successful practice of the invention, and any such sequence may be employed such as human growth hormone and SV40 polyadenylation signals. Also contemplated as an element of the expression cassette is a terminator. These elements can serve to enhance message levels and to minimize read through from the cassette into other sequences.

10 Vectors containing the appropriate DNA sequence as described above can be utilized to transform an appropriate host to allow the expression of the desired polypeptide or polynucleotide.

3) Selectable markers

Such markers would confer an identifiable change to the cell permitting easy identification of cells containing the expression construct. The selectable marker genes for selection of 15 transformed host cells are preferably dihydrofolate reductase or neomycin resistance for eukaryotic cell culture, TRP1 for *S. cerevisiae* or tetracycline, rifampicin or ampicillin resistance in *E. coli*, or levan saccharase for mycobacteria, this latter marker being a negative selection marker.

4) Preferred vectors

Bacterial vectors

20 As a representative but non-limiting example, useful expression vectors for bacterial use can comprise a selectable marker and a bacterial origin of replication derived from commercially available plasmids comprising genetic elements of pBR322 (ATCC 37017). Such commercial vectors include, but are not limited to, pKK223-3 (Pharmacia, Uppsala, Sweden) and pGEM1 (Promega Biotec, Madison, WI, USA).

25 Large numbers of other suitable vectors are known to those of skill in the art, and are commercially available, such as the following bacterial vectors : pTrc-His, pET30-His, pQE70, pQE60, pQE-9 (Qiagen), pbs, pD10, phagescript, psiX174, pbluescript SK, pbsks, pNH8A, pNH16A, pNH18A, pNH46A (Stratagene); ptrc99a, pKK223-3, pKK233-3, pDR540, pRIT5 (Pharmacia); pWLNEO, pSV2CAT, pOG44, pXT1, pSG (Stratagene); pSVK3, pBPV, pMSG, pSVL (Pharmacia); pQE-30 30 (QIAexpress).

Baculovirus vectors

A suitable vector for the expression of polypeptides of the invention is a baculovirus vector that can be propagated in insect cells and in insect cell lines. A specific suitable host vector system is the pVL1392/1393 baculovirus transfer vector (Pharmingen) that is used to transfect the SF9 cell line (ATCC N°CRL 1711) which is derived from *Spodoptera frugiperda*.

Further suitable baculovirus vectors are known to those skilled in the art, for example, FastBacHT. Other suitable vectors for the expression of an APM1 globular head polypeptide in a

baculovirus expression system include, but are not limited to, those described by Chai et al. (1993; Biotechnol Appl Biochem Dec;18 (Pt 3):259-73); Vlasak et al. (1983; Eur J Biochem Sep 1;135(1):123-6); and Lenhard et al. (1996; Gene Mar 9;169(2):187-90).

Mammalian vectors

5 Further suitable vectors for the expression of polypeptides of the invention are mammalian vectors. A number of suitable vector systems are known to those skilled in the art, for example, pcDNA4HisMax, pcDNA3.1Hygro-His and pcDNA3.1Hygro.

Viral vectors

In one specific embodiment, the vector is derived from an adenovirus. Preferred adenovirus 10 vectors according to the invention are those described by Feldman and Steg (1996; Semin Interv Cardiol 1(3):203-8) or Ohno et al. (1994; Scicnce 265(5173):781-4). Another preferred recombinant adenovirus according to this specific embodiment of the present invention is the human adenovirus type 2 or 5 (Ad 2 or Ad 5) or an adenovirus of animal origin (French patent application No. FR-93.05954).

15 Retrovirus vectors and adeno-associated virus vectors are generally understood to be the recombinant gene delivery systems of choice for the transfer of exogenous polynucleotides *in vivo*, particularly to mammals, including humans. These vectors provide efficient delivery of genes into cells, and the transferred nucleic acids are stably integrated into the chromosomal DNA of the host.

Particularly preferred retroviruses for the preparation or construction of retroviral *in vitro* or 20 *in vivo* gene delivery vehicles of the present invention include retroviruses selected from the group consisting of Mink-Cell Focus Inducing Virus, Murine Sarcoma Virus, Reticuloendothelios virus and Rous Sarcoma virus. Particularly preferred Murine Leukemia Viruses include the 4070A and the 1504A viruses, Abelson (ATCC No VR-999), Friend (ATCC No VR-245), Gross (ATCC No VR-590), Rauscher (ATCC No VR-998) and Moloney Murine Leukemia Virus (ATCC No VR-190; 25 PCT Application No WO 94/24298). Particularly preferred Rous Sarcoma Viruses include Bryan high titer (ATCC Nos VR-334, VR-657, VR-726, VR-659 and VR-728). Other preferred retroviral vectors are those described in Roth et al. (1996), PCT Application No WO 93/25234, PCT Application No WO 94/06920, Roux et al., ((1989) Proc Natl Acad Sci USA 86(23):9079-83), Julian et al., (1992) J. Gen. Virol. 3:3251-3255 and Neda et al. ((1991) J Biol Chem 266(22):14143-6).

30 Yet another viral vector system that is contemplated by the invention consists of the adeno-associated virus (AAV). The adeno-associated virus is a naturally occurring defective virus that requires another virus, such as an adenovirus or a herpes virus, as a helper virus for efficient replication and a productive life cycle (Muzyczka et al., (1992) Curr Top Microbiol Immunol 158:97-129). It is also one of the few viruses that may integrate its DNA into non-dividing cells, 35 and exhibits a high frequency of stable integration (Flotte et al., (1992) Am J Respir Cell Mol Biol 7(3):349-56; Samulski et al., (1989) J Virol 63(9):3822-8; McLaughlin et al., (1989) Am J Hum

Genet 59:561-569). One advantageous feature of AAV derives from its reduced efficacy for transducing primary cells relative to transformed cells.

5) Delivery of the recombinant vectors

In order to effect expression of the polynucleotides of the invention, these constructs must 5 be delivered into a cell. This delivery may be accomplished *in vitro*, as in laboratory procedures for transforming cell lines, or *in vivo* or *ex vivo*, as in the treatment of certain disease states.

One mechanism is viral infection where the expression construct is encapsulated in an infectious viral particle.

Several non-viral methods for the transfer of polynucleotides into cultured mammalian cells 10 are also contemplated by the present invention, and include, without being limited to, calcium phosphate precipitation (Graham et al., (1973) Virology 54(2):536-9; Chen et al., (1987) Mol Cell Biol 7(8):2745-52), DEAE-dextran (Gopal, (1985) Mol Cell Biol 5(5):1188-90), electroporation (Tur-Kaspa et al., (1986) Mol Cell Biol 6(2):716-8; Potter et al., (1984) Proc Natl Acad Sci USA 81(22):7161-5.), direct microinjection (Harland et al., (1985) J Cell Biol 101(3):1094-9), DNA- 15 loaded liposomes (Nicolau et al., (1982) Biochim Biophys Acta 721(2):185-90; Fraley et al., (1979) Proc Natl Acad Sci USA 76(7):3348-52), and receptor-mediated transfection (Wu and Wu, (1987) J Biol Chem 262(10):4429-32; Wu and Wu (1988) Biochemistry 27(3):887-92). Some of these techniques may be successfully adapted for *in vivo* or *ex vivo* use.

Once the expression polynucleotide has been delivered into the cell, it may be stably 20 integrated into the genome of the recipient cell. This integration may be in the cognate location and orientation via homologous recombination (gene replacement) or it may be integrated in a random, non-specific location (gene augmentation). In yet further embodiments, the nucleic acid may be stably maintained in the cell as a separate, episomal segment of DNA. Such nucleic acid segments or "episomes" encode sequences sufficient to permit maintenance and replication independent of or 25 in synchronization with the host cell cycle.

One specific embodiment for a method for delivering a protein or peptide to the interior of a cell of a vertebrate *in vivo* comprises the step of introducing a preparation comprising a physiologically acceptable carrier and a naked polynucleotide operatively coding for the polypeptide of interest into the interstitial space of a tissue comprising the cell, whereby the naked 30 polynucleotide is taken up into the interior of the cell and has a physiological effect. This is particularly applicable for transfer *in vitro* but it may be applied to *in vivo* as well.

Compositions for use *in vitro* and *in vivo* comprising a "naked" polynucleotide are described in PCT application No. WO 90/11092 (Vical Inc.) and also in PCT application No. WO 95/11307 (Institut Pasteur, INSERM, Université d'Ottawa) as well as in the articles of Tascon et al. (1996) 35 Nature Medicine 2(8):888-892 and of Huygen et al. ((1996) Nat Med 2(8):893-8).

In still another embodiment of the invention, the transfer of a naked polynucleotide of the invention, including a polynucleotide construct of the invention, into cells may be proceeded with a

particle bombardment (biolistic), said particles being DNA-coated microparticles accelerated to a high velocity allowing them to pierce cell membranes and enter cells without killing them, such as described by Klein et al. ((1990) *Curr Genet* Feb;17(2):97-103).

In a further embodiment, the polynucleotide of the invention may be entrapped in a

5 liposome (Ghosh and Bacchawat, (1991) *Targeted Diagn Ther* 4:87-103; Wong et al., (1980) *Gene* 10:87-94; Nicolau et al., (1987) *Methods Enzymol* 149:157-76). These liposomes may further be targeted to cells expressing LSR by incorporating leptin, triglycerides, ACRP30, or other known LSR ligands into the liposome membrane.

In a specific embodiment, the invention provides a composition for the *in vivo* production of

10 GMG-2 globular head polypeptide described herein. It comprises a naked polynucleotide operatively coding for this polypeptide, in solution in a physiologically acceptable carrier, and suitable for introduction into a tissue to cause cells of the tissue to express the said polypeptide.

The amount of vector to be injected to the desired host organism varies according to the site of injection. As an indicative dose, it will be injected between 0.1 and 100 µg of the vector in an

15 animal body, preferably a mammal body, for example a mouse body.

In another embodiment of the vector according to the invention, it may be introduced *in vitro* in a host cell, preferably in a host cell previously harvested from the animal to be treated and more preferably a somatic cell such as a muscle cell. In a subsequent step, the cell that has been transformed with the vector coding for the desired GMG-2 globular head polypeptide or the desired

20 fragment thereof is reintroduced into the animal body in order to deliver the recombinant protein within the body either locally or systemically.

IV. Recombinant Cells of the Invention

Another object of the invention consists of host cells recombinant for, i.e., that have been

25 transformed or transfected with one of the polynucleotides described herein, and more precisely a polynucleotide comprising a polynucleotide encoding an GMG-2 polypeptide fragment of the invention such as any one of those described in "Polynucleotides of the Invention". These polynucleotides can be present in cells as a result of transient or stable transfection. The invention includes host cells that are transformed (prokaryotic cells) or that are transfected (eukaryotic cells)

30 with a recombinant vector such as any one of those described in "Recombinant Vectors of the Invention".

Generally, a recombinant host cell of the invention comprises at least one of the polynucleotides or the recombinant vectors of the invention that are described herein.

Preferred host cells used as recipients for the recombinant vectors of the invention are the

35 following :

a) Prokaryotic host cells : *Escherichia coli* strains (I.E. DH5- α strain), *Bacillus subtilis*, *Salmonella typhimurium*, and strains from species like *Pseudomonas*, *Streptomyces* and *Staphylococcus*, and

b) Eukaryotic host cells : HeLa cells (ATCC N°CCL2; N°CCL2.1; N°CCL2.2), Cv 1 cells (ATCC N°CCL70), COS cells (ATCC N°CRL1650; N°CRL1651), Sf-9 cells (ATCC N°CRL1711), C127 cells (ATCC N° CRL-1804), 3T3 (ATCC N° CRL-6361), CHO (ATCC N° CCL-61), human kidney 293 (ATCC N° 45504; N° CRL-1573), BHK (ECACC N° 84100501; N° 84111301), PLC cells, HepG2, and Hep3B.

The constructs in the host cells can be used in a conventional manner to produce the gene product encoded by the recombinant sequence.

Following transformation of a suitable host and growth of the host to an appropriate cell density, the selected promoter is induced by appropriate means, such as temperature shift or chemical induction, and cells are cultivated for an additional period.

Cells are typically harvested by centrifugation, disrupted by physical or chemical means, and the resulting crude extract retained for further purification.

Microbial cells employed in the expression of proteins can be disrupted by any convenient method, including freeze-thaw cycling, sonication, mechanical disruption, or use of cell lysing agents. Such methods are well known by the skilled artisan.

Further, according to the invention, these recombinant cells can be created *in vitro* or *in vivo* in an animal, preferably a mammal, most preferably selected from the group consisting of mice, rats, dogs, pigs, sheep, cattle, and primates, not to include humans. Recombinant cells created *in vitro* can also be later surgically implanted in an animal, for example. Methods to create recombinant cells *in vivo* in animals are well known in the art.

The present invention also encompasses primary, secondary, and immortalized homologously recombinant host cells of vertebrate origin, preferably mammalian origin and particularly human origin, that have been engineered to: a) insert exogenous (heterologous) polynucleotides into the endogenous chromosomal DNA of a targeted gene, b) delete endogenous chromosomal DNA, and/or c) replace endogenous chromosomal DNA with exogenous polynucleotides. Insertions, deletions, and/or replacements of polynucleotide sequences may be to the coding sequences of the targeted gene and/or to regulatory regions, such as promoter and enhancer sequences, operably associated with the targeted gene.

The present invention further relates to a method of making a homologously recombinant host cell *in vitro* or *in vivo*, wherein the expression of a targeted gene not normally expressed in the cell is altered. Preferably the alteration causes expression of the targeted gene under normal growth conditions or under conditions suitable for producing the polypeptide encoded by the targeted gene. The method comprises the steps of: (a) transfecting the cell *in vitro* or *in vivo* with a polynucleotide construct, the polynucleotide construct comprising: (i) a targeting sequence; (ii) a regulatory

sequence and/or a coding sequence; and (iii) an unpaired splice donor site, if necessary, thereby producing a transfected cell; and (b) maintaining the transfected cell *in vitro* or *in vivo* under conditions appropriate for homologous recombination.

The present invention further relates to a method of altering the expression of a targeted gene in a cell *in vitro* or *in vivo* wherein the gene is not normally expressed in the cell, comprising the steps of: (a) transfecting the cell *in vitro* or *in vivo* with a polynucleotide construct, the polynucleotide construct comprising: (i) a targeting sequence; (ii) a regulatory sequence and/or a coding sequence; and (iii) an unpaired splice donor site, if necessary, thereby producing a transfected cell; and (b) maintaining the transfected cell *in vitro* or *in vivo* under conditions appropriate for homologous recombination, thereby producing a homologously recombinant cell; and (c) maintaining the homologously recombinant cell *in vitro* or *in vivo* under conditions appropriate for expression of the gene.

The present invention further relates to a method of making a polypeptide of the present invention by altering the expression of a targeted endogenous gene in a cell *in vitro* or *in vivo* wherein the gene is not normally expressed in the cell, comprising the steps of: a) transfecting the cell *in vitro* with a polynucleotide construct, the polynucleotide construct comprising: (i) a targeting sequence; (ii) a regulatory sequence and/or a coding sequence; and (iii) an unpaired splice donor site, if necessary, thereby producing a transfected cell; (b) maintaining the transfected cell *in vitro* or *in vivo* under conditions appropriate for homologous recombination, thereby producing a homologously recombinant cell; and c) maintaining the homologously recombinant cell *in vitro* or *in vivo* under conditions appropriate for expression of the gene thereby making the polypeptide.

The present invention further relates to a polynucleotide construct that alters the expression of a targeted gene in a cell type in which the gene is not normally expressed. This occurs when a polynucleotide construct is inserted into the chromosomal DNA of the target cell, wherein the polynucleotide construct comprises: a) a targeting sequence; b) a regulatory sequence and/or coding sequence; and c) an unpaired splice-donor site, if necessary. Further included are polynucleotide constructs, as described above, wherein the construct further comprises a polynucleotide that encodes a polypeptide and is in-frame with the targeted endogenous gene after homologous recombination with chromosomal DNA.

The compositions may be produced, and methods performed, by techniques known in the art, such as those described in U.S. Patent Nos: 6,054,288; 6,048,729; 6,048,724; 6,048,524; 5,994,127; 5,968,502; 5,965,125; 5,869,239; 5,817,789; 5,783,385; 5,733,761; 5,641,670; 5,580,734; International Publication Nos: WO96/29411, WO 94/12650; and scientific articles described by Koller et al., (1994) *Annu. Rev. Immunol.* 10:705-730; the disclosures of each of which are incorporated by reference in their entireties).

The GMG-2 gene expression in mammalian, and typically human, cells may be rendered defective, or alternatively it may be enhanced, with the insertion of an GMG-2 genomic or cDNA

sequence with the replacement of the GMG-2 gene counterpart in the genome of an animal cell by an GMG-2 polynucleotide according to the invention. These genetic alterations may be generated by homologous recombination events using specific DNA constructs that have been previously described.

5 One kind of host cell that may be used are mammalian zygotes, such as murine zygotes. For example, murine zygotes may undergo microinjection with a purified DNA molecule of interest, for example a purified DNA molecule that has previously been adjusted to a concentration range from 1 ng/ml -for BAC inserts- 3 ng/μl -for P1 bacteriophage inserts- in 10 mM Tris-HCl, pH 7.4, 250 μM EDTA containing 100 mM NaCl, 30 μM spermine, and 70 μM spermidine. When the DNA to be 10 microinjected has a large size, polyamines and high salt concentrations can be used in order to avoid mechanical breakage of this DNA, as described by Schedl et al ((1993) *Nature* 362(6417):258-61).

Any one of the polynucleotides of the invention, including the DNA constructs described herein, may be introduced in an embryonic stem (ES) cell line, preferably a mouse ES cell line. ES cell lines are derived from pluripotent, uncommitted cells of the inner cell mass of pre-implantation 15 blastocysts. Preferred ES cell lines are the following: ES-E14TG2a (ATCC No.CRL-1821), ES-D3 (ATCC No.CRL1934 and No. CRL-11632), YS001 (ATCC No. CRL-11776), 36.5 (ATCC No. CRL-11116). To maintain ES cells in an uncommitted state, they are cultured in the presence of growth inhibited feeder cells that provide the appropriate signals to preserve this embryonic 20 phenotype and serve as a matrix for ES cell adherence. Preferred feeder cells are primary embryonic fibroblasts that are established from tissue of day 13- day 14 embryos of virtually any mouse strain, that are maintained in culture, such as described by Abbondanzo et al. (1993; *Methods Enzymol* 225:803-23) and are inhibited in growth by irradiation, such as described by Robertson ((1987) *Embryo-derived stem cell lines*. In: E.J. Robertson Ed. *Teratocarcinomas and Embryonic Stem Cells: A Practical Approach*, IRL Press, Oxford), or by the presence of an inhibitory concentration 25 of LIF, such as described by Pease and Williams (1990; *Exp Cell Res* 190(2):209-11).

The constructs in the host cells can be used in a conventional manner to produce the gene product encoded by the recombinant sequence.

Following transformation of a suitable host and growth of the host to an appropriate cell density, the selected promoter is induced by appropriate means, such as temperature shift or chemical induction, 30 and cells are cultivated for an additional period. Cells are typically harvested by centrifugation, disrupted by physical or chemical means, and the resulting crude extract retained for further purification. Microbial cells employed in the expression of proteins can be disrupted by any convenient method, including freeze-thaw cycling, sonication, mechanical disruption, or use of cell lysing agents. Such methods are well known by the skilled artisan.

IV. Transgenic animals

The present invention also provides methods and compositions for the generation of non-human animals and plants that express recombinant GMG-2 polypeptide, i.e. recombinant gGMG-2 polypeptide fragment or full-length GMG-2 polypeptide. The animals or plants can be transgenic, 5 i.e. each of their cells contains a gene encoding the GMG-2 polypeptide, or, alternatively, a polynucleotide encoding the polypeptide can be introduced into somatic cells of the animal or plant, e.g. into mammary secretory epithelial cells of a mammal. In preferred embodiments, the non-human animal is a mammal such as a cow, sheep, goat, pig, or rabbit. In further preferred 10 embodiments, said gene encoding said gGMG-2 polypeptide fragment or said full-length GMG-2 polypeptide comprises the polynucleotide of SEQ ID NO:5.

Methods of making transgenic animals such as mammals are well known to those of skill in the art, and any such method can be used in the present invention. Briefly, transgenic mammals can be produced, e.g., by transfecting a pluripotential stem cell such as an ES cell with a polynucleotide encoding a polypeptide of interest. Successfully transformed ES cells can then be introduced into an 15 early stage embryo that is then implanted into the uterus of a mammal of the same species. In certain cases, the transformed ("transgenic") cells will comprise part of the germ line of the resulting animal, and adult animals comprising the transgenic cells in the germ line can then be mated to other animals, thereby eventually producing a population of transgenic animals that have the transgene in each of their cells, and which can stably transmit the transgene to each of their offspring. Other 20 methods of introducing the polynucleotide can be used, for example introducing the polynucleotide encoding the polypeptide of interest into a fertilized egg or early stage embryo via microinjection. Alternatively, the transgene may be introduced into an animal by infection of zygotes with a retrovirus containing the transgene (Jaenisch, R. (1976) Proc Natl Acad Sci USA 73, 1260-1264). Methods of making transgenic mammals are described, e.g., in Wall et al. (1992) J Cell Biochem 25 1992 49(2):113-20; Hogan, et al. (1986) in Manipulating the Mouse Embryo: A Laboratory Manual, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y.; in WO 91/08216; or in US Patent Number 4,736,866.

In a preferred method, the polynucleotides are microinjected into the fertilized oocyte. Typically, fertilized oocytes are microinjected using standard techniques, and then cultured in vitro 30 until a "pre-implantation embryo" is obtained. Such pre-implantation embryos preferably contain approximately 16 to 150 cells. Methods for culturing fertilized oocytes to the pre-implantation stage are described, e.g., by Gordon et al. ((1984) Methods in Enzymology, 101, 414); Hogan et al. ((1986) in Manipulating the Mouse Embryo: A Laboratory Manual, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y) (for the mouse embryo); Hammer et al. ((1985) Nature, 315, 680 35 (for rabbit and porcine embryos); Gandolfi et al. ((1987) J Reprod Fert 81, 23-28); Rexroad et al. ((1988) J Anim Sci 66, 947-953) (for ovine embryos); and Eyestone et al. ((1989) J Reprod Fert 85, 715-720); Camous et al. ((1984) J Reprod Fert 72, 779-785); and Heyman et al. ((1987)

Theriogenology 27, 5968) (for bovine embryos); the disclosures of each of which are incorporated herein in their entireties. Pre-implantation embryos are then transferred to an appropriate female by standard methods to permit the birth of a transgenic or chimeric animal, depending upon the stage of development when the transgene is introduced.

5 As the frequency of transgene incorporation is often low, the detection of transgene integration in pre-implantation embryos is often desirable using any of the herein-described methods. Any of a number of methods can be used to detect the presence of a transgene in a pre-implantation embryo. For example, one or more cells may be removed from the pre-implantation embryo, and the presence or absence of the transgene in the removed cell or cells can be detected using any standard 10 method e.g. PCR. Alternatively, the presence of a transgene can be detected in utero or post partum using standard methods.

In a particularly preferred embodiment of the present invention, transgenic mammals are generated that secrete recombinant GMG-2 polypeptides in their milk. As the mammary gland is a highly efficient protein-producing organ, such methods can be used to produce protein

15 concentrations in the gram per liter range, and often significantly more. Preferably, expression in the mammary gland is accomplished by operably linking the polynucleotide encoding the GMG-2 polypeptide to a mammary gland specific promoter and, optionally, other regulatory elements. Suitable promoters and other elements include, but are not limited to, those derived from mammalian short and long WAP, alpha, beta, and kappa, casein, alpha and beta lactoglobulin, beta-CN 5' gcnos, 20 as well as the mouse mammary tumor virus (MMTV) promoter. Such promoters and other elements may be derived from any mammal, including, but not limited to, cows, goats, sheep, pigs, mice, rabbits, and guinea pigs. Promoter and other regulatory sequences, vectors, and other relevant teachings are provided, e.g., by Clark (1998) J Mammary Gland Biol Neoplasia 3:337-50; Jost et al. (1999) Nat Biotechnol 17:160-4; U.S. Patent Nos. 5,994,616; 6,140,552; 6,013,857; Sohn et al. 25 (1999) DNA Cell Biol. 18:845-52; Kim et al. (1999) J Biochem (Japan) 126:320-5; Soulier et al. (1999) Euro J Biochem 260:533-9; Zhang et al. (1997) Chin J Biotech 13:271-6; Rijnkels et al. (1998) Transgen Res 7:5-14; Korhonen et al. (1997) Euro J Biochem 245:482-9; Uusi-Oukari et al. (1997) Transgen Res 6:75-84; Hitchin et al. (1996) Prot Expr Purif 7:247-52; Platenburg et al. (1994) 30 Transgen Res 3:99-108; Heng-Cherl et al. (1993) Animal Biotech 4:89-107; and Christa et al. (2000) Euro J Biochem 267:1665-71; the entire disclosures of each of which is herein incorporated by reference.

In another embodiment, the polypeptides of the invention can be produced in milk by introducing polynucleotides encoding the polypeptides into somatic cells of the mammary gland in vivo, e.g. mammary secreting epithelial cells. For example, plasmid DNA can be infused through 35 the nipple canal, e.g. in association with DEAE-dextran (see, e.g., Hens et al. (2000) Biochim. Biophys. Acta 1523:161-171), in association with a ligand that can lead to receptor-mediated endocytosis of the construct (see, e.g., Sobolev et al. (1998) 273:7928-33), or in a viral vector such

as a retroviral vector, e.g. the Gibbon ape leukemia virus (see, e.g., Archer et al. (1994) PNAS 91:6840-6844). In any of these embodiments, the polynucleotide may be operably linked to a mammary gland specific promoter, as described above, or, alternatively, any strongly expressing promoter such as CMV or MoMLV LTR.

5 The suitability of any vector, promoter, regulatory element, etc. for use in the present invention can be assessed beforehand by transfecting cells such as mammary epithelial cells, e.g. MacT cells (bovine mammary epithelial cells) or GME cells (goat mammary epithelial cells), *in vitro* and assessing the efficiency of transfection and expression of the transgene in the cells.

For *in vivo* administration, the polynucleotides can be administered in any suitable 10 formulation, at any of a range of concentrations (e.g. 1-500 µg/ml, preferably 50-100 µg/ml), at any volume (e.g. 1-100 ml, preferably 1 to 20 ml), and can be administered any number of times (e.g. 1, 2, 3, 5, or 10 times), at any frequency (e.g. every 1, 2, 3, 5, 10, or any number of days). Suitable 15 concentrations, frequencies, modes of administration, etc. will depend upon the particular polynucleotide, vector, animal, etc., and can readily be determined by one of skill in the art.

15 In a preferred embodiment, a retroviral vector such as as Gibbon ape leukemia viral vector is used, as described in Archer et al. ((1994) PNAS 91:6840-6844). As retroviral infection typically requires cell division, cell division in the mammary glands can be stimulated in conjunction with the administration of the vector, e.g. using a factor such as estradiol benzoate, progesterone, reserpine, or dexamethasone. Further, retroviral and other methods of infection can be facilitated using 20 accessory compounds such as polybrene.

In any of the herein-described methods for obtaining GMG-2 polypeptides from milk, the quantity of milk obtained, and thus the quantity of GMG-2 polypeptides produced, can be enhanced using any standard method of lactation induction, e.g. using hexestrol, estrogen, and/or progesterone.

The polynucleotides used in such embodiments can either encode a full-length GMG-2 25 polypeptide or a gGMG-2 polypeptide fragment. Typically, the encoded polypeptide will include a signal sequence to ensure the secretion of the protein into the milk. Where a full-length GMG-2 sequence is used, the full-length protein can, e.g., be isolated from milk and cleaved *in vitro* using a suitable protease. Alternatively, a second, protease-encoding polynucleotide can be introduced into the animal or into the mammary gland cells, whereby expression of the protease results in the 30 cleavage of the GMG-2 polypeptide *in vivo*, thereby allowing the direct isolation of gGMG-2 polypeptide fragments from milk.

V. Pharmaceutical or Physiologically Acceptable Compositions of the Invention

The gGMG-2 polypeptide fragments of the invention can be administered to non-human 35 animals and/or humans, alone or in pharmaceutical or physiologically acceptable compositions where they are mixed with suitable carriers or excipient(s). The pharmaceutical or physiologically acceptable composition is then provided at a therapeutically effective dose. A therapeutically effective dose refers

to that amount of gGMG-2 fragment sufficient to result in prevention or amelioration of symptoms or physiological status of obesity-related diseases or disorders as determined by the methods described herein. A therapeutically effective dose can also refer to the amount of gGMG-2 fragment necessary for a reduction in weight or a prevention of an increase in weight or prevention of an increase in the 5 rate of weight gain in persons desiring this affect for cosmetic reasons. A therapeutically effective dosage of a gGMG-2 fragment of the invention is that dosage that is adequate to promote weight loss or weight gain with continued periodic use or administration. Techniques for formulation and administration of GMG-2 polypeptide fragments may be found in "Remington's Pharmaceutical Sciences," Mack Publishing Co., Easton, PA, latest edition.

10 Other diseases or disorders that GMG-2 polypeptide fragments of the invention could be used to treat or prevent include, but are not limited to, obesity and obesity-related diseases and disorders such as obesity, impaired glucose tolerance, insulin resistance, atherosclerosis, atheromatous disease, heart disease, hypertension, stroke, Syndrome X, Noninsulin Dependent Diabetes Mellitus (NIDDM, or Type II diabetes) and Insulin Dependent Diabetes Mellitus (IDDM or Type I diabetes). Diabetes-related complications to be treated by the methods of the invention include microangiopathic lesions, 15 ocular lesions, retinopathy, neuropathy, and renal lesions. Heart disease includes, but is not limited to, cardiac insufficiency, coronary insufficiency, and high blood pressure. Other obesity-related disorders to be treated by compounds of the invention include hyperlipidemia and hyperuricemia. Yet other obesity-related diseases or disorders of the invention include cachexia, wasting, AIDS-related weight loss, cancer-related weight loss, anorexia, and bulimia. The gGMG-2 polypeptide fragments may also be used to enhance physical performance during work or exercise or enhance a 20 feeling of general well-being. Physical performance activities include walking, running, jumping, lifting and/or climbing.

The gGMG-2 polypeptide fragments or antagonists thereof may also be used to treat 25 dyslexia, attention-deficit disorder (ADD), attention-deficit/hyperactivity disorder (ADHD), and psychiatric disorders such as schizophrenia by modulating fatty acid metabolism, more specifically, the production of certain long-chain polyunsaturated fatty acids. Further preferred embodiments relate to methods for the prophylaxis or treatment of inflammation-related disorders, such as atherosclerosis, comprising administering to a subject in need of treatment (alternatively on a timed 30 daily basis) homotrimeric gGMG-2 polypeptide fragment (or polynucleotide encoding said polypeptide) in dosage amount and for a period sufficient to reduce proinflammatory cytokines, and/or (ii) cell adhesion molecule levels in said animal or human subject.

It is expressly considered that the gGMG-2 polypeptide fragments of the invention may be provided alone or in combination with other pharmaceutically or physiologically acceptable 35 compounds. Other compounds useful for the treatment of obesity and other diseases and disorders are currently well-known in the art.

In a preferred embodiment, the gGMG-2 polypeptide fragments are useful for, and used in, the treatment of insulin resistance and diabetes using methods described herein and known in the art. More particularly, a preferred embodiment relates to process for the therapeutic modification and regulation of glucose metabolism in an animal or human subject, which comprises administering to a 5 subject in need of treatment (alternatively on a timed daily basis) a GMG-2 polypeptide fragment (or polynucleotide encoding said polypeptide) in dosage amount and for a period sufficient to reduce plasma glucose levels in said animal or human subject.

Further preferred embodiments relate to methods for the prophylaxis or treatment of diabetes comprising administering to a subject in need of treatment (alternatively on a timed daily 10 basis) a GMG-2 polypeptide fragment (or polynucleotide encoding said polypeptide) in dosage amount and for a period sufficient to reduce plasma glucose levels in said animal or human subject.

Routes of Administration.

Suitable routes of administration include oral, nasal, rectal, transmucosal, or intestinal administration, parenteral delivery, including intramuscular, subcutaneous, intramedullary injections, 15 as well as intrathecal, direct intraventricular, intravenous, intraperitoneal, intranasal, intrapulmonary (inhaled) or intraocular injections using methods known in the art. A particularly useful method of administering compounds for promoting weight loss involves surgical implantation, for example into the abdominal cavity of the recipient, of a device for delivering GMG-2 or gGMG-2 polypeptide fragments over an extended period of time. Other particularly preferred routes of administration are 20 aerosol and depot formulation. Sustained release formulations, particularly depot, of the invented medicaments are expressly contemplated.

Composition/Formulation

Pharmaceutical or physiologically acceptable compositions and medicaments for use in accordance with the present invention may be formulated in a conventional manner using one or more 25 physiologically acceptable carriers comprising excipients and auxiliaries. Proper formulation is dependent upon the route of administration chosen.

Certain of the medicaments described herein will include a pharmaceutically or physiologically acceptable carrier and at least one polypeptide that is an GMG-2 polypeptide fragment of the invention. For injection, the agents of the invention may be formulated in 30 aqueous solutions, preferably in physiologically compatible buffers such as Hanks's solution, Ringer's solution, or physiological saline buffer such as a phosphate or bicarbonate 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.

Pharmaceutical or physiologically acceptable preparations that can be taken orally include 35 push-fit capsules made of gelatin, as well as soft, sealed capsules made of gelatin and a plasticizer, such as glycerol or sorbitol. The push-fit capsules can contain the active ingredients in admixture with fillers such as lactose, binders such as starches, and/or lubricants such as talc or magnesium stearate

and, optionally, stabilizers. In soft capsules, the active compounds may be dissolved or suspended in suitable liquids, such as fatty oils, liquid paraffin, or liquid polyethylene glycols. In addition, stabilizers may be added. All formulations for oral administration should be in dosages suitable for such administration.

5 For buccal administration, the compositions may take the form of tablets or lozenges formulated in conventional manner.

For administration by inhalation, the compounds for use according to the present invention are conveniently delivered in the form of an aerosol spray presentation from pressurized packs or a nebulizer, with the use of a suitable gaseous propellant, *e.g.*, carbon dioxide. In the case of a

10 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.

15 The compounds may be formulated for parenteral administration by injection, *e.g.*, by 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 aqueous vehicles, and may contain formulatory agents such as suspending, stabilizing and/or dispersing agents.

20 Pharmaceutical or physiologically acceptable formulations for parenteral administration include aqueous solutions of the active compounds in water-soluble form. Aqueous 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.

25 Alternatively, the active ingredient may be in powder or lyophilized form for constitution with a suitable vehicle, such as sterile pyrogen-free water, before use.

30 In addition to the formulations described previously, the compounds may also be formulated as a depot preparation. Such long acting formulations may be administered by implantation (for example subcutaneously or intramuscularly) or by intramuscular injection. Thus, for example, the compounds may be formulated with suitable polymeric or hydrophobic materials (for example as an emulsion in an acceptable oil) or ion exchange resins, or as sparingly soluble derivatives, for example, as a sparingly soluble salt.

35 Additionally, the compounds may be delivered using a sustained-release system, such as semipermeable matrices of solid hydrophobic polymers containing the therapeutic agent. Various sustained release materials have been established and are well known by those skilled in the art. Sustained-release capsules may, depending on their chemical nature, release the compounds for a few weeks up to over 100 days.

Depending on the chemical nature and the biological stability of the therapeutic reagent, additional strategies for protein stabilization may be employed. The pharmaceutical or physiologically acceptable compositions also may comprise suitable solid or gel phase carriers or excipients. Examples of such carriers or excipients include but are not limited to 5 calcium carbonate, calcium phosphate, various sugars, starches, cellulose derivatives, gelatin, and polymers such as polyethylene glycols.

Effective Dosage.

Pharmaceutical or physiologically acceptable compositions suitable for use in the present invention include compositions wherein the active ingredients are contained in an effective amount to 10 achieve their intended purpose. More specifically, a therapeutically effective amount means an amount effective to prevent development of or to alleviate the existing symptoms of the subject being treated. Determination of the effective amounts is well within the capability of those skilled in the art, especially in light of the detailed disclosure provided herein.

For any compound used in the method of the invention, the therapeutically effective dose can 15 be estimated initially from cell culture assays. For example, a dose can be formulated in animal models to achieve a circulating concentration range that includes or encompasses a concentration point or range shown to increase leptin or lipoprotein uptake or binding in an *in vitro* system. Such information can be used to more accurately determine useful doses in humans.

A therapeutically effective dose refers to that amount of the compound that results in 20 amelioration of symptoms in a patient. Toxicity and therapeutic efficacy of such compounds can be determined by standard pharmaceutical procedures in cell cultures or experimental animals, e.g., for determining the LD50, (the dose lethal to 50% of the test population) and the ED50 (the dose therapeutically effective in 50% of the population). The dose ratio between toxic and therapeutic effects is the therapeutic index and it can be expressed as the ratio between LD50 and ED50. 25 Compounds that exhibit high therapeutic indices are preferred.

The data obtained from these cell culture assays and animal studies can be used in formulating a range of dosage for use in humans. The dosage of such compounds lies preferably within a range of circulating concentrations that include the ED50, with little or no toxicity. The dosage may vary within this range depending upon the dosage form employed and the route of administration utilized. 30 The exact formulation, route of administration and dosage can be chosen by the individual physician in view of the patient's condition. (See, e.g., Fingl et al., 1975, in "The Pharmacological Basis of Therapeutics", Ch. 1).

Dosage amount and interval may be adjusted individually to provide plasma levels of the 35 active compound which are sufficient to maintain or prevent weight loss or gain, depending on the particular situation. Dosages necessary to achieve these effects will depend on individual characteristics and route of administration.

Dosage intervals can also be determined using the value for the minimum effective concentration. Compounds should be administered using a regimen that maintains plasma levels above the minimum effective concentration for 10-90% of the time, preferably between 30-90%; and most preferably between 50-90%. In cases of local administration or selective uptake, the effective local concentration of the drug may not be related to plasma concentration.

The amount of composition administered will, of course, be dependent on the subject being treated, on the subject's weight, the severity of the affliction, the manner of administration and the judgment of the prescribing physician.

A preferred dosage range for the amount of an GMG-2 polypeptide fragment of the invention, 10 which can be administered on a daily or regular basis to achieve desired results, including a reduction in levels of circulating plasma triglyceride-rich lipoproteins, range from 0.01 – 0.5 mg/kg body mass. A more preferred dosage range is from 0.05 – 0.1 mg/kg. Of course, these daily dosages can be delivered or administered in small amounts periodically during the course of a day. It is noted that these dosage ranges are only preferred ranges and are not meant to be limiting to the 15 invention.

VI. Methods of Treatment

Treatment of mice with gGMG-2 polypeptide fragments results in decreased triglyceride levels, decreased free fatty acid levels, decreased glucose levels, and decreased body weight as 20 well as increased muscle oxidation.

The invention is drawn *inter alia* to methods of preventing or treating obesity-related diseases and disorders comprising providing an individual in need of such treatment with a gGMG-2 polypeptide fragment of the invention. Preferably, the GMG-2 polypeptide fragment has obesity-related activity either *in vitro* or *in vivo*. Preferably the GMG-2 polypeptide fragment is 25 provided to the individual in a pharmaceutical composition that is preferably taken orally. Preferably the individual is a mammal, and most preferably a human. In preferred embodiments, the obesity-related disease or disorder is selected from the group consisting of atherosclerosis, cardiovascular disease, impaired glucose tolerance, insulin resistance, hypertension, stroke, Syndrome X, Type I diabetes, Type II diabetes and lipoatrophic diabetes. Diabetes-related 30 complications to be treated by the methods of the invention include microangiopathic lesions, ocular lesions, retinopathy, neuropathy and renal lesions. Heart disease includes, but is not limited to, cardiac insufficiency, coronary insufficiency, and high blood pressure. Other obesity-related disorders to be treated by compounds of the invention include hyperlipidemia, hypertriglyceridemia, and hyperuricemia. Yet other obesity-related diseases or disorders of the 35 invention include cachexia, wasting, AIDS-related weight loss, neoplasia-related weight loss, anorexia, and bulimia. In highly preferred embodiments, GMG-2 polypeptide polypeptide

fragments in pharmaceutical compositions are used to modulate body weight in healthy individuals for cosmetic reasons.

The invention also features a method of preventing or treating obesity-related diseases and disorders comprising providing an individual in need of such treatment with a compound identified by assays of the invention (described in Section VI of the Preferred Embodiments of the Invention and in the Examples). Preferably these compounds antagonize or agonize effects of gGMG-2 polypeptide fragments in cells *in vitro*, muscles *ex vivo*, or in animal models. Alternatively, these compounds agonize or antagonize the effects of gGMG-2 polypeptide fragments on leptin and/or lipoprotein uptake and/or binding. Optionally, these compounds prevent the interaction, binding, or uptake of gGMG-2 polypeptide fragments with LSR *in vitro* or *in vivo*. Preferably, the compound is provided to the individual in a pharmaceutical composition that is preferably taken orally. Preferably the individual is a mammal, and most preferably a human. In preferred embodiments, the obesity-related disease or disorder is selected from the group consisting of obesity and obesity-related diseases and disorders such as atherosclerosis, heart disease, impaired glucose tolerance, insulin resistance, hypertension, stroke, Syndrome X, Type I diabetes, Type II diabetes, and lipoatrophic diabetes. Diabetes-related complications to be treated by the methods of the invention include microangiopathic lesions, ocular lesions, retinopathy, neuropathy and renal lesions. Heart disease includes, but is not limited to, cardiac insufficiency, coronary insufficiency, and high blood pressure. Other obesity-related disorders to be treated by compounds of the invention include hyperlipidemia, hypertriglyceridemia, and hyperuricemia. Yet other obesity-related diseases or disorders of the invention include cachexia, wasting, AIDS-related weight loss, neoplasia-related weight loss, anorexia, and bulimia. In highly preferred embodiments, the pharmaceutical compositions are used to modulate body weight for cosmetic reasons.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control blood glucose in some individuals, particularly those with Type I diabetes, Type II diabetes, or insulin resistance, in combination with insulin therapy. In still a further preferred embodiment, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to treat inflammatory disorders, including, but not limited to, atherosclerosis, coronary heart disease, myocardial infarction, and disseminated intravascular coagulation.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control body weight in some individuals, particularly those with Type I diabetes, Type II diabetes, or insulin resistance, in combination with insulin therapy.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control blood glucose in some

individuals, particularly those with Type I diabetes, Type II diabetes, or insulin resistance, alone, without combination of insulin therapy.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to control body weight in some 5 individuals, particularly those with Type II diabetes or insulin resistance, alone, without combination of insulin therapy.

In a further preferred embodiment, the present invention may be used in complementary therapy, particularly in some individuals, particularly those with Type I diabetes, Type II diabetes, or insulin resistance, to improve their weight or glucose control in combination with an oral insulin

10 secretagogue or an insulin sensitising agent. Preferably, the oral insulin secretagogue is 1,1-dimethyl-2-(2-morpholino phenyl)guanidine fumarate (BTS67582) or a sulphonylurea selected from tolbutamide, tolazamide, chlorpropamide, glibenclamide, glimepiride, glipizide and glidazide. Preferably, the insulin sensitising agent is selected from metformin, cigitazone, troglitazone and pioglitazone.

15 The present invention further provides a method of improving the body weight or glucose control of some individuals, particularly those with Type I diabetes, Type II diabetes, or insulin resistance, alone, without an oral insulin secretagogue or an insulin sensitising agent.

In a further preferred embodiment, the present invention may be administered either 20 concomitantly or concurrently, with the oral insulin secretagogue or insulin sensitising agent for example in the form of separate dosage units to be used simultaneously, separately or sequentially (either before or after the secretagogue or either before or after the sensitising agent). Accordingly, the present invention further provides for a composition of pharmaceutical or physiologically acceptable composition and an oral insulin secretagogue or insulin sensitising agent as a combined preparation for simultaneous, separate or sequential use for the improvement of body weight or 25 glucose control in some individuals, particularly those with Type I diabetes, Type II diabetes, or insulin resistance.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition further provides a method for the use as an insulin sensitiser.

In further preferred embodiments, the present invention of said pharmaceutical or 30 physiologically acceptable composition can be used as a method to improve insulin sensitivity in some individuals, particularly those with Type I diabetes, Type II diabetes, or insulin resistance, in combination with insulin therapy.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition can be used as a method to improve insulin sensitivity in 35 some individuals, particularly those with Type II diabetes or insulin resistance, without insulin therapy.

In further preferred embodiments, the present invention of said pharmaceutical or physiologically acceptable composition further provides a method for the use as an inhibitor of the progression from impaired glucose tolerance to insulin resistance.

More generally, the instant invention is drawn to treatment with gGMG-2 polypeptide fragments where an individual is shown to have a particular genotype for an GMG-2 marker, or where they have been shown to have a reduced amount of plasma GMG-2, either full-length or preferably a more biologically active fragment of GMG-2, as compared to control values, e.g. values representative of non-diseased individuals, or as compared to that individual prior to the onset of a disease or condition. In either case, treatment comprises providing pharmaceutically acceptable gGMG-2 or GMG-2 polypeptide fragments to the individual. The exact amount of gGMG-2 fragment provided would be determined through clinical trials under the guidance of qualified physicians, but would be expected to be in the range of 5-7 mg per individual per day. In general, a preferred range would be from 0.5 to 14 mg per individual per day, with a highly preferred range being between 1 and 10 mg per individual per day. Individuals who could benefit from treatment with gGMG-2 or GMG-2 polypeptide fragments could be identified through at least two methods: plasma serum level determinations and genotyping.

GMG-2 levels

Preliminary studies have shown that obese people have lower levels of full-length GMG-2 than non-obese people. The invention envisions treatment of individuals (preferably obese) that have low levels of full-length GMG-2 with gGMG-2 polypeptide fragments of the invention. In addition, the invention preferably is drawn to treatment of individuals with low levels of the biologically active fragment of GMG-2 with gGMG-2 polypeptide fragments of the invention. In further embodiments, GMG-2 or GMG-2 polypeptide fragments of the present invention are administered to individuals, preferably obese individuals, that levels of full-length GMG-2 (or alternatively a mature GMG-2 polypeptide fragment) at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, about 100% or 100% lower than non-obese individuals, preferably healthy individuals as determined by a physician using normal standards in the art. Methods to determine and compare the levels of full-length GMG-2 in individuals are well-known in the art and include, but are not limited to using an antibody specific for GMG-2 in a format such as a Radio Immune Assay, ELISA, Western blot, dotblot, or as part of an array, for example. Methods of generating antibodies to, and detection of, GMG-2 and fragments thereof as well as to proteins with SNPs are included in the present invention and are discussed in PCT/IB99/01858, US application No. 09/434,848, and WO 99/07736, hereby incorporated herein by reference in its entirety including and drawings, figures, or tables. Further, antibodies specific for GMG-2/gGMG-2 polypeptide fragments of the invention, their generation, and their use are described herein.

VII. Assays for Identifying Modulators of gGMG-2 Polypeptide Fragment Activity

The invention features methods of screening for one or more compounds that modulate gGMG-2 polypeptide fragment activity in cells, that includes providing potential compounds to be tested to the cells, and where modulation of a gGMG-2 polypeptide fragment effect or activity

- 5 indicates the one or more compounds. Exemplary assays that may be used are described in the Examples 4-5, 7-14, 16, and 18. To these assays would be added compounds to be tested for their inhibitory or stimulatory activity as compared to the effects of gGMG-2 polypeptide fragment alone. Other assays in which an effect is observed based on the addition of gGMG-2 polypeptide fragment can also be used to screen for modulators of gGMG-2 polypeptide fragment activity or effects of the
- 10 presence of gGMG-2 polypeptide fragment on cells. The essential step is to apply an unknown compound and then to monitor an assay for a change from what is seen when only gGMG-2 polypeptide fragment is applied to the cell. A change is defined as something that is significantly different in the presence of the compound plus gGMG-2 polypeptide fragment compared to gGMG-2 polypeptide fragment alone. In this case, significantly different would be an "increase" or a
- 15 "decrease" in a measurable effect of at least 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, or 75%.

The term "modulation" as used herein refers to a measurable change in an activity.

Examples include, but are not limited to, lipolysis stimulated receptor (LSR) modulation, leptin modulation, lipoprotein modulation, plasma FFA levels, FFA oxidation, TG levels, glucose levels, weight. These effects can be *in vitro* or preferably *in vivo*. Modulation of an activity can be either an increase or a decrease in the activity. Thus, LSR activity can be increased or decreased, leptin activity can be increased or decreased, and lipoprotein activity can be increased or decreased. Similarly, FFA, TG, and glucose levels (and weight) can be increased or decreased *in vivo*. Free Fatty Acid oxidation can be increased or decreased *in vivo* or *ex vivo*.

- 25 By "LSR" activity is meant expression of LSR on the surface of the cell, or in a particular conformation, as well as its ability to bind, uptake, and degrade leptin and lipoprotein. By "leptin" activity is meant its binding, uptake and degradation by LSR, as well as its transport across a blood brain barrier, and potentially these occurrences where LSR is not necessarily the mediating factor or the only mediating factor. Similarly, by "lipoprotein" activity is meant its binding, uptake and
- 30 degradation by LSR, as well as these occurrences where LSR is not necessarily the mediating factor or the only mediating factor. Exemplary assays are provided in Example 4-5, 7-14, 16, and 18. These assay and other comparable assays can be used to determine/identify compounds that modulate gGMG-2 polypeptide fragment activity. In some cases it may be important to identify compounds that modulate some but not all of the gGMG-2 polypeptide fragment activities, although
- 35 preferably all activities are modified.

The term "increasing" as used herein refers to the ability of a compound to increase an gGMG-2 polypeptide fragment activity in some measurable way compared to the effect of an

gGMG-2 polypeptide fragment in its absence. As a result of the presence of the compound leptin binding and/or uptake might increase, for example, as compared to controls in the presence of the gGMG-2 polypeptide fragment alone. Preferably, an increase in activity is at least 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, or 75% compared to the level of activity in the presence of the gGMG-2 polypeptide fragment.

Similarly, the term "decreasing" as used herein refers to the ability of a compound to decrease an activity in some measurable way compared to the effect of a gGMG-2 fragment in its absence. For example, the presence of the compound decreases the plasma concentrations of FFA, TG, and glucose in mice. Also as a result of the presence of a compound leptin binding and/or uptake might decrease, for example, as compared to controls in the presence of the gGMG-2 polypeptide fragment alone. Preferably, a decrease in activity is at least 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, or 75% as compared to the level of activity in the presence of the gGMG-2 polypeptide fragment alone.

The invention features a method for identifying a potential compound to modulate body mass in individuals in need of modulating body mass comprising: a) contacting a cell with a gGMG-2 polypeptide fragment and a candidate compound; b) detecting a result selected from the group consisting of LSR modulation, leptin modulation, lipoprotein modulation, FFA oxidation modulation; and c) wherein said result identifies said potential compound if said result differs from said result when said cell is contacted with the gGMG-2 polypeptide fragment alone.

In preferred embodiments, said contacting further comprises a ligand of said LSR. Preferably said ligand is selected from the group consisting of cytokine, lipoprotein, free fatty acids, and C1q, and more preferably said cytokine is leptin, and most preferably said leptin is a leptin polypeptide fragment as described in US Provisional application No. 60/155,506 hereby incorporated by reference herein in its entirety including any figures, drawings, or tables.

In other preferred embodiments, said gGMG-2 polypeptide fragment is mouse or is human. In other preferred embodiments, said cell is selected from the group consisting of PLC, CHO-K1, Hep3B, and HepG2.

In yet other preferred embodiments, said lipoprotein modulation is selected from the group consisting of binding, uptake, and degradation. Preferably, said modulation is an increase in said binding, uptake, or degradation. Alternatively, said modulation is a decrease in said binding, uptake, or degradation.

In other preferred embodiments, leptin modulation is selected from the group consisting of binding, uptake, degradation, and transport. Preferably, said modulation is an increase in said binding, uptake, degradation, or transport. Alternatively, said modulation is a decrease in said binding, uptake, degradation, or transport. Preferably, said transport is across a blood-brain barrier.

In yet other preferred embodiments, said LSR modulation is expression on the surface of said cell. Preferably, said detecting comprises FACS, more preferably said detecting further

comprises antibodies that bind specifically to said LSR, and most preferably said antibodies bind specifically to the carboxy terminus of said LSR.

In still other preferred embodiments, said potential compound is selected from the group consisting of peptides, peptide libraries, non-peptide libraries, peptoids, fatty acids, lipoproteins, 5 medicaments, antibodies, small molecules, and proteases. Other characteristics and advantages of the invention are described in the Brief Description of the Figures and the Examples. These are meant to be exemplary only, and not to limit the invention in any way. Throughout this application, various publications, patents and published patent applications are cited. The disclosures of these publications, patents and published patent specifications referenced in this application are hereby 10 incorporated by reference into the present disclosure.

VIII. Epitopes and Antibody Fusions

A preferred embodiment of the present invention is directed to epitope-bearing polypeptides and epitope-bearing polypeptide fragments. These epitopes may be "antigenic epitopes" or both an 15 "antigenic epitope" and an "immunogenic epitope". An "immunogenic epitope" is defined as a part of a protein that elicits an antibody response *in vivo* when the polypeptide is the immunogen. On the other hand, a region of polypeptide to which an antibody binds is defined as an "antigenic determinant" or "antigenic epitope." The number of immunogenic epitopes of a protein generally is less than the number of antigenic epitopes. See, e.g., Geysen, et al. (1983) Proc. Natl. Acad. Sci. 20 USA 81:39984002. It is particularly noted that although a particular epitope may not be immunogenic, it is nonetheless useful since antibodies can be made *in vitro* to any epitope.

An epitope can comprise as few as 3 amino acids in a spatial conformation which is unique to the epitope. Generally an epitope consists of at least 6 such amino acids, and more often at least 8-10 such amino acids. In preferred embodiment, antigenic epitopes comprise a number of amino 25 acids that is any integer between 3 and 50. Fragments which function as epitopes may be produced by any conventional means. See, e.g., Houghten, R. A., Proc. Natl. Acad. Sci. USA 82:5131-5135 (1985), further described in U.S. Patent No. 4,631,211. Methods for determining the amino acids which make up an immunogenic epitope include x-ray crystallography, 2-dimensional nuclear magnetic resonance, and epitope mapping, e.g., the Pepscan method described by H. Mario Geysen 30 et al. (1984); Proc. Natl. Acad. Sci. U.S.A. 81:3998-4002; PCT Publication No. WO 84/03564; and PCT Publication No. WO 84/03506. Another example is the algorithm of Jameson and Wolf, Comp. Appl. Biosci. 4:181-186 (1988) (said references incorporated by reference in their entireties). The Jameson-Wolf antigenic analysis, for example, may be performed using the computer program PROTEAN, using default parameters (Version 4.0 Windows, DNASTAR, Inc., 1228 South Park 35 Street Madison, WI).

The epitope-bearing fragments of the present invention preferably comprises 6 to 50 amino acids (i.e. any integer between 6 and 50, inclusive) of a polypeptide of the present invention. Also,

included in the present invention are antigenic fragments between the integers of 6 and the full length sequence of the sequence listing. All combinations of sequences between the integers of 6 and the full-length sequence of a polypeptide of the present invention are included. The epitope-bearing fragments may be specified by either the number of contiguous amino acid residues (as a 5 sub-genus) or by specific N-terminal and C-terminal positions (as species) as described above for the polypeptide fragments of the present invention. Any number of epitope-bearing fragments of the present invention may also be excluded in the same manner.

Antigenic epitopes are useful, for example, to raise antibodies, including monoclonal antibodies that specifically bind the epitope (See, Wilson et al., 1984; and Sutcliffe, J. G. et al., 10 1983). The antibodies are then used in various techniques such as diagnostic and tissue/cell identification techniques, as described herein, and in purification methods.

Similarly, immunogenic epitopes can be used to induce antibodies according to methods well known in the art (See, Sutcliffe et al., *supra*; Wilson et al., *supra*; Chow, M. et al.;(1985) and Bittle, F. J. et al., (1985). A preferred immunogenic epitope includes the polypeptides of the 15 sequence listing. The immunogenic epitopes may be presented together with a carrier protein, such as an albumin, to an animal system (such as rabbit or mouse) if necessary. Immunogenic epitopes comprising as few as 8 to 10 amino acids have been shown to be sufficient to raise antibodies capable of binding to, at the very least, linear epitopes in a denatured polypeptide (e.g., in Western blotting.).

Epitope-bearing polypeptides of the present invention are used to induce antibodies according to methods well known in the art including, but not limited to, *in vivo* immunization, *in vitro* immunization, and phage display methods (See, e.g., Sutcliffe, et al., *supra*; Wilson, et al., *supra*, and Bittle, et al., 1985). If *in vivo* immunization is used, animals may be immunized with free peptide; however, anti-peptide antibody titer may be boosted by coupling of the peptide to a 20 macromolecular carrier, such as keyhole limpet hemacyanin (KLH) or tetanus toxoid. For instance, peptides containing cysteine residues may be coupled to a carrier using a linker such as - maleimidobenzoyl-N-hydroxysuccinimide ester (MBS), while other peptides may be coupled to carriers using a more general linking agent such as glutaraldehyde. Animals such as rabbits, rats and mice are immunized with either free or carrier-coupled peptides, for instance, by intraperitoneal 25 and/or intradermal injection of emulsions containing about 100 µgs of peptide or carrier protein and Freund's adjuvant. Several booster injections may be needed, for instance, at intervals of about two weeks, to provide a useful titer of anti-peptide antibody, which can be detected, for example, by ELISA assay using free peptide adsorbed to a solid surface. The titer of anti-peptide antibodies in serum from an immunized animal may be increased by selection of anti-peptide antibodies, for 30 instance, by adsorption to the peptide on a solid support and elution of the selected antibodies according to methods well known in the art.

As one of skill in the art will appreciate, and discussed above, the polypeptides of the present invention including, but not limited to, polypeptides comprising an immunogenic or antigenic epitope can be fused to heterologous polypeptide sequences. For example, the polypeptides of the present invention may be fused with the constant region comprising portions of immunoglobulins (IgA, IgE, IgG, IgM), or portions of the constant region (CH1, CH2, CH3, any combination thereof including both entire domains and portions thereof) resulting in chimeric polypeptides. These fusion proteins facilitate purification, and show an increased half-life in vivo. This has been shown, e.g., for chimeric proteins consisting of the first two domains of the human CD4-polypeptide and various domains of the constant regions of the heavy or light chains of mammalian immunoglobulins (See, e.g., EPA 0,394,827; and Traunecker et al., 1988). Fusion proteins that have a disulfide-linked dimeric structure due to the IgG portion can also be more efficient in binding and neutralizing other molecules than monomeric polypeptides or fragments thereof alone (See, e.g., Fountoulakis et al., 1995). Nucleic acids encoding the above epitopes can also be recombined with a gene of interest as an epitope tag to aid in detection and purification of the expressed polypeptide.

Additional fusion proteins of the invention may be generated through the techniques of gene-shuffling, motif-shuffling, exon-shuffling, or codon-shuffling (collectively referred to as "DNA shuffling"). DNA shuffling may be employed to modulate the activities of polypeptides of the present invention thereby effectively generating agonists and antagonists of the polypeptides. See, for example, U.S. Patent Nos.: 5,605,793; 5,811,238; 5,834,252; 5,837,458; and Patten, P.A., et al., (1997); Harayama, S., (1998); Hansson, L.O., et al (1999); and Lorenzo, M.M. and Blasco, R., (1998). (Each of these documents are hereby incorporated by reference). In one embodiment, one or more components, motifs, sections, parts, domains, fragments, etc., of coding polynucleotides of the invention, or the polypeptides encoded thereby may be recombined with one or more components, motifs, sections, parts, domains, fragments, etc. of one or more heterologous molecules.

Antibodies

The present invention further relates to antibodies and T-cell antigen receptors (TCR), which specifically bind the polypeptides, and more specifically, the epitopes of the polypeptides of the present invention. The antibodies of the present invention include IgG (including IgG1, IgG2, IgG3, and IgG4), IgA (including IgA1 and IgA2), IgD, IgE, or IgM, and IgY. As used herein, the term "antibody" (Ab) is meant to include whole antibodies, including single-chain whole antibodies, and antigen binding fragments thereof. In a preferred embodiment the antibodies are human antigen binding antibody fragments of the present invention include, but are not limited to, Fab, Fab' F(ab)2 and F(ab')2, Fd, single-chain Fvs (scFv), single-chain antibodies, disulfide-linked Fvs (sdFv) and fragments comprising either a V_L or V_H domain. The antibodies may be from any animal origin

including birds and mammals. Preferably, the antibodies are human, murine, rabbit, goat, guinea pig, camel, horse, or chicken.

Antigen-binding antibody fragments, including single-chain antibodies, may comprise the variable region(s) alone or in combination with the entire or partial of the following: hinge region, 5 CH1, CH2, and CH3 domains. Also included in the invention are any combinations of variable region(s) and hinge region, CH1, CH2, and CH3 domains. The present invention further includes chimeric, humanized, and human monoclonal and polyclonal antibodies, which specifically bind the polypeptides of the present invention. The present invention further includes antibodies that are anti-idiotypic to the antibodies of the present invention.

10 The antibodies of the present invention may be monospecific, bispecific, and trispecific or have greater multispecificity. Multispecific antibodies may be specific for different epitopes of a polypeptide of the present invention or may be specific for both a polypeptide of the present invention as well as for heterologous compositions, such as a heterologous polypeptide or solid support material. See, e.g., WO 93/17715; WO 92/08802; WO 91/00360; WO 92/05793; Tutt, A. et 15 al. (1991); US Patents 5,573,920, 4,474,893, 5,601,819, 4,714,681, 4,925,648; Kostelny, S.A. et al. (1992).

Antibodies of the present invention may be described or specified in terms of the epitope(s) or epitope-bearing portion(s) of a polypeptide of the present invention, which are recognized or specifically bound by the antibody. In the case of proteins of the present invention secreted proteins, 20 the antibodies may specifically bind a full-length protein encoded by a nucleic acid of the present invention, a mature protein (i.e., the protein generated by cleavage of the signal peptide) encoded by a nucleic acid of the present invention, a signal peptide encoded by a nucleic acid of the present invention, or any other polypeptide of the present invention. Therefore, the epitope(s) or epitope bearing polypeptide portion(s) may be specified as described herein, e.g., by N-terminal and C-terminal 25 positions, by size in contiguous amino acid residues, or otherwise described herein. Antibodies which specifically bind any epitope or polypeptide of the present invention may also be excluded as individual species. Therefore, the present invention includes antibodies that specifically bind specified polypeptides of the present invention, and allows for the exclusion of the same.

Antibodies of the present invention may also be described or specified in terms of their 30 cross-reactivity. Antibodies that do not specifically bind any other analog, ortholog, or homolog of the polypeptides of the present invention are included. Antibodies that do not bind polypeptides with less than 95%, less than 90%, less than 85%, less than 80%, less than 75%, less than 70%, less than 65%, less than 60%, less than 55%, and less than 50% identity (as calculated using methods known in the art and described herein, e.g., using FASTDB and the parameters set forth herein) to a 35 polypeptide of the present invention are also included in the present invention. Further included in the present invention are antibodies, which only bind polypeptides encoded by polynucleotides, which hybridize to a polynucleotide of the present invention under stringent hybridization conditions

(as described herein). Antibodies of the present invention may also be described or specified in terms of their binding affinity. Preferred binding affinities include those with a dissociation constant or Kd value less than 5×10^{-6} M, 10^{-6} M, 5×10^{-7} M, 10^{-7} M, 5×10^{-8} M, 10^{-8} M, 5×10^{-9} M, 10^{-9} M, 5×10^{-10} M, 10^{-10} M, 5×10^{-11} M, 10^{-11} M, 5×10^{-12} M, 10^{-12} M, 5×10^{-13} M, 10^{-13} M, 5×10^{-14} M, 10^{-14} M, 5×10^{-15} M, and 10^{-15} M.

Antibodies of the present invention have uses that include, but are not limited to, methods known in the art to purify, detect, and target the polypeptides of the present invention including both in vitro and in vivo diagnostic and therapeutic methods. For example, the antibodies have use in immunoassays for qualitatively and quantitatively measuring levels of the polypeptides of the present invention in biological samples (See, e.g., Harlow et al., 1988).

The antibodies of the present invention may be used either alone or in combination with other compositions. The antibodies may further be recombinantly fused to a heterologous polypeptide at the N- or C-terminus or chemically conjugated (including covalent and non-covalent conjugations) to polypeptides or other compositions. For example, antibodies of the present invention may be recombinantly fused or conjugated to molecules useful as labels in detection assays and effector molecules such as heterologous polypeptides, drugs, or toxins. See, e.g., WO 92/08495; WO 91/14438; WO 89/12624; US Patent 5,314,995; and EP 0 396 387.

The antibodies of the present invention may be prepared by any suitable method known in the art. For example, a polypeptide of the present invention or an antigenic fragment thereof can be administered to an animal in order to induce the production of sera containing polyclonal antibodies. The term "monoclonal antibody" is not limited to antibodies produced through hybridoma technology. The term "antibody" refers to a polypeptide or group of polypeptides which are comprised of at least one binding domain, where a binding domain is formed from the folding of variable domains of an antibody molecule to form three-dimensional binding spaces with an internal surface shape and charge distribution complementary to the features of an antigenic determinant of an antigen, which allows an immunological reaction with the antigen. The term "monoclonal antibody" refers to an antibody that is derived from a single clone, including eukaryotic, prokaryotic, or phage clone, and not the method by which it is produced. Monoclonal antibodies can be prepared using a wide variety of techniques known in the art including the use of hybridoma, recombinant, and phage display technology.

Hybridoma techniques include those known in the art (See, e.g., Harlow et al. 1988); Hammerling, et al, 1981). (Said references incorporated by reference in their entireties). Fab and F(ab')2 fragments may be produced, for example, from hybridoma-produced antibodies by proteolytic cleavage, using enzymes such as papain (to produce Fab fragments) or pepsin (to produce F(ab')2 fragments).

Alternatively, antibodies of the present invention can be produced through the application of recombinant DNA technology or through synthetic chemistry using methods known in the art. For

example, the antibodies of the present invention can be prepared using various phage display methods known in the art. In phage display methods, functional antibody domains are displayed on the surface of a phage particle, which carries polynucleotide sequences encoding them. Phage with a desired binding property are selected from a repertoire or combinatorial antibody library (e.g. human or murine) by selecting directly with antigen, typically antigen bound or captured to a solid surface or bead. Phage used in these methods are typically filamentous phage including fd and M13 with Fab, Fv or disulfide stabilized Fv antibody domains recombinantly fused to either the phage gene III or gene VIII protein. Examples of phage display methods that can be used to make the antibodies of the present invention include those disclosed in Brinkman U. et al. (1995); Ames, R.S. et al. (1995); Kettleborough, C.A. et al. (1994); Persic, L. et al. (1997); Burton, D.R. et al. (1994); PCT/GB91/01134; WO 90/02809; WO 91/10737; WO 92/01047; WO 92/18619; WO 93/11236; WO 95/15982; WO 95/20401; and US Patents 5,698,426, 5,223,409, 5,403,484, 5,580,717, 5,427,908, 5,750,753, 5,821,047, 5,571,698, 5,427,908, 5,516,637, 5,780,225, 5,658,727 and 5,733,743.

As described in the above references, after phage selection, the antibody coding regions from the phage can be isolated and used to generate whole antibodies, including human antibodies, or any other desired antigen binding fragment, and expressed in any desired host including mammalian cells, insect cells, plant cells, yeast, and bacteria. For example, techniques to recombinantly produce Fab, Fab' F(ab)2 and F(ab)2 fragments can also be employed using methods known in the art such as those disclosed in WO 92/22324; Mullinax, R.L. et al. (1992); and Sawai, H. et al. (1995); and Better, M. et al. (1988).

Examples of techniques which can be used to produce single-chain Fvs and antibodies include those described in U.S. Patents 4,946,778 and 5,258,498; Huston et al. (1991); Shu, L. et al. (1993); and Skerra, A. et al. (1988). For some uses, including *in vivo* use of antibodies in humans and *in vitro* detection assays, it may be preferable to use chimeric, humanized, or human antibodies. Methods for producing chimeric antibodies are known in the art. See e.g., Morrison, (1985); Oi et al., (1986); Gillies, S.D. et al. (1989); and US Patent 5,807,715. Antibodies can be humanized using a variety of techniques including CDR-grafting (EP 0 239 400; WO 91/09967; US Patent 5,530,101; and 5,585,089), veneering or resurfacing, (EP 0 592 106; EP 0 519 596; Padlan E.A., 1991; Studnicka G.M. et al., 1994; Roguska M.A. et al., 1994), and chain shuffling (US Patent 5,565,332). Human antibodies can be made by a variety of methods known in the art including phage display methods described above. See also, US Patents 4,444,887, 4,716,111, 5,545,806, and 5,814,318; WO 98/46645; WO 98/50433; WO 98/24893; WO 96/34096; WO 96/33735; and WO 91/10741.

Further included in the present invention are antibodies recombinantly fused or chemically conjugated (including both covalently and non-covalently conjugations) to a polypeptide of the present invention. The antibodies may be specific for antigens other than polypeptides of the present invention. For example, antibodies may be used to target the polypeptides of the present invention

to particular cell types, either in vitro or in vivo, by fusing or conjugating the polypeptides of the present invention to antibodies specific for particular cell surface receptors. Antibodies fused or conjugated to the polypeptides of the present invention may also be used in in vitro immunoassays and purification methods using methods known in the art (See e.g., Harbor et al. *supra*; WO

5 93/21232; EP 0 439 095; Naramura, M. et al. 1994; US Patent 5,474,981; Gillies, S.O. et al., 1992; Fell, H.P. et al., 1991).

The present invention further includes compositions comprising the polypeptides of the present invention fused or conjugated to antibody domains other than the variable regions. For example, the polypeptides of the present invention may be fused or conjugated to an antibody Fc region, or portion thereof. The antibody portion fused to a polypeptide of the present invention may comprise the hinge region, CH1 domain, CH2 domain, and CH3 domain or any combination of whole domains or portions thereof. The polypeptides of the present invention may be fused or conjugated to the above antibody portions to increase the in vivo half-life of the polypeptides or for use in immunoassays using methods known in the art. The polypeptides may also be fused or conjugated to the above antibody portions to form multimers. For example, Fc portions fused to the polypeptides of the present invention can form dimers through disulfide bonding between the Fc portions. Higher multimeric forms can be made by fusing the polypeptides to portions of IgA and IgM. Methods for fusing or conjugating the polypeptides of the present invention to antibody portions are known in the art. See e.g., US Patents 5,336,603, 5,622,929, 5,359,046, 5,349,053, 20 5,447,851, 5,112,946; EP 0 307 434, EP 0 367 166; WO 96/04388, WO 91/06570; Ashkenazi, A. et al. (1991); Zheng, X.X. et al. (1995); and Vil, H. et al. (1992).

The invention further relates to antibodies that act as agonists or antagonists of the polypeptides of the present invention. For example, the present invention includes antibodies that disrupt the receptor/ligand interactions with the polypeptides of the invention either partially or fully. Included are both receptor-specific antibodies and ligand-specific antibodies. Included are receptor-specific antibodies, which do not prevent ligand binding but prevent receptor activation. Receptor activation (i.e., signaling) may be determined by techniques described herein or otherwise known in the art. Also included are receptor-specific antibodies which both prevent ligand binding and receptor activation. Likewise, included are neutralizing antibodies that bind the ligand and prevent binding of the ligand to the receptor, as well as antibodies that bind the ligand, thereby preventing receptor activation, but do not prevent the ligand from binding the receptor. Further included are antibodies that activate the receptor. These antibodies may act as agonists for either all or less than all of the biological activities affected by ligand-mediated receptor activation. The antibodies may be specified as agonists or antagonists for biological activities comprising specific activities disclosed herein. The above antibody agonists can be made using methods known in the art. See e.g., WO 96/40281; US Patent 5,811,097; Deng, B. et al. (1998); Chen, Z. et al. (1998); Harrop, J.A. et al. (1998); Zhu, Z. et al. (1998); Yoon, D.Y. et al. (1998); Prat, M. et al. (1998) J.;

Pitard, V. et al. (1997); Lautard, J. et al. (1997); Carlson, N.G. et al. (1997) J.; Taryman, R.E. et al. (1995); Muller, Y.A. et al. (1998); Bartunek, P. et al. (1996).

As discussed above, antibodies of the polypeptides of the invention can, in turn, be utilized to generate anti-idiotypic antibodies that "mimic" polypeptides of the invention using techniques well known to those skilled in the art (See, e.g. Greenspan and Bona (1989); and Nissinoff (1991). For example, antibodies which bind to and competitively inhibit polypeptide multimerization or binding of a polypeptide of the invention to ligand can be used to generate anti-idiotypes that "mimic" the polypeptide multimerization or binding domain and, as a consequence, bind to and neutralize polypeptide or its ligand. Such neutralization anti-idiotypic antibodies can be used to bind a polypeptide of the invention or to bind its ligands/receptors, and thereby block its biological activity,

The invention also concerns a purified or isolated antibody capable of specifically binding to a mutated full length or mature polypeptide of the present invention or to a fragment or variant thereof comprising an epitope of the mutated polypeptide. In another preferred embodiment, the present invention concerns an antibody capable of binding to a polypeptide comprising at least 10 consecutive amino acids of a polypeptide of the present invention and including at least one of the amino acids which can be encoded by the trait causing mutations.

Non-human animals or mammals, whether wild-type or transgenic, which express a different species of a polypeptide of the present invention than the one to which antibody binding is desired, and animals which do not express a polypeptide of the present invention (i.e. a knock out animal) are particularly useful for preparing antibodies. Gene knock out animals will recognize all or most of the exposed regions of a polypeptide of the present invention as foreign antigens, and therefore produce antibodies with a wider array of epitopes. Moreover, smaller polypeptides with only 10 to 30 amino acids may be useful in obtaining specific binding to any one of the polypeptides of the present invention. In addition, the humoral immune system of animals which produce a species of a polypeptide of the present invention that resembles the antigenic sequence will preferentially recognize the differences between the animal's native polypeptide species and the antigen sequence, and produce antibodies to these unique sites in the antigen sequence. Such a technique will be particularly useful in obtaining antibodies that specifically bind to any one of the polypeptides of the present invention.

Antibody preparations prepared according to either protocol are useful in quantitative immunoassays which determine concentrations of antigen-bearing substances in biological samples; they are also used semi-quantitatively or qualitatively to identify the presence of antigen in a biological sample. The antibodies may also be used in therapeutic compositions for killing cells expressing the protein or reducing the levels of the protein in the body.

The antibodies of the invention may be labeled by any one of the radioactive, fluorescent or enzymatic labels known in the art.

Consequently, the invention is also directed to a method for detecting specifically the presence of a polypeptide of the present invention according to the invention in a biological sample, said method comprising the following steps:

- 5 a) obtaining a biological sample suspected of containing a polypeptide of the present invention;
- b) contacting the biological sample with a polyclonal or monoclonal antibody that specifically binds a polypeptide of the present invention under conditions suitable for antigen-antibody binding; and
- c) detecting the antigen-antibody complex formed.

10 The invention also concerns a diagnostic kit for detecting in vitro the presence of a polypeptide of the present invention in a biological sample, wherein said kit comprises:

- a) a polyclonal or monoclonal antibody that specifically binds a polypeptide of the present invention, optionally labeled;
- b) a reagent allowing the detection of the antigen-antibody complexes formed, said reagent

15 carrying optionally a label, or being able to be recognized itself by a labeled reagent, more particularly in the case when the above-mentioned monoclonal or polyclonal antibody is not labeled by itself.

A. Monoclonal Antibody Production by Hybridoma Fusion

20 Monoclonal antibody to epitopes of any of the peptides identified and isolated as described can be prepared from murine hybridomas according to the classical method of Kohler, G. and Milstein, C., *Nature* 256:495 (1975) or derivative methods thereof. Briefly, a mouse is repetitively inoculated with a few micrograms of the selected protein or peptides derived therefrom over a period of a few weeks. The mouse is then sacrificed, and the antibody producing cells of the spleen

25 isolated. The spleen cells are fused by means of polyethylene glycol with mouse myeloma cells, and the excess unfused cells destroyed by growth of the system on selective media comprising aminopterin (HAT media). The successfully fused cells are diluted and aliquots of the dilution placed in wells of a microtiter plate where growth of the culture is continued. Antibody-producing clones are identified by detection of antibody in the supernatant fluid of the wells by immunoassay

30 procedures, such as Elisa, as originally described by Engvall, E., *Meth. Enzymol.* 70:419 (1980), and derivative methods thereof. Selected positive clones can be expanded and their monoclonal antibody product harvested for use. Detailed procedures for monoclonal antibody production are described in Davis, L. et al. Basic Methods in Molecular Biology Elsevier, New York, Section 21-2.

Also particularly included in the present invention are monoclonal antibodies that

35 specifically bind a GMG-2 polypeptide fragment comprised of all or part of the C-terminal C1q homology region but not said fragment from which the N-terminal dipeptide has been proteolytically removed by dipeptidyl peptidase [Deacon (2000) *Journal of Clinical Endocrinology and Metabolism*

85:3575-3581 which disclosure is hereby incorporated by reference in its entirety]. Preferred said GMG-2 polypeptide fragment is selected from amino acids 144-288 or 162-288 of SEQ ID NO: 2, or amino acids 134-278 or 152-278 of SEQ ID NO: 4, or amino acids 115-259 or 133-259 of SEQ ID NO: 6. Methods of making monoclonal antibodies are known to those of ordinary skill in the art.

5 Further particularly included are methods of selecting monoclonal antibodies, wherein said monoclonal antibody specifically binds to 144-288 of SEQ ID NO: 2 but not to 146-288 of SEQ ID NO: 2 comprising the steps of: obtaining a sample comprising GMG-2 (144-288), obtaining a sample comprising GMG-2 (146-288), contacting said antibody with 144-288, contacting said antibody with 146-288, quantifying the level of antibody binding to 144-288 and to 146-288 by

10 enzyme-linked immunosorbent assay (ELISA). Further particularly included are methods of selecting monoclonal antibodies, wherein said monoclonal antibody specifically binds to 134-278 but not to 136-278 of SEQ ID NO: 4 comprising the steps of: obtaining a sample comprising 134-278, obtaining a sample comprising 136-278, contacting said antibody with 134-278, contacting said antibody with 136-278, quantifying the level of antibody binding to 134-278 and to 136-278 by

15 ELISA. Still further particularly included are methods of selecting monoclonal antibodies, wherein said monoclonal antibody specifically binds to 115-259 but not to 117-259 of SEQ ID NO: 6 comprising the steps of: obtaining a sample comprising 115-259, obtaining a sample comprising 117-259, contacting said antibody with 115-259, contacting said antibody with 117-259, quantifying the level of antibody binding to 115-259 and to 117-259 by ELISA. Still further particularly

20 included are methods of selecting monoclonal antibodies, wherein said monoclonal antibody specifically binds to 162-288 but not to 164-288 of SEQ ID NO: 2 comprising the steps of: obtaining a sample comprising 162-288, obtaining a sample comprising 164-288, contacting said antibody with 162-288, contacting said antibody with 164-288, quantifying the level of antibody binding to 162-288 and to 164-288 by ELISA. Still further particularly included are methods of

25 selecting monoclonal antibodies, wherein said monoclonal antibody specifically binds to 152-278 but not to 154-278 of SEQ ID NO: 4 comprising the steps of: obtaining a sample comprising 152-278, obtaining a sample comprising 154-278, contacting said antibody with 152-278, contacting said antibody with 154-278, quantifying the level of antibody binding to 152-278 and to 154-278 by ELISA. Still further particularly included are methods of selecting monoclonal antibodies, wherein

30 said monoclonal antibody specifically binds to 133-259 but not to 135-259 of SEQ ID NO: 6 comprising the steps of: obtaining a sample comprising 133-259, obtaining a sample comprising 135-259, contacting said antibody with 133-259, contacting said antibody with 135-259, quantifying the level of antibody binding to 133-259 and to 135-259 by ELISA.

35 B. Polyclonal Antibody Production by Immunization

Polyclonal antiserum containing antibodies to heterogenous epitopes of a single protein can be prepared by immunizing suitable animals with the expressed protein or peptides derived

therefrom described above, which can be unmodified or modified to enhance immunogenicity. Effective polyclonal antibody production is affected by many factors related both to the antigen and the host species. For example, small molecules tend to be less immunogenic than others and may require the use of carriers and adjuvant. Also, host animals vary in response to site of inoculations and dose, with both inadequate or excessive doses of antigen resulting in low titer antisera. Small doses (ng level) of antigen administered at multiple intradermal sites appears to be most reliable. An effective immunization protocol for rabbits can be found in Vaitukaitis, J. et al. *J. Clin. Endocrinol. Metab.* 33:988-991 (1971).

Booster injections can be given at regular intervals, and antiserum harvested when antibody titer thereof, as determined semi-quantitatively, for example, by double immunodiffusion in agar against known concentrations of the antigen, begins to fall. See, for example, Ouchterlony, O. et al., Chap. 19 in: *Handbook of Experimental Immunology* D. Wier (ed) Blackwell (1973). Plateau concentration of antibody is usually in the range of 0.1 to 0.2 mg/ml of serum (about 12 μ M). Affinity of the antisera for the antigen is determined by preparing competitive binding curves, as described, for example, by Fisher, D., Chap. 42 in: *Manual of Clinical Immunology*, 2d Ed. (Rose and Friedman, Eds.) Amer. Soc. For Microbiol., Washington, D.C. (1980).

Antibody preparations prepared according to either protocol are useful in quantitative immunoassays which determine concentrations of antigen-bearing substances in biological samples; they are also used semi-quantitatively or qualitatively to identify the presence of antigen in a biological sample. The antibodies may also be used in therapeutic compositions for killing cells expressing the protein or reducing the levels of the protein in the body.

Other characteristics and advantages of the invention are described in the Brief Description of the Figures and the Examples. These are meant to be exemplary only, and not to limit the invention in any way. Throughout this application, various publications, patents and published patent applications are cited. The disclosures of these publications, patents and published patent specifications referenced in this application are hereby incorporated by reference into the present disclosure.

IX. Assays for Identifying Antagonists of Homotrimeric gGMG-2 Polypeptide Fragment Activity

The invention features methods of screening for one or more antagonist compounds that block N-terminal cleavage of GMG-2 polypeptide fragments by dipeptidyl peptidase. Preferred said compound is selected from but is not restricted to small molecular weight organic or inorganic compound, protein, peptide, carbohydrate, or lipid. Preferred said dipeptidyl peptidase is human plasma comprised of dipeptidyl peptidase. Preferred dipeptidyl peptidase is selected from but not restricted to human CD26 or human Attractin. Further preferred dipeptidyl peptidase is selected from but is not restricted to soluble human CD26 or soluble human Attractin. Soluble human CD26 is produced by recombinant means using methods well known to those of ordinary skill in the art.

(US Patent No. 6,265,551 which disclosure is hereby incorporated by reference in its entirety).

Soluble human Attractin is produced by recombinant means using methods well known to those of ordinary skill in the art (International Patent Application No. WO15651A1 which disclosure is hereby incorporated by reference in its entirety). Preferred said GMG-2 polypeptide fragment is

5 selected from amino acids 144-288 or 162-288 of SEQ ID NO: 2, or amino acids 134-278 or 152-278 of SEQ ID NO: 4, or amino acids 115-259 or 133-259 of SEQ ID NO: 6. Said dipeptidyl peptidase cleavage of said preferred GMG-2 polypeptide fragment (144-288) of SEQ ID NO: 2 removes the N-terminal dipeptide SP. Said dipeptidyl peptidase cleavage of said preferred GMG-2 polypeptide fragment (162-288) of SEQ ID NO: 2 removes the N-terminal dipeptide TA. Said
10 dipeptidyl peptidase cleavage of said preferred GMG-2 polypeptide fragment (134-278) of SEQ ID NO: 4 removes the N-terminal dipeptide SP. Said dipeptidyl peptidase cleavage of said preferred GMG-2 polypeptide fragment (152-278) of SEQ ID NO: 4 removes the N-terminal dipeptide TA. Said dipeptidyl peptidase cleavage of said preferred GMG-2 polypeptide fragment (115-259) of SEQ ID NO: 6 removes the N-terminal dipeptide SP. Said dipeptidyl peptidase cleavage of said preferred
15 GMG-2 polypeptide fragment (133-259) of SEQ ID NO: 6 removes the N-terminal dipeptide TA.

The invention further features methods of screening compounds for said antagonist of gGMG-2 polypeptide fragment activity comprising: a) contacting said homotrimeric gGMG-2 polypeptide fragment with or without said compound; b) detecting a result on the basis of activity, wherein said activity is selected from but not restricted to lipid partitioning, lipid metabolism, and
20 insulin-like activity; and c) wherein said result identifies said compound as an antagonist of homotrimeric gGMG-2 polypeptide fragment activity if said result with compound differs from said result without compound.

EXAMPLES

25 The following Examples are provided for illustrative purposes and not as a means of limitation. One of ordinary skill in the art would be able to design equivalent assays and methods based on the disclosure herein all of which form part of the instant invention.

It should be noted that the term full-length GMG-2 polypeptide used throughout the specification is intended to encompass the protein homologs mouse ACRP30 [Scherer, *et al.*, "A
30 novel serum protein similar to C1q, produced exclusively in adipocytes"; J Biol Chem 270, 26746-26749 (1995)], mouse AdipoQ [Hu, *et al.*, "AdipoQ is a novel adipose-specific gene dysregulated in obesity", J Biol Chem 271, 10697-10703 (1996)], human APM1 [Maeda, *et al.*, "cDNA cloning and expression of a novel adipose specific collagen-like factor, APM1 (AdiPose Most abundant Gene transcript 1)", Biochem Biophys Res Commun 221, 286-289 (1996)] and human GBP28 [Nakano, *et
35 al.*, "Isolation and characterization of GBP28, a novel gelatin-binding protein purified from human plasma", J Biochem (Tokyo) 120, 803-812 (1996)]. GMG-2 is also intended to encompass other

homologs. gGMG-2 is understood to refer to polypeptide fragments of full-length GMG-2 polypeptide comprised of the globular domain.

EXAMPLE 1: Northern Analysis of GMG-2 DNA

5 Analysis of GMG-2 expression in different human tissues (adult and fetal) and cell lines, as well as mouse embryos in different stages of development, is accomplished by using poly A⁺ RNA blots purchased from Clontech (e.g. #7780-1, 7757-1, 7756-1, 7768-1 and 7763-1). Labeling of RNA probes is performed using the RNA Strip-EZ kit from Ambion as per manufacturer's instructions. Hybridization of RNA probes to RNA blots is performed Ultrahyb hybridization solution (Ambion). Briefly, blots are prehybridized for 30 min at 58°C (low-stringency) or 65°C (high stringency). After adding the labeled probe (2x10⁶ cpm/ml), blots are hybridized overnight (14-24 hrs), and washed 2 x 20 min at 50°C with 2x SSC/0.1% SDS (low stringency), 2 x 20 min at 58°C with 1x SSC/0.1% SDS (medium stringency) and 2 x 20 min at 65°C with 1x SSC/0.1% SDS (high stringency). After washings are completed blots are exposed on the phosphoimager (Molecular Dynamics) for 1-3 days.

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EXAMPLE 2: In Vitro Tests of Metabolic-Related Activity

The activity of various preparations and various sequence variants of GMG-2 polypeptides are assessed using various *in vitro* assays including those provided below. These assays are also exemplary of those that can be used to develop GMG-2 polypeptide antagonists and agonists. To do that, the effect of GMG-2 polypeptides in the above assays, e.g. on leptin and/or LSR activity, in the presence of the candidate molecules would be compared with the effect of GMG-2 polypeptides in the assays in the absence of the candidate molecules. Since GMG-2 polypeptides are believed to reduce body weight in mice on a high-cafeteria diet (Example 5), these assays also serve to identify candidate treatments for reducing (or increasing) body weight.

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Liver Cell Line:

Tests of efficacy of GMG-2 polypeptides on LSR can be performed using liver cell lines, including for example, PLC, HepG2, Hep3B (human), Hepa 1-6, BPRCL (mouse), or MCA-RH777, MCA-RH8994 (rat).

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BPRCL mouse liver cells (ATCC Repository) are plated at a density of 300,000 cells/well in 6-well plates (day 0) in DMEM (high glucose) containing glutamine and penicillin-streptomycin (Bihain & Yen, 1992). Media is changed on day 2. On day 3, the confluent monolayers are washed once with phosphate-buffered saline (PBS, pH 7.4) (2 mL/well). Cells are incubated at 37°C for 30 min with increasing concentrations of recombinant AdipoQ (AQ) or globular AdipoQ (AQ-GH) in DMEM containing 0.2% (w/v) BSA, 5 mM Hepes, 2 mM CaCl₂, 3.7 g/L sodium bicarbonate, pH 7.5. Incubations are continued for 3 h at 37°C after addition of 10 ng/ml ¹²⁵I-mouse leptin (specific activity, 22100 cpm/ng). Monolayers are washed 2 times consecutively with PBS containing 0.2%

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BSA, followed by 1 wash with PBS/BSA, and then 2 times consecutively with PBS. Cells are lysed with 0.1 N NaOH containing 0.24 mM EDTA. Lysates are collected into tubes, and counted in a gamma-counter.

5 **Blood Brain Barrier Model:**

The effect of GMG-2 polypeptides on leptin transport in the brain can be determined using brain-derived cells. One method that is envisioned is to use the blood/brain barrier model described by Dehouck, *et al* (J Neurochem 54:1798-801, 1990; hereby incorporated herein by reference in its entirety including any figures, tables, or drawings) that uses a co-culture of brain capillary

10 endothelial cells and astrocytes to test the effects of GMG-2 polypeptides on leptin (or other molecules) transport via LSR or other receptors.

This assay would be an indicator of the potential effect of GMG-2 polypeptides on leptin transport to the brain and could be used to screen GMG-2 polypeptide variants for their ability to modulate leptin transport through LSR or other receptors in the brain. In addition, putative agonists 15 and antagonists of the effect of GMG-2 polypeptides on leptin transport through LSR or other receptors could also be screened using this assay. Increased transport of leptin across the blood/brain barrier would presumably increase its action as a satiety factor.

FACS Analysis of LSR Expression

20 The effect of GMG-2 polypeptides on LSR can also be determined by measuring the level of LSR expression at the cell surface by flow surface cytometry, using anti-LSR antibodies and fluorescent secondary antibodies. Flow cytometry is a laser-based technology that is used to measure characteristics of biological particles. The underlying principle of flow cytometry is that light is scattered and fluorescence is emitted as light from the excitation source strikes the moving 25 particles.

This is a high through-put assay that could be easily adapted to screen GMG-2 polypeptides and variants as well as putative agonists or antagonists of GMG-2 polypeptides. Two assays are provided below. The antibody, cell-line and GMG-2 polypeptide analogs would vary depending on the experiment, but a human cell-line, human anti-LSR antibody and globular GMG-2 could be used 30 to screen for variants, agonists, and antagonists to be used to treat humans.

Assay 1:

Cells are pretreated with either intact GMG-2 polypeptides (or untreated) before harvesting and analysis by FACS. Cells are harvested using non-enzymatic dissociation solution (Sigma), and then are incubated for 1 h at 4°C with a 1:200 dilution of anti-LSR 81B or an irrelevant anti-serum 35 in PBS containing 1% (w/v) BSA. After washing twice with the same buffer, goat anti-rabbit FITC-conjugated antibody (Rockland, Gilbertsville, PA) is added to the cells, followed by a further incubation for 30 min at 4 °C. After washing, the cells are fixed in 2% formalin. Flow cytometry analysis is done on a FACSCalibur cytometer (Becton-Dickinson, Franklin Lakes, NJ).

Assay 2:

Cells are cultured in T175 flasks according to manufacturer's instructions for 48 hours prior to analysis.

Cells are washed once with FACS buffer (1x PBS/2% FBS, filter sterilized), and manually scraped from the flask in 10 mLs of FACS buffer. The cell suspension is transferred to a 15 mL conical tube and centrifuged at 1200 rpm, 4°C for 5 minutes. Supernatant is discarded and cells are resuspended in 10 mL FACS buffer chilled to 4°C. A cell count is performed and the cell density adjusted with FACS buffer to a concentration of 1×10^6 cells/ mL. One milliliter of cell suspension was added to each well of a 48 well plate for analysis. Cells are centrifuged at 1200 rpm for 5 minutes at 4°C. Plates are checked to ensure that cells are pelleted, the supernatant is removed and cells resuspended by running plate over a vortex mixer. One milliliter of FACS buffer is added to each well, followed by centrifugation at 1200 rpm for 5 minutes at 4°C. This described cell washing was performed a total of 3 times.

Primary antibody, titered in screening experiments to determine proper working dilutions (for example 1:25, 1:50, 1:100, 1:200, 1:400, 1:500, 1:800, 1:1000, 1:2000, 1:4000, 1:5000, or 1:10000), is added to cells in a total volume of 50 μ L FACS buffer. Plates are incubated for 1h at 4°C protected from light. Following incubation, cells are washed 3 times as directed above. Appropriate secondary antibody, titered in screening experiments to determine proper working dilutions (for example 1:25, 1:50, 1:100, 1:200, 1:400, 1:500, 1:800, 1:1000, 1:2000, 1:4000, 1:5000, or 1:10000), is added to cells in a total volume of 50 μ L FACS buffer. Plates are incubated for 1h at 4°C protected from light. Following incubation, cells are washed 3 times as directed above. Upon final wash, cells are resuspended in 500 μ L FACS buffer and transferred to a FACS acquisition tube. Samples are placed on ice protected from light and analyzed within 1 hour.

25 Cellular Binding and Uptake of GMG-2 Polypeptides as Detected by Fluorescence Microscopy

Fluorescein isothiocyanate (FITC) conjugation of GMG-2 polypeptides: Purified GMG-2 proteins at 1 mg/mL concentration are labeled with FITC using Sigma's FluoroTag FITC conjugation kit (Stock No. FITC-1). Protocol outlined in the Sigma Handbook for small scale conjugation is followed for GMG-2 protein labeling.

30 Cell Culture: C2C12 mouse skeletal muscle cells (ATCC, Manassas, VA CRL-1772) and Hepa-1-6 mouse hepatocytes (ATCC, Manassas, VA CRL-1830) are seeded into 6 well plates at a cell density of 2×10^5 cells per well. C2C12 and Hepa-1-6 cells are cultured according to repository's instructions for 24-48 hours prior to analysis. Assay is performed when cells were 80% confluent.

35 FITC labeled GMG-2 protein cellular binding and uptake using microscopy: C2C12 and Hepa 1-6 cells are incubated in the presence/absence of antibody directed against human LSR (81B: N-terminal sequence of human LSR; does not cross react with mouse LSR and 93A: c-terminal sequence, cross reacts with mouse LSR) or an antiserum directed against gC1qr (953) for 1 hour at

37°C, 5% CO₂. LSR antibodies are added to the media at a concentration of 2 µg/mL. The anti-gC1qr antiserum is added to the media at a volume of 2.5 µL undiluted serum (high concentration) or 1:100 dilution (low concentration). Following incubation with specified antibody, FITC-GMG-2 polypeptide (50 nM/mL) is added to each cell culture well. Cells are again incubated for 1 hour at 5 37°C, 5% CO₂. Cells are washed 2x with PBS, cells are scraped from well into 1 mL of PBS. Cell suspension is transferred to an eppendorf tube and centrifuged at 1000 rpm for 2 minutes. Supernatant is removed and cells resuspended in 200 µL of PBS. Binding and uptake of FITC-GMG-2 polypeptide is analyzed by fluorescence microscopy under 40X magnification.

This assay may be useful for identifying agents that facilitate or prevent the uptake and/or 10 binding of GMG-2 polypeptides to cells.

Effect on LSR as a Lipoprotein Receptor

The effect of GMG-2 protein on the lipoprotein binding, internalizing and degrading activity of LSR can also be tested. Measurement of LSR as lipoprotein receptor is described in Bihain & 15 Yen, ((1992) Biochemistry May 19;31(19):4628-36; hereby incorporated herein in its entirety including any drawings, tables, or figures). The effect of GMG-2 protein on the lipoprotein binding, internalizing and degrading activity of LSR (or other receptors) can be compared with that of intact GMG-2 protein, with untreated cells as an additional control. This assay can also be used to screen 20 for active and inhibitory variants of GMG-2 protein, as well as agonists and antagonists of metabolic-related activity.

Human liver PLC cells (ATCC Repository) are plated at a density of 300,000 cells/well in 6-well plates (day 0) in DMEM (high glucose) containing glutamine and penicillin-streptomycin (Bihain & Yen, 1992). Media is changed on day 2. On day 3, the confluent monolayers are washed once with phosphate-buffered saline (PBS, pH 7.4) (2 mL/well). Cells are incubated at 37°C for 30 25 min with 10 ng/mL human recombinant leptin in DMEM containing 0.2% (w/v) BSA, 5 mM Hepes, 2 mM CaCl₂, 3.7 g/L sodium bicarbonate, pH 7.5, followed by another 30 min incubation at 37°C with increasing concentrations of GMG-2 polypeptide. Incubations are continued for 2 h at 37°C after addition of 0.8 mM oleate and 20 µg/mL ¹²⁵I-LDL. Monolayers are washed 2 times consecutively with PBS containing 0.2% BSA, followed by 1 wash with PBS/BSA, and then 2 times 30 consecutively with PBS. The amounts of oleate-induced binding, uptake and degradation of ¹²⁵I-LDL are measured as previously described (Bihain & Yen, 1992, supra). Results are shown as the mean of triplicate determinations.

The inventors believe the addition of GMG-2 protein leads to an increased activity of LSR as a lipoprotein receptor. The oleate-induced binding and uptake of LDL would be more affected by 35 GMG-2 protein compared to the degradation. This increased LSR activity would potentially result in an enhanced clearance of triglyceride-rich lipoproteins during the postprandial state. Thus, more dietary fat would be removed through the liver, rather than being deposited in the adipose tissue.

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This assay could be used to determine the efficiency of a compound (or agonists or antagonists) to increase or decrease LSR activity (or lipoprotein uptake, binding and degradation through other receptors), and thus affect the rate of clearance of triglyceride-rich lipoproteins.

5 Effect on Muscle Differentiation

C2C12 cells (murine skeletal muscle cell line; ATCC CRL 1772, Rockville, MD) are seeded sparsely (about 15-20%) in complete DMEM (w/glutamine, pen/strep, etc) + 10% FCS. Two days later they become 80-90% confluent. At this time, the media is changed to DMEM+2% horse serum to allow differentiation. The media is changed daily. Abundant myotube formation occurs after 3-4 days of being in 2% horse serum, although the exact time course of C2C12 differentiation depends on how long they have been passaged and how they have been maintained, among other things.

To test the effect of the presence of GMG-2 protein on muscle differentiation, GMG-2 (1 to 2.5 μ g/mL) is added the day after seeding when the cells are still in DMEM w/ 10% FCS. Two days after plating the cells (one day after GMG-2 was first added), at about 80-90% confluency, the media is changed to DMEM+2% horse serum plus GMG-2.

Effect on Muscle Cell Fatty Acid Oxidation

C2C12 cells are differentiated in the presence or absence of 2 μ g/mL GMG-2 protein for 4 days. On day 4, oleate oxidation rates are determined by measuring conversion of 1-¹⁴C-oleate (0.2 mM) to ¹⁴CO₂ for 90 min. This experiment can be used to screen for active polypeptides and peptides as well as agonists and antagonists or activators and inhibitors of GMG-2 polypeptides.

The effect of GMG-2 on the rate of oleate oxidation can be compared in differentiated C2C12 cells (murine skeletal muscle cells; ATCC, Manassas, VA CRL-1772) and in a hepatocyte cell line (Hepa1-6; ATCC, Manassas, VA CRL-1830). Cultured cells are maintained according to manufacturer's instructions. The oleate oxidation assay is performed as previously described (Muonio et al (1999) Biochem J 338;783-791). Briefly, nearly confluent myocytes are kept in low serum differentiation media (DMEM, 2.5% Horse serum) for 4 days, at which time formation of myotubes became maximal. Hepatocytes are kept in the same DMEM medium supplemented with 10% FCS for 2 days. One hour prior to the experiment the media is removed and 1 mL of preincubation media (MEM, 2.5% Horse serum, 3 mM glucose, 4 mM Glutamine, 25 mM Hepes, 1% FFA free BSA, 0.25 mM Oleate, 5 μ g/mL gentamycin) is added. At the start of the oxidation experiment ¹⁴C-Oleic acid (1 μ Ci/mL, American Radiolabeled Chemical Inc., St. Louis, MO) is added and cells are incubated for 90 min at 37°C in the absence/presence of 2.5 μ g/mL GMG-2. After the incubation period 0.75 mL of the media is removed and assayed for ¹⁴C-oxidation products as described below for the muscle FFA oxidation experiment.

Triglyceride and Protein Analysis following Oleate Oxidation in cultured cells

Following transfer of media for oleate oxidation assay, cells are placed on ice. To determine triglyceride and protein content, cells are washed with 1 mL of 1x PBS to remove residual media. To each well 300 μ L of cell dissociation solution (Sigma) is added and incubated at 37°C for 10 min.

- 5 Plates are tapped to loosen cells, and 0.5 mL of 1x PBS was added. The cell suspension is transferred to an eppendorf tube, each well is rinsed with an additional 0.5 mL of 1x PBS, and is transferred to appropriate eppendorf tube. Samples are centrifuged at 1000 rpm for 10 minutes at room temperature. Supernatant is discarded and 750 μ L of 1x PBS/2% chaps is added to cell pellet. Cell suspension is vortexed and placed on ice for 1 hour. Samples are then centrifuged at 13000 rpm
- 10 for 20 min at 4°C. Supernatants are transferred to new tube and frozen at -20°C until analyzed. Quantitative measure of triglyceride level in each sample is determined using Sigma Diagnostics GPO-TRINDER enzymatic kit. The procedure outlined in the manual is adhered to, with the following exceptions: assay is performed in 48 well plate, 350 μ L of sample volume was assayed, control blank consisted of 350 μ L PBS/2% chaps, and standard contained 10 μ L standard provide in
- 15 kit plus 690 μ L PBS/2% chaps. Analysis of samples is carried out on a Packard Spectra Count at a wavelength of 550 nm. Protein analysis is carried out on 25 μ L of each supernatant sample using the BCA protein assay (Pierce) following manufacturer's instructions. Analysis of samples is carried out on a Packard Spectra Count at a wavelength of 550 nm.

20 In Vitro Glucose Uptake by Muscle Cells

L6 Muscle cells are obtained from the European Culture Collection (Porton Down) and are used at passages 7-11. Cells are maintained in standard tissue culture medium DMEM, and glucose uptake is assessed using [³H]-2-deoxyglucose (2DG) with or without GMG-2 polypeptide fragment in the presence or absence of insulin (10^{-8} M) as has been previously described (Walker, P.S. et al. 1990) Glucose transport activity in L6 muscle cells is regulated by the coordinate control of subcellular glucose transporter distribution, biosynthesis, and mRNA transcription. JBC 265(3):1516-1523; and Kilp, A. et al. (1992) Stimulation of hexose transport by metformin in L6 muscle cells in culture. Endocrinology 130(5):2535-2544, which disclosures are hereby incorporated by reference in their entireties). Uptake of 2DG is expressed as the percentage change compared 30 with control (no added insulin or GMG-2 polypeptide fragment). Values are presented as mean \pm SEM of sets of 4 wells per experiment. Differences between sets of wells are evaluated by Student's t test, probability values $p < 0.05$ are considered to be significant.

EXAMPLE 3: Effect of GMG-2 Polypeptides on Mice Fed a High-Fat Diet

35 Experiments are performed using approximately 6 week old C57Bl/6 mice (8 per group). All mice are housed individually. The mice are maintained on a high fat diet throughout each experiment. The high fat diet (cafeteria diet; D12331 from Research Diets, Inc.) has the following

composition: protein kcal% 16, sucrose kcal% 26, and fat kcal% 58. The fat is primarily composed of coconut oil, hydrogenated.

After the mice are fed a high fat diet for 6 days, micro-osmotic pumps are inserted using isoflurane anesthesia, and are used to provide full-length GMG-2 polypeptides, GMG-2 polypeptide 5 fragments, saline, and an irrelevant peptide to the mice subcutaneously (s.c.) for 18 days. GMG-2 polypeptides are provided at doses of 100, 50, 25, and 2.5 µg/day and the irrelevant peptide is provided at 10 µg/day. Body weight is measured on the first, third and fifth day of the high fat diet, and then daily after the start of treatment. Final blood samples are taken by cardiac puncture and are used to determine triglyceride (TG), total cholesterol (TC), glucose, leptin, and insulin levels. The 10 amount of food consumed per day is also determined for each group.

EXAMPLE 4: Tests of Metabolic-related Activity in Humans

Tests of the efficacy of GMG-2 polypeptides in humans are performed in accordance with a physician's recommendations and with established guidelines. The parameters tested in mice are 15 also tested in humans (e.g. food intake, weight, TG, TC, glucose, insulin, leptin, FFA). It is expected that the physiological factors would show changes over the short term. Changes in weight gain might require a longer period of time. In addition, the diet would need to be carefully monitored. GMG-2 polypeptides, preferably GMG-2 polypeptides comprising the C1q homology region, would be given in daily doses of about 6 mg protein per 70 kg person or about 10 mg per 20 day. Other doses would also be tested, for instance 1 mg or 5 mg per day up to 20 mg, 50 mg, or 100 mg per day.

EXAMPLE 5: Tests of Metabolic-related Activity in a Murine Lipoatrophic Diabetes Model

Previously, leptin was reported to reverse insulin resistance and diabetes mellitus in mice 25 with congenital lipodystrophy (Shimomura et al. *Nature* 401: 73-76 (1999); hereby incorporated herein in its entirety including any drawings, figures, or tables). Leptin was found to be less effective in a different lipodystrophic mouse model of lipoatrophic diabetes (Gavrilova et al *Nature* 403: 850 (2000); hereby incorporated herein in its entirety including any drawings, figures, or tables). The instant invention encompasses the use of GMG-2 polypeptides for reducing the insulin 30 resistance and hyperglycaemia in this model either alone or in combination with leptin, the leptin peptide (US provisional application No 60/155,506), or other compounds. Assays include that described previously in Gavrilova et al. ((2000) *Diabetes* Nov;49(11):1910-6; (2000) *Nature* Feb 24;403(6772):850) using Δ-ZIP/F-1 mice, except that GMG-2 polypeptides would be administered using the methods previously described in Example 3 (or Examples 6-8). The glucose and insulin 35 levels of the mice would be tested, and the food intake and liver weight monitored, as well as other factors, such as leptin, FFA, and TG levels, typically measured in our experiments (see Example 3, above, or Examples 6-8).

EXAMPLE 6: Effect of GMG-2 Polypeptides on Plasma Free Fatty Acid in C57 BL/6 Mice

The effect of GMG-2 polypeptides on postprandial lipemia (PPL) in normal C57BL6/J mice is tested.

5 The mice used in this experiment are fasted for 2 hours prior to the experiment after which a baseline blood sample is taken. All blood samples are taken from the tail using EDTA coated capillary tubes (50 μ L each time point). At time 0 (8:30 AM), a standard high fat meal (6g butter, 6 g sunflower oil, 10 g nonfat dry milk, 10 g sucrose, 12 mL distilled water prepared fresh following Nb#6, JF, pg.1) is given by gavage (vol.=1% of body weight) to all animals.

10 Immediately following the high fat meal, 25 μ g a GMG-2 polypeptide is injected i.p. in 100 μ L saline. The same dose (25 μ g/mL in 100 μ L) is again injected at 45 min and at 1 hr 45 min. Control animals are injected with saline (3x100 μ L). Untreated and treated animals are handled in an alternating mode.

Blood samples are taken in hourly intervals, and are immediately put on ice. Plasma is 15 prepared by centrifugation following each time point. Plasma is kept at -20°C and free fatty acids (FFA), triglycerides (TG) and glucose are determined within 24 hours using standard test kits (Sigma and Wako). Due to the limited amount of plasma available, glucose is determined in duplicate using pooled samples. For each time point, equal volumes of plasma from all 8 animals per treatment group are pooled.

20 EXAMPLE 7: Effect of GMG-2 Polypeptides on Plasma Leptin and Insulin in C57 BL/6 Mice
The effect of GMG-2 polypeptides on plasma leptin and insulin levels during postprandial lipemia (PPL) in normal C57BL6/J mice is tested. The experimental procedure is the same as that described in Example 6, except that blood is drawn only at 0, 2 and 4 hours to allow for greater 25 blood samples needed for the determination of leptin and insulin by RIA.

Briefly, 16 mice are fasted for 2 hours prior to the experiment after which a baseline blood sample is taken. All blood samples are taken from the tail using EDTA coated capillary tubes (100 μ L each time point). At time 0 (9:00AM), a standard high fat meal (see Example 6) is given by gavage (vol.=1% of body weight) to all animals. Immediately following the high fat meal, 25 μ g of 30 a GMG-2 polypeptide is injected i.p. in 100 μ L saline. The same dose (25 μ g in 100 μ L) is again injected at 45 min and at 1 hr 45 min (treated group). Control animals are injected with saline (3x100 μ L). Untreated and treated animals are handled in an alternating mode.

Blood samples are immediately put on ice and plasma is prepared by centrifugation 35 following each time point. Plasma is kept at -20°C and free fatty acids (FFA) are determined within 24 hours using a standard test kit (Wako). Leptin and Insulin are determined by RIA (ML-82K and SRI-13K, LINCO Research, Inc., St. Charles, MO) following the manufacturer's protocol. However, only 20 μ L plasma is used. Each determination is done in duplicate. Due to the limited

amount of plasma available, leptin and insulin are determined in 4 pools of 2 animals each in both treatment groups.

EXAMPLE 8: Effect of GMG-2 Polypeptides on Plasma FFA, TG and Glucose in C57 BL/6 Mice

5 The effect of GMG-2 polypeptides on plasma FFA, TG, glucose, leptin and insulin levels during postprandial lipemia (PPL) in normal C57BL6/J mice has been described. Weight loss resulting from GMG-2 polypeptides (2.5 μ g/day) given to normal C57BL6/J mice on a high fat diet has also been shown (Example 3).

10 The experimental procedure is similar to that described in Example 6. Briefly, 14 mice re fasted for 2 hours prior to the experiment after which a baseline blood sample is taken. All blood samples are taken from the tail using EDTA coated capillary tubes (50 μ L each time point). At time 0 (9:00AM), a standard high fat meal (see Example 6) is given by gavage (vol.=1% of body weight) to all animals. Immediately following the high fat meal, 4 mice are injected 25 μ g of a GMG-2 polypeptide i.p. in 100 μ L saline. The same dose (25 μ g in 100 μ L) is again injected at 45 min and at 15 1 hr 45 min. A second treatment group receives 3 times 50 μ g GMG-2 polypeptide at the same intervals. Control animals are injected with saline (3x100 μ L). Untreated and treated animals are handled in an alternating mode.

20 Blood samples are immediately put on ice. Plasma is prepared by centrifugation following each time point. Plasma is kept at -20 °C and free fatty acids (FFA), triglycerides (TG) and glucose are determined within 24 hours using standard test kits (Sigma and Wako).

EXAMPLE 9: Effect of GMG-2 Polypeptides on FFA following Epinephrine Injection

25 In mice, plasma free fatty acids increase after intragastric administration of a high fat/sucrose test meal. These free fatty acids are mostly produced by the activity of lipolytic enzymes *i.e.* lipoprotein lipase (LPL) and hepatic lipase (HL). In this species, these enzymes are found in significant amounts both bound to endothelium and freely circulating in plasma. Another source of plasma free fatty acids is hormone sensitive lipase (HSL) that releases free fatty acids from adipose tissue after β -adrenergic stimulation. To test whether GMG-2 polypeptides also regulate the metabolism of free fatty acid released by HSL, mice are injected with epinephrine.

30 Two groups of mice are given epinephrine (5 μ g) by intraperitoneal injection. A treated group is injected with a GMG-2 polypeptide (25 μ g) one hour before and again together with epinephrine, while control animals receive saline. Plasma is isolated and free fatty acids and glucose are measured as described above (Example 8).

35 EXAMPLE 10: Effect of GMG-2 Polypeptides on Muscle FFA Oxidation

To investigate the effect of GMG-2 polypeptides on muscle free fatty acid oxidation, intact hind limb muscles from C57BL/6J mice are isolated and FFA oxidation is measured using oleate as

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substrate (Clee, S. M. *et al.* Plasma and vessel wall lipoprotein lipase have different roles in atherosclerosis. *J Lipid Res* 41, 521-531 (2000); Muoio, D. M., Dohm, G. L., Tapscott, E. B. & Coleman, R. A. Leptin opposes insulin's effects on fatty acid partitioning in muscles isolated from obese ob/ob mice. *Am J Physiol* 276, E913-921 (1999)) Oleate oxidation in isolated muscle is measured as previously described (Cuendet *et al* (1976) *J Clin Invest* 58:1078-1088; Le Marchand-Brustel, Y., Jeanrenaud, B. & Freychet, P. Insulin binding and effects in isolated soleus muscle of lean and obese mice. *Am J Physiol* 234, E348-E358 (1978). Briefly, mice are sacrificed by cervical dislocation and soleus and EDL muscles are rapidly isolated from the hind limbs. The distal tendon of each muscle is tied to a piece of suture to facilitate transfer among different media. All incubations are carried out at 30°C in 1.5 mL of Krebs-Henseleit bicarbonate buffer (118.6 mM NaCl, 4.76 mM KCl, 1.19 mM KH₂PO₄, 1.19 mM MgSO₄, 2.54 mM CaCl₂, 25mM NaHCO₃, 10 mM Hcpes, pH 7.4) supplemented with 4% FFA free bovine serum albumin (fraction V, RIA grade, Sigma) and 5 mM glucose (Sigma). The total concentration of oleate (Sigma) throughout the experiment is 0.25 mM. All media are oxygenated (95% O₂; 5% CO₂) prior to incubation. The gas mixture is hydrated throughout the experiment by bubbling through a gas washer (Kontes Inc., Vineland, NJ).

Muscles are rinsed for 30 min in incubation media with oxygenation. The muscles are then transferred to fresh media (1.5 mL) and incubated at 30°C in the presence of 1 μ Ci/mL [1-¹⁴C] oleic acid (American Radiolabeled Chemicals). The incubation vials containing this media are sealed with a rubber septum from which a center well carrying a piece of Whatman paper (1.5 cm x 11.5 cm) is suspended.

After an initial incubation period of 10min with constant oxygenation, gas circulation is removed to close the system to the outside environment and the muscles are incubated for 90 min at 30°C. At the end of this period, 0.45 mL of Solvable (Packard Instruments, Meriden, CT) is injected onto the Whatman paper in the center well and oleate oxidation by the muscle is stopped by transferring the vial onto ice.

After 5 min, the muscle is removed from the medium, and an aliquot of 0.5 mL medium is also removed. The vials are closed again and 1 mL of 35% perchloric acid is injected with a syringe into the media by piercing through the rubber septum. The CO₂ released from the acidified media is collected by the Solvable in the center well. After a 90 min collection period at 30°C, the Whatman paper is removed from the center well and placed in scintillation vials containing 15 mL of scintillation fluid (HionicFlour, Packard Instruments, Meriden, CT). The amount of ¹⁴C radioactivity is quantitated by liquid scintillation counting. The rate of oleate oxidation is expressed as nmol oleate produced in 90min/g muscle.

To test the effect of GMG-2 on oleate oxidation, these proteins are added to the media at a final concentration of 2.5 μ g/mL and maintained in the media throughout the procedure.

EXAMPLE 11: Effect of GMG-2 Polypeptides on Triglyceride in Muscle & Liver Isolated from Mice

To determine whether the increased FFA oxidation induced by GMG-2 polypeptides is also accompanied by increased FFA delivery into muscle or liver, the hindlimb muscle and liver triglyceride content is measured after the GMG-2 polypeptide treatment of mice. Hind limb muscles as well as liver samples are removed from treated and untreated animals and the triglyceride and free fatty acid concentration is determined following a standard lipid extraction method (Shimabukuro, M. *et al.* Direct antidiabetic effect of leptin through triglyceride depletion of tissues. *Proc Natl Acad Sci U S A* 94, 4637-4641 (1997)) followed by TG and FFA analysis using standard test kits.

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EXAMPLE 12: Effect of GMG-2 Polypeptides on FFA following Intralipid Injection

Two groups of mice are intravenously (tail vein) injected with 30 μ L bolus of Intralipid-20% (Clintec) to generate a sudden rise in plasma FFAs, thus by-passing intestinal absorption. (Intralipid is an intravenous fat emulsion used in nutritional therapy). A treated group (GMG-2 polypeptide-treated) is injected with a GMG-2 polypeptide (25 μ g) at 30 and 60 minutes before Intralipid is given, while control animals (σ control) received saline. Plasma is isolated and FFAs are measured as described previously. The effect of GMG-2 polypeptides on the decay in plasma FFAs following the peak induced by Intralipid injection is then monitored.

20 EXAMPLE 13: *In Vitro* Glucose Uptake by Muscle Cells

L6 Muscle cells are obtained from the European Culture Collection (Porton Down) and are used at passages 7-11. Cells are maintained in standard tissue culture medium DMEM, and glucose uptake is assessed using [3 H]-2-deoxyglucose (2DG) with or without GMG-2 polypeptides in the presence or absence of insulin (10. μ M) as has been previously described (Walker, P.S. et al. (1990) Glucose transport activity in L6 muscle cells is regulated by the coordinate control of subcellular glucose transporter distribution, biosynthesis, and mRNA transcription. *JBC* 265(3):1516-1523; and Kilp, A. *et al.* (1992) Stimulation of hexose transport by metformin in L6 muscle cells in culture. *Endocrinology* 130(5):2535-2544, which disclosures are hereby incorporated by reference in their entireties). Uptake of 2DG is expressed as the percentage change compared with control (no added insulin or GMG-2). Values are presented as mean \pm SEM of sets of 4 wells per experiment. Differences between sets of wells are evaluated by Student's t test, probability values $p < 0.05$ are considered to be significant.

EXAMPLE 14: *In Vivo* Tests for Metabolic-related Activity in Rodent Diabetes Models

35 As metabolic profiles differ among various animal models of obesity and diabetes, analysis of multiple models is undertaken to separate the effects GMG-2 polypeptides on hyperglycemia, hyperinsulinemia, hyperlipidemia and obesity. Mutation in colonies of laboratory animals and

different sensitivities to dietary regimens have made the development of animal models with non-insulin dependent diabetes associated with obesity and insulin resistance possible. Genetic models such as db/db and ob/ob (See Diabetes, (1982) 31(1): 1-6) in mice and fa/fa in zucker rats have been developed by the various laboratories for understanding the pathophysiology of disease and testing the efficacy of new antidiabetic compounds (Diabetes, (1983) 32: 830-838; Annu. Rep. Sankyo Res. Lab. (1994). 46: 1-57). The homozygous animals, C57 BL/KsJ-db/db mice developed by Jackson Laboratory, US, are obese, hyperglycemic, hyperinsulinemic and insulin resistant (J. Clin. Invest., (1990) 85: 962-967), whereas heterozygous are lean and normoglycemic. In db/db model, mouse progressively develops insulinopenia with age, a feature commonly observed in late stages of human type II diabetes when blood sugar levels are insufficiently controlled. The state of pancreas and its course vary according to the models. Since this model resembles that of type II diabetes mellitus, the compounds of the present invention are tested for blood sugar and triglycerides lowering activities. Zucker (fa/fa) rats are severely obese, hyperinsulinemic, and insulin resistant (Coleman, Diabetes 31:1, 1982; E. Shafir, in Diabetes Mellitus; H. Rifkin and D. Porte, Jr. Eds. (Elsevier Science Publishing Co., Inc., New York, ed. 4, 1990), pp. 299-340), and the fa/fa mutation may be the rat equivalent of the murine db mutation (Friedman et al., Cell 69:217-220, 1992; Truett et al., Proc. Natl. Acad. Sci. USA 88:7806, 1991). Tubby (tub/tub) mice are characterized by obesity, moderate insulin resistance and hyperinsulinemia without significant hyperglycemia (Coleman et al., J. Heredity 81:424, 1990).

Previously, leptin was reported to reverse insulin resistance and diabetes mellitus in mice with congenital lipodystrophy (Shimomura et al. Nature 401: 73-76 (1999). Leptin is found to be less effective in a different lipodystrophic mouse model of lipoatrophic diabetes (Gavrilova et al. Nature 403: 850 (2000); hereby incorporated herein in its entirety including any drawings, figures, or tables).

The streptozotocin (STZ) model for chemically-induced diabetes is tested to examine the effects of hyperglycemia in the absence of obesity. STZ-treated animals are deficient in insulin and severely hyperglycemic (Coleman, Diabetes 31:1, 1982; E. Shafir, in Diabetes Mellitus; H. Rifkin and D. Porte, Jr. Eds. (Elsevier Science Publishing Co., Inc., New York, ed. 4, 1990), pp. 299-340). The monosodium glutamate (MSG) model for chemically-induced obesity (Olney, Science 164:719, 1969; Cameron et al., Cli. Exp. Pharmacol. Physiol. 5:41, 1978), in which obesity is less severe than in the genetic models and develops without hyperphagia, hyperinsulinemia and insulin resistance, is also examined. Finally, a non-chemical, non-genetic model for induction of obesity includes feeding rodents a high fat/high carbohydrate (cafeteria diet) diet ad libitum.

The instant invention encompasses the use of GMG-2 polypeptides for reducing the insulin resistance and hyperglycemia in any or all of the above rodent diabetes models or in humans with Type I or Type II diabetes or other preferred metabolic diseases described previously or models based on other mammals. In the compositions of the present invention the GSSP4 polypeptides may, if

desired, be associated with other compatible pharmacologically-active antidiabetic agents such as insulin, leptin (US provisional application No 60/155,506), or troglitazone, either alone or in combination. Assays include that described previously in Gavrilova et al. (2000) *Diabetes Nov*;49(11):1910-6; (2000) *Nature Feb* 24;403(6772):850 using Δ -ZIP/F-1 mice, except that 5 GSSP4 polypeptides are administered intraperitoneally, subcutaneously, intramuscularly or intravenously. The glucose and insulin levels of the mice would be tested, and the food intake and liver weight monitored, as well as other factors, such as leptin, FFA, and TG levels, typically measured in our experiments.

In Vivo Assay for Anti-hyperglycemic Activity of GMG-2 polypeptides

10 Genetically altered obese diabetic mice (db/db) (male, 7-9 weeks old) are housed (7-9 mice/cage) under standard laboratory conditions at 22.degree. C. and 50% relative humidity, and maintained on a diet of Purina rodent chow and water ad libitum. Prior to treatment, blood is collected from the tail vein of each animal and blood glucose concentrations are determined using One Touch BasicGlucose Monitor System (Lifescan). Mice that have plasma glucose levels 15 between 250 to 500 mg/dl are used. Each treatment group consists of seven mice that are distributed so that the mean glucose levels are equivalent in each group at the start of the study. db/db mice are dosed by micro-osmotic pumps, inserted using isoflurane anesthesia, to provide GMG-2 polypeptides, saline, and an irrelevant peptide to the mice subcutaneously (s.c.). Blood is sampled from the tail vein hourly for 4 hours and at 24, 30 h post-dosing and analyzed for blood glucose 20 concentrations. Food is withdrawn from 0-4 h post dosing and reintroduced thereafter. Individual body weights and mean food consumption (each cage) are also measured after 24 h. Significant differences between groups (comparing GMG-2 treated to saline-treated) are evaluated using Student t-test.

In Vivo Insulin Sensitivity Assay

25 In vivo insulin sensitivity is examined by utilizing two-step hyperinsulinemic-euglycemic clamps according to the following protocol. Rodents from any or all of the various models described in Example 2 are housed for at least a week prior to experimental procedures. Surgeries for the placement of jugular vein and carotid artery catheters are performed under sterile conditions using ketamine and xylazine (i.m.) anesthesia. After surgery, all rodents are allowed to regain 30 consciousness and placed in individual cages. GMG-2 polypeptides or vehicle is administered through the jugular vein after complete recovery and for the following two days. Sixteen hours after the last treatment, hyperinsulinemic-euglycemic clamps are performed. Rodents are placed in restrainers and a bolus of 4 .mu Ci [3-.sup.3 H] glucose (NEN) is administered, followed by a continuous infusion of the tracer at a dose of 0.2 .mu Ci/min (20 .mu l/min). Two hours after the 35 start of the tracer infusion, 3 blood samples (0.3 ml each) are collected at 10 minute intervals (-20-0 min) for basal measurements. An insulin infusion is then started (5 mU/kg/min), and 100 .mu l blood samples are taken every 10 min. to monitor plasma glucose. A 30% glucose solution is infused using

a second pump based on the plasma glucose levels in order to reach and maintain euglycemia. Once a steady state is established at 5 mU/kg/min insulin (stable glucose infusion rate and plasma glucose), 3 additional blood samples (0.3 ml each) are obtained for measurements of glucose, [3-^{sup.3}H] glucose and insulin (100-120 min.). A higher dose of insulin (25 mU/kg/min.) is then

5 administered and glucose infusion rates are adjusted for the second euglycemic clamp and blood samples are taken at min. 220-240. Glucose specific activity is determined in deproteinized plasma and the calculations of Rd and hepatic glucose output (HGO) are made, as described (Lang et al., Endocrinology 130:43, 1992). Plasma insulin levels at basal period and after 5 and 25 mU/kg/min. infusions are then determined and compared between GMG-2 treated and vehicle treated rodents.

10 Insulin regulation of glucose homeostasis has two major components; stimulation of peripheral glucose uptake and suppression of hepatic glucose output. Using tracer studies in the glucose clamps, it is possible to determine which portion of the insulin response is affected by the GMG-2 polypeptides.

15 **EXAMPLE 15: Assay for Dipeptidyl Peptidase Cleavage of GMG-2 Polypeptide Fragment**
Dipeptidyl peptidase cleavage of GMG-2 (144-288 or 162-288 of SEQ ID NO: 2, or 134-278 or 152-278 of SEQ ID NO: 4, or 115-259 or 133-259 of SEQ ID NO: 6) polypeptide fragment is determined by ELISA using a monoclonal antibody that specifically binds to intact GMG-2 polypeptide fragment but not to said GMG-2 polypeptide fragment from which the N-terminal

20 dipeptide EP has been removed. That is, said antibody binds to GMG-2 (144-288 or 162-288 of SEQ ID NO: 2, or 134-278 or 152-278 of SEQ ID NO: 4, or 115-259 or 133-259 of SEQ ID NO: 6) but not to GMG-2 (146-288 or 164-288 of SEQ ID NO: 2, or 136-278 or 154-278 of SEQ ID NO: 4, or 117-259 or 135-259 of SEQ ID NO: 6). Dipetidyl peptidase is selected from but not restricted to human plasma comprised of dipeptidyl peptidase, soluble human CD26, or soluble human Attractin.

25 Briefly, GMG-2 (5 µl, 100 fmol) is added to plasma samples (95 µl) and incubated for 1 h at 37°C, after which the amount of GMG-2 polypeptide fragment that remains undegraded is determined by enzyme-linked immunosorbent assay (ELISA) using a monoclonal antibody specific for intact GMG-2 polypeptide fragment. As a reference, GMG-2 polypeptide fragment (5 µl, 100 fmol) is added to heat-inactivated plasma (95 µl), which contains 0.01 mmol/l valine-pyrrolidide and 30 500 KIE/ml aprotinin. By defining the dipeptidyl peptidase activity in the reference as zero and comparing the amount of intact GMG-2 polypeptide fragment in the samples with the reference, the extent of dipeptidyl peptidase cleavage of GMG-2 polypeptide fragment is calculated relative to the reference and expressed as a percentage.

35 **EXAMPLE 16: Effect of gACRP30 on Maintenance of Weight Loss in Mice**

In order to demonstrate the weight loss maintaining properties of gACRP30, normal mice are put on a reduced calorie diet to promote weight loss. The reduced calorie diet is continued until

the mice lose 10% of their initial weight. A second group of mice are continued on the weight reduced diet until the mice lose 20% of their initial weight. The mice are then surgically implanted with an osmotic pump (Alzet, Newark, DE) delivering either 2.5 µg/day of gACRP30, 5µg/day of ACRP30, or physiological saline. The mice are returned to a normal diet and their body weights are recorded over a 10-day period. After 10 days, the result that mice that have been treated with gACRP30 have a lower weight than mice that were treated with saline will be taken to provide evidence that treatment with gACRP30 promotes the maintenance of weight loss.

EXAMPLE 17: Solubilization of GMG-2 and Fragments Thereof

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Vector construction: Polynucleotides encoding polypeptides selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2 wherein the cysteines at positions 66, 69 or 70 are substituted by an amino acid other than cysteine; amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2; amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 or 152-278 of SEQ ID NO:4 wherein the cysteines at positions 56, 59 or 60 are substituted by an amino acid other than cysteine; or amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4; or amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at position 37, 40 or 41 are replaced by said substitute amino acid(s) are cloned into bacterial expression vector pTrcHis.

Polynucleotides encoding polypeptides selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2 wherein the cysteines at positions 66, 69 or 70 are substituted by an amino acid other than cysteine; amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2; amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 or 152-278 of SEQ ID NO:4 wherein the cysteines at positions 56, 59 or 60 are substituted by an amino acid other than cysteine; or amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 143-278, 151-278 or

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152-278 of SEQ ID NO: 4; or amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at position 37, 40 or 41 are replaced by said 5 substitute amino acid(s) are cloned into a modified bacterial expression vector pET30a (providing a His Tag at the C-terminus of the GMG-2 polypeptide).

Polynucleotides encoding polypeptides selected from amino acids 1-288 of SEQ ID NO:2, or amino acids 1-278 of SEQ ID NO:4, or amino acids 1-259 of SEQ ID NO:6 are cloned into Baculoviral expression vector FastBacHT. Polynucleotides encoding a heterologous polypeptide 10 comprised of human zinc-alpha 2-glycoprotein signal peptide fused N-terminally to gGMG-2 polypeptide fragment of the invention, wherein said gGMG-2 polypeptide fragment is selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2 15 wherein the cysteines at positions 66, 69 or 70 are substituted by an amino acid other than cysteine; amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2; amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 20 or 152-278 of SEQ ID NO:4 wherein the cysteines at positions 56, 59 or 60 are substituted by an amino acid other than cysteine; or amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4; or amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at 25 position 37, 40 or 41 are replaced by said substitute amino acid(s) are cloned into Baculoviral expression vector FastBacHT.

Polynucleotides encoding polypeptides comprising amino acids 1-288 of SEQ ID NO:2, or amino acids 1-278 of SEQ ID NO:4, or amino acids 1-259 of SEQ ID NO:6 are cloned into 30 mammalian expression vector pcDNA4HisMax. Polynucleotides encoding a heterologous polypeptide comprised of human zinc-alpha 2-glycoprotein signal peptide fused N-terminally to gGMG-2 polypeptide fragment of the invention, wherein said gGMG-2 polypeptide fragment is selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ 35 ID NO:2 wherein the cysteines at positions 66, 69 or 70 are substituted by an amino acid other than cysteine; amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-

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288, 161-288 or 162-288 of SEQ ID NO: 2; amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 or 152-278 of SEQ ID NO:4 wherein the cysteines at positions 56, 59 or 60 are substituted by an amino acid other than cysteine; or amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4; or amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at position 37, 40 or 41 are replaced by said substitute amino acid(s) are cloned into mammalian expression vector pcDNA4HisMax.

Polynucleotides encoding polypeptides comprising amino acids 1-288 of SEQ ID NO:2, or amino acids 1-278 of SEQ ID NO:4, or amino acids 1-259 of SEQ ID NO:6 are cloned into mammalian expression vector pcDNA3.1Hygro. Polynucleotides encoding a heterologous

15 polypeptide comprised of human zinc-alpha 2-glycoprotein signal peptide fused N-terminally to gGMG-2 polypeptide fragment of the invention, wherein said gGMG-2 polypeptide fragment is selected from amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2 wherein the cysteines at positions 66, 69 or 70 are substituted by an amino acid other than cysteine; amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288 of SEQ ID NO: 2; amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 or 152-278 of SEQ ID NO:4 wherein the cysteines at positions 56, 59 or 60 are substituted by an amino acid other than cysteine; or amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4; or amino acids 28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at position 37, 40 or 41 are replaced by said substitute amino acid(s) are cloned into mammalian expression vector pcDNA3.1Hygro.

Alternatively, polynucleotides encoding for polypeptides comprising amino acids 1-288, 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-288,

35 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2 wherein the cysteines at positions 66, 69 or 70 are substituted by an amino acid other than cysteine; amino acids

57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288
of SEQ ID NO: 2; amino acids 1-278, 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-
278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278,
142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 or
5 152-278 of SEQ ID NO:4 wherein the cysteines at positions 56, 59 or 60 are substituted by an amino
acid other than cysteine; or amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278,
142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4; or amino acids 28-259, 29-259, 30-259,
31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259,
119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-
10 259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at position 37,
40 or 41 are replaced by said substitute amino acid(s) are cloned into any bacterial, mammalian, or
baculoviral expression vector, preferably selected from pTrcHis, pET30a, FastBacHT, pcDNA4His,
or pcDNA3.1Hygro. Further alternatively, polynucleotides encoding a heterologous polypeptide
comprised of human zinc-alpha 2-glycoprotein signal peptide fused N-terminally to gGMG-2
15 polypeptide fragment of the invention, wherein said gGMG-2 polypeptide fragment is selected from
amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288,
144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-
288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2
wherein the cysteines at positions 66, 69 or 70 are substituted by an amino acid other than cysteine;
20 amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288
or 162-288 of SEQ ID NO: 2; amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278,
54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-
278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278
or 152-278 of SEQ ID NO:4 wherein the cysteines at positions 56, 59 or 60 are substituted by an
25 amino acid other than cysteine; or amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278,
134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4; or amino acids 28-259, 29-259,
30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259,
118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-
259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at
30 position 37, 40 or 41 are replaced by said substitute amino acid(s) are cloned into any bacterial,
mammalian, or baculoviral expression vector, preferably selected from pTrcHis, pET30a,
FastBacHT, pcDNA4His, or pcDNA3.1Hygro.
Alternatively, polynucleotides encoding for polypeptides selected from amino acids 1-288,
57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288, 143-288, 144-288, 145-
35 288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-288, 154-288, 155-288,
156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ ID NO:2 wherein the
cysteines at positions 66, 69 or 70 are substituted by an amino acid other than cysteine; amino acids

57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-288, 161-288 or 162-288
of SEQ ID NO: 2; amino acids 1-278, 47-278, 48-278, 49-278, 50-278, 51-278, 52-278, 53-278, 54-
278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278, 140-278, 141-278,
142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-278, 151-278 or
5 152-278 of SEQ ID NO:4 wherein the cysteines at positions 56, 59 or 60 are substituted by an amino
acid other than cysteine; or amino acids 47-278, 48-278, 49-278, 50-278, 51-278, 133-278, 134-278,
142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4; or amino acids 28-259, 29-259, 30-259,
31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-259, 117-259, 118-259,
119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259, 127-259, 128-259, 129-
10 259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the cysteine at position 37,
40 or 41 are replaced by said substitute amino acid(s) are cloned into *Pichia Pastoris* (ycast)
expression vector, preferably PHIL-S1. Further alternatively, polynucleotides encoding a
heterologous polypeptide comprised of human zinc-alpha 2-glycoprotein signal peptide fused N-
terminally to gGMG-2 polypeptide fragment of the invention, wherein said gGMG-2 polypeptide
15 fragment is selected from 57-288, 58-288, 59-288, 60-288, 61-288, 62-288, 63-288, 64-288, 65-288,
143-288, 144-288, 145-288, 146-288, 147-288, 148-288, 149-288, 150-288, 151-288, 152-288, 153-
288, 154-288, 155-288, 156-288, 157-288, 158-288, 159-288, 160-288, 161-288 or 162-288 of SEQ
ID NO:2 wherein the cysteines at positions 66, 69 or 70 are substituted by an amino acid other than
cysteine; amino acids 57-288, 58-288, 59-288, 60-288, 61-288, 143-288, 144-288, 152-288, 153-
288, 161-288 or 162-288 of SEQ ID NO: 2; amino acids 47-278, 48-278, 49-278, 50-278, 51-278,
52-278, 53-278, 54-278, 55-278, 133-278, 134-278, 135-278, 136-278, 137-278, 138-278, 139-278,
140-278, 141-278, 142-278, 143-278, 144-278, 145-278, 146-278, 147-278, 148-278, 149-278, 150-
278, 151-278 or 152-278 of SEQ ID NO:4 wherein the cysteines at positions 56, 59 or 60 are
substituted by an amino acid other than cysteine; or amino acids 47-278, 48-278, 49-278, 50-278,
25 51-278, 133-278, 134-278, 142-278, 143-278, 151-278 or 152-278 of SEQ ID NO: 4; or amino acids
28-259, 29-259, 30-259, 31-259, 32-259, 33-259, 34-259, 35-259, 36-259, 114-259, 115-259, 116-
259, 117-259, 118-259, 119-259, 120-259, 121-259, 122-259, 123-259, 124-259, 125-259, 126-259,
127-259, 128-259, 129-259, 130-259, 131-259, 132-259 or 133-259 of SEQ ID NO:6, wherein the
cysteine at position 37, 40 or 41 are replaced by said substitute amino acid(s) are cloned into *Pichia*
30 *Pastoris* (yeast) expression vector, preferably PHIL-S1.

EXAMPLE 18: Infant formula supplementation.

The following example describes a method of administering gGMG-2 polypeptides to
newborns as supplemental nutritional support and further provides a method of promoting growth of
35 an infant by administering gGMG-2-fortified human breast milk, or gGMG-2-fortified breast milk
substitute formulation from a nonhuman source. Dehydrated or lyophilized gGMG-2 polypeptide
powder is directly added to pumped human breast milk (freshly pumped or prewarmed after storage)

or any prewarmed breast milk substitute formulation from a nonhuman source, in a range of 5-1000 ng/ml, preferably 20-800 ng/ml, more preferably 65-650 ng/ml. Supplementation with polypeptides of the invention is provided to infants, particularly preterm infants, in bottle feedings of human breast milk or breast milk substitute at every feeding throughout the day, and is continued to be provided from birth to 6 months of age. Preterm infants may be of low birth weight or very low birth weight.

A primary objective of the study is to demonstrate that a polypeptide of the invention added to human milk (HM) or human milk substitute (HMS) supports acceptable growth in preterm infants. A second objective is to evaluate the serum biochemistries (ie, protein status, calcium, alkaline phosphatase), tolerance, clinical problems, and morbidity of premature infants consuming the nutritional module. Another secondary objective is to compare the supplemental composition of the instant invention to a commercial fortifier powder that has been in use for a number of years to promote growth in preterm infants. An intent-to-treat, prospective, randomized, double-blinded multicenter study is conducted to evaluate preterm infants receiving preterm milk supplemented with either a commercially available powdered human milk fortifier (Enfamil.RTM. Human Milk Fortifier, control) or the supplemental polypeptide (test) powder of the current invention (experimental) at every feeding. Subjects are enrolled and randomized to each fortifier powder prior to 21 days of life. Study Day 1 is when fortification of the test powder begins and the subject reaches an intake of at least 100 mL/kg/day. Anthropometric indices, serum biochemistries, intake, tolerance, and morbidity data are assessed. Each infant is studied until hospital discharge; only anthropometric variables (weight, length, and head circumference) are collected after Study Day 29. Premature infants are recruited from neonatal intensive care units that had agreed to collaborate with study investigators. Single, twin, or triplet infants born around 33 weeks gestational age, with appropriate weight for gestational age, and weighing around 1600 g are eligible to participate. One-hundred and forty-four infants are randomized to either control or experimental; 70 preterm infants are randomized to the control group and 74 preterm infants are randomized to the experimental group. The randomization is proportional for birth weight and gender.

The independent variables (treatments) are the control fortifier powder and the experimental test powder which are added to HM or HMS. Both fortifiers (test and control) are provided in small packets in powdered form and are added to 25 mL HM or HMS. The primary outcome variable is weight gain (g/kg/day) from study day 1 to study day 29 or discharge, whichever comes first. Secondary outcome variables are length gain (mm/day) and serum biochemistries to evaluate protein status, electrolyte status, mineral homeostasis, and vitamin A and E status. Serum biochemistries also include unscheduled laboratory results to be recorded in the medical chart. Tertiary variables include head circumference gain (mm/day), clinical history, intake, tolerance, clinical problems/morbidity, respiratory status, antibiotic use, and the number of transfusions. Mean total energy intakes during the study period is not different between the groups, around 118 kcal/kg/day.

EXAMPLE 19: Assessment of homotrimer formation by gGMG-2 polypeptide fragment.

Homotrimer formation by gGMG-2 polypeptide fragment is assessed using sedimentation equilibrium in analytical centrifuges, a method that determines molecular weight accurately and 5 independently of other physical factors such as shape.

Candidate gGMG-2 polypeptide fragment homotrimer is purified, for example using a protocol comprising a method of gel filtration such as 16/60 superdex 200 gel filtration column (Amersham). Said purified candidate gGMG-2 polypeptide fragment homotrimer protein concentration is made 3 μ M in 5.7 mM phosphate (pH 7.5), 137 mM NaCl, 2.7 mM KCl. Samples 10 are centrifuged at 8,000 rpm for 18 hours at 10°C in a Beckman XL-A analytical ultracentrifuge before absorbance is recorded. The data are fit globally, using MacNonlin PPC to the following equation that describes the sedimentation of a homogeneous species: $Abs = B + A' \exp[H x M (x^2 - x_0^2)]$ where Abs = absorbance at radius x, A' = absorbance at reference radius x_0 , H = $(1-vp)\omega^2/2RT$, R = gas constant, T = temperature in Kelvin, v = partial specific volume = 0.71896131 mL/g, p = 15 density of solvent = 1.0061 g/ml, ω = angular velocity in radians/s, M = apparent molecular weight, and B = solvent absorbance (blank).

EXAMPLE 20: Effect of GMG-2 Polypeptides on the Phosphorylation State of Protein Kinase C Alpha (PKC α).

20 Cells are treated with either 5 μ g/ml GMG-2 polypeptide or physiological saline for 5, 10, 30, and 60 min. Cells are then washed and lysed in 50 mM Tris pH7.6, 150 mM NaCl, 1% NP-40, 0.25% deoxycholate, 1 mM EDTA, 1:100 Phosphatase Inhibitor Cocktail I and II (Sigma), and Complete protease inhibitor cocktail (Roche Diagnostics). The amount of Ser657-phosphorylated PKC α was assessed by Western blot analysis using an affinity-purified PKC antibody that 25 recognizes a conserved hydrophobic C-terminal EXXF(S/T)(F/Y) motif only when the serine/threonine residues are phosphorylated (Cell Signaling Technology). Total amounts of protein in the individual lanes are normalized by Western blotting using a monoclonal antibody against β -tubulin (Sigma).

EXAMPLE 21: Effect of GMG-2 Polypeptides on NF- κ B Activation.Activation of NF- κ B by GMG-2 Polypeptide

Luciferase activity is measured in transfected cells following overnight incubation with 200 ng/ml LPS (*E. coli* serotype 055:B5, Sigma) or 5 μ g/ml GMG-2 polypeptide before and after 30 proteinase K and heat treatment. Cells are transfected with an E-selectin promoter-luciferase construct 35 [Schindler U et al. (1994) Mol Cell Biol Sep;14(9):5820-31, which is hereby incorporated by reference in its entirety] and CMV promoter- β -galactosidase as internal transfection efficiency control using FuGene 6 reagent (Roche) according to manufacturer's instructions. Incubation is performed in

normal growth media. To test for endotoxin contamination, GMG-2 polypeptide and LPS are treated with proteinase K (0.2 mg/ml) for 90 min at 50°C, followed by 12 min at 99°C. Resistance of LPS and sensitivity of GMG-2 polypeptide to digestion establishes that activities of the latter are not due to contamination by bacterial endotoxin.

5 Ser32 Phosphorylation and Degradation of I_KB- α by GMG-2 Polypeptide

Cells are treated with 200 ng/ml LPS or 5 μ g/ml GMG-2 polypeptide in normal growth media. After 30 and 120 min of incubation, cells are washed with PBS containing Ca²⁺ and Mg²⁺ and lysed as described herein. The amount of phosphorylated and total I_KB- α in lysates is assessed by Western blot analysis using affinity purified Ser32 phospho-specific antibody and a different phosphorylation state-independent I_KB- α antibody (Cell Signaling Technology).

EXAMPLE 22: Effect of iAFLP Gene Expression Profiling Analysis of Poly A+ and Total RNA from Different Tissue Sources

15 Introduced Amplified Fragment Length Polymorphism (iAFLP) methodology is adapted from an article entitled "Expression Profiling by iAFLP: A PCR based Method for Genome Wide Gene Expression Profiling" (Kawamoto et al., *Genome Research*. 9:1305-1312, 1999).

IAFLP gene expression is performed using Poly A+ RNA and Total RNA from different adult human tissues purchased from Ambion (#7961-Liver, 7967-Heart, 7963-Brain, 7983-Skeletal 20 Muscle, 7951-Placenta, and 7951-Small Intestine) and Research Genetics (#D6005-01-Adipose Tissue), respectively. Total RNA is DNase treated for 30 minutes at 37°C. 20 μ g of total RNA or 2 μ g of Poly A+ RNA is converted to dsDNA using the cDNA Synthesis System supplied by Roche Applied Science as per the manufacturer's instructions. The purified and quantified dsDNA is cleaved using the MboI restriction enzyme kit supplied by New England Biolabs as per the 25 manufacturer's instructions. One-third of the MboI cleaved dsDNA is ligated to kinased adaptor cassette primers using the T4 DNA Ligation kit supplied by Roche Applied Science as per the manufacturer's instructions. The ligated dsDNA is diluted in glycogen and DI water to a final concentration of 1ng/ μ l. One ng is added to a final PCR master mix volume of 10 μ l containing 0.2mM dNTPs, 1mM PCR Buffer, 2mM MgCl₂, 2uM Vic fluorescent labeled T7 primer, 2uM of a 30 gene-specific reverse primer, 8% glycerol, and 1Unit AmpliTaq Gold DNA Polymerase. The template is incubated for 10 min at 95°C, denatured for 30 sec. at 95°C, annealed for 1 min at 60°C, extended for 30 sec. at 72°C for 35 cycles and extended 7 min at 72°C for 1 cycle.

PCR reaction is performed using the Applied Biosystem's 9700 GeneAmp thermalcycler. One μ l of the PCR reaction is diluted 1:100. 1 μ l of the diluted PCR product is combined with 0.1 μ l of the Liz 500 size standard (Applied Biosystems) and 8.9 μ l of HiDi Formamide (Applied 35 Biosystems). The mixture is denatured for 5 min. at 95°C. 1 μ l of denatured mixture is loaded into a 3700 DNA Analyzer (Applied Biosystems) and separated by size. Analysis of the differently sized

fragments is performed by the Genescan software package supplied by Applied Biosystems as per the manufacturer's instructions.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A polypeptide forming homotrimers, comprising (a) a collagen-like region corresponding to amino acids 107-148 of SEQ ID NO:2, amino acids 97-138 of SEQ ID NO:4 or amino acids 5 78-119 of SEQ ID NO:6; and (b) an N-terminally disposed unique region corresponding to amino acids 57-106 of SEQ ID NO:2, amino acids 47-96 of SEQ ID NO:4 or amino acids 28-77 of SEQ ID NO:6; wherein a cysteine in the N-terminally disposed unique region at the position 66, 69 or 70 of SEQ ID NO:2, at the position 56, 59 or 60 of SEQ ID NO:4 or at the position 37, 40 or 41 of SEQ ID NO:6 is substituted with an amino acid selected from the group consisting of alanine, aspartic acid, glutamic acid, phenylalanine, glycine, histidine, isoleucine, lysine, leucine, methionine, asparagine, proline, glutamine, arginine, serine, threonine, valine, tryptophane and tyrosine, and wherein the polypeptide has an activity selected from the group consisting of i) the ability to affect the location of dietary lipids among the major tissue groups; ii) the ability to affect the level of free fatty acids in the plasma; and iii) the ability to modulate the 10 15 level of glucose in the plasma.
2. A polypeptide according to claim 1, selected from the group consisting of:
 - a) a polypeptide consisting of the amino acids 57-288, of SEQ ID NO:2;
 - 20 b) a polypeptide consisting of the amino acids 47-278, of SEQ ID NO:4; and
 - c) a polypeptide consisting of the amino acids 28-259, of SEQ ID NO:6.
3. A polypeptide according to claim 1 or claim 2, wherein the polypeptide is fused to:
 - a) a compound to increase the half-life of the polypeptide such as polyethylene glycol;
 - 25 b) IgG Fc;
 - c) a leader or secretory sequence; and/or
 - d) a sequence employed for purification of the polypeptide.
4. An isolated polynucleotide, or complement thereof, encoding a polypeptide according to 30 claim 1 or claim 2.
5. A vector comprising an isolated polynucleotide sequence encoding a polypeptide according to claim 4.
- 35 6. A transformed host cell comprising a vector according to claim 5.

7. A process for the production of a polypeptide according to claim 1 or claim 2, comprising:
 - a) ligating the polynucleotide according to claim 4 into an expression vector;
 - b) using an eukaryotic or prokaryotic host cell to form recombinant polypeptide according to claim 1 or claim 2;
 - c) isolating the polypeptide from the lysed host cell or from the culture medium; and
 - d) purifying said polypeptide.
8. A composition comprising a pharmaceutically-acceptable carrier and:
 - a) a polypeptide according to claim 1 or claim 2,
 - b) a polypeptide fusion according to claim 3,
 - c) an isolated polynucleotide according to claim 4; or
 - d) a vector according to claim 5.
9. Use of a polypeptide according to claim 1 or claim 2, a polypeptide fusion according to claim 3, a polynucleotide according to claim 4, a vector according to claim 5 or a composition according to claim 8 in the manufacture of a medicament for lowering circulating free fatty acid levels in an individual.
10. A use according to claim 9, wherein the medicament also reduces body mass.
11. Use of a polypeptide according to claim 1 or claim 2, a polypeptide fusion according to claim 3, a polynucleotide according to claim 4, a vector according to claim 5 or a composition according to claim 8 in the manufacture of a medicament for the treatment of an obesity-related disease.
12. A use according to claim 11, in which the obesity-related disease is selected from the group consisting of obesity, impaired glucose tolerance, insulin resistance, atherosclerosis, atheromatous disease, heart disease, hypertension, stroke, Syndrome X Noninsulin Dependent Diabetes Mellitus and Insulin Dependent Diabetes Mellitus.
13. A method of lowering circulating free fatty acid levels in an individual, comprising the step of administering a polypeptide according to claim 1 or claim 2, a polypeptide fusion according to claim 3, a polynucleotide according to claim 4, a vector according to claim 5, or a composition according to claim 8 to the individual.

35

14. A method according to claim 13, in which body mass is also reduced.
15. A method of treatment of an obesity-related disease, comprising the step of administering a polypeptide according to claim 1 or claim 2, a polypeptide fusion according to claim 3, a 5 polynucleotide according to claim 4, a vector according to claim 5, or a composition according to claim 8 in a subject in need of such treatment.
16. A method according to claim 15, in which the obesity-related disease is selected from the group consisting of obesity, impaired glucose tolerance, insulin resistance, atherosclerosis, 10 atheromatous disease, heart disease, hypertension, stroke, Syndrome X Noninsulin Dependent Diabetes Mellitus and Insulin Dependent Diabetes Mellitus.
17. A polypeptide according to claim 1, substantially as herein described with reference to any of the examples.

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 gctgcctca gacactgtg tctgtccca ggtgctctc gccttcatg cccttcac 1097
 cggccctgtg cccctgttca cggctttca tcaagggtgt aaggcccggtg tggcagctc 1157
 ctgcgttcag agcccttcctt cggcctgtgt ctgcctttac aaacacctgc aggaaagg 1217
 ccacggaaagc cccctgttca gcaagggtgttgg gggcttagag caaaggagg 1277
 acctcaaggcc ttccttttct tcttccagggg tgggttgccc ttagcttc 1337
 aaacccctgttca ggcctgttcc tcttccagggg tgggttgccc ttagcttc 1397
 gcaactctg gggctgttcc tcttccagggg tgggttgccc ttagcttc 1457
 cgtggcttca tggccatgttca agggaaacag ggttgcacca agtggccatgttca 1517
 tataaaaccac cttgttccatgttca tggccatgttca agggaaacag ggttgcacca 1577
 tgattaaaga atgtgttcc tctttggaaa aaaaaaaaaaaa aaaa 1621

<210> 2
 <211> 288
 <212> PRT
 <213> Homo sapiens

<220>
<221> SIGNAL
<222> 1..56

<221> VARIANT
<222> 65
<223> Polymorphic amino acid Asp or Gly

<221> VARIANT
<222> 148
<223> Polymorphic amino acid Pro or Leu

<400> 2
Met Pro Arg Val Arg Lys Glu Pro Glu Ala Met Gln Trp Leu Arg Val
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Arg Glu Ser Pro Gly Glu Ala Thr Gly His Arg Val Thr Met Gly Thr
20 25 30
Ala Ala Leu Gly Pro Val Trp Ala Ala Leu Leu Phe Leu Leu Met
35 40 45
Cys Glu Ile Pro Met Val Glu Leu Thr Phe Asp Arg Ala Val Ala Ser
50 55 60
Asp Cys Gln Arg Cys Cys Asp Ser Glu Asp Pro Leu Asp Pro Ala His
65 70 75 80
Val Ser Ser Ala Ser Ser Ser Gly Arg Pro His Ala Leu Pro Glu Ile
85 90 95
Arg Pro Tyr Ile Asn Ile Thr Ile Leu Lys Gly Asp Lys Gly Asp Pro
100 105 110
Gly Pro Met Gly Leu Pro Gly Tyr Met Gly Arg Glu Gly Pro Gln Gly
115 120 125
Glu Pro Gly Pro Gln Gly Ser Lys Gly Asp Lys Gly Glu Met Gly Ser
130 135 140
Pro Gly Ala Pro Cys Gln Lys Arg Phe Phe Ala Phe Ser Val Gly Arg
145 150 155 160
Lys Thr Ala Leu His Ser Gly Glu Asp Phe Gln Thr Leu Leu Phe Glu
165 170 175
Arg Val Phe Val Asn Leu Asp Gly Cys Phe Asp Met Ala Thr Gly Gln
180 185 190
Phe Ala Ala Pro Leu Arg Gly Ile Tyr Phe Phe Ser Leu Asn Val His
195 200 205
Ser Trp Asn Tyr Lys Glu Thr Tyr Val His Ile Met His Asn Gln Lys
210 215 220
Glu Ala Val Ile Leu Tyr Ala Gln Pro Ser Glu Arg Ser Ile Met Gln
225 230 235 240
Ser Gln Ser Val Met Leu Asp Leu Ala Tyr Gly Asp Arg Val Trp Val
245 250 255
Arg Leu Phe Lys Arg Gln Arg Glu Asn Ala Ile Tyr Ser Asn Asp Phe
260 265 270
Asp Thr Tyr Ile Thr Phe Ser Gly His Leu Ile Lys Ala Glu Asp Asp
275 280 285

<210> 3
<211> 1169
<212> DNA
<213> Homo sapiens

<220>
<221> CDS
<222> (19)...(855)

<400> 3
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Met Gln Trp Leu Arg Val Arg Glu Ser Pro Gly

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gag gcc aca gga cac agg gtc acc atg ggg aca gcc gcc ctg ggt ccc 99				
Glu Ala Thr Gly His Arg Val Thr Met Gly Thr Ala Ala Leu Gly Pro				
15	20	25		
gtc tgg gca ggc ctc ctg ctc ttc ctg atg tgg gag atc cct atg 147				
Val Trp Ala Ala Leu Leu Phe Leu Leu Met Cys Glu Ile Pro Met				
30	35	40		
gtg gag ctc acc ttt gac aga gct gtg gcc agc ggc tgc caa cgg tgc 195				
Val Glu Leu Thr Phe Asp Arg Ala Val Ala Ser Gly Cys Gln Arg Cys				
45	50	55		
tgt gag tct gag gac ccc ctg gat cct gcc cat gta tcc tca gcc tct 243				
Cys Asp Ser Glu Asp Pro Leu Asp Pro Ala His Val Ser Ser Ala Ser				
60	65	70	75	
tcc tcc ggc cgc ccc cac gcc ctg cct gag atc aga ccc tac att aat 291				
Ser Ser Gly Arg Pro His Ala Leu Pro Glu Ile Arg Pro Tyr Ile Asn				
80	85	90		
atc acc atc ctg aag ggt gac aaa ggg gac cca ggc cca atg ggc ctg 339				
Ile Thr Ile Leu Lys Gly Asp Lys Gly Asp Pro Gly Pro Met Gly Leu				
95	100	105		
cca ggg tac atg ggc agg gag ggt ccc caa ggg gag cct ggc cct cag 387				
Pro Gly Tyr Met Gly Arg Glu Gly Pro Gln Gly Glu Pro Gly Pro Gln				
110	115	120		
ggc agc aag ggt gac aag ggg gag atg ggc agc ccc ggc gcc cgg tgc 435				
Gly Ser Lys Gly Asp Lys Gly Glu Met Gly Ser Pro Gly Ala Pro Cys				
125	130	135		
cag aag cgc ttc ttc gcc ttc tca gtg ggc cgc aag acg gcc ctg cac 483				
Gln Lys Arg Phe Phe Ser Val Gly Arg Lys Thr Ala Leu His				
140	145	150	155	
agc ggc gag gac ttc cag acg ctg ctc ttc gaa agg gtc ttt gtg aac 531				
Ser Gly Glu Asp Phe Gln Thr Leu Leu Phe Glu Arg Val Phe Val Asn				
160	165	170		
ctt gat ggg tgc ttt gac atg gcg acc ggc cag ttt gct gct ccc ctg 579				
Leu Asp Gly Cys Phe Asp Met Ala Thr Gly Gln Phe Ala Ala Pro Leu				
175	180	185		
cgt ggc atc tac ttc ttc agc ctc aat gtg cac agc tgg aat tac aag 627				
Arg Gly Ile Tyr Phe Phe Ser Leu Asn Val His Ser Trp Asn Tyr Lys				
190	195	200		
gag acg tac gtg cac att atg cat aac gag aaa gag gct gtc atc ctg 675				
Glu Thr Tyr Val His Ile Met His Asn Gln Lys Glu Ala Val Ile Leu				
205	210	215		
tac gcg cag ccc agc gag cgc agc atc atg cag agc cag agt gtc atg 723				
Tyr Ala Gln Pro Ser Glu Arg Ser Ile Met Gln Ser Gln Ser Val Met				
220	225	230	235	
ctg gac ctg gcc tac ggg gac cgc gtc tgg gtg cgg ctc ttc aag cgc 771				
Leu Asp Leu Ala Tyr Gly Asp Arg Val Trp Val Arg Leu Phe Lys Arg				
240	245	250		
cag cgc gag aac gcc atc tac agc aac gac ttc gac acc tac atc acc 819				

5

Gln Arg Glu Asn Ala Ile Tyr Ser Asn Asp Phe Asp Thr Tyr Ile Thr
 255 260 265

ttc agc ggc cac ctc atc aag gcc gag gac tga gggcctctgg 865
 Phe Ser Gly His Leu Ile Lys Ala Glu Asp Asp *
 270 275

ggcacccctccggctggaga gtcaggtgc tggcccgctc cccgtcagggg ctcagtttgc 925
 actgtgtga agcaggagg ccaggagggt ccccgccggac ctggcattct ggggagaccc 985
 tgcttcatac ttggctgcca tcataccctcc cagctatattt ctgttcctctt ctttctt 1045
 ggacatattt taagaagctt gctaaccctaa atattctaga actttccctag cctctgtggcc 1105
 cagcacttc caaacttgga aatgcatgcg aatcaccctgg gtttcgtgtt aaatgcagat 1165
 tctg 1169

<210> 4
 <211> 278
 <212> PRT
 <213> Homo sapiens

<220>
 <221> SIGNAL
 <222> 1..46

<221> VARIANT
 <222> 55
 <223> Polymorphic amino acid Gly or Asp

<221> VARIANT
 <222> 138
 <223> Polymorphic amino acid Pro or Leu

<400> 4
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 Arg Val Thr Met Gly Thr Ala Ala Leu Gly Pro Val Trp Ala Ala Leu
 20 25 30
 Leu Leu Phe Leu Leu Met Cys Glu Ile Pro Met Val Glu Leu Thr Phe
 35 40 45
 Asp Arg Ala Val Ala Ser Gly Cys Gln Arg Cys Cys Asp Ser Glu Asp
 50 55 60
 Pro Leu Asp Pro Ala His Val Ser Ser Ala Ser Ser Ser Gly Arg Pro
 65 70 75 80
 His Ala Leu Pro Glu Ile Arg Pro Tyr Ile Asn Ile Thr Ile Leu Lys
 85 90 95
 Gly Asp Lys Gly Asp Pro Gly Pro Met Gly Leu Pro Gly Tyr Met Gly
 100 105 110
 Arg Glu Gly Pro Gln Gly Glu Pro Gly Pro Gln Gly Ser Lys Gly Asp
 115 120 125
 Lys Gly Glu Met Gly Ser Pro Gly Ala Pro Cys Gln Lys Arg Phe Phe
 130 135 140
 Ala Phe Ser Val Gly Arg Lys Thr Ala Leu His Ser Gly Glu Asp Phe
 145 150 155 160
 Gln Thr Leu Leu Phe Glu Arg Val Phe Val Asn Leu Asp Gly Cys Phe
 165 170 175
 Asp Met Ala Thr Gly Gln Phe Ala Ala Pro Leu Arg Gly Ile Tyr Phe
 180 185 190
 Phe Ser Leu Asn Val His Ser Trp Asn Tyr Lys Glu Thr Tyr Val His
 195 200 205
 Ile Met His Asn Gln Lys Glu Ala Val Ile Leu Tyr Ala Gln Pro Ser
 210 215 220
 Glu Arg Ser Ile Met Gln Ser Gln Ser Val Met Leu Asp Leu Ala Tyr
 225 230 235 240
 Gly Asp Arg Val Trp Val Arg Leu Phe Lys Arg Gln Arg Glu Asn Ala

6

245	250	255
Ile Tyr Ser Asn Asp Phe Asp Thr Tyr	Ile Thr Phe Ser Gly His Leu	
260	265	270
Ile Lys Ala Glu Asp Asp		
275		
<210> 5		
<211> 1604		
<212> DNA		
<213> Homo sapiens		
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<221> CDS		
<222> (106)...(885)		
<400> 5		
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Met Gly Thr Ala		
1		
gcc ctg ggt ccc gtc tgg gca gcg ctc ctc ttt ctc ctg atg tgt 165		
Ala Leu Gly Pro Val Trp Ala Ala Leu Leu Leu Phe Leu Leu Met Cys		
5	10	15
		20
gag atc cct atg gtg gag ctc acc ttt gac aga gct gtg gcc agc ggc 213		
Glu Ile Pro Met Val Glu Leu Thr Phe Asp Arg Ala Val Ala Ser Gly		
25	30	35
tgc caa cgg tgc tgt gac tct gag gac ccc ctg gat cct gcc cat gta 261		
Cys Gln Arg Cys Cys Asp Ser Glu Asp Pro Leu Asp Pro Ala His Val		
40	45	50
tcc tca gcc tct tcc tcc ggc cgc ccc cac gcc ctg cct gag atc aga 309		
Ser Ser Ala Ser Ser Gly Arg Pro His Ala Leu Pro Glu Ile Arg		
55	60	65
ccc tac att aat atc acc atc ctg aag ggt gac aaa ggg gac cca ggc 357		
Pro Tyr Ile Asn Ile Thr Ile Leu Lys Gly Asp Lys Gly Asp Pro Gly		
70	75	80
cca atg ggc ctg cca ggg tac atg ggc agg gag ggt ccc caa ggg gag 405		
Pro Met Gly Leu Pro Gly Tyr Met Gly Arg Glu Gly Pro Gln Gly Glu		
85	90	95
		100
cct ggc cct cag ggc agc aag ggt gac aag ggg gag atg ggc agc ccc 453		
Pro Gly Pro Gln Gly Ser Lys Gly Asp Lys Gly Glu Met Gly Ser Pro		
105	110	115
ggc gcc ctg tgc cag aag cgc ttc ttc gcc ttc tca gtg ggc cgc aag 501		
Gly Ala Leu Cys Gln Lys Arg Phe Phe Ala Phe Ser Val Gly Arg Lys		
120	125	130
acg gcc ctg cac agc ggc gag gac ttc cag aca ctg ctc ttc gaa agg 549		
Thr Ala Leu His Ser Gly Glu Asp Phe Gln Thr Leu Leu Phe Glu Arg		
135	140	145
gtc ttt gtg aac ctt gat ggg tgc ttt gac atg ggc acc ggc cag ttt 597		
Val Phe Val Asn Leu Asp Gly Cys Phe Asp Met Ala Thr Gly Gln Phe		
150	155	160
gct gct ccc ctg cgt ggc atc tac ttc ttc agc ctc aat gtg cac agc 645		

7

Ala Ala Pro Leu Arg Gly Ile Tyr Phe Ser Leu Asn Val His Ser
 165 170 175 180

tgg aat tac aag gag acg tac gtg cac att atg cat aac cag aaa gag 693
 Trp Asn Tyr Lys Glu Thr Tyr Val His Ile Met His Asn Gln Lys Glu
 185 190 195

gct gtc atc ctg tac gcg cag ccc aac gag cgc aac atc atg cag agc 741
 Ala Val Ile Leu Tyr Ala Gln Pro Ser Glu Arg Ser Ile Met Gln Ser
 200 205 210

cag agt gtg atg ctg gac ctg gcc tac ggg gac cgc gtc tgg gtg cgg 789
 Gln Ser Val Met Leu Asp Leu Ala Tyr Gly Asp Arg Val Trp Val Arg
 215 220 225

ctc ttc aag cgc cag cgc gag aac gcc atc tac agc aac gac ttc gac 837
 Leu Phe Lys Arg Gln Arg Glu Asn Ala Ile Tyr Ser Asn Asp Phe Asp
 230 235 240

acc tac atc acc ttc agc ggc cac ctc atc aag gcc gag gac gac tga 885
 Thr Tyr Ile Thr Phe Ser Gly His Leu Ile Lys Ala Glu Asp Asp *
 245 250 255

gggcctctgg gccaccctcc cggctggaga gctcagctga tacggcatcc tgcgagaaga 945
 cctgcctcc tcactggat cccttcctg cctccctccca gggctctgc agggccttc 1005
 tcagtcctt ccacaaagt catctgaact tcctgttccc cagggcctcc agctgcctc 1065
 agacactgat gtctgtcccc aggtgctctc tgccctctat gcccctctca ccggccca 1125
 gccccactc tcacgctttt atcaagggtgt taaggccccggg gtgggcagct cctctgtctca 1185
 gagccctctt ccggccctgg tgctgcctt acaaacaactt gcaggagaag ggccacggga 1245
 agccccaggc tttagagcccc tcacagggtc gggagactag agcaaaggag ggacccctcagg 1305
 ctttcgtttt ctttcctccag ggtgggtggc ctgggttccc cttagcccttc caaaccggc 1365
 tggcctgccc ttctcccccag agggaggccgg cttccgeccca ttgggtgtctca tgcagactct 1425
 ggggctgagg tgccccgggg ggtgatctct ggtgctcaca gccgagggag ccgtggctcc 1485
 atggccagat gacggaaaca gggtctgacc aagtgcagg aagacctgtg ctataaacca 1545
 ccctgcctga tcctgcctt gctgacccc gcacgcctt gcgcgtccaggc atgattaaa 1604

<210> 6
 <211> 259
 <212> PRT
 <213> Homo sapiens

<220>
 <221> SIGNAL
 <222> 1..27

<221> VARIANT
 <222> 36
 <223> Polymorphic amino acid Gly or Asp

<221> VARIANT
 <222> 119
 <223> Polymorphic amino acid Leu or Pro

<400> 6
 Met Gly Thr Ala Ala Leu Gly Pro Val Trp Ala Ala Leu Leu Leu Phe
 1 5 10 15
 Leu Leu Met Cys Glu Ile Pro Met Val Glu Leu Thr Phe Asp Arg Ala
 20 25 30
 Val Ala Ser Gly Cys Gln Arg Cys Cys Asp Ser Glu Asp Pro Leu Asp
 35 40 45
 Pro Ala His Val Ser Ser Ala Ser Ser Ser Gly Arg Pro His Ala Leu
 50 55 60
 Pro Glu Ile Arg Pro Tyr Ile Asn Ile Thr Ile Leu Lys Gly Asp Lys

65 70 75 80
Gly Asp Pro Gly Pro Met Gly Leu Pro Gly Tyr Met Gly Arg Glu Gly
85 90 95
Pro Gln Gly Glu Pro Gly Pro Gln Gly Ser Lys Gly Asp Lys Gly Glu
100 105 110
Met Gly Ser Pro Gly Ala Leu Cys Gln Lys Arg Phe Phe Ala Phe Ser
115 120 125
Val Gly Arg Lys Thr Ala Leu His Ser Gly Glu Asp Phe Gln Thr Leu
130 135 140
Leu Phe Glu Arg Val Phe Val Asn Leu Asp Gly Cys Phe Asp Met Ala
145 150 155 160
Thr Gly Gln Phe Ala Ala Pro Leu Arg Gly Ile Tyr Phe Phe Ser Leu
165 170 175
Asn Val His Ser Trp Asn Tyr Lys Glu Thr Tyr Val His Ile Met His
180 185 190
Asn Gln Lys Glu Ala Val Ile Leu Tyr Ala Gln Pro Ser Glu Arg Ser
195 200 205
Ile Met Gln Ser Gln Ser Val Met Leu Asp Leu Ala Tyr Gly Asp Arg
210 215 220
Val Trp Val Arg Leu Phe Lys Arg Gln Arg Glu Asn Ala Ile Tyr Ser
225 230 235 240
Asn Asp Phe Asp Thr Tyr Ile Thr Phe Ser Gly His Leu Ile Lys Ala
245 250 255
Glu Asp Asp