

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

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
4 October 2001 (04.10.2001)

PCT

(10) International Publication Number
WO 01/73033 A2

(51) International Patent Classification⁷: **C12N 15/12**,
15/62, 15/86, C07K 14/78, 16/18, A61K 38/39, A01K
67/027

(21) International Application Number: PCT/US01/09921

(22) International Filing Date: 28 March 2001 (28.03.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/192,875 29 March 2000 (29.03.2000) US

(71) Applicant (for all designated States except US): **BETH ISRAEL DEACONESS MEDICAL CENTER** [US/US];
330 Brookline Avenue, Boston, MA 02215 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **KALLURI, Raghuram** [US/US]; 28 Holyoke Street, Boston, MA 02116 (US).

(74) Agents: **HOGLE, Doreen, M.** et al.; Hamilton, Brook, Smith & Reynolds, P.C., Two Militia Drive, Lexington, MA 02421 (US).

(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, EE, 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, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, 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 01/73033 A2

(54) Title: ANTI-ANGIOGENIC AND ANTI-TUMOR PROPERTIES OF MATIN AND OTHER LAMININ DOMAINS

(57) Abstract: A protein with anti-angiogenic properties is disclosed.

ANTI-ANGIOGENIC AND ANTI-TUMOR PROPERTIES
OF MATIN AND OTHER LAMININ DOMAINS

RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No.
5 60/192875, filed on March 29, 2000, the entire teachings of the which are
incorporated herein by reference.

BACKGROUND OF THE INVENTION

Basement membranes are thin layers of specialized extracellular matrix that
provide supporting structure on which epithelial and endothelial cells grow, and that
10 surround muscle or fat (Paulsson, M., 1992, *Crit. Rev. Biochem. Mol. Biol.* 27:93-
127). Basement membranes are always associated with cells, and it has been well
documented that basement membranes not only provide mechanical support, but
also influence cellular behavior such as differentiation and proliferation. Vascular
basement membranes are composed of macromolecules such as collagen, laminin,
15 heparan sulfate proteoglycans, fibronectin and nidogen (also called entactin) (Timpl,
R., 1996, *Curr. Opin. Cell. Biol.* 8:618-624).

Angiogenesis is the process of formation of new blood vessels from pre-
existing ones (Madri, J.A. *et al.*, 1986, *J. Histochem. Cytochem.* 34:85-91; Folkman,
J., 1972, *Ann. Surg.* 175:409-416). Angiogenesis is a complex process, and requires
20 sprouting and migration of endothelial cells, proliferation of those cells, and their
differentiation into tube-like structures and the production of a basement membrane
matrix around the developing blood vessel. Additionally angiogenesis is a process
critical for normal physiological events such as wound repair and endometrium
remodeling (Folkman, J. *et al.*, 1995, *J. Biol. Chem.* 267:10931-10934). It is now
25 well documented that angiogenesis is required for metastasis and growth of solid
tumors beyond a few mm³ in size (Folkman, J., 1972, *Ann. Surg.* 175:409-416;
Folkman, J., 1995, *Nat. Med.* 1:27-31). Expansion of tumor mass occurs not only by
perfusion of blood through the tumor, but also by paracrine stimulation of tumor
cells by several growth factors and matrix proteins produced by the new capillary
30 endothelium (Folkman, J., 1995, *Nat. Med.* 1:27-31). Recently, a number of

-2-

angiogenesis inhibitors have been identified, namely angiostatin (O'Reilly, M.S. *et al.*, 1994, *Cell* 79:315-28), endostatin (O'Reilly, M.S. *et al.*, 1997, *Cell* 88:277-85), restin (Ramchandran, R. *et al.*, 1999, *Biochem. Biophys. Res. Commun.* 255:735-9), Arresten (Colorado, P.C. *et al.*, 2000, *Cancer Res.* 60:2520-6), Canstatin
5 (Kamphaus, G.D. *et al.*, 2000, *J. Biol. Chem.* 275:1209-15) and Tumstatin
(Maeshima, Y. *et al.*, 2000, *J. Biol. Chem.* 275:21340-8; Maeshima, Y. *et al.*, 2000, *J. Biol. Chem.* 275:23745-50) and pigment epithelium-derived factor (PEDF)
(Dawson, D.W. *et al.*, 1999, *Science* 285:245-8).

SUMMARY OF THE INVENTION

10 The present invention relates to proteins comprising the globular domains of
the $\alpha 1$ chain of laminin having anti-angiogenic properties. In particular, the present
invention relates to the novel protein designated herein as "Matin," which comprises
the G1 domain of laminin, and to biologically active (*e.g.*, anti-angiogenic)
fragments, mutants, analogs, homologs and derivatives thereof, as well as multimers
15 (*e.g.*, dimers, trimers, etc.) and fusion proteins (also referred to herein as chimeric
proteins) thereof. In particular, Matin is a monomeric protein, and arrests
endothelial cell proliferation *in vivo*.

In particular, the invention features isolated Matin, where Matin is an
isolated protein of the G1 domain of the $\alpha 1$ chain of laminin, or a fragment, analog,
20 derivative or mutant thereof, where the protein, fragment, analog, derivative or
mutant thereof has anti-angiogenic activity. The Matin can be the G1 domain of the
 $\alpha 1$ chain of another laminin, other globular domains, globular domains from other α
chains, other laminins, laminins from other mammals, and fragments, mutants,
homologs, analogs and allelic variants of the Matin amino acid sequence. The
25 Matin, or a fragment, analog, derivative or mutant thereof, can be a monomer, a
multimer, or a chimeric protein, having anti-angiogenic or anti-tumor activity. The
Matin can be about 28 to about 32 kDa in size, or about 30 kDa in size.

The invention also features the isolated protein of about residue 2148 to
about residue 2354 of SEQ ID NO:2, about residue 2352 to about residue 2553 of
30 SEQ ID NO:2, about residue 2534 to about residue 2761 of SEQ ID NO:2, about

residue 2762 to about residue 2895 of SEQ ID NO:2, about residue 2896 to about residue 3100 of SEQ ID NO:2, or a fragment, analog, derivative or mutant thereof, where the protein, fragment, analog, derivative or mutant has anti-angiogenic activity. The protein, or a fragment, analog, derivative or mutant thereof, can be a monomer, dimer, trimer, multimer, or a chimeric protein, having anti-angiogenic or anti-tumor activity. The proteins, fragments, etc., from the other G domains of laminin are alternative sources of Matin.

The invention also features an isolated protein or peptide having 90% or greater sequence identity with SEQ ID NO:2, where the protein or peptide has anti-angiogenic activity, and an isolated protein or peptide having 85% or greater sequence identity with SEQ ID NO:2, where the protein or peptide has anti-angiogenic activity.

The invention also features an isolated polynucleotide having 90% or greater sequence identity with SEQ ID NO:1, where the polynucleotide encodes a protein having anti-angiogenic activity.

The chimeric protein described above can further comprise at least one protein molecule selected from the group consisting of: Vascostatin or fragments thereof, arresten or fragments thereof, canstatin or fragments thereof, tumstatin or fragments thereof, endostatin or fragments thereof, angiostatin or fragments thereof, restin or fragments thereof, apomigren or fragments thereof, or other anti-angiogenic proteins or fragments thereof. Vascostatin comprises the C-terminal globular domain of nidogen, and has anti-angiogenic properties. Vascostatin is described in International application PCT/US01/____, "Anti-Angiogenic and Anti-tumor Properties of Vascostatin and Other Nidogen Domains", by Raghuram Kalluri, filed March 28, 2001.

The invention further features a composition comprising, as a biologically active ingredient, one or more of the proteins, fragments, analogs, derivatives, mutants, monomers, multimers or chimeric proteins described above. The composition may also include a pharmaceutically-compatible carrier. The composition may further comprise at least one protein molecule selected from the group consisting of: Vascostatin or fragments thereof, arresten or fragments thereof,

canstatin or fragments thereof, tumstatin or fragments thereof, endostatin or fragments thereof, angiostatin or fragments thereof, restin or fragments thereof, apomigren or fragments thereof, or other anti-angiogenic proteins, or fragments thereof. The composition may be used in a method of inhibiting a disease
5 characterized by angiogenic activity, where the method comprises administering to a patient with the disease, the composition in conjunction with radiation therapy, chemotherapy, or immunotherapy.

In another aspect, the invention features a process for producing a protein encoded by the polynucleotide described above, where the process comprises: (a)
10 growing a culture of a host cell transformed with the polynucleotide described above, where the host cell is selected from the group comprising bacterial, yeast, mammalian, insect or plant cells; and (b) purifying the protein from the culture, so that the protein encoded by the polynucleotide described above is produced.

The invention also features an isolated polynucleotide produced according to
15 the process of: (a) preparing one or more polynucleotide probes that hybridize under conditions under moderate stringency to the polynucleotide described above; (b) hybridizing the probe(s) to mammalian DNA; and (c) isolating the DNA polynucleotide detected with the probe(s); so that the nucleotide sequence of the isolated polynucleotide corresponds to the nucleotide sequence of the polynucleotide
20 described above.

The invention further features a process for providing a mammal with an anti-angiogenic protein, where the process comprises introducing mammalian cells into a mammal, the mammalian cells having been treated *in vitro* to insert within them the polynucleotide described above, and where the mammalian cell express *in*
25 *vivo* within the mammal a therapeutically effective amount of the anti-angiogenic protein in an amount sufficient to inhibit angiogenic activity in the mammal. The expression of the anti-angiogenic protein may be transient or permanent expression. The mammalian cells may be chosen from the group consisting of: blood cells, TIL cells, bone marrow cells, vascular cells, tumor cells, liver cells, muscle cells,
30 fibroblast cells. The polynucleotide may be inserted into the cells by a viral vector.

The invention additionally features antibodies that specifically bind to the isolated Matin protein, fragment, analog, derivative or mutant, or the Matin monomers, dimer, trimers, multimers or chimeric proteins described above.

In another aspect, the invention features a method for inhibiting angiogenic activity in mammalian tissue, where the method comprises contacting the tissue with
5 a composition comprising one or more of the following: the Matin protein, fragment, analog, derivative or mutant described above, or the Matin monomers, multimers or chimeric proteins as described above. The angiogenic activity may be characteristic of a disease selected from the group comprising angiogenesis-
10 dependent cancers, benign tumors, rheumatoid arthritis, diabetic retinopathy, psoriasis, ocular angiogenesis diseases, Osler-Webber Syndrome, myocardial angiogenesis, plaque neovascularization, telangiectasia, hemopheliac joints, angiofibroma, wound granulation, intestinal adhesions, atherosclerosis, scleroderma, hypertrophic scars, cat scratch disease, *Helicobacter pylori* ulcers, dialysis graft
15 vascular access stenosis, contraception and obesity. The disease may be cancer.

The invention further features an isolated polynucleotide encoding an anti-angiogenic protein, where the isolated polynucleotide is produced by the process of:
(a) preparing one or more polynucleotide probes that hybridize under conditions under moderate to high stringency to nucleotide 6442 to nucleotide 7062 of SEQ ID
20 NO:1; (b) hybridizing the probe(s) to mammalian DNA; and (c) isolating the polynucleotide detected with the probe(s); so that the nucleotide sequence of the isolated polynucleotide has anti-angiogenic activity and corresponds to the nucleotide sequence of nucleotide 6442 to nucleotide 7062 of SEQ ID NO:1. The probes may be SEQ ID NO:3 and SEQ ID NO:4. The isolated polynucleotide may
25 also be a subsequence of SEQ ID NO:1. Alternatively, the polynucleotide can also correspond to about nucleotide 7054 to about nucleotide 7599, nucleotide 7600 to about nucleotide 78283, nucleotide 8284 to about nucleotide 8685, or nucleotide 8686 to about nucleotide 9300.

The invention also features a method for producing an anti-angiogenic
30 polypeptide, where the method comprises: (a) growing a culture of a host cell transformed with the polynucleotide of nucleotide 6442 to nucleotide 7062 of SEQ

ID NO:1, where the host cell is selected from the group comprising bacterial, yeast, mammalian, insect or plant cells; and (b) purifying the protein from the culture; so that an anti-angiogenic polypeptide is produced. Alternatively, the polynucleotide can also correspond to about nucleotide 7054 to about nucleotide 7599, nucleotide
5 7600 to about nucleotide 78283, nucleotide 8284 to about nucleotide 8685, or nucleotide 8686 to about nucleotide 9300.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H, 1I and 1J are a diagram depicting the nucleotide (SEQ ID NO:1) and amino acid (SEQ ID NO:2) sequences of the five
10 globular domains (G1, G2, G3, G4 and G5) of the α 1 chain of laminin-1 (GenBank Acc.No. NM_008480). Forward primers are depicted in bold face type with single underlining, and reverse primers are shown with double underlining. Globular domain 1 (G1) extends from about nucleotide 6442 to about nucleotide 7062, and about amino acid 2132 to about amino acid 2338. The forward primer used for the
15 G1 domain was 5'-CGG-GAT-CCT-AGA-GAC-TGC-ATC-CGC-GCC-TAT-3' (SEQ ID NO:3), and the reverse primer was 5'-CCC-AAG-CTT-TAC-TAT-CTG-CGT-CAC-GGT-GGG-3' (SEQ ID NO:4). Globular domain 2 (G2) extends from about nucleotide 7054 to about nucleotide 7599, and about amino acid 2336 to about amino acid 2517. The forward primer used for the G2 domain was 5'-CGG-GAT-
20 CCT-CAG-ATA-GTA-ATT-CTC-TTC-AGC-ACC-3' (SEQ ID NO:5), and the reverse primer was 5'-CCC-AAG-CTT-GGA-TGA-CTC-AGG-TGA-GAG-AGA-3' (SEQ ID NO:6). Globular domain 3 (G3) extends from about nucleotide 7600 to about nucleotide 8283, and about amino acid 2518 to about amino acid 2745. The forward primer used for the G3 domain was 5'-CGG-GAT-CCT-CTG-CTG-GCC-ACA-TTC-GCC-A-3' (SEQ ID NO:7), and the reverse primer was 5'-CCC-AAG-
25 CTT-CCT-CTT-CCG-GAC-ATC-AGA-C-3' (SEQ ID NO:8). Globular domain 4 (G4) extends from about nucleotide 8284 to about nucleotide 8685, and about amino acid 2746 to about amino acid 2879. The forward primer used for the G4 domain was 5'-CGG-GAT-CCT-CTC-CAG-GTG-CAG-CTG-AGC-ATT-3' (SEQ ID NO:9),
30 and the reverse primer was 5'-CCC-AAG-CTT-CTG-TTG-GCC-ATT-AAC-CAT-

GAT-3' (SEQ ID NO:10). Globular domain 5 (G5) extends from about nucleotide 8686 to about nucleotide 9300, and about amino acid 2880 to about amino acid 3084. The forward primer used for the G5 domain was 5'-CGG-GAT-CCT-CTG GAT-AAA-GAC-AGG-CCC-TTG-3' (SEQ ID NO:11), and the reverse primer was 5'-CCC-AAG-CTT-GGG-CTC-AGG-CCC-GGG-GCA-GGA-AT-3' (SEQ ID NO:12). Underlined portions of the above primers correspond to the laminin sequence.

Fig. 2 is a schematic diagram representing the Matin cloning vector pET22b(+). Forward (SEQ ID NO:3) and reverse (SEQ ID NO:4) primers and site into which Matin was cloned are indicated.

Figs. 3A and 3B are histograms showing the effect of varying concentrations of Matin (x-axis) on proliferation of endothelial (C-PAE) cells (Fig. 3A) and non-endothelial (PC-3) cells (Fig. 3B). Proliferation was measured as a function of methylene blue staining.

Fig. 4 is a plot showing annexin V fluorescence for cells treated with Matin as compared to controls.

Figs. 5A and 5B are a pair of bar charts showing caspase-3 activity in Matin-treated CPAE cells (Fig. 5A) as compared to PC-3 cells (Fig. 5B).

Figs. 6A and 6B are a pair of histograms showing cell viability at increasing concentrations of Matin (x-axis) as a function of OD₅₉₀ (y-axis) in an MTT apoptosis assay for CPAE cells (Fig. 6A) as compared to PC-3 cells (Fig. 6B). Each point represents the mean +/- the standard error of the mean for triplicate wells.

Fig. 7 is a line graph showing the effect on tumor size (mm³, y-axis) against days of treatment (x-axis) with 20 mg/ml Matin (■) versus controls (20 mg/ml nephrin (○) and PBS (□)).

DETAILED DESCRIPTION OF THE INVENTION

A wide variety of diseases are the result of undesirable angiogenesis. Put another way, many diseases and undesirable conditions could be prevented or alleviated if it were possible to stop the growth and extension of capillary blood vessels under some conditions, at certain times, or in particular tissues.

The formation of new capillaries from pre-existing vessels, angiogenesis, is essential for the process of tumor growth and metastasis (Folkman, J. *et al.*, 1992, *J. Biol. Chem.* 267:10931-10934; Folkman, J., 1995, *Nat. Med.* 1:27-31; Hanahan, D. *et al.*, 1996, *Cell* 86:353-364). Human and animal tumors are not vascularized at the beginning, however for a tumor to grow beyond few mm³, it might vascularize (Folkman, J., 1995, *Nat. Med.* 1:27-31; Hanahan, D. *et al.*, 1996, *Cell* 86:353-364). The switch to an angiogenic phenotype requires both upregulation of angiogenic stimulators and downregulation of angiogenesis inhibitors (Folkman, J., 1995, *Nat. Med.* 1:27-31). Vascular endothelial growth factor (VEGF) and basic fibroblast growth factor (bFGF) are the most commonly expressed angiogenic factors in tumors. Vascularized tumors may overexpress one or more of these angiogenic factors which can synergistically promote tumor growth. Inhibition of a single angiogenic factor such as VEGF with a receptor antagonist may not be enough to arrest tumor growth. A number of angiogenesis inhibitors have been recently identified, and certain factors such as IFN- α , platelet-factor-4 (Maione, T.E. *et al.*, 1990, *Science* 247:77-79) and PEX (Brooks, P.C. *et al.*, 1998, *Cell* 92:391-400) are not endogenously associated with tumor cells, whereas angiostatin (O'Reilly, M.S. *et al.*, 1994, *Cell* 79:315-328) and endostatin (O'Reilly, M.S. *et al.*, 1997, *Cell* 88:277-285) are tumor associated angiogenesis inhibitors generated by tumor tissue itself. Although treatment of tumor growth and metastasis with these endogenous angiogenesis inhibitors is very effective and an attractive idea, some potential problems associated with anti-angiogenic therapies must be considered. Delayed toxicity induced by chronic anti-angiogenic therapy as well as the possibility of impaired wound healing and reproductive angiogenesis occurring during treatment are to be considered seriously.

In the present invention, a protein, and fragments, analogs, derivatives, homologs and mutants thereof with anti-angiogenic properties are described, along with methods of use of this protein, analogs, derivatives, homologs and mutants to inhibit angiogenesis-mediated proliferative diseases. The protein comprises the G1 domain of the α 1 chain of laminin, and is called "Matin." This protein is about 30 kDa, and inhibits endothelial cell proliferation.

Laminin is the most abundant noncollagenous protein found in basement membranes. It was initially purified from mouse EHS (Engelbreth-Holm-Swarm) tumors and the mouse embryonal carcinoma cell line M1536-B3. These oncogenic sources produce large amounts of easily extractable basement membrane-like substance, and most early research into components of the basement membrane used these tumor lines as sources, rather than naturally-occurring basement membranes. The patterns of gene expression are known to be different, however, between oncogenic and naturally-occurring tissues.

Laminin is a multidomain protein (Paulsson, M., 1992, *Crit. Rev. Biochem. Mol. Biol.* 27:93-127), with three distinct polypeptide chains, α , $\beta 1$ and $\beta 2$, connected into a cross shape by disulfide bonds. The N-terminal portion of each chain, containing domains III through VI, each forms one arm of the cross, and the C-terminal portions (containing domains I and II) of all three chains are joined together by disulfide bonds into the fourth arm. Put another way, the N-terminal half of the α chain makes up the vertical arms of the cross, while the N-terminal half of the $\beta 1$ and $\beta 2$ chains make up the left and right arms. The C-terminal halves of all three chains join together to form the lower vertical arm of the cross. The G domain only exists at the C-terminal end of the α chain, not on either of the β chains. The G domain is subdivided into five subdomains, G1 through G5. Merosin, an isoform of laminin, was found to share some amino acid identity with the C-terminus of the α chain of mouse laminin, and the general domain structure is conserved between the two.

Matin can be obtained from a variety of sources. Such sources include, but are not limited to, P19137 (LAMININ ALPHA-1 CHAIN PRECURSOR (LAMININ A CHAIN)), MMMSA (laminin alpha-1 chain precursor - mouse) and AAA39410 (laminin A chain [Mus musculus]). Human laminin has a slightly lower sequence identity with SEQ ID NO:2, e.g., around 83%. Such sequences are also useful for obtaining Matin, and include, but are not limited to, P25391 (LAMININ ALPHA-1 CHAIN PRECURSOR (LAMININ A CHAIN)), S14458 (laminin alpha-1 chain precursor - human) and CAA41418 (laminin A chain [Homo sapiens]). Other sequences have a lower identity with SEQ ID NO:2, but may still be useful sources

of anti-angiogenic Matin. These may include, but are not necessarily limited to, PX0082 (laminin, M chain - human (fragment)), MMHUMH (laminin alpha-2 chain - human (fragment)), AAB33989 (laminin M chain, merosin=basement membrane protein {G-domain} [human, placenta, Peptide Partial, 1751 aa] [Homo sapiens]),
 5 AAA63215 (merosin [Homo sapiens]), AAB18388 (laminin alpha 2 chain [Homo sapiens]), NP_000417 (laminin alpha 2 subunit precursor; Laminin, alpha-2 (merosin) [Homo sapiens]), P24043 (LAMININ ALPHA-2 CHAIN PRECURSOR (LAMININ M CHAIN) (MEROSIN HEAVY CHAIN)), CAA81394 (laminin M chain (merosin) [Homo sapiens]), XP_011387 (laminin alpha 2 subunit precursor
 10 [Homo sapiens]), Q60675 (LAMININ ALPHA-2 CHAIN PRECURSOR (LAMININ M CHAIN) (MEROSIN HEAVY CHAIN)), S53868 (laminin alpha-2 chain precursor - mouse), AAC52165 (laminin-2 alpha2 chain precursor [Mus musculus]).

Interestingly, the various globular domains themselves possess varying levels of sequence identity with each other. This is shown in Table 1, below.

15 Table 1. Percent sequence identity of the globular domains of the mouse laminin α chain.

	G1	G2	G3	G4	G5
G1					
G2	31				
G3	-	27			
G4	24	25	-		
G5	23	31	27	25	

Polynucleotides encoding Matin can also be obtained from a variety of sources. For instance, other mouse laminin α chain globular domains (*e.g.*,) generally possess greater than 90% sequence identity with SEQ ID NO:1, and
 25 include, but are not limited to, J04064 (Mus musculus laminin A chain mRNA, complete cds) and X58531 (Human LAMA mRNA for laminin A chain, partial cds).

As disclosed herein, Matin can be produced in *E. coli* using a bacterial expression plasmid, such as pET22b, which is capable of periplasmic transport, thus resulting in soluble protein. Matin can also be produced in other cells, for instance, it can be produced as a secreted soluble protein in 293 kidney cells using the pcDNA
5 3.1 eukaryotic vector.

E. coli-produced Matin inhibits endothelial cell proliferation of endothelial cells in a dose-dependent manner.

Specific inhibition of endothelial cell proliferation and migration by Matin demonstrates its anti-angiogenic activity, and that it may function via a cell surface
10 protein/receptor. Integrins are potential candidate molecules based on their extracellular matrix binding capacity and ability to modulate cell behavior such as migration and proliferation. In particular, $\alpha_v\beta_3$ integrin is a possible receptor, due to its induction during angiogenesis, and its promiscuous binding capacity. Angiogenesis also depends on specific endothelial cell adhesive events mediated by
15 integrin $\alpha_v\beta_3$ (Brooks, P.C. *et al.*, 1994, *Cell* 79:1157-1164). Matin may disrupt the interaction of proliferating endothelial cells to the matrix component, and thus drive endothelial cells to undergo apoptosis (Re, F. *et al.*, 1994, *J. Cell. Biol.* 127:537-546). Matrix metalloproteinases (MMP's) have been implicated as key enzymes that regulate the formation of new blood vessels in tumors (Ray, J.M. *et al.*, 1994, *Eur.*
20 *Respir. J.* 7:2062-2072). Recently, it was demonstrated that an inhibitor of MMP-2 (PEX) can suppress tumor growth by inhibiting angiogenesis (Brooks, P.C. *et al.*, 1998, *Cell* 92:391-400). Matin may function through inhibiting the activity of MMPs.

As used herein, the term "angiogenesis" means the generation of new blood
25 vessels into a tissue or organ, and involves endothelial cell proliferation. Under normal physiological conditions, humans or animals undergo angiogenesis only in very specific restricted situations. For example, angiogenesis is normally observed in wound healing, fetal and embryonal development, and formation of the corpus luteum, endometrium and placenta. The term "endothelium" means a thin layer of
30 flat epithelial cells that lines serous cavities, lymph vessels, and blood vessels. "Anti-angiogenic activity" therefore refers to the capability of a composition to

inhibit the growth of blood vessels. The growth of blood vessels is a complex series of events, and includes localized breakdown of the basement membrane lying under the individual endothelial cells, proliferation of those cells, migration of the cells to the location of the future blood vessel, reorganization of the cells to form a new vessel membrane, cessation of endothelial cell proliferation, and, incorporation of pericytes and other cells that support the new blood vessel wall. “Anti-angiogenic activity” as used herein therefore includes interruption of any or all of these stages, with the end result that formation of new blood vessels is inhibited.

Anti-angiogenic activity may include endothelial inhibiting activity, which refers to the capability of a composition to inhibit angiogenesis in general and, for example, to inhibit the growth or migration of bovine capillary endothelial cells in culture in the presence of fibroblast growth factor, angiogenesis-associated factors, or other known growth factors. A “growth factor” is a composition that stimulates the growth, reproduction, or synthetic activity of cells. An “angiogenesis-associated factor” is a factor which either inhibits or promotes angiogenesis. An example of an angiogenesis-associated factor is an angiogenic growth factor, such as basic fibroblastic growth factor (bFGF), which is an angiogenesis promoter. Another example of an angiogenesis-associated factor is an angiogenesis inhibiting factor such as *e.g.*, angiostatin (see, *e.g.*, U.S. Pat. No. 5,801,012, U.S. Pat. No. 5,837,682, U.S. Pat. No. 5,733,876, U.S. Pat. No. 5,776,704, U.S. Pat. No. 5,639,725, U.S. Pat. No. 5,792,845, WO 96/35774, WO 95/29242, WO 96/41194, WO 97/23500) or endostatin (see, *e.g.*, U.S. Pat. No. 5,854,205; U.S. Pat. No. 6,174,861; WO 97/15666).

By “substantially the same biological activity” or “substantially the same or superior biological activity” is meant that a composition has anti-angiogenic activity, and behaves similarly as does Matin, as determined in standard assays. “Standard assays” include, but are not limited to, those protocols used in the molecular biological arts to assess anti-angiogenic activity, cell cycle arrest, and apoptosis. Such assays include, but are not limited to, assays of endothelial cell proliferation, endothelial cell migration, cell cycle analysis, and endothelial cell tube formation, detection of apoptosis, *e.g.*, by apoptotic cell morphology or Annexin V-FITC assay,

chorioallantoic membrane (CAM) assay, and inhibition of renal cancer tumor growth in nude mice. Such assays are provided in the Examples below, and also in U.S.S.N. 09/335,224, "Anti-Angiogenic Proteins and Methods of Use thereof," filed June 17, 1999, by Raghuram Kalluri, and in U.S.S.N. 09/479,118, "Anti-Angiogenic Proteins and Receptors and Methods of Use thereof," by Raghuram Kalluri, filed January 7, 2000, all of which are incorporated herein by reference in their entirety.

"Matin" is intended to include fragments, mutants, homologs, analogs, and allelic variants of the amino acid sequence of the Matin sequence, as well as Matin from other globular domains, globular domains from other α chains, other laminins, laminins from other mammals, and fragments, mutants, homologs, analogs and allelic variants of the Matin amino acid sequence.

It is to be understood that the present invention is contemplated to include any derivatives of Matin that have endothelial inhibitory activity (*e.g.*, the capability of a composition to inhibit angiogenesis in general and, for example, to inhibit the growth or migration of bovine capillary endothelial cells in culture in the presence of fibroblast growth factor, angiogenesis-associated factors, or other known growth factors). The present invention includes the entire Matin protein, derivatives of this protein and biologically-active fragments of this protein. This includes proteins with Matin activity that have amino acid substitutions or have sugars or other molecules attached to amino acid functional groups.

The invention also describes fragments, mutants, homologs and analogs of Matin. A "fragment" of a protein is defined herein as any amino acid sequence shorter than that protein, comprising at least 25 consecutive amino acids of the full polypeptide. Such a fragment may alternatively comprise 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49 or 50 consecutive amino acids of the full polypeptide. The fragment may comprise 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74 or 75 consecutive amino acids of the full polypeptide. Such molecules may or may not also comprise additional amino acids derived from the process of cloning, *e.g.*, amino acid residues or amino acid sequences corresponding to full or partial linker sequences. To be encompassed by the present invention, such molecules, with or

without such additional amino acid residues, must have substantially the same biological activity as the reference polypeptide.

Where the full-length molecule possesses more than one activity, *e.g.*, it may be possible to “split” the activities by splitting the full-length protein into several
5 fragments, *e.g.*, the full-length protein can be split into two fragments, one of which may possess one activity, while the other possesses another activity. The two fragments may or may not overlap, and the two activities may or may not be apparent in the full-length molecule. For instance, the full-length molecule may possess activity “A”, and two fragments whereof may possess activities “A₁” and
10 “A₂”, respectively, or they may possess activities “B” and “C”. Therefore, when it is stated that a fragment or mutant “must have substantially the same biological activity as the reference polypeptide”, it is intended that in situations where one or more biological activities are split, the “reference polypeptide” is that subsequence of the overall molecule that corresponds to the fragment or mutant. That is, the
15 fragment or mutant must have the substantially the same biological activity as that portion of the overall molecule to which they correspond.

By “mutant” of Matin is meant a polypeptide that includes any change in the amino acid sequence relative to the amino acid sequence of the equivalent reference Matin polypeptide. Such changes can arise either spontaneously or by manipulations
20 by man, by chemical energy (*e.g.*, X-ray), or by other forms of chemical mutagenesis, or by genetic engineering, or as a result of mating or other forms of exchange of genetic information. Mutations include, *e.g.*, base changes, deletions, insertions, inversions, translocations, or duplications. Mutant forms of Matin may display either increased or decreased anti-angiogenic activity relative to the
25 equivalent reference Matin polynucleotide, and such mutants may or may not also comprise additional amino acids derived from the process of cloning, *e.g.*, amino acid residues or amino acid sequences corresponding to full or partial linker sequences. Mutants/fragments of the anti-angiogenic proteins of the present invention can also be generated by PCR cloning, or by *Pseudomonas* elastase
30 digestion, as described by Mariyama, M. *et al.* (1992, *J. Biol. Chem.* 267:1253-1258).

By “analog” of Matin is meant a non-natural molecule substantially similar to either the entire Matin molecule or a fragment or allelic variant thereof, and having substantially the same or superior biological activity. Such analogs are intended to include derivatives (*e.g.*, chemical derivatives, as defined above) of the biologically active Matin, as well as its fragments, mutants, homologs, and allelic variants, which derivatives exhibit a qualitatively similar agonist or antagonist effect to that of the unmodified Matin polypeptide, fragment, mutant, homolog, or allelic variant.

By “allele” of Matin is meant a polypeptide sequence containing a naturally-occurring sequence variation relative to the polypeptide sequence of the reference Matin polypeptide. By “allele” of a polynucleotide encoding the Matin polypeptide is meant a polynucleotide containing a sequence variation relative to the reference polynucleotide sequence encoding the reference Matin polypeptide, where the allele of the polynucleotide encoding the Matin polypeptide encodes an allelic form of the Matin polypeptide.

It is possible that a given polypeptide may be either a fragment, a mutant, an analog, or allelic variant of Matin, or it may be two or more of those things, *e.g.*, a polypeptide may be both an analog and a mutant of the Matin polypeptide. For example, a shortened version of the Matin molecule (*e.g.*, a fragment of Matin) may be created in the laboratory. If that fragment is then mutated through means known in the art, a molecule is created that is both a fragment and a mutant of Matin. In another example, a mutant may be created, which is later discovered to exist as an allelic form of Matin in some mammalian individuals. Such a mutant Matin molecule would therefore be both a mutant and an allelic variant. Such combinations of fragments, mutants, allelic variants, and analogs are intended to be encompassed in the present invention.

Encompassed by the present invention are proteins that have substantially the same amino acid sequence as Matin, or polynucleotides that have substantially the same nucleic acid sequence as the polynucleotides encoding Matin. “Substantially the same sequence” means a nucleic acid or polypeptide that exhibits at least about 70 % sequence identity with a reference sequence, *e.g.*, another nucleic acid or

polypeptide, typically at least about 80% sequence identity with the reference sequence, preferably at least about 90% sequence identity, more preferably at least about 95% identity, and most preferably at least about 97% sequence identity with the reference sequence. The length of comparison for sequences will generally be at least 75 nucleotide bases or 25 amino acids, more preferably at least 150 nucleotide bases or 50 amino acids, and most preferably 243-264 nucleotide bases or 81-88 amino acids. "Polypeptide" as used herein indicates a molecular chain of amino acids and does not refer to a specific length of the product. Thus, peptides, oligopeptides and proteins are included within the definition of polypeptide. This term is also intended to include polypeptide that have been subjected to post-expression modifications such as, for example, glycosylations, acetylations, phosphorylations and the like.

"Sequence identity," as used herein, refers to the subunit sequence similarity between two polymeric molecules, *e.g.*, two polynucleotides or two polypeptides. When a subunit position in both of the two molecules is occupied by the same monomeric subunit, *e.g.*, if a position in each of two peptides is occupied by serine, then they are identical at that position. The identity between two sequences is a direct function of the number of matching or identical positions, *e.g.*, if half (*e.g.*, 5 positions in a polymer 10 subunits in length) of the positions in two peptide or compound sequences are identical, then the two sequences are 50% identical; if 90% of the positions, *e.g.*, 9 of 10 are matched, the two sequences share 90% sequence identity. By way of example, the amino acid sequences $R_2R_5R_7R_{10}R_6R_3$ and $R_9R_8R_1R_{10}R_6R_3$ have 3 of 6 positions in common, and therefore share 50% sequence identity, while the sequences $R_2R_5R_7R_{10}R_6R_3$ and $R_8R_1R_{10}R_6R_3$ have 3 of 5 positions in common, and therefore share 60% sequence identity. The identity between two sequences is a direct function of the number of matching or identical positions. Thus, if a portion of the reference sequence is deleted in a particular peptide, that deleted section is not counted for purposes of calculating sequence identity, *e.g.*, $R_2R_5R_7R_{10}R_6R_3$ and $R_2R_5R_7R_{10}R_3$ have 5 out of 6 positions in common, and therefore share 83.3% sequence identity.

Identity is often measured using sequence analysis software *e.g.*, BLASTN or BLASTP (available at <http://www.ncbi.nlm.nih.gov/BLAST/>). The default parameters for comparing two sequences (*e.g.*, “Blast”-ing two sequences against each other, <http://www.ncbi.nlm.nih.gov/gorf/bl2.html>) by BLASTN (for nucleotide
5 sequences) are reward for match = 1, penalty for mismatch = -2, open gap = 5, extension gap = 2. When using BLASTP for protein sequences, the default parameters are reward for match = 0, penalty for mismatch = 0, open gap = 11, and extension gap = 1.

When two sequences share “sequence homology,” it is meant that the two
10 sequences differ from each other only by conservative substitutions. For polypeptide sequences, such conservative substitutions consist of substitution of one amino acid at a given position in the sequence for another amino acid of the same class (*e.g.*, amino acids that share characteristics of hydrophobicity, charge, pK or other conformational or chemical properties, *e.g.*, valine for leucine, arginine for lysine),
15 or by one or more non-conservative amino acid substitutions, deletions, or insertions, located at positions of the sequence that do not alter the conformation or folding of the polypeptide to the extent that the biological activity of the polypeptide is destroyed. Examples of “conservative substitutions” include substitution of one non-polar (hydrophobic) residue such as isoleucine, valine, leucine or methionine for
20 one another; the substitution of one polar (hydrophilic) residue for another such as between arginine and lysine, between glutamine and asparagine, between threonine and serine; the substitution of one basic residue such as lysine, arginine or histidine for one another; or the substitution of one acidic residue, such as aspartic acid or glutamic acid for one another; or the use of a chemically derivatized residue in place
25 of a non-derivatized residue; provided that the polypeptide displays the requisite biological activity. Two sequences which share sequence homology may called “sequence homologs.”

The invention contemplates mutants of the proteins and peptides disclosed herein, where the mutation(s) do not substantially alter the activity of the protein or
30 peptide, that is the mutations are effectively “silent” mutations.

Homology, for polypeptides, is typically measured using sequence analysis software (*e.g.*, Sequence Analysis Software Package of the Genetics Computer Group, University of Wisconsin Biotechnology Center, 1710 University Avenue, Madison, WI 53705). Protein analysis software matches similar sequences by
5 assigning degrees of homology to various substitutions, deletions, and other modifications. Conservative substitutions typically include substitutions within the following groups: glycine, alanine; valine, isoleucine, leucine; aspartic acid, glutamic acid, asparagine, glutamine; serine, threonine; lysine, arginine; and phenylalanine, tyrosine.

10 Also encompassed by the present invention are chemical derivatives of Matin. "Chemical derivative" refers to a subject polypeptide having one or more residues chemically derivatized by reaction of a functional side group. Such derivatized residues include for example, those molecules in which free amino groups have been derivatized to form amine hydrochlorides, p-toluene sulfonyl
15 groups, carbobenzoxy groups, t-butyloxycarbonyl groups, chloroacetyl groups or formyl groups. Free carboxyl groups may be derivatized to form salts, methyl and ethyl esters or other types of esters or hydrazides. Free hydroxyl groups may be derivatized to form O-acyl or O-alkyl derivatives. The imidazole nitrogen of histidine may be derivatized to form N-imbenzylhistidine. Also included as
20 chemical derivatives are those peptides which contain one or more naturally occurring amino acid derivatives of the twenty standard amino acids. For examples: 4-hydroxyproline may be substituted for proline; 5-hydroxylysine may be substitute for lysine; 3-methylhistidine may be substituted for histidine; homoserine may be substituted for serine; and ornithine may be substituted for lysine.

25 The present invention also includes fusion proteins and chimeric proteins comprising the anti-angiogenic proteins, their fragments, mutants, homologs, analogs, and allelic variants. A fusion or chimeric protein can be produced as a result of recombinant expression and the cloning process, *e.g.*, the protein may be produced comprising additional amino acids or amino acid sequences corresponding
30 to full or partial linker sequences. A fusion or chimeric protein can consist of a multimer of a single protein, *e.g.*, repeats of the anti-angiogenic proteins, or the

fusion and chimeric proteins can be made up of several proteins, *e.g.*, several of the anti-angiogenic proteins. The fusion or chimeric protein can comprise a combination of two or more known anti-angiogenic proteins (*e.g.*, angiostatin and endostatin, or biologically active fragments of angiostatin and endostatin), or an anti-angiogenic protein in combination with a targeting agent (*e.g.*, endostatin with epidermal growth factor (EGF) or RGD peptides), or an anti-angiogenic protein in combination with an immunoglobulin molecule (*e.g.*, endostatin and IgG, specifically with the Fc portion removed). The fusion and chimeric proteins can also include the anti-angiogenic proteins, their fragments, mutants, homologs, analogs, and allelic variants, and other anti-angiogenic proteins, *e.g.*, endostatin, or angiostatin. Other anti-angiogenic proteins can include Arresten, Canstatin or Tumstatin (PCT/US99/13737, the entire teachings of which are herein incorporated by reference), Vascostatin, restin and apomigren (PCT/US98/26058, the entire teachings of which are herein incorporated by reference) and fragments of endostatin (PCT/US98/26057, the entire teachings of which are herein incorporated by reference). The term “fusion protein” or “chimeric protein” as used herein can also encompass additional components for *e.g.*, delivering a chemotherapeutic agent, wherein a polynucleotide encoding the chemotherapeutic agent is linked to the polynucleotide encoding the anti-angiogenic protein. Fusion or chimeric proteins can also encompass multimers of an anti-angiogenic protein, *e.g.*, a dimer or trimer. Such fusion or chimeric proteins can be linked together via post-translational modification (*e.g.*, chemically linked), or the entire fusion protein may be made recombinantly.

Multimeric proteins comprising Matin, its fragments, mutants, homologs, analogs and allelic variants are also intended to be encompassed by the present invention. By “multimer” is meant a protein comprising two or more copies of a subunit protein. The subunit protein may be one of the proteins of the present invention, *e.g.*, Matin repeated two or more times, or a fragment, mutant, homolog, analog or allelic variant, *e.g.*, a Matin mutant or fragment, repeated two or more times. Such a multimer may also be a fusion or chimeric protein, *e.g.*, a repeated tumstatin mutant may be combined with polylinker sequence, and/or one or more

anti-angiogenic peptides, which may be present in a single copy, or may also be tandemly repeated, *e.g.*, a protein may comprise two or more multimers within the overall protein.

The invention also encompasses a composition comprising one or more
5 isolated polynucleotide(s) encoding *Matin*, as well as vectors and host cells
containing such a polynucleotide, and processes for producing *Matin* and its
fragments, mutants, homologs, analogs and allelic variants. The term "vector" as
used herein means a carrier into which pieces of nucleic acid may be inserted or
cloned, which carrier functions to transfer the pieces of nucleic acid into a host cell.
10 Such a vector may also bring about the replication and/or expression of the
transferred nucleic acid pieces. Examples of vectors include nucleic acid molecules
derived, *e.g.*, from a plasmid, bacteriophage, or mammalian, plant or insect virus, or
non-viral vectors such as ligand-nucleic acid conjugates, liposomes, or lipid-nucleic
acid complexes. It may be desirable that the transferred nucleic molecule is
15 operatively linked to an expression control sequence to form an expression vector
capable of expressing the transferred nucleic acid. Such transfer of nucleic acids is
generally called "transformation," and refers to the insertion of an exogenous
polynucleotide into a host cell, irrespective of the method used for the insertion. For
example, direct uptake, transduction or f-mating are included. The exogenous
20 polynucleotide may be maintained as a non-integrated vector, for example, a
plasmid, or alternatively, may be integrated into the host genome. "Operably linked"
refers to a situation wherein the components described are in a relationship
permitting them to function in their intended manner, *e.g.*, a control sequence
"operably linked" to a coding sequence is ligated in such a manner that expression of
25 the coding sequence is achieved under conditions compatible with the control
sequence. A "coding sequence" is a polynucleotide sequence which is transcribed
into mRNA and translated into a polypeptide when placed under the control of (*e.g.*,
operably linked to) appropriate regulatory sequences. The boundaries of the coding
sequence are determined by a translation start codon at the 5'-terminus and a
30 translation stop codon at the 3'-terminus. Such boundaries can be naturally-
occurring, or can be introduced into or added the polynucleotide sequence by

methods known in the art. A coding sequence can include, but is not limited to, mRNA, cDNA, and recombinant polynucleotide sequences.

The vector into which the cloned polynucleotide is cloned may be chosen because it functions in a prokaryotic, or alternatively, it is chosen because it
5 functions in a eukaryotic organism. Two examples of vectors which allow for both the cloning of a polynucleotide encoding the Matin protein, and the expression of that protein from the polynucleotide, are the pET22b and pET28(a) vectors (Novagen, Madison, Wisconsin, USA) and a modified pPICZ α A vector (Invitrogen, San Diego, California, USA), which allow expression of the protein in bacteria and
10 yeast, respectively (see for example, WO 99/29878 and U.S.S.N. 09/589,483, the entire teachings which are hereby incorporated by reference).

Once a polynucleotide has been cloned into a suitable vector, it can be transformed into an appropriate host cell. By "host cell" is meant a cell which has been or can be used as the recipient of transferred nucleic acid by means of a vector.
15 Host cells can be prokaryotic or eukaryotic, mammalian, plant, or insect, and can exist as single cells, or as a collection, *e.g.*, as a culture, or in a tissue culture, or in a tissue or an organism. Host cells can also be derived from normal or diseased tissue from a multicellular organism, *e.g.*, a mammal. Host cell, as used herein, is intended to include not only the original cell which was transformed with a nucleic acid, but
20 also descendants of such a cell, which still contain the nucleic acid.

In one embodiment, the isolated polynucleotide encoding the anti-angiogenic protein additionally comprises a polynucleotide linker encoding a peptide. Such linkers are known to those of skill in the art and, for example the linker can comprise at least one additional codon encoding at least one additional amino acid. Typically
25 the linker comprises one to about twenty or thirty amino acids. The polynucleotide linker is translated, as is the polynucleotide encoding the anti-angiogenic protein, resulting in the expression of an anti-angiogenic protein with at least one additional amino acid residue at the amino or carboxyl terminus of the anti-angiogenic protein. Importantly, the additional amino acid, or amino acids, do not compromise the
30 activity of the anti-angiogenic protein.

After inserting the selected polynucleotide into the vector, the vector is transformed into an appropriate prokaryotic strain and the strain is cultured (*e.g.*, maintained) under suitable culture conditions for the production of the biologically active anti-angiogenic protein, thereby producing a biologically active
5 anti-angiogenic protein, or mutant, derivative, fragment or fusion protein thereof. In one embodiment, the invention comprises cloning of a polynucleotide encoding an anti-angiogenic protein into the vectors pET22b, pET17b or pET28a, which are then transformed into bacteria. The bacterial host strain then expresses the anti-angiogenic protein. Typically the anti-angiogenic proteins are produced in quantities
10 of about 10-20 milligrams, or more, per liter of culture fluid.

In another embodiment of the present invention, the eukaryotic vector comprises a modified yeast vector. One method is to use a pPICZ α plasmid wherein the plasmid contains a multiple cloning site. The multiple cloning site has inserted into the multiple cloning site a His.Tag motif. Additionally the vector can be
15 modified to add a *Nde*I site, or other suitable restriction sites. Such sites are well known to those of skill in the art. Anti-angiogenic proteins produced by this embodiment comprise a histidine tag motif (His.tag) comprising one, or more histidines, typically about 5-20 histidines. The tag must not interfere with the anti-angiogenic properties of the protein.

20 One method of producing Matin, for example, is to amplify the polynucleotide of SEQ ID NO:1 and clone it into an expression vector, *e.g.*, pET22b, pET28(a), pPICZ α A, or some other expression vector, transform the vector containing the polynucleotide into a host cell capable of expressing the polypeptide encoded by the polynucleotide, culturing the transformed host cell under culture
25 conditions suitable for expressing the protein, and then extracting and purifying the protein from the culture. Exemplary methods of producing anti-angiogenic proteins in general, are provided in the Examples below and in U.S.S.N. 09/335, 224, "Anti-Angiogenic Proteins and Methods of Use Thereof," by Raghuram Kalluri, filed June 17, 1999. The Matin protein may also be expressed as a product of transgenic
30 animals, *e.g.*, as a component of the milk of transgenic cows, goats, sheep or pigs, as is described in U.S. Pat. No. 5,962,648, or as a product of a transgenic plant, *e.g.*,

combined or linked with starch molecules in maize, or as is described in U.S. Pat. No. 5,639,947 or 5,990,385.

Matin may also be produced by conventional, known methods of chemical synthesis. Methods for constructing the proteins of the present invention by
5 synthetic means are known to those skilled in the art. The synthetically-constructed Matin protein sequence, by virtue of sharing primary, secondary or tertiary structural and/or conformational characteristics with *e.g.*, recombinantly-produced Matin, may possess biological properties in common therewith, including biological activity. Thus, the synthetically-constructed Matin protein sequence may be employed as
10 biologically active or immunological substitutes for *e.g.*, recombinantly-produced, purified Matin protein in screening of therapeutic compounds and in immunological processes for the development of antibodies.

The Matin protein is useful in inhibiting angiogenesis, as determined in standard assays, and provided in the Examples below.

15 Polynucleotides encoding Matin can be cloned out of isolated DNA or a cDNA library. Nucleic acids polypeptides, referred to herein as "isolated" are nucleic acids or polypeptides substantially free (*i.e.*, separated away from) the material of the biological source from which they were obtained (*e.g.*, as exists in a mixture of nucleic acids or in cells), which may have undergone further processing.
20 "Isolated" nucleic acids or polypeptides include nucleic acids or polypeptides obtained by methods described herein, similar methods, or other suitable methods, including essentially pure nucleic acids or polypeptides, nucleic acids or polypeptides produced by chemical synthesis, by combinations of chemical or biological methods, and recombinantly produced nucleic acids or polypeptides
25 which are isolated. An isolated polypeptide therefore means one which is relatively free of other proteins, carbohydrates, lipids, and other cellular components with which it is normally associated. An isolated nucleic acid is not immediately contiguous with (*i.e.*, covalently linked to) both of the nucleic acids with which it is immediately contiguous in the naturally-occurring genome of the organism from
30 which the nucleic acid is derived. The term, therefore, includes, for example, a nucleic acid which is incorporated into a vector (*e.g.*, an autonomously replicating

virus or plasmid), or a nucleic acid which exists as a separate molecule independent of other nucleic acids such as a nucleic acid fragment produced by chemical means or restriction endonuclease treatment.

The polynucleotides and proteins of the present invention can also be used to
5 design probes to isolate other anti-angiogenic proteins. Exceptional methods are provided in U.S. Pat. No. 5,837,490, by Jacobs *et al.*, the entire teachings of which are herein incorporated by reference in its entirety. The design of the oligonucleotide probe should preferably follow these parameters: (a) it should be designed to an area of the sequence which has the fewest ambiguous bases ("N's"),
10 if any, and (b) it should be designed to have a T_m of approx. 80°C (assuming 2°C for each A or T and 4 degrees for each G or C).

The oligonucleotide should preferably be labeled with γ -³²P-ATP (specific activity 6000 Ci/mmol) and T4 polynucleotide kinase using commonly employed techniques for labeling oligonucleotides. Other labeling techniques can also be
15 used. Unincorporated label should preferably be removed by gel filtration chromatography or other established methods. The amount of radioactivity incorporated into the probe should be quantitated by measurement in a scintillation counter. Preferably, specific activity of the resulting probe should be approximately 4×10^6 dpm/pmol. The bacterial culture containing the pool of full-length clones
20 should preferably be thawed and 100 μ l of the stock used to inoculate a sterile culture flask containing 25 ml of sterile L-broth containing ampicillin at 100 μ g/ml. The culture should preferably be grown to saturation at 37°C, and the saturated culture should preferably be diluted in fresh L-broth. Aliquots of these dilutions should preferably be plated to determine the dilution and volume which will yield
25 approximately 5000 distinct and well-separated colonies on solid bacteriological media containing L-broth containing ampicillin at 100 μ g/ml and agar at 1.5% in a 150 mm petri dish when grown overnight at 37°C. Other known methods of obtaining distinct, well-separated colonies can also be employed.

Standard colony hybridization procedures should then be used to transfer the
30 colonies to nitrocellulose filters and lyse, denature and bake them. Highly stringent conditions are those that are at least as stringent as, for example, 1x SSC at 65°C, or

1x SSC and 50% formamide at 42°C. Moderate stringency conditions are those that are at least as stringent as 4x SSC at 65°C, or 4x SSC and 50% formamide at 42°C. Reduced stringency conditions are those that are at least as stringent as 4x SSC at 50°C, or 6x SSC and 50% formamide at 40°C.

5 The filter is then preferably incubated at 65°C for 1 hour with gentle agitation in 6x SSC (20x stock is 175.3 g NaCl/liter, 88.2 g Na citrate/liter, adjusted to pH 7.0 with NaOH) containing 0.5% SDS, 100 µg/ml of yeast RNA, and 10 mM EDTA (approximately 10 mL per 150 mm filter). Preferably, the probe is then added to the hybridization mix at a concentration greater than or equal to 1×10^6
10 dpm/mL. The filter is then preferably incubated at 65°C with gentle agitation overnight. The filter is then preferably washed in 500 mL of 2x SSC/0.5% SDS at room temperature without agitation, preferably followed by 500 mL of 2x SSC/0.1% SDS at room temperature with gentle shaking for 15 minutes. A third wash with 0.1x SSC/0.5% SDS at 65°C for 30 minutes to 1 hour is optional. The filter is then
15 preferably dried and subjected to autoradiography for sufficient time to visualize the positives on the X-ray film. Other known hybridization methods can also be employed. The positive colonies are then picked, grown in culture, and plasmid DNA isolated using standard procedures. The clones can then be verified by restriction analysis, hybridization analysis, or DNA sequencing.

20 Stringency conditions for hybridization refers to conditions of temperature and buffer composition which permit hybridization of a first nucleic acid sequence to a second nucleic acid sequence, wherein the conditions determine the degree of identity between those sequences which hybridize to each other. Therefore, "high stringency conditions" are those conditions wherein only nucleic acid sequences
25 which are very similar to each other will hybridize. The sequences may be less similar to each other if they hybridize under moderate stringency conditions. Still less similarity is needed for two sequences to hybridize under low stringency conditions. By varying the hybridization conditions from a stringency level at which no hybridization occurs, to a level at which hybridization is first observed,
30 conditions can be determined at which a given sequence will hybridize to those sequences that are most similar to it. The precise conditions determining the

stringency of a particular hybridization include not only the ionic strength, temperature, and the concentration of destabilizing agents such as formamide, but also on factors such as the length of the nucleic acid sequences, their base composition, the percent of mismatched base pairs between the two sequences, and the frequency of occurrence of subsets of the sequences (*e.g.*, small stretches of repeats) within other non-identical sequences. Washing is the step in which conditions are set so as to determine a minimum level of similarity between the sequences hybridizing with each other. Generally, from the lowest temperature at which only homologous hybridization occurs, a 1% mismatch between two sequences results in a 1°C decrease in the melting temperature (T_m) for any chosen SSC concentration. Generally, a doubling of the concentration of SSC results in an increase in the T_m of about 17°C. Using these guidelines, the washing temperature can be determined empirically, depending on the level of mismatch sought.

Hybridization and wash conditions are explained in *Current Protocols in Molecular Biology* (Ausubel, F.M. *et al.*, eds., John Wiley & Sons, Inc., 1995, with supplemental updates) on pages 2.10.1 to 2.10.16, and 6.3.1 to 6.3.6.

High stringency conditions can employ hybridization at either (1) 1x SSC (10x SSC = 3 M NaCl, 0.3 M Na₃-citrate·2H₂O (88 g/liter), pH to 7.0 with 1 M HCl), 1% SDS (sodium dodecyl sulfate), 0.1 - 2 mg/ml denatured salmon sperm DNA at 65°C, (2) 1x SSC, 50% formamide, 1% SDS, 0.1 - 2 mg/ml denatured salmon sperm DNA at 42°C, (3) 1% bovine serum albumen (fraction V), 1 mM Na₂·EDTA, 0.5 M NaHPO₄ (pH 7.2) (1 M NaHPO₄ = 134 g Na₂HPO₄·7H₂O, 4 ml 85% H₃PO₄ per liter), 7% SDS, 0.1 - 2 mg/ml denatured salmon sperm DNA at 65°C, (4) 50% formamide, 5x SSC, 0.02 M Tris-HCl (pH 7.6), 1x Denhardt's solution (100x = 10 g Ficoll 400, 10 g polyvinylpyrrolidone, 10 g bovine serum albumin (fraction V), water to 500 ml), 10% dextran sulfate, 1% SDS, 0.1 - 2 mg/ml denatured salmon sperm DNA at 42°C, (5) 5x SSC, 5x Denhardt's solution, 1% SDS, 100 µg/ml denatured salmon sperm DNA at 65°C, or (6) 5x SSC, 5x Denhardt's solution, 50% formamide, 1% SDS, 100 µg/ml denatured salmon sperm DNA at 42°C, with high stringency washes of either (1) 0.3 - 0.1x SSC, 0.1% SDS at 65°C, or (2) 1 mM Na₂EDTA, 40 mM NaHPO₄ (pH 7.2), 1% SDS at 65°C. The

above conditions are intended to be used for DNA-DNA hybrids of 50 base pairs or longer. Where the hybrid is believed to be less than 18 base pairs in length, the hybridization and wash temperatures should be 5 - 10°C below that of the calculated T_m of the hybrid, where T_m in °C = (2 x the number of A and T bases) + (4 x the number of G and C bases). For hybrids believed to be about 18 to about 49 base pairs in length, the T_m in °C = (81.5°C + 16.6(log₁₀M) + 0.41(% G + C) - 0.61 (% formamide) - 500/L), where "M" is the molarity of monovalent cations (e.g., Na⁺), and "L" is the length of the hybrid in base pairs.

Moderate stringency conditions can employ hybridization at either (1) 4x SSC, (10x SSC = 3 M NaCl, 0.3 M Na₃-citrate·2H₂O (88 g/liter), pH to 7.0 with 1 M HCl), 1% SDS (sodium dodecyl sulfate), 0.1 - 2 mg/ml denatured salmon sperm DNA at 65°C, (2) 4x SSC, 50% formamide, 1% SDS, 0.1 - 2 mg/ml denatured salmon sperm DNA at 42°C, (3) 1% bovine serum albumen (fraction V), 1 mM Na₂-EDTA, 0.5 M NaHPO₄ (pH 7.2) (1 M NaHPO₄ = 134 g Na₂HPO₄·7H₂O, 4 ml 85% H₃PO₄ per liter), 7% SDS, 0.1 - 2 mg/ml denatured salmon sperm DNA at 65°C, (4) 50% formamide, 5x SSC, 0.02 M Tris-HCl (pH 7.6), 1x Denhardt's solution (100x = 10 g Ficoll 400, 10 g polyvinylpyrrolidone, 10 g bovine serum albumin (fraction V), water to 500 ml), 10% dextran sulfate, 1% SDS, 0.1 - 2 mg/ml denatured salmon sperm DNA at 42°C, (5) 5x SSC, 5x Denhardt's solution, 1% SDS, 100 µg/ml denatured salmon sperm DNA at 65°C, or (6) 5x SSC, 5x Denhardt's solution, 50% formamide, 1% SDS, 100 µg/ml denatured salmon sperm DNA at 42°C, with moderate stringency washes of 1x SSC, 0.1% SDS at 65°C. The above conditions are intended to be used for DNA-DNA hybrids of 50 base pairs or longer. Where the hybrid is believed to be less than 18 base pairs in length, the hybridization and wash temperatures should be 5 - 10°C below that of the calculated T_m of the hybrid, where T_m in °C = (2 x the number of A and T bases) + (4 x the number of G and C bases). For hybrids believed to be about 18 to about 49 base pairs in length, the T_m in °C = (81.5°C + 16.6(log₁₀M) + 0.41(% G + C) - 0.61 (% formamide) - 500/L), where "M" is the molarity of monovalent cations (e.g., Na⁺), and "L" is the length of the hybrid in base pairs.

-28-

Low stringency conditions can employ hybridization at either (1) 4x SSC, (10x SSC = 3 M NaCl, 0.3 M Na₃-citrate·2H₂O (88 g/liter), pH to 7.0 with 1 M HCl), 1% SDS (sodium dodecyl sulfate), 0.1 - 2 mg/ml denatured salmon sperm DNA at 50°C, (2) 6x SSC, 50% formamide, 1% SDS, 0.1 - 2 mg/ml denatured salmon sperm DNA at 40°C, (3) 1% bovine serum albumen (fraction V), 1 mM Na₂·EDTA, 0.5 M NaHPO₄ (pH 7.2) (1 M NaHPO₄ = 134 g Na₂HPO₄·7H₂O, 4 ml 85% H₃PO₄ per liter), 7% SDS, 0.1 - 2 mg/ml denatured salmon sperm DNA at 50°C, (4) 50% formamide, 5x SSC, 0.02 M Tris-HCl (pH 7.6), 1x Denhardt's solution (100x = 10 g Ficoll 400, 10 g polyvinylpyrrolidone, 10 g bovine serum albumin (fraction V), water to 500 ml), 10% dextran sulfate, 1% SDS, 0.1 - 2 mg/ml denatured salmon sperm DNA at 40°C, (5) 5x SSC, 5x Denhardt's solution, 1% SDS, 100 µg/ml denatured salmon sperm DNA at 50°C, or (6) 5x SSC, 5x Denhardt's solution, 50% formamide, 1% SDS, 100 µg/ml denatured salmon sperm DNA at 40°C, with low stringency washes of either 2x SSC, 0.1% SDS at 50°C, or (2) 0.5% bovine serum albumin (fraction V), 1 mM Na₂EDTA, 40 mM NaHPO₄ (pH 7.2), 5% SDS. The above conditions are intended to be used for DNA-DNA hybrids of 50 base pairs or longer. Where the hybrid is believed to be less than 18 base pairs in length, the hybridization and wash temperatures should be 5 - 10°C below that of the calculated T_m of the hybrid, where T_m in °C = (2 x the number of A and T bases) + (4 x the number of G and C bases). For hybrids believed to be about 18 to about 49 base pairs in length, the T_m in °C = (81.5°C + 16.6(log₁₀M) + 0.41(% G + C) - 0.61 (% formamide) - 500/L), where "M" is the molarity of monovalent cations (e.g., Na⁺), and "L" is the length of the hybrid in base pairs.

The present invention includes methods of inhibiting angiogenesis in mammalian tissue using Matin or its biologically-active fragments, analogs, homologs, derivatives or mutants. In particular, the present invention includes methods of treating an angiogenesis-mediated disease with an effective amount of one or more of the anti-angiogenic proteins, or one or more biologically active fragment thereof, or combinations of fragments that possess anti-angiogenic activity, or agonists and antagonists. An effective amount of anti-angiogenic protein is an amount sufficient to inhibit the angiogenesis which results in the disease or

condition, thus completely, or partially, alleviating the disease or condition.

Alleviation of the angiogenesis-mediated disease can be determined by observing an alleviation of symptoms of the disease, *e.g.*, a reduction in the size of a tumor, or arrested tumor growth. As used herein, the term "effective amount" also means the

5 total amount of each active component of the composition or method that is sufficient to show a meaningful patient benefit, *i.e.*, treatment, healing, prevention or amelioration of the relevant medical condition, or an increase in rate of treatment, healing, prevention or amelioration of such conditions. When applied to a combination, the term refers to combined amounts of the active ingredients that

10 result in the therapeutic effect, whether administered in combination, serially or simultaneously. Angiogenesis-mediated diseases include, but are not limited to, cancers, solid tumors, blood-born tumors (*e.g.*, leukemias), tumor metastasis, benign tumors (*e.g.*, hemangiomas, acoustic neuromas, neurofibromas, organ fibrosis, trachomas, and pyogenic granulomas), rheumatoid arthritis, psoriasis, ocular

15 angiogenic diseases (*e.g.*, diabetic retinopathy, retinopathy of prematurity, macular degeneration, corneal graft rejection, neovascular glaucoma, retrolental fibroplasia, rubeosis), Osler-Webber Syndrome, myocardial angiogenesis, plaque neovascularization, telangiectasia, hemophilic joints, angiofibroma, and wound granulation. The anti-angiogenic proteins are useful in the treatment of diseases of

20 excessive or abnormal stimulation of endothelial cells. These diseases include, but are not limited to, intestinal adhesions, Crohn's disease, atherosclerosis, scleroderma, fibrosis and hypertrophic scars (*i.e.*, keloids). The anti-angiogenic proteins can be used as a birth control agent by preventing vascularization required for embryo implantation. The anti-angiogenic proteins are useful in the treatment of

25 diseases that have angiogenesis as a pathologic consequence such as cat scratch disease (*Rochele minalia quintosa*) and ulcers (*Helicobacter pylori*). The anti-angiogenic proteins can also be used to prevent dialysis graft vascular access stenosis, and obesity, *e.g.*, by inhibiting capillary formation in adipose tissue, thereby preventing its expansion. The anti-angiogenic proteins can also be used to

30 treat localized (*e.g.*, nonmetastisized) diseases. "Cancer" means neoplastic growth, hyperplastic or proliferative growth or a pathological state of abnormal cellular

development and includes solid tumors, non-solid tumors, and any abnormal cellular proliferation, such as that seen in leukemia. As used herein, "cancer" also means angiogenesis-dependent cancers and tumors, *i.e.*, tumors that require for their growth (expansion in volume and/or mass) an increase in the number and density of the

5 blood vessels supplying them with blood. "Regression" refers to the reduction of tumor mass and size as determined using methods well-known to those of skill in the art.

Alternatively, where an increase in angiogenesis is desired, *e.g.*, in wound healing, or in post-infarct heart tissue, antibodies or antisera to the anti-angiogenic

10 proteins can be used to block localized, native anti-angiogenic proteins and processes, and thereby increase formation of new blood vessels so as to inhibit atrophy of tissue.

The anti-angiogenic proteins may be used in combination with themselves, or other compositions and procedures for the treatment of diseases, *e.g.*, Matin and

15 Vascostatin can be combined in a pharmaceutical composition, one or more of their fragments can be combined in a composition, or a tumor may be treated conventionally with surgery, radiation, chemotherapy, or immunotherapy, combined with the anti-angiogenic proteins and then the anti-angiogenic proteins may be

20 subsequently administered to the patient to extend the dormancy of micrometastases and to stabilize and inhibit the growth of any residual primary tumor. The anti-angiogenic proteins, or fragments, antisera, receptor agonists, or receptor antagonists thereof, or combinations thereof can also be combined with other anti-angiogenic

25 compounds, or proteins, fragments, antisera, receptor agonists, receptor antagonists of other anti-angiogenic proteins (*e.g.*, angiostatin, endostatin). Additionally, the anti-angiogenic proteins, or their fragments, antisera, receptor agonists, receptor

30 antagonists, or combinations thereof, are combined with pharmaceutically acceptable excipients, and optionally sustained-release matrix, such as biodegradable polymers, to form therapeutic compositions. The compositions of the present invention may also contain other anti-angiogenic proteins or chemical compounds, such as endostatin or angiostatin, and mutants, fragments, and analogs thereof. The compositions may further contain other agents which either enhance the activity of

the protein or compliment its activity or use in treatment, such as chemotherapeutic or radioactive agents. Such additional factors and/or agents may be included in the composition to produce a synergistic effect with protein of the invention, or to minimize side effects. Additionally, administration of the composition of the present invention may be administered concurrently with other therapies, *e.g.*, administered in conjunction with a chemotherapy or radiation therapy regimen.

The invention includes methods for inhibiting angiogenesis in mammalian (*e.g.*, human) tissues by contacting the tissue with a composition comprising the proteins of the invention. By "contacting" is meant not only topical application, but also those modes of delivery that introduce the composition into the tissues, or into the cells of the tissues.

Use of timed release or sustained release delivery systems are also included in the invention. Such systems are highly desirable in situations where surgery is difficult or impossible, *e.g.*, patients debilitated by age or the disease course itself, or where the risk-benefit analysis dictates control over cure.

A sustained-release matrix, as used herein, is a matrix made of materials, usually polymers, which are degradable by enzymatic or acid/base hydrolysis or by dissolution. Once inserted into the body, the matrix is acted upon by enzymes and body fluids. The sustained-release matrix desirably is chosen from biocompatible materials such as liposomes, polylactides (polylactic acid), polyglycolide (polymer of glycolic acid), polylactide co-glycolide (co-polymers of lactic acid and glycolic acid) polyanhydrides, poly(ortho)esters, polyproteins, hyaluronic acid, collagen, chondroitin sulfate, carboxylic acids, fatty acids, phospholipids, polysaccharides, nucleic acids, polyamino acids, amino acids such as phenylalanine, tyrosine, isoleucine, polynucleotides, polyvinyl propylene, polyvinylpyrrolidone and silicone. A preferred biodegradable matrix is a matrix of one of either polylactide, polyglycolide, or polylactide co-glycolide (co-polymers of lactic acid and glycolic acid).

The angiogenesis-modulating composition of the present invention may be a solid, liquid or aerosol and may be administered by any known route of administration. Examples of solid compositions include pills, creams, and

implantable dosage units. The pills may be administered orally, the therapeutic creams may be administered topically. The implantable dosage unit may be administered locally, for example at a tumor site, or which may be implanted for systemic release of the angiogenesis-modulating composition, for example
5 subcutaneously. Examples of liquid composition include formulations adapted for injection subcutaneously, intravenously, intraarterially, and formulations for topical and intraocular administration. Examples of aerosol formulation include inhaler formulation for administration to the lungs.

The proteins and protein fragments with the anti-angiogenic activity
10 described above can be provided as isolated and substantially purified proteins and protein fragments in pharmaceutically acceptable formulations using formulation methods known to those of ordinary skill in the art. These formulations can be administered by standard routes. In general, the combinations may be administered by the topical, transdermal, intraperitoneal, intracranial, intracerebroventricular,
15 intracerebral, intravaginal, intrauterine, oral, rectal or parenteral (*e.g.*, intravenous, intraspinal, subcutaneous or intramuscular) route. In addition, the anti-angiogenic proteins may be incorporated into biodegradable polymers allowing for sustained release of the compound, the polymers being implanted in the vicinity of where drug delivery is desired, for example, at the site of a tumor or implanted so that the anti-
20 angiogenic proteins are slowly released systemically. Osmotic minipumps may also be used to provide controlled delivery of high concentrations of the anti-angiogenic proteins through cannulae to the site of interest, such as directly into a metastatic growth or into the vascular supply to that tumor. The biodegradable polymers and their use are described, for example, in detail in Brem *et al.* (1991, *J. Neurosurg.*
25 74:441-6), which is hereby incorporated by reference in its entirety.

The compositions containing a polypeptide of this invention can be administered intravenously, as by injection of a unit dose, for example. The term “unit dose” when used in reference to a therapeutic composition of the present invention refers to physically discrete units suitable as unitary dosage for the subject,
30 each unit containing a predetermined quantity of active material calculated to

produce the desired therapeutic effect in association with the required diluent; *i.e.*, carrier or vehicle.

Modes of administration of the compositions of the present inventions include intravenous, intramuscular, intraperitoneal, intrasternal, subcutaneous and
5 intraarticular injection and infusion. Pharmaceutical compositions for parenteral injection comprise pharmaceutically acceptable sterile aqueous or nonaqueous solutions, dispersions, suspensions or emulsions as well as sterile powders for reconstitution into sterile injectable solutions or dispersions just prior to use. Examples of suitable aqueous and nonaqueous carriers, diluents, solvents or vehicles
10 include water, ethanol, polyols (*e.g.*, glycerol, propylene glycol, polyethylene glycol and the like), carboxymethylcellulose and suitable mixtures thereof, vegetable oils (*e.g.*, olive oil) and injectable organic esters such as ethyl oleate. Proper fluidity may be maintained, for example, by the use of coating materials such as lecithin, by the maintenance of the required particle size in the case of dispersions and by the use
15 of surfactants. These compositions may also contain adjuvants such as preservatives, wetting agents, emulsifying agents and dispersing agents. Prevention of the action of microorganisms may be ensured by the inclusion of various antibacterial and antifungal agents such as paraben, chlorobutanol, phenol sorbic acid and the like. It may also be desirable to include isotonic agents such as sugars,
20 sodium chloride and the like. Prolonged absorption of the injectable pharmaceutical form may be brought about by the inclusion of agents, such as aluminum monostearate and gelatin, which delay absorption. Injectable depot forms are made by forming microcapsule matrices of the drug in biodegradable polymers such as polylactide-polyglycolide, poly(orthoesters) and poly(anhydrides). Depending upon
25 the ratio of drug to polymer and the nature of the particular polymer employed, the rate of drug release can be controlled. Depot injectable formulations are also prepared by entrapping the drug in liposomes or microemulsions which are compatible with body tissues. The injectable formulations may be sterilized, for example, by filtration through a bacterial-retaining filter or by incorporating
30 sterilizing agents in the form of sterile solid compositions which can be dissolved or dispersed in sterile water or other sterile injectable media just prior to use.

The therapeutic compositions of the present invention can include pharmaceutically acceptable salts of the components therein, *e.g.*, which may be derived from inorganic or organic acids. By "pharmaceutically acceptable salt" is meant those salts which are, within the scope of sound medical judgement, suitable for use in contact with the tissues of humans and lower animals without undue toxicity, irritation, allergic response and the like and are commensurate with a reasonable benefit/risk ratio. Pharmaceutically acceptable salts are well-known in the art. For example, S. M. Berge, et al. describe pharmaceutically acceptable salts in detail in *J. Pharmaceutical Sciences* (1977) 66:1 *et seq.*, which is incorporated herein by reference. Pharmaceutically acceptable salts include the acid addition salts (formed with the free amino groups of the polypeptide) that are formed with inorganic acids such as, for example, hydrochloric or phosphoric acids, or such organic acids as acetic, tartaric, mandelic and the like. Salts formed with the free carboxyl groups can also be derived from inorganic bases such as, for example, sodium, potassium, ammonium, calcium or ferric hydroxides, and such organic bases as isopropylamine, trimethylamine, 2-ethylamino ethanol, histidine, procaine and the like. The salts may be prepared *in situ* during the final isolation and purification of the compounds of the invention or separately by reacting a free base function with a suitable organic acid. Representative acid addition salts include, but are not limited to acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxymethanesulfonate (isethionate), lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, pamoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartate, thiocyanate, phosphate, glutamate, bicarbonate, p-toluenesulfonate and undecanoate. Also, the basic nitrogen-containing groups can be quaternized with such agents as lower alkyl halides such as methyl, ethyl, propyl, and butyl chlorides, bromides and iodides; dialkyl sulfates like dimethyl, diethyl, dibutyl, and diamyl sulfates; long chain halides such as decyl, lauryl, myristyl and stearyl chlorides, bromides and iodides; arylalkyl halides like benzyl and phenethyl bromides and

others. Water or oil-soluble or dispersible products are thereby obtained. Examples of acids which may be employed to form pharmaceutically acceptable acid addition salts include such inorganic acids as hydrochloric acid, hydrobromic acid, sulphuric acid and phosphoric acid and such organic acids as oxalic acid, maleic acid, succinic acid and citric acid.

As used herein, the terms "pharmaceutically acceptable," "physiologically tolerable" and grammatical variations thereof as they refer to compositions, carriers, diluents and reagents, are used interchangeably and represent that the materials are capable of administration to or upon a mammal with a minimum of undesirable physiological effects such as nausea, dizziness, gastric upset and the like. The preparation of a pharmacological composition that contains active ingredients dissolved or dispersed therein is well understood in the art and need not be limited based on formulation. Typically such compositions are prepared as injectables either as liquid solutions or suspensions, however, solid forms suitable for solution, or suspensions, in liquid prior to use can also be prepared. The preparation can also be emulsified.

The active ingredient can be mixed with excipients which are pharmaceutically acceptable and compatible with the active ingredient and in amounts suitable for use in the therapeutic methods described herein. Suitable excipients include, for example, water, saline, dextrose, glycerol, ethanol or the like and combinations thereof. In addition, if desired, the composition can contain minor amounts of auxiliary substances such as wetting or emulsifying agents, pH buffering agents and the like which enhance the effectiveness of the active ingredient.

The anti-angiogenic proteins of the present invention can also be included in a composition comprising a prodrug. As used herein, the term "prodrug" refers to compounds which are rapidly transformed *in vivo* to yield the parent compound, for example, by enzymatic hydrolysis in blood. A thorough discussion is provided in T. Higuchi and V. Stella, *Prodrugs as Novel Delivery Systems*, Vol. 14 of the ACS Symposium Series and in Edward B. Roche, ed., *Bioreversible Carriers in Drug Design*, American Pharmaceutical Association and Permagon Press, 1987, both of which are incorporated herein by reference. As used herein, the term

“pharmaceutically acceptable prodrug” refers to (1) those prodrugs of the compounds of the present invention which are, within the scope of sound medical judgement, suitable for use in contact with the tissues of humans and animals without undue toxicity, irritation, allergic response and the like, commensurate with
5 a suitable benefit-to-risk ratio and effective for their intended use and (2) zwitterionic forms, where possible, of the parent compound.

The dosage of the anti-angiogenic proteins of the present invention will depend on the disease state or condition being treated and other clinical factors such as weight and condition of the human or animal and the route of administration of
10 the compound. Depending upon the half-life of the anti-angiogenic proteins in the particular animal or human, the anti-angiogenic proteins can be administered between several times per day to once a week. It is to be understood that the present invention has application for both human and veterinary use. The methods of the present invention contemplate single as well as multiple administrations, given
15 either simultaneously or over an extended period of time. In addition, the anti-angiogenic proteins can be administered in conjunction with other forms of therapy, *e.g.*, chemotherapy, radiotherapy, or immunotherapy.

The anti-angiogenic protein formulations include those suitable for oral, rectal, ophthalmic (including intravitreal or intracameral), nasal, topical (including
20 buccal and sublingual), intrauterine, vaginal or parenteral (including subcutaneous, intraperitoneal, intramuscular, intravenous, intradermal, intracranial, intratracheal, and epidural) administration. The anti-angiogenic protein formulations may conveniently be presented in unit dosage form and may be prepared by conventional pharmaceutical techniques. Such techniques include the step of bringing into
25 association the active ingredient and the pharmaceutical carrier(s) or excipient(s). In general, the formulations are prepared by uniformly and intimately bringing into association the active ingredient with liquid carriers or finely divided solid carriers or both, and then, if necessary, shaping the product.

Formulations suitable for parenteral administration include aqueous and non-
30 aqueous sterile injection solutions which may contain anti-oxidants, buffers, bacteriostats and solutes which render the formulation isotonic with the blood of the

intended recipient; and aqueous and non-aqueous sterile suspensions which may include suspending agents and thickening agents. The formulations may be presented in unit-dose or multi-dose containers, for example, sealed ampules and vials, and may be stored in a freeze-dried (lyophilized) condition requiring only the
5 addition of the sterile liquid carrier, for example, water for injections, immediately prior to use. Extemporaneous injection solutions and suspensions may be prepared from sterile powders, granules and tablets of the kind previously described.

When an effective amount of protein of the present invention is administered orally, the anti-angiogenic proteins of the present invention will be in the form of a
10 tablet, capsule, powder, solution or elixir. When administered in tablet form, the pharmaceutical composition of the invention may additionally contain a solid carrier such as a gelatin or an adjuvant. The tablet, capsule, and powder contain from about 5 to 95% protein of the present invention, and preferably from about 25 to 90% protein of the present invention. When administered in liquid form, a liquid carrier
15 such as water, petroleum, oils of animal or plant origin such as peanut oil, mineral oil, soybean oil, or sesame oil, or synthetic oils may be added. The liquid form of the pharmaceutical composition may further contain physiological saline solution, dextrose or other saccharide solution, or glycols such as ethylene glycol, propylene glycol or polyethylene glycol. When administered in liquid form, the
20 pharmaceutical composition contains from about 0.5 to 90% by weight of protein of the present invention, and preferably from about 1 to 50% protein of the present invention.

When an effective amount of protein of the present invention is administered by intravenous, cutaneous or subcutaneous injection, protein of the present invention
25 will be in the form of a pyrogen-free, parenterally acceptable aqueous solution. The preparation of such parenterally acceptable protein solutions, having due regard to pH, isotonicity, stability, and the like, is within the skill in the art. A preferred pharmaceutical composition for intravenous, cutaneous, or subcutaneous injection should contain, in addition to protein of the present invention, an isotonic vehicle
30 such as Sodium Chloride Injection, Ringer's Injection, Dextrose Injection, Dextrose and Sodium Chloride Injection, Lactated Ringer's Injection, or other vehicle as

known in the art. The pharmaceutical composition of the present invention may also contain stabilizers, preservatives, buffers, antioxidants, or other additives known to those of skill in the art.

The amount of protein of the present invention in the pharmaceutical
5 composition of the present invention will depend upon the nature and severity of the condition being treated, and on the nature of prior treatments which the patient has undergone. Ultimately, the attending physician will decide the amount of protein of the present invention with which to treat each individual patient. Initially, the attending physician will administer low doses of protein of the present invention and
10 observe the patient's response. Larger doses of protein of the present invention may be administered until the optimal therapeutic effect is obtained for the patient, and at that point the dosage is not increased further.

The duration of intravenous therapy using the pharmaceutical composition of the present invention will vary, depending on the severity of the disease being
15 treated and the condition and potential idiosyncratic response of each individual patient. It is contemplated that the duration of each application of the protein of the present invention will be in the range of 12 to 24 hours of continuous intravenous administration. Ultimately the attending physician will decide on the appropriate duration of intravenous therapy using the pharmaceutical composition of the present
20 invention.

Preferred unit dosage formulations are those containing a daily dose or unit, daily sub-dose, or an appropriate fraction thereof, of the administered ingredient. It should be understood that in addition to the ingredients, particularly mentioned above, the formulations of the present invention may include other agents
25 conventional in the art having regard to the type of formulation in question. Optionally, cytotoxic agents may be incorporated or otherwise combined with the anti-angiogenic proteins, or biologically functional protein fragments thereof, to provide dual therapy to the patient.

The therapeutic compositions are also presently valuable for veterinary
30 applications. Particularly domestic animals and thoroughbred horses, in addition to

humans, are desired patients for such treatment with proteins of the present invention.

Cytotoxic agents such as ricin, can be linked to the anti-angiogenic proteins, and fragments thereof, thereby providing a tool for destruction of cells that bind the anti-angiogenic proteins. These cells may be found in many locations, including but not limited to, micrometastases and primary tumors. Proteins linked to cytotoxic agents are infused in a manner designed to maximize delivery to the desired location. For example, ricin-linked high affinity fragments are delivered through a cannula into vessels supplying the target site or directly into the target. Such agents are also delivered in a controlled manner through osmotic pumps coupled to infusion cannulae. A combination of antagonists to the anti-angiogenic proteins may be co-applied with stimulators of angiogenesis to increase vascularization of tissue. This therapeutic regimen provides an effective means of destroying metastatic cancer.

Additional treatment methods include administration of the anti-angiogenic proteins, fragments, analogs, antisera, or receptor agonists and antagonists thereof, linked to cytotoxic agents. It is to be understood that the anti-angiogenic proteins can be human or animal in origin. The anti-angiogenic proteins can also be produced synthetically by chemical reaction or by recombinant techniques in conjunction with expression systems. The anti-angiogenic proteins can also be produced by enzymatically cleaving isolated laminin to generate proteins having anti-angiogenic activity. The anti-angiogenic proteins may also be produced by compounds that mimic the action of endogenous enzymes that cleave laminin to the anti-angiogenic proteins. Production of the anti-angiogenic proteins may also be modulated by compounds that affect the activity of cleavage enzymes.

The present invention also encompasses gene therapy whereby a polynucleotide encoding the anti-angiogenic proteins, integrins, integrin subunits, or a mutant, fragment, or fusion protein thereof, is introduced and regulated in a patient. Various methods of transferring or delivering DNA to cells for expression of the gene product protein, otherwise referred to as gene therapy, are disclosed in *Gene Transfer into Mammalian Somatic Cells in vivo*, N. Yang (1992) *Crit. Rev. Biotechn.* 12(4):335-56, which is hereby incorporated by reference. Gene therapy

encompasses incorporation of DNA sequences into somatic cells or germ line cells for use in either ex vivo or in vivo therapy. Gene therapy functions to replace genes, augment normal or abnormal gene function, and to combat infectious diseases and other pathologies.

5 Strategies for treating these medical problems with gene therapy include therapeutic strategies such as identifying the defective gene and then adding a functional gene to either replace the function of the defective gene or to augment a slightly functional gene; or prophylactic strategies, such as adding a gene for the product protein that will treat the condition or that will make the tissue or organ
10 more susceptible to a treatment regimen. As an example of a prophylactic strategy, a gene such as that encoding one or more of the anti-angiogenic proteins may be placed in a patient and thus prevent occurrence of angiogenesis; or a gene that makes tumor cells more susceptible to radiation could be inserted and then radiation of the tumor would cause increased killing of the tumor cells.

15 Many protocols for transfer of the DNA or regulatory sequences of the anti-angiogenic proteins are envisioned in this invention. Transfection of promoter sequences, other than one normally found specifically associated with the anti-angiogenic proteins, or other sequences which would increase production of the anti-angiogenic proteins are also envisioned as methods of gene therapy. An example of
20 this technology is found in Transkaryotic Therapies, Inc., of Cambridge, Mass., using homologous recombination to insert a "genetic switch" that turns on an erythropoietin gene in cells. See *Genetic Engineering News*, Apr. 15, 1994. Such "genetic switches" could be used to activate the anti-angiogenic proteins (or their receptors) in cells not normally expressing those proteins (or receptors).

25 Gene transfer methods for gene therapy fall into three broad categories: physical (e.g., electroporation, direct gene transfer and particle bombardment), chemical (e.g., lipid-based carriers, or other non-viral vectors) and biological (e.g., virus-derived vector and receptor uptake). For example, non-viral vectors may be used which include liposomes coated with DNA. Such liposome/DNA complexes
30 may be directly injected intravenously into the patient. It is believed that the liposome/DNA complexes are concentrated in the liver where they deliver the DNA

to macrophages and Kupffer cells. These cells are long lived and thus provide long term expression of the delivered DNA. Additionally, vectors or the “naked” DNA of the gene may be directly injected into the desired organ, tissue or tumor for targeted delivery of the therapeutic DNA.

5 Gene therapy methodologies can also be described by delivery site. Fundamental ways to deliver genes include *ex vivo* gene transfer, *in vivo* gene transfer, and *in vitro* gene transfer. In *ex vivo* gene transfer, cells are taken from the patient and grown in cell culture. The DNA is transfected into the cells, the transfected cells are expanded in number and then reimplanted in the patient. In *in*
10 *vitro* gene transfer, the transformed cells are cells growing in culture, such as tissue culture cells, and not particular cells from a particular patient. These “laboratory cells” are transfected, the transfected cells are selected and expanded for either implantation into a patient or for other uses.

In vivo gene transfer involves introducing the DNA into the cells of the
15 patient when the cells are within the patient. Methods include using virally mediated gene transfer using a noninfectious virus to deliver the gene in the patient or injecting naked DNA into a site in the patient and the DNA is taken up by a percentage of cells in which the gene product protein is expressed. Additionally, the other methods described herein, such as use of a “gene gun,” may be used for in
20 *vitro* insertion of the DNA or regulatory sequences controlling production of the anti-angiogenic proteins.

Chemical methods of gene therapy may involve a lipid based compound, not necessarily a liposome, to transfer the DNA across the cell membrane. Lipofectins or cytofectins, lipid-based positive ions that bind to negatively charged DNA, make
25 a complex that can cross the cell membrane and provide the DNA into the interior of the cell. Another chemical method uses receptor-based endocytosis, which involves binding a specific ligand to a cell surface receptor and enveloping and transporting it across the cell membrane. The ligand binds to the DNA and the whole complex is transported into the cell. The ligand gene complex is injected into the blood stream
30 and then target cells that have the receptor will specifically bind the ligand and transport the ligand-DNA complex into the cell.

Many gene therapy methodologies employ viral vectors to insert genes into cells. For example, altered retrovirus vectors have been used in *ex vivo* methods to introduce genes into peripheral and tumor-infiltrating lymphocytes, hepatocytes, epidermal cells, myocytes, or other somatic cells. These altered cells are then
5 introduced into the patient to provide the gene product from the inserted DNA.

Viral vectors have also been used to insert genes into cells using *in vivo* protocols. To direct the tissue-specific expression of foreign genes, *cis-acting* regulatory elements or promoters that are known to be tissue-specific can be used. Alternatively, this can be achieved using *in situ* delivery of DNA or viral vectors to
10 specific anatomical sites *in vivo*. For example, gene transfer to blood vessels *in vivo* was achieved by implanting *in vitro* transduced endothelial cells in chosen sites on arterial walls. The virus infected surrounding cells which also expressed the gene product. A viral vector can be delivered directly to the *in vivo* site, by a catheter for example, thus allowing only certain areas to be infected by the virus, and providing
15 long-term, site specific gene expression. *In vivo* gene transfer using retrovirus vectors has also been demonstrated in mammary tissue and hepatic tissue by injection of the altered virus into blood vessels leading to the organs.

Viral vectors that have been used for gene therapy protocols include but are not limited to, retroviruses, other RNA viruses such as poliovirus or Sindbis virus,
20 adenovirus, adeno-associated virus, herpes viruses, SV 40, vaccinia and other DNA viruses. Replication-defective murine retroviral vectors are the most widely utilized gene transfer vectors. Murine leukemia retroviruses are composed of a single strand RNA complexed with a nuclear core protein and polymerase (pol) enzymes, encased by a protein core (gag) and surrounded by a glycoprotein envelope (env) that
25 determines host range. The genomic structure of retroviruses include the *gag*, *pol*, and *env* genes enclosed at by the 5' and 3' long terminal repeats (LTR). Retroviral vector systems exploit the fact that a minimal vector containing the 5' and 3' LTRs and the packaging signal are sufficient to allow vector packaging, infection and integration into target cells providing that the viral structural proteins are supplied in
30 trans in the packaging cell line. Fundamental advantages of retroviral vectors for gene transfer include efficient infection and gene expression in most cell types,

precise single copy vector integration into target cell chromosomal DNA, and ease of manipulation of the retroviral genome.

The adenovirus is composed of linear, double stranded DNA complexed with core proteins and surrounded with capsid proteins. Advances in molecular virology have led to the ability to exploit the biology of these organisms to create vectors capable of transducing novel genetic sequences into target cells *in vivo*. Adenoviral-based vectors will express gene product proteins at high levels. Adenoviral vectors have high efficiencies of infectivity, even with low titers of virus. Additionally, the virus is fully infective as a cell free virion so injection of producer cell lines is not necessary. Another potential advantage to adenoviral vectors is the ability to achieve long term expression of heterologous genes *in vivo*.

Mechanical methods of DNA delivery include fusogenic lipid vesicles such as liposomes or other vesicles for membrane fusion, lipid particles of DNA incorporating cationic lipid such as lipofectin, polylysine-mediated transfer of DNA, direct injection of DNA, such as microinjection of DNA into germ or somatic cells, pneumatically delivered DNA-coated particles, such as the gold particles used in a "gene gun," and inorganic chemical approaches such as calcium phosphate transfection. Particle-mediated gene transfer methods were first used in transforming plant tissue. With a particle bombardment device, or "gene gun," a motive force is generated to accelerate DNA-coated high density particles (such as gold or tungsten) to a high velocity that allows penetration of the target organs, tissues or cells. Particle bombardment can be used in *in vitro* systems, or with *ex vivo* or *in vivo* techniques to introduce DNA into cells, tissues or organs. Another method, ligand-mediated gene therapy, involves complexing the DNA with specific ligands to form ligand-DNA conjugates, to direct the DNA to a specific cell or tissue.

It has been found that injecting plasmid DNA into muscle cells yields high percentage of the cells which are transfected and have sustained expression of marker genes. The DNA of the plasmid may or may not integrate into the genome of the cells. Non-integration of the transfected DNA would allow the transfection and expression of gene product proteins in terminally differentiated, non-proliferative

tissues for a prolonged period of time without fear of mutational insertions, deletions, or alterations in the cellular or mitochondrial genome. Long-term, but not necessarily permanent, transfer of therapeutic genes into specific cells may provide treatments for genetic diseases or for prophylactic use. The DNA could be
5 reinjected periodically to maintain the gene product level without mutations occurring in the genomes of the recipient cells. Non-integration of exogenous DNAs may allow for the presence of several different exogenous DNA constructs within one cell with all of the constructs expressing various gene products.

Electroporation for gene transfer uses an electrical current to make cells or
10 tissues susceptible to electroporation-mediated mediated gene transfer. A brief electric impulse with a given field strength is used to increase the permeability of a membrane in such a way that DNA molecules can penetrate into the cells. This technique can be used in *in vitro* systems, or with *ex vivo* or *in vivo* techniques to introduce DNA into cells, tissues or organs.

Carrier mediated gene transfer *in vivo* can be used to transfect foreign DNA
15 into cells. The carrier-DNA complex can be conveniently introduced into body fluids or the bloodstream and then site-specifically directed to the target organ or tissue in the body. Both liposomes and polycations, such as polylysine, lipofectins or cytofectins, can be used. Liposomes can be developed which are cell specific or
20 organ specific and thus the foreign DNA carried by the liposome will be taken up by target cells. Injection of immunoliposomes that are targeted to a specific receptor on certain cells can be used as a convenient method of inserting the DNA into the cells bearing the receptor. Another carrier system that has been used is the asialoglycoprotein/polylysine conjugate system for carrying DNA to hepatocytes for
25 *in vivo* gene transfer.

The transfected DNA may also be complexed with other kinds of carriers so that the DNA is carried to the recipient cell and then resides in the cytoplasm or in the nucleoplasm. DNA can be coupled to carrier nuclear proteins in specifically engineered vesicle complexes and carried directly into the nucleus.

30 Gene regulation of the anti-angiogenic proteins may be accomplished by administering compounds that bind to the gene encoding one of the anti-angiogenic

proteins, or control regions associated with the gene, or its corresponding RNA transcript to modify the rate of transcription or translation. Additionally, cells transfected with a DNA sequence encoding the anti-angiogenic proteins may be administered to a patient to provide an *in vivo* source of those proteins. For
5 example, cells may be transfected with a vector containing a nucleic acid sequence encoding the anti-angiogenic proteins. The transfected cells may be cells derived from the patient's normal tissue, the patient's diseased tissue, or may be non-patient cells.

For example, tumor cells removed from a patient can be transfected with a
10 vector capable of expressing the proteins of the present invention, and re-introduced into the patient. The transfected tumor cells produce levels of the protein in the patient that inhibit the growth of the tumor. Patients may be human or non-human animals. Cells may also be transfected by non-vector, or physical or chemical methods known in the art such as electroporation, ionoporation, or via a "gene gun."
15 Additionally, the DNA may be directly injected, without the aid of a carrier, into a patient. In particular, the DNA may be injected into skin, muscle or blood.

The gene therapy protocol for transfecting the anti-angiogenic proteins into a patient may either be through integration of the anti-angiogenic protein DNA into the genome of the cells, into minichromosomes or as a separate replicating or non-
20 replicating DNA construct in the cytoplasm or nucleoplasm of the cell. Expression of the anti-angiogenic proteins may continue for a long-period of time or may be reinjected periodically to maintain a desired level of the protein(s) in the cell, the tissue or organ or a determined blood level.

In addition, the invention encompasses antibodies and antisera, which can be
25 used for testing of novel anti-angiogenic proteins, and can also be used in diagnosis, prognosis, or treatment of diseases and conditions characterized by, or associated with, angiogenic activity or lack thereof. Such antibodies and antisera can also be used to up-regulate angiogenesis where desired, *e.g.*, in post-infarct heart tissue, antibodies or antisera to the proteins of the invention can be used to block localized,
30 native anti-angiogenic proteins and processes, and increase formation of new blood vessels and inhibit atrophy of heart tissue.

Such antibodies and antisera can be combined with pharmaceutically-acceptable compositions and carriers to form diagnostic, prognostic or therapeutic compositions. The term "antibody" or "antibody molecule" refers to a population of immunoglobulin molecules and/or immunologically active portions of immunoglobulin molecules, *i.e.*, molecules that contain an antibody combining site or paratope.

Passive antibody therapy using antibodies that specifically bind the anti-angiogenic proteins can be employed to modulate angiogenic-dependent processes such as reproduction, development, and wound healing and tissue repair. In addition, antisera directed to the Fab regions of antibodies of the anti-angiogenic proteins can be administered to block the ability of endogenous antisera to the proteins to bind the proteins.

The the anti-angiogenic proteins of the present invention also can be used to generate antibodies that are specific for the inhibitor(s) and receptor(s). The antibodies can be either polyclonal antibodies or monoclonal antibodies. These antibodies that specifically bind to the anti-angiogenic proteins or their receptors can be used in diagnostic methods and kits that are well known to those of ordinary skill in the art to detect or quantify the anti-angiogenic proteins or their receptors in a body fluid or tissue. Results from these tests can be used to diagnose or predict the occurrence or recurrence of a cancer and other angiogenic mediated diseases.

The invention also includes use of the anti-angiogenic proteins, antibodies to those proteins, and compositions comprising those proteins and/or their antibodies in diagnosis or prognosis of diseases characterized by angiogenic activity. As used herein, the term "prognostic method" means a method that enables a prediction regarding the progression of a disease of a human or animal diagnosed with the disease, in particular, an angiogenesis dependent disease. The term "diagnostic method" as used herein means a method that enables a determination of the presence or type of angiogenesis-dependent disease in or on a human or animal.

The the anti-angiogenic proteins can be used in a diagnostic method and kit to detect and quantify antibodies capable of binding the proteins. These kits would permit detection of circulating antibodies to the anti-angiogenic proteins which

indicates the spread of micrometastases in the presence of the anti-angiogenic proteins secreted by primary tumors *in situ*. Patients that have such circulating anti-protein antibodies may be more likely to develop multiple tumors and cancers, and may be more likely to have recurrences of cancer after treatments or periods of
5 remission. The Fab fragments of these anti-protein antibodies may be used as antigens to generate anti-protein Fab-fragment antisera which can be used to neutralize anti-protein antibodies. Such a method would reduce the removal of circulating protein by anti-protein antibodies, thereby effectively elevating circulating levels of the anti-angiogenic proteins.

10 The present invention also includes isolation of receptors specific for the anti-angiogenic proteins. Protein fragments that possess high affinity binding to tissues can be used to isolate the receptor of the anti-angiogenic proteins on affinity columns. Isolation and purification of the receptor(s) is a fundamental step towards elucidating the mechanism of action of the anti-angiogenic proteins. Isolation of a
15 receptor and identification of agonists and antagonists will facilitate development of drugs to modulate the activity of the receptor, the final pathway to biological activity. Isolation of the receptor enables the construction of nucleotide probes to monitor the location and synthesis of the receptor, using *in situ* and solution hybridization technology. Further, the gene for the receptor can be isolated,
20 incorporated into an expression vector and transfected into cells, such as patient tumor cells to increase the ability of a cell type, tissue or tumor to bind the anti-angiogenic proteins and inhibit local angiogenesis.

The anti-angiogenic proteins are employed to develop affinity columns for isolation of the receptor(s) for the anti-angiogenic proteins from cultured tumor
25 cells. Isolation and purification of the receptor is followed by amino acid sequencing. Using this information the gene or genes coding for the receptor can be identified and isolated. Next, cloned nucleic acid sequences are developed for insertion into vectors capable of expressing the receptor. These techniques are well known to those skilled in the art. Transfection of the nucleic acid sequence(s)
30 coding for the receptor into tumor cells, and expression of the receptor by the transfected tumor cells enhances the responsiveness of these cells to endogenous or

exogenous anti-angiogenic proteins and thereby decreasing the rate of metastatic growth.

Angiogenesis-inhibiting proteins of the present invention can be synthesized in a standard microchemical facility and purity checked with HPLC and mass spectrophotometry. Methods of protein synthesis, HPLC purification and mass spectrophotometry are commonly known to those skilled in these arts. The anti-angiogenic proteins and their receptors proteins are also produced in recombinant *E. coli* or yeast expression systems, and purified with column chromatography.

Different protein fragments of the intact the anti-angiogenic proteins can be synthesized for use in several applications including, but not limited to the following; as antigens for the development of specific antisera, as agonists and antagonists active at binding sites of the anti-angiogenic proteins, as proteins to be linked to, or used in combination with, cytotoxic agents for targeted killing of cells that bind the anti-angiogenic proteins.

The synthetic protein fragments of the anti-angiogenic proteins have a variety of uses. The protein that binds to the receptor(s) of the anti-angiogenic proteins with high specificity and avidity is radiolabeled and employed for visualization and quantitation of binding sites using autoradiographic and membrane binding techniques. This application provides important diagnostic and research tools. Knowledge of the binding properties of the receptor(s) facilitates investigation of the transduction mechanisms linked to the receptor(s).

The anti-angiogenic proteins and proteins derived from them can be coupled to other molecules using standard methods. The amino and carboxyl termini of the anti-angiogenic proteins both contain tyrosine and lysine residues and are isotopically and nonisotopically labeled with many techniques, for example radiolabeling using conventional techniques (tyrosine residues-chloramine T, iodogen, lactoperoxidase; lysine residues-Bolton-Hunter reagent). These coupling techniques are well known to those skilled in the art. Alternatively, tyrosine or lysine is added to fragments that do not have these residues to facilitate labeling of reactive amino and hydroxyl groups on the protein. The coupling technique is chosen on the basis of the functional groups available on the amino acids including,

but not limited to amino, sulfhydryl, carboxyl, amide, phenol, and imidazole.

Various reagents used to effect these couplings include among others, glutaraldehyde, diazotized benzidine, carbodiimide, and p-benzoquinone.

The anti-angiogenic proteins are chemically coupled to isotopes, enzymes, carrier proteins, cytotoxic agents, fluorescent molecules, chemiluminescent, bioluminescent and other compounds for a variety of applications. The efficiency of the coupling reaction is determined using different techniques appropriate for the specific reaction. For example, radiolabeling of a protein of the present invention with ^{125}I is accomplished using chloramine T and Na^{125}I of high specific activity. The reaction is terminated with sodium metabisulfite and the mixture is desalted on disposable columns. The labeled protein is eluted from the column and fractions are collected. Aliquots are removed from each fraction and radioactivity measured in a gamma counter. In this manner, the unreacted Na^{125}I is separated from the labeled protein. The protein fractions with the highest specific radioactivity are stored for subsequent use such as analysis of the ability to bind to antisera of the anti-angiogenic proteins.

In addition, labeling the anti-angiogenic proteins with short lived isotopes enables visualization of receptor binding sites *in vivo* using positron emission tomography or other modern radiographic techniques to locate tumors with the proteins' binding sites.

Systematic substitution of amino acids within these synthesized proteins yields high affinity protein agonists and antagonists to the receptor(s) of the anti-angiogenic proteins that enhance or diminish binding to the receptor(s). Such agonists are used to suppress the growth of micrometastases, thereby limiting the spread of cancer. Antagonists to the anti-angiogenic proteins are applied in situations of inadequate vascularization, to block the inhibitory effects of the anti-angiogenic proteins and promote angiogenesis. For example, this treatment may have therapeutic effects to promote wound healing in diabetics.

The invention is further illustrated by the following examples, which are not meant to be construed in any way as imposing limitations upon the scope thereof. On the contrary, it is to be clearly understood that resort may be had to various other

embodiments, modifications, and equivalents thereof, which, after reading the description herein, may suggest themselves to those skilled in the art without departing from the spirit of the present invention and/or the scope of the appended claims.

5 EXAMPLES

Example 1: Recombinant Production of Matin in *E. coli*.

The nucleotide (SEQ ID NO:1) and amino acid (SEQ ID NO:2) sequences for the $\alpha 1$ chain of laminin (GenBank Acc. No. NM_008480) are shown in Fig. 1. The sequence encoding Matin (globular domain 1, or the G1 domain, extending
10 approximately from nucleotide 6442 to nucleotide 7062) was amplified by PCR from the plasmid FBssrAi using the forward primer 5'-CGG-GAT-CCT-AGA-GAC-TGC-ATC-CGC-GCC-TAT-3' (SEQ ID NO:3), and the reverse primer was 5'-CCC-AAG-CTT-TAC-TAT-CTG-CGT-CAC-GGT-GGG-3' (SEQ ID NO:4) (underlined portions of the primer represent laminin sequence). The resulting cDNA fragment
15 was digested with *Bam*HI and *Hind*III and ligated into predigested pET22b(+) (Novagen, Madison, Wisconsin, USA). The construct is shown in Fig. 2. The ligation placed Matin in-frame with the *pelB* leader sequence, allowing for periplasmic localization and expression of soluble protein. The 3' end of the sequence was ligated in-frame with the polyhistidine tag sequence.

20 Plasmid constructs encoding Matin were first transformed into *E. coli* HMS174 (Novagen, Madison, Wisconsin, USA) and then transformed into BL21 for expression (Novagen, Madison, Wisconsin, USA). Overnight bacterial culture was used to inoculate a 500 ml culture in LB medium (Fisher Scientific, Pittsburgh, Pennsylvania, USA). This culture was grown for approximately 4 hours until the
25 cells reached an OD₆₀₀ of 0.6. Protein expression was then induced by addition of IPTG to a final concentration of 1 mM. After a 2-hour induction, cells were harvested by centrifugation at 5,000 x g and lysed by resuspension in 6 M guanidine, 0.1 M NaH₂PO₄, 0.01 M Tris-HCl, pH 8.0. Resuspended cells were sonicated briefly, and centrifuged at 12,000 x g for 30 minutes. The supernatant fraction was
30 passed over a 5 ml Ni-NTA agarose column (Qiagen, Hilden, Germany) 4-6 times at

a speed of 2 ml per minute. Non-specifically bound protein was removed by washing with both 10 mM and 25 mM imidazole in 8 M urea, 0.1 M NaH₂PO₄, 0.01 M Tris-HCl, pH 8.0. Matin protein was eluted from the column with increasing concentrations of imidazole (50 mM, 125 mM, and 250 mM) in 8 M urea, 0.1 M NaH₂PO₄, 0.01 M Tris-HCl, pH 8.0. The eluted protein was dialyzed twice against PBS at 4°C. A portion of the total protein precipitated during dialysis. Dialyzed protein was collected and centrifuged at approximately 3,500 x g and separated into insoluble (pellet) and soluble (supernatant) fractions.

E. coli-expressed Matin was isolated predominantly as a soluble protein and SDS-PAGE analysis revealed a monomeric band at about 30 kDa. The eluted fractions containing this band were used in the following experiments. Protein concentration in each fraction was determined by the BCA assay (Pierce Chemical Co., Rockford, Illinois, USA) and quantitative SDS-PAGE analysis using scanning densitometry.

Example 2: Matin Inhibits Endothelial Cell Proliferation.

The anti-proliferative effect of Matin on C-PAE cells was examined by the methylene blue staining assay using *E. coli* produced soluble protein.

Cell lines and culture. PC-3 (human prostate adenocarcinoma cell line) and C-PAE (bovine pulmonary arterial endothelial cell line) cells were obtained from American Type Culture Collection. The C-PAE cell lines were maintained in DMEM (Life Technologies/Gibco BRL, Gaithersburg, Maryland, USA) supplemented with 10% fetal calf serum (FCS), 100 units/ml of penicillin, and 100 mg/ml of streptomycin.

Proliferation assay. C-PAE cells were grown to confluence in DMEM with 10% FCS and kept contact-inhibited for 48 hours. C-PAE cells were used between the second and fourth passages. PC-3 cells were used as non-endothelial controls in this experiment. Cells were harvested by trypsinization (Life Technologies/Gibco BRL, Gaithersburg, Maryland, USA) at 37°C for 5 minutes. A suspension of 12,500 cells in DMEM with 0.1% FCS was added to each well of a 24-well plate coated with 10

-52-

µg/ml fibronectin. The cells were incubated for 24 hours at 37°C with 5% CO₂ and 95% humidity. Medium was removed and replaced with DMEM containing 20% FCS. Unstimulated control cells were incubated with 0.1% FCS.

Using the methylene-blue staining method, 7000 cells were plated into each well of a 96-well plate, and treated as described above. Cells were then counted using the method of Oliver *et al.* (Oliver, M.H. *et al.*, 1989, *J. Cell. Sci.* 92:513-518). After 48 hours of treatment, all wells were washed with 100 µl of PBS, and the cells fixed with 10% formalin in neutral-buffered saline (Sigma Chemical Co., St. Louis, Missouri, USA). The cells were then stained with 1% methylene blue (Sigma) in 0.01M borate buffer, pH 8.5. Wells were washed with 0.01M borate buffer, and the methylene blue extracted from the cells with 0.1N HCl/ethanol, and the absorbance measured in a microplate reader (Bio-Rad, Hercules, California, USA) at 655 nm. Polymyxin B (Sigma) at a final concentration of 5 µg/ml was used to inactivate endotoxin (Liu, S. *et al.*, 1997, *Clin. Biochem.* 30:455-463).

The results are shown in Figs. 3A and 3B, which are a pair of histograms showing the effect of increasing amounts of Matin on the uptake of dye by C-PAE cells relative to PC-3 cells. Absorbance at OD₆₅₅ is shown on the y-axis. "0.5% FCS" represents the 0.5% FCS-treated (unstimulated) control, and "10% FCS" is the 10% FCS-treated (stimulated) control. The remaining bars represent treatments with increasing concentrations of Matin. Matin inhibited FCS-stimulated proliferation of C-PAE cells in a dose-dependent manner. The difference between the mean value of the cell number in the Matin treatment versus the control was significant in the 0.1 - 10.0 µg/ml range, with $p < 0.05$. When PC-3 cells were treated with Matin, no inhibitory effect was observed. In C-PAE cells, dye uptake dropped off to the level seen in unstimulated cells at a Matin treatment level of about 0.1 µg/ml. Each bars represents the mean of the relative absorbance units at 655 nm ± the standard error of the mean for triplicate wells. This endothelial cell specificity indicates that Matin is likely an effective anti-angiogenic agent.

Example 3: Matin Induces Endothelial Cell Apoptosis.

Annexin V-FITC assay. In the early stage of apoptosis, translocation of the membrane phospholipid PS from the inner surface of plasma membrane to outside is observed (van Engeland, M. *et al.*, 1998, *Cytometry* 31:1-9; Zhang, G. *et al.*, 1997, 5 *Biotechniques* 23:525-531; Koopman, G. *et al.* 1994, *Blood* 84:1415-1420).

Externalized PS can be detected by staining with a FITC conjugate of Annexin V that has a naturally high binding affinity to PS (van Engeland, *supra*). Apoptosis of endothelial cells upon treatment with Matin was therefore evaluated using annexin V-FITC labeling.

10 C-PAE cells (0.5×10^6 per well) were seeded onto a 6-well plate in 10% FCS supplemented DMEM. The next day, fresh medium containing 10% FCS was added with either 80 ng/ml of TNF- α (positive control) or Matin ranging from 0.02 to 20 μ g/ml. Control cells received an equal volume of PBS. After 18 hours of treatment, medium containing floating cells was collected, and attached cells were trypsinized 15 and centrifuged together with floating cells at 3,000 x g. The cells were then washed in PBS and resuspended in binding buffer (10 mM HEPES/NaOH, pH 7.4, 140 mM NaCl, 2.5 mM CaCl₂). Annexin V-FITC (Clontech, Palo Alto, California, USA) was added to a final concentration of 150 ng/ml, and the cells were incubated in the dark for 10 minutes. The cells were washed again in PBS and resuspended in 20 binding buffer. Annexin V-FITC labeled cells were counted using a FACStar Plus flow cytometer (Becton-Dickinson, Waltham, Massachusetts, USA). For each treatment, 15,000 cells were counted and stored in listmode. This data was then analyzed using Cell Quest software (Becton-Dickinson, Waltham, Massachusetts, USA).

25 The results are shown in Fig. 4, which is a plot showing annexin fluorescence activity. After 18 hours of treatment with Matin at 20 μ g/ml, a distinct shift of peak annexin fluorescence was observed. The shift in fluorescence intensity was similar for Matin at 20 μ g/ml and the positive control TNF- α (80 ng/ml). Matin at 2 μ g/ml also showed a mild shift in annexin fluorescence intensity, but 30 concentrations below 0.2 μ g/ml did not demonstrate any annexin V positivity. This

shift of peak intensity was not observed when nonendothelial cells (PC-3) were used.

Caspase-3 assay. Caspase-3 (CPP32) is an intracellular protease activated at the early stage of apoptosis, and initiates cellular breakdown by degrading structural and DNA repair proteins (Casciola-Rosen, L. *et al.*, 1996, *J. Exp. Med.* 183:1957-1964; Salvesen, G.S. *et al.*, 1997, *Cell* 91:443-446). The protease activity of Caspase-3 was measured spectrophotometrically by detection of the chromophore (p-nitroanilide) cleaved from the labeled substrate (DEVD-pNA).

C-PAE cells or PC-3 cells (0.5×10^6 per well) were plated onto a 6-well plate precoated with fibronectin (10 $\mu\text{g/ml}$) in DMEM supplemented with 10% FCS, and incubated overnight. The next day, the medium was replaced with DMEM containing 2% FCS and then incubated overnight at 37°C. Then cells were then stimulated with bFGF (3ng/ml) in DMEM supplemented with 2% FCS, and also containing either TNF- α (80 ng/ml, positive control) or Matin (10 $\mu\text{g/ml}$), and incubated for 24 hours. Controls received PBS buffer. After 24 hours, the supernatant cells were collected, and attached cells were trypsinized and combined with the supernatant cells. Cells were counted and resuspended in cell lysis buffer (Clontech, Palo Alto, California, USA) at a concentration of 4×10^7 cells/ml. The rest of the protocol followed the manufacturer's instructions (Clontech, Palo Alto, California, USA). A specific inhibitor of Caspase-3, DEVD-fmk (Asp-Glu-Val-Asp-fluoromethyl ketone) was used to confirm the specificity of the assay. The absorbance was measured in a microplate reader (Bio-Rad, Hercules, California, USA) at 405 nm.

The results are shown in Figs. 5A and 5B, which are a pair of histograms showing the amount of Caspase-3 activity as a function of absorbance at OD₄₀₅ (y-axis) for C-PAE cells (Fig. 5A) and PC-3 cells (Fig. 5B) under various treatments (x-axis).

C-PAE cells treated with 20 $\mu\text{g/ml}$ Matin exhibited a 1.6-fold increase in Caspase-3 activity, whereas the positive control TNF- α gave a comparable (1.7-fold) increase compared with control. A specific inhibitor of Caspase-3, DEVD-fmk,

decreased the protease activity to baseline indicating that the increase in the measured activity was specific for Caspase-3. In nonendothelial PC-3 cells, there was no difference in Caspase-3 activity between control and Matin-treated cells.

MTT Assay. The pro-apoptotic activity of Matin was examined in C-PAE cells.

- 5 Cell viability was assessed by MTT (3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyl tetrasolium bromide) assay (Sugiyama, H. *et al.*, 1998, *Kidney Int.* 54:1188-1196). This assay is a quantitative colorimetric analysis for cell survival based on the ability of living cells to cleave the tetrasolium ring in active mitochondria. C-PAE cells (7,000 cells per well) were plated to a 96-well plate in 10% FCS containing DMEM.
- 10 The next day, either TNF- α (positive control, 80 ng/ml), or varying concentrations of Matin were added to the wells and incubated for 24 hours. MTT solution (5 mg/ml; CHEMICON International, Temecula, California, USA) was then added to the wells at a rate of 10 μ l/well and incubated at 37°C for 4 hours. Acid-isopropanol was added and mixed thoroughly. The absorbance was measured in a microplate reader
- 15 (Bio-Rad, Hercules, California, USA) at 590 nm.

The results are shown in Figs. 6A and 6B, which are a pair of histograms showing cell viability (as a function of OD₅₉₀, y-axis) at increasing concentrations of Matin (x-axis). Each point represents the mean +/- the standard error of the mean for triplicate wells.

- 20 Matin decreased cell viability in a dose-dependent manner. At 10 μ g/ml, Matin decreased the cell viability by about 80% compared to controls. No inhibitory effect was observed in Matin-treated PC-3 cells.

Example 4: Matin Inhibits Tumor Growth in vivo.

- Five million PC-3 cells were harvested and injected subcutaneously on the
- 25 back of 7- to 9-week-old male athymic nude mice. The tumors were measured using Vernier calipers and the volume was calculated using the standard formula width² x length x 0.52. The tumors were allowed to grow to about 100 mm³, and animals were then divided into groups of 5 or 6 mice. Matin or nephrin was intraperitoneally injected daily (20 mg/kg) for 10 days in sterile PBS to their respective experimental

group. The control group received vehicle injection (either BSA or PBS). Tumor volume was calculated every 2 or 3 days over 10 days. Nephtrin is a non-collagen-derived protein which was used as a control. The nephtrin was expressed in pET22b, as for Matin.

5 The results are shown in Fig. 7, which is a graph showing tumor size in mm³ (y-axis) against days of treatment (x-axis) for the PBS control (□), 20 mg/kg Matin (■) and 20 mg/kg nephtrin (○). Matin, produced in *E. coli*, significantly inhibited the growth of PC-3 human prostate tumors (Fig. 7).

 All references, patents, and patent applications are incorporated herein by
10 reference in their entirety. While this invention has been particularly shown and described with references
to preferred embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended
15 claims.

CLAIMS

What is claimed is:

1. Isolated Matin, wherein Matin is an isolated protein of the G1 domain of the α chain of laminin, or a fragment, analog, derivative or mutant thereof,
5 wherein the protein, fragment, analog, derivative or mutant thereof has anti-angiogenic activity.
2. The Matin of Claim 1, wherein the Matin is the G1 domain of the α 1 chain of mouse lamin.
3. The isolated protein of SEQ ID NO:2, or a fragment, analog, derivative or
10 mutant thereof, wherein the protein, fragment, analog, derivative or mutant has anti-angiogenic activity.
4. An isolated protein or peptide having 90% or greater sequence identity with SEQ ID NO:2, wherein the protein or peptide has anti-angiogenic activity.
5. An isolated protein or peptide having 80% or greater sequence identity with
15 SEQ ID NO:2, wherein the protein or peptide has anti-angiogenic activity.
6. The protein, fragment, analog, derivative or mutant of any of Claims 1 to 5, wherein the protein, fragment, analog, derivative or mutant is a monomer.
7. A multimer of the protein, fragment, analog, derivative or mutant of any of Claims 1 to 5, wherein the multimer has anti-angiogenic activity.
- 20 8. A chimeric protein comprising one or more protein, fragment, analog, derivative or mutant of any of Claims 1 to 5, wherein the chimeric protein has anti-angiogenic activity.

-58-

9. The chimeric protein of Claim 8, further comprising at least one protein molecule selected from the group consisting of: Vascostatin or fragments thereof, arreten or fragments thereof, canstatin or fragments thereof, tumstatin or fragments thereof, endostatin or fragments thereof, angiostatin or fragments thereof, restin or fragments thereof, apomigren or fragments thereof, or other anti-angiogenic proteins or fragments thereof.
- 5
10. The use of the protein, fragment, analog, derivative, mutant, multimer or chimeric protein of any of Claims 1 to 9 in the preparation of a medicament for treating a disorder involving inhibiting angiogenesis in a tissue.
- 10 11. The use according to Claim 10, wherein the disorder is tumor growth.
12. The use of the protein, fragment, analog, derivative, mutant, multimer or chimeric protein of any of Claims 1 to 9 in the preparation of a medicament for treating a disorder by promoting or inducing endothelial cell apoptosis in a tissue.
- 15 13. The use of Claims 10 or 11, wherein the angiogenesis is inhibited by inhibiting one or more of the following: endothelial cell proliferation, endothelial cell migration, or endothelial cell tube formation.
14. A pharmaceutical composition comprising one or more of the proteins, fragments, analogs, derivatives, mutants, multimers or chimeric proteins of any of Claims 1 to 9.
- 20
15. The pharmaceutical composition of Claim 14, and a pharmaceutically-compatible carrier.
16. The pharmaceutical composition of Claim 15, further comprising at least one protein molecule selected from the group consisting of: Vascostatin or

fragments thereof, arresten or fragments thereof, canstatin or fragments thereof, tumstatin or fragments thereof, endostatin or fragments thereof, angiostatin or fragments thereof, restin or fragments thereof, apomigren or fragments thereof, or other anti-angiogenic proteins, or fragments thereof.

- 5 17. A method of treating a subject comprising using the pharmaceutical composition of any of Claims 14 to 16.
18. A method for inhibiting angiogenic activity in mammalian tissue, the method comprising contacting the tissue with the composition of any of Claims 14 to 16.
- 10 19. The method of Claim 18, wherein the angiogenic activity is characteristic of a disease selected from the group comprising angiogenesis-dependent cancers, benign tumors, rheumatoid arthritis, diabetic retinopathy, fibrosis, psoriasis, ocular angiogenesis diseases, Osler-Webber Syndrome, myocardial angiogenesis, plaque neovascularization, telangiectasia, hemopheliac joints, 15 angiofibroma, wound granulation, intestinal adhesions, atherosclerosis, scleroderma, hypertrophic scars, cat scratch disease, *Helicobacter pylori* ulcers, dialysis graft vascular access stenosis, contraception and obesity.
20. The method of Claim 19, wherein the disease is cancer.
21. A method of using the composition of any of Claims 14 to 16 to inhibit a 20 disease characterized by angiogenic activity, the method comprising administering to a patient with the disease, the composition in conjunction with radiation therapy, chemotherapy, or immunotherapy.
22. An isolated polynucleotide encoding the protein, fragment, analog, derivative or mutant of any of Claims 1 to 5, wherein the protein, fragment, analog, 25 derivative or mutant has anti-angiogenic activity.

23. The isolated polynucleotide of Claim 17, wherein the polynucleotide is SEQ ID NO:1.
24. An isolated polynucleotide having 90% or greater sequence identity with SEQ ID NO:1, wherein the isolated polynucleotide encodes a polypeptide having anti-angiogenic activity.
25. An isolated polynucleotide having 85% or greater sequence identity with SEQ ID NO:1, wherein the isolated polynucleotide encodes a polypeptide having anti-angiogenic activity.
26. The isolated polynucleotide of any of Claims 17 to 20, wherein the polynucleotide is operably linked to an expression control sequence.
27. A host cell transformed with the polynucleotide of Claim 21.
28. The host cell of Claim 22, where the cell is selected from the group comprising bacterial, yeast, mammalian, insect or plant cells.
29. Antibodies that specifically bind to the isolated protein, fragment, analog, derivative, mutant, multimer or chimeric protein of any of Claims 1 to 5.
30. A process for producing a protein encoded by the polynucleotide of any of Claims 22 to 26, wherein the process comprises:
- (a) growing a culture of a host cell transformed with the polynucleotide of any of Claims 22 to 26, where the host cell is selected from the group comprising bacterial, yeast, mammalian, insect or plant cells; and
 - (b) purifying the protein from the culture;
- thereby producing the protein encoded by the polynucleotide of any of Claims 22 to 26.

31. An isolated polynucleotide produced according to the process of:
- (a) preparing one or more polynucleotide probes that hybridize under conditions under moderate stringency to the polynucleotide of any of Claims 22 to 26;
 - 5 (b) hybridizing said probe(s) to mammalian DNA; and
 - (c) isolating the DNA polynucleotide detected with the probe(s);
- wherein the nucleotide sequence of the isolated polynucleotide corresponds to the nucleotide sequence of the polynucleotide of any of Claims 22 to 26.
32. A method for providing a mammal with an anti-angiogenic protein, the
10 method comprising introducing mammalian cells into a mammal, said mammalian cells having been treated *in vitro* to insert therein the polynucleotide of any of Claims 22 to 26, and expressing *in vivo* in said mammal a therapeutically effective amount of the anti-angiogenic protein in an amount sufficient to inhibit angiogenic activity in the mammal.
- 15 33. The method of Claim 32 wherein the expression of the anti-angiogenic protein is transient expression.
34. The process of Claim 32, wherein the cells are chosen from the group consisting of: blood cells, TIL cells, bone marrow cells, vascular cells, tumor cells, liver cells, muscle cells, fibroblast cells.
- 20 35. The process of Claim 34, wherein the polynucleotide is inserted into the cells by a viral vector.

agc acg ggc gag acc ttc ccc agg agc gca ggg agc ggc ggc gac aac	48
atg cgc ggc agc ggc acg gga gcc gcg ctc ctg gtg ctc ctg gcc tcg	96
Met Arg Gly Ser Gly Thr Gly Ala Ala Leu Leu Val Leu Leu Ala Ser	16
gtg ctc tgg gtc acc gtg cgg agc cag cag aga ggc ttg ttc cct gcc	144
Val Leu Trp Val Thr Val Arg Ser Gln Gln Arg Gly Leu Phe Pro Ala	32
att ctc aac ctg gcc acc aat gcc cac atc agc gcc aat gct acc tgt	192
Ile Leu Asn Leu Ala Thr Asn Ala His Ile Ser Ala Asn Ala Thr Cys	48
gga gag aag ggc cct gag atg ttc tgc aaa ctc gtg gag cac gtg ccg	240
Gly Glu Lys Gly Pro Glu Met Phe Cys Lys Leu Val Glu His Val Pro	64
ggc cgg cct gtt cga cac gcc caa tgc cgg gtc tgt gac ggt aac agt	288
Gly Arg Pro Val Arg His Ala Gln Cys Arg Val Cys Asp Gly Asn Ser	80
acg aat cct aga gag cgc cat ccg ata tca cac gca atc gat ggc acc	336
Thr Asn Pro Arg Glu Arg His Pro Ile Ser His Ala Ile Asp Gly Thr	96
aac aac tgg tgg cag agc ccc agt att cag aat ggg aga gag tat cac	384
Asn Asn Trp Trp Gln Ser Pro Ser Ile Gln Asn Gly Arg Glu Tyr His	112
tgg gtc act gtc acc ctg gac tta cgg cag gtc ttt caa gtt gca tac	432
Trp Val Thr Val Thr Leu Asp Leu Arg Gln Val Phe Gln Val Ala Tyr	128
atc atc att aaa gct gcc aat gcc cct cgg cct gga aac tgg att ttg	480
Ile Ile Ile Lys Ala Ala Asn Ala Pro Arg Pro Gly Asn Trp Ile Leu	144
gag cgc tcc gtg gat ggc gtc aag ttc aaa ccc tgg cag tac tat gcc	528
Glu Arg Ser Val Asp Gly Val Lys Phe Lys Pro Trp Gln Tyr Tyr Ala	160
gtc agc gat aca gag tgt ttg acc cgc tac aaa ata act cca cgg cgg	576
Val Ser Asp Thr Glu Cys Leu Thr Arg Tyr Lys Ile Thr Pro Arg Arg	176
gga cct ccc act tac aga gca gac aac gaa gtc atc tgc acc tcg tat	624
Gly Pro Pro Thr Tyr Arg Ala Asp Asn Glu Val Ile Cys Thr Ser Tyr	192
tat tca aag ctg gtg cca ctt gaa cat gga gag att cac aca tca ctc	672
Tyr Ser Lys Leu Val Pro Leu Glu His Gly Glu Ile His Thr Ser Leu	208
atc aat ggc aga ccc agc gct gac gac ccc tca ccc cag ttg ctg gaa	720
Ile Asn Gly Arg Pro Ser Ala Asp Asp Pro Ser Pro Gln Leu Leu Glu	224
ttc acc tca gca cgg tac att cgc ctt cgt ctt cag cgc atc aga aca	768
Phe Thr Ser Ala Arg Tyr Ile Arg Leu Arg Leu Gln Arg Ile Arg Thr	240
ctc aac gca gac ctc atg acc ctt agc cat cgg gac ctc aga gac ctt	816
Leu Asn Ala Asp Leu Met Thr Leu Ser His Arg Asp Leu Arg Asp Leu	256
gac ccc att gtc aca aga cgt tat tac tat tcg ata aaa gac att tcc	864
Asp Pro Ile Val Thr Arg Arg Tyr Tyr Tyr Ser Ile Lys Asp Ile Ser	272
gtt gga ggc atg tgc att tgc tac ggc cat gcc agc agc tgc ccg tgg	912
Val Gly Gly Met Cys Ile Cys Tyr Gly His Ala Ser Ser Cys Pro Trp	288
gat gaa gaa gca aag caa cta cag tgt cag tgt gaa cac aat acg tgt	960
Asp Glu Glu Ala Lys Gln Leu Gln Cys Gln Cys Glu His Asn Thr Cys	304
ggc gag agc tgc gac agg tgc tgt cct ggc tac cat cag cag ccc tgg	1008
Gly Glu Ser Cys Asp Arg Cys Cys Pro Gly Tyr His Gln Gln Pro Trp	320
agg ccc gga acc att tcc tcc ggc aac gag tgt gag gaa tgc aac tgt	1056
Arg Pro Gly Thr Ile Ser Ser Gly Asn Glu Cys Glu Glu Cys Asn Cys	336

Fig. 1A

cac	aac	aaa	gcc	aaa	gat	tgt	tac	tat	gac	agc	agt	gtt	gca	aag	gag	1104
His	Asn	Lys	Ala	Lys	Asp	Cys	Tyr	Tyr	Asp	Ser	Ser	Val	Ala	Lys	Glu	352
agg	aga	agc	ctg	aac	act	gcc	ggg	cag	tac	agt	gga	gga	ggg	gtt	tgt	1152
Arg	Arg	Ser	Leu	Asn	Thr	Ala	Gly	Gln	Tyr	Ser	Gly	Gly	Gly	Val	Cys	368
gtc	aac	tgc	tcg	cag	aat	acc	aca	ggg	atc	aac	tgt	gaa	acc	tgt	atc	1200
Val	Asn	Cys	Ser	Gln	Asn	Thr	Thr	Gly	Ile	Asn	Cys	Glu	Thr	Cys	Ile	384
gac	cag	tat	tac	aga	cct	cac	aag	gta	tct	cct	tat	gat	gac	cac	cct	1248
Asp	Gln	Tyr	Tyr	Arg	Pro	His	Lys	Val	Ser	Pro	Tyr	Asp	Asp	His	Pro	400
tgc	cgt	ccc	tgt	aac	tgt	gac	cct	gtg	ggg	tct	ctg	agt	tct	gtc	tgt	1296
Cys	Arg	Pro	Cys	Asn	Cys	Asp	Pro	Val	Gly	Ser	Leu	Ser	Ser	Val	Cys	416
atc	aag	gat	gac	cgc	cat	gcc	gat	tta	gcc	aat	gga	aag	tgg	cca	ggt	1344
Ile	Lys	Asp	Asp	Arg	His	Ala	Asp	Leu	Ala	Asn	Gly	Lys	Trp	Pro	Gly	432
cag	tgt	cca	tgt	agg	aaa	ggt	tat	gct	gga	gat	aaa	tgt	gac	cgc	tgc	1392
Gln	Cys	Pro	Cys	Arg	Lys	Gly	Tyr	Ala	Gly	Asp	Lys	Cys	Asp	Arg	Cys	448
cag	ttt	ggc	tac	cgg	ggt	ttc	cca	aat	tgc	atc	ccc	tgt	gac	tgc	agg	1440
Gln	Phe	Gly	Tyr	Arg	Gly	Phe	Pro	Asn	Cys	Ile	Pro	Cys	Asp	Cys	Arg	464
act	gtc	ggc	agc	ctg	aat	gag	gat	cca	tgc	ata	gag	ccg	tgt	ctt	tgt	1488
Thr	Val	Gly	Ser	Leu	Asn	Glu	Asp	Pro	Cys	Ile	Glu	Pro	Cys	Leu	Cys	480
aag	aaa	aat	gtt	gag	ggt	aag	aac	tgt	gat	cgc	tgc	aag	cca	gga	ttc	1536
Lys	Lys	Asn	Val	Glu	Gly	Lys	Asn	Cys	Asp	Arg	Cys	Lys	Pro	Gly	Phe	496
tac	aac	ttg	aag	gaa	cga	aac	ccc	gag	ggc	tgc	tcc	gag	tgc	ttc	tgc	1584
Tyr	Asn	Leu	Lys	Glu	Arg	Asn	Pro	Glu	Gly	Cys	Ser	Glu	Cys	Phe	Cys	512
ttc	ggt	gtc	tct	ggt	gtc	tgt	gac	agc	ctc	acg	tgg	tcc	att	agt	cag	1632
Phe	Gly	Val	Ser	Gly	Val	Cys	Asp	Ser	Leu	Thr	Trp	Ser	Ile	Ser	Gln	528
gtg	acc	aat	atg	tca	ggg	tgg	ctg	gtc	act	gac	ttg	atg	agc	aca	aat	1680
Val	Thr	Asn	Met	Ser	Gly	Trp	Leu	Val	Thr	Asp	Leu	Met	Ser	Thr	Asn	544
aag	atc	cgg	tcc	cag	caa	gat	gtc	ctg	ggt	ggg	cac	cgt	cag	atc	agc	1728
Lys	Ile	Arg	Ser	Gln	Gln	Asp	Val	Leu	Gly	Gly	His	Arg	Gln	Ile	Ser	560
atc	aac	aac	acg	gcg	gtc	atg	cag	agg	ctg	act	tcc	act	tac	tac	tgg	1776
Ile	Asn	Asn	Thr	Ala	Val	Met	Gln	Arg	Leu	Thr	Ser	Thr	Tyr	Tyr	Trp	576
gca	gct	cct	gag	gcc	tac	ctc	gga	aac	aag	ctg	aca	gca	ttt	ggc	ggt	1824
Ala	Ala	Pro	Glu	Ala	Tyr	Leu	Gly	Asn	Lys	Leu	Thr	Ala	Phe	Gly	Gly	592
ttc	ctg	aaa	tac	act	gtg	tct	tac	gac	att	cca	gtg	gag	acg	gtg	gac	1872
Phe	Leu	Lys	Tyr	Thr	Val	Ser	Tyr	Asp	Ile	Pro	Val	Glu	Thr	Val	Asp	608
agt	gac	ctc	atg	tct	cat	gct	gac	atc	atc	atc	aag	ggg	aat	ggg	ctc	1920
Ser	Asp	Leu	Met	Ser	His	Ala	Asp	Ile	Ile	Ile	Lys	Gly	Asn	Gly	Leu	624
acc	ata	agc	aca	aga	gct	gag	ggc	ctg	tcc	ttg	caa	ccc	tat	gag	gaa	1968
Thr	Ile	Ser	Thr	Arg	Ala	Glu	Gly	Leu	Ser	Leu	Gln	Pro	Tyr	Glu	Glu	640
tac	ttc	aac	gtg	ggt	aga	ctt	gtg	cct	gag	aac	ttc	cgg	gac	ttt	aat	2016
Tyr	Phe	Asn	Val	Val	Arg	Leu	Val	Pro	Glu	Asn	Phe	Arg	Asp	Phe	Asn	656
acc	aga	agg	gag	att	gac	cgt	gac	cag	ctg	atg	act	gtc	ctg	gcc	aat	2064
Thr	Arg	Arg	Glu	Ile	Asp	Arg	Asp	Gln	Leu	Met	Thr	Val	Leu	Ala	Asn	672

Fig. 1B

gtg	aca	cat	ctc	ttg	atc	aga	gcc	aat	tat	aat	tct	gct	aaa	atg	gcg	2112
Val	Thr	His	Leu	Leu	Ile	Arg	Ala	Asn	Tyr	Asn	Ser	Ala	Lys	Met	Ala	688
ctc	tat	agg	ctg	gat	tct	gtc	tct	ctg	gac	ata	gca	agc	cct	aat	gct	2160
Leu	Tyr	Arg	Leu	Asp	Ser	Val	Ser	Leu	Asp	Ile	Ala	Ser	Pro	Asn	Ala	704
ata	gac	ttg	gca	gtg	gct	gct	gat	gtg	gaa	cac	tgt	gaa	tgt	ccc	caa	2208
Ile	Asp	Leu	Ala	Val	Ala	Ala	Asp	Val	Glu	His	Cys	Glu	Cys	Pro	Gln	720
ggc	tac	acg	ggg	acc	tcc	tgt	gag	gcc	tgc	ctc	cct	ggc	tat	tat	cga	2256
Gly	Tyr	Thr	Gly	Thr	Ser	Cys	Glu	Ala	Cys	Leu	Pro	Gly	Tyr	Tyr	Arg	736
gtg	gac	ggg	ata	ctc	ttt	gga	gga	atc	tgt	cag	ccc	tgc	gag	tgc	cac	2304
Val	Asp	Gly	Ile	Leu	Phe	Gly	Gly	Ile	Cys	Gln	Pro	Cys	Glu	Cys	His	752
ggg	cat	gca	tcc	gag	tgt	gac	att	cat	gga	att	tgc	tct	gtg	tgt	aca	2352
Gly	His	Ala	Ser	Glu	Cys	Asp	Ile	His	Gly	Ile	Cys	Ser	Val	Cys	Thr	768
cac	aac	acc	acg	ggg	gat	cac	tgt	gag	cag	tgc	ctg	cct	ggc	ttc	tat	2400
His	Asn	Thr	Thr	Gly	Asp	His	Cys	Glu	Gln	Cys	Leu	Pro	Gly	Phe	Tyr	784
ggg	aca	cct	tca	cgt	ggg	acc	cca	gga	gac	tgc	cag	cct	tgt	gcc	tgc	2448
Gly	Thr	Pro	Ser	Arg	Gly	Thr	Pro	Gly	Asp	Cys	Gln	Pro	Cys	Ala	Cys	800
cct	ctc	tcc	att	gac	tct	aac	aat	ttc	agc	cct	acc	tgc	cac	ctc	act	2496
Pro	Leu	Ser	Ile	Asp	Ser	Asn	Asn	Phe	Ser	Pro	Thr	Cys	His	Leu	Thr	816
gat	gga	gag	gaa	gtg	ggt	tgt	gac	caa	tgt	gcc	ccg	ggt	tac	tca	gga	2544
Asp	Gly	Glu	Glu	Val	Val	Cys	Asp	Gln	Cys	Ala	Pro	Gly	Tyr	Ser	Gly	832
tcc	tgg	tgt	gag	aga	tgt	gca	gat	ggt	tac	tat	gga	aac	cca	acc	gtg	2592
Ser	Trp	Cys	Glu	Arg	Cys	Ala	Asp	Gly	Tyr	Tyr	Gly	Asn	Pro	Thr	Val	848
cca	ggg	gga	acc	tgt	gta	cca	tgc	aac	tgc	agt	ggc	aat	ggt	gat	ccc	2640
Pro	Gly	Gly	Thr	Cys	Val	Pro	Cys	Asn	Cys	Ser	Gly	Asn	Val	Asp	Pro	864
ttg	gag	gct	ggc	cac	tgt	gac	tct	gtc	acg	ggg	gaa	tgc	ctg	aag	tgc	2688
Leu	Glu	Ala	Gly	His	Cys	Asp	Ser	Val	Thr	Gly	Glu	Cys	Leu	Lys	Cys	880
tta	tgg	aac	aca	gac	ggt	gcc	cat	tgt	gag	agg	tgt	gca	gat	ggc	ttc	2736
Leu	Trp	Asn	Thr	Asp	Gly	Ala	His	Cys	Glu	Arg	Cys	Ala	Asp	Gly	Phe	896
tat	gga	gat	gcc	gtg	act	gcc	aaa	aac	tgc	cga	gcc	tgt	gac	tgc	cac	2784
Tyr	Gly	Asp	Ala	Val	Thr	Ala	Lys	Asn	Cys	Arg	Ala	Cys	Asp	Cys	His	912
gag	aat	ggc	tcc	ctt	tct	ggc	gtc	tgc	cat	ctg	gag	act	gga	ctg	tgt	2832
Glu	Asn	Gly	Ser	Leu	Ser	Gly	Val	Cys	His	Leu	Glu	Thr	Gly	Leu	Cys	928
gac	tgc	aaa	cct	cac	gtg	aca	gga	cag	cag	tgt	gac	cag	tgc	ctg	tct	2880
Asp	Cys	Lys	Pro	His	Val	Thr	Gly	Gln	Gln	Cys	Asp	Gln	Cys	Leu	Ser	944
ggc	tac	tac	ggg	ttg	gac	acg	ggg	ctt	ggc	tgt	gtg	ccc	tgt	aac	tgc	2928
Gly	Tyr	Tyr	Gly	Leu	Asp	Thr	Gly	Leu	Gly	Cys	Val	Pro	Cys	Asn	Cys	960
agt	gtg	gaa	ggc	tct	gta	tct	gac	aac	tgc	acg	gag	gaa	gga	cag	tgt	2976
Ser	Val	Glu	Gly	Ser	Val	Ser	Asp	Asn	Cys	Thr	Glu	Glu	Gly	Gln	Cys	976
cac	tgt	gga	cca	ggt	gtc	tct	ggg	aaa	cag	tgt	gac	agg	tgt	tca	cat	3024
His	Cys	Gly	Pro	Gly	Val	Ser	Gly	Lys	Gln	Cys	Asp	Arg	Cys	Ser	His	992
ggt	ttc	tat	gca	ttc	cag	gat	ggc	ggc	tgc	aca	ccc	tgt	gac	tgt	gct	3072
Gly	Phe	Tyr	Ala	Phe	Gln	Asp	Gly	Gly	Cys	Thr	Pro	Cys	Asp	Cys	Ala	1008

Fig. 1C

cat	acc	cag	aat	aac	tgt	gac	ccc	gcc	tct	gga	gag	tgt	ctc	tgc	ccg	3120
His	Thr	Gln	Asn	Asn	Cys	Asp	Pro	Ala	Ser	Gly	Glu	Cys	Leu	Cys	Pro	1024
cct	cac	acg	cag	ggg	ctg	aag	tgt	gag	gag	tgt	gaa	gag	gca	tac	tgg	3168
Pro	His	Thr	Gln	Gly	Leu	Lys	Cys	Glu	Glu	Cys	Glu	Glu	Ala	Tyr	Trp	1040
ggt	ctg	gac	ccg	gag	cag	ggg	tgc	cag	gct	tgc	aat	tgc	agt	gct	gtg	3216
Gly	Leu	Asp	Pro	Glu	Gln	Gly	Cys	Gln	Ala	Cys	Asn	Cys	Ser	Ala	Val	1056
ggc	tcc	acg	agt	gcc	cag	tgt	gat	ggt	ctc	tct	ggc	cac	tgc	ccc	tgc	3264
Gly	Ser	Thr	Ser	Ala	Gln	Cys	Asp	Val	Leu	Ser	Gly	His	Cys	Pro	Cys	1072
aaa	aaa	ggg	ttt	ggt	ggg	cag	agc	tgc	cat	cag	tgt	tcc	tta	ggc	tac	3312
Lys	Lys	Gly	Phe	Gly	Gly	Gln	Ser	Cys	His	Gln	Cys	Ser	Leu	Gly	Tyr	1088
aga	agt	ttt	cct	gac	tgt	gtc	ccc	tgt	ggc	tgt	gac	ctg	agg	ggg	aca	3360
Arg	Ser	Phe	Pro	Asp	Cys	Val	Pro	Cys	Gly	Cys	Asp	Leu	Arg	Gly	Thr	1104
ctg	cct	gac	acc	tgt	gac	ctg	gaa	cag	ggt	ctc	tgc	agc	tgc	tca	gag	3408
Leu	Pro	Asp	Thr	Cys	Asp	Leu	Glu	Gln	Gly	Leu	Cys	Ser	Cys	Ser	Glu	1120
gac	agt	ggt	acc	tgc	tcc	tgc	aag	gag	aat	gtc	gtg	ggc	ccc	cag	tgc	3456
Asp	Ser	Gly	Thr	Cys	Ser	Cys	Lys	Glu	Asn	Val	Val	Gly	Pro	Gln	Cys	1136
agt	aag	tgc	caa	gcc	ggc	acc	ttt	gcc	ttg	cga	ggg	gac	aac	cct	caa	3504
Ser	Lys	Cys	Gln	Ala	Gly	Thr	Phe	Ala	Leu	Arg	Gly	Asp	Asn	Pro	Gln	1152
ggc	tgc	agc	ccc	tgc	ttc	tgc	ttc	ggt	ctg	tcg	cag	ctc	tgc	tca	gag	3552
Gly	Cys	Ser	Pro	Cys	Phe	Cys	Phe	Gly	Leu	Ser	Gln	Leu	Cys	Ser	Glu	1168
ttg	gag	ggt	tac	gtg	agg	act	ctg	ata	act	cta	gcc	tcc	gat	cag	ccc	3600
Leu	Glu	Gly	Tyr	Val	Arg	Thr	Leu	Ile	Thr	Leu	Ala	Ser	Asp	Gln	Pro	1184
ctc	ctg	cat	gtg	ggt	tca	cag	agc	aac	ctc	aag	ggc	aca	atc	gaa	ggc	3648
Leu	Leu	His	Val	Val	Ser	Gln	Ser	Asn	Leu	Lys	Gly	Thr	Ile	Glu	Gly	1200
gtg	cat	ttc	cag	cct	cct	gac	acc	ttg	ctg	gac	gca	gag	gct	gtc	cgc	3696
Val	His	Phe	Gln	Pro	Pro	Asp	Thr	Leu	Leu	Asp	Ala	Glu	Ala	Val	Arg	1216
cag	cat	atc	tat	gca	gag	cca	ttt	tac	tgg	cgg	cta	cca	aag	cag	ttc	3744
Gln	His	Ile	Tyr	Ala	Glu	Pro	Phe	Tyr	Trp	Arg	Leu	Pro	Lys	Gln	Phe	1232
cag	gga	gac	cag	ctc	ttg	gcc	tat	ggt	ggg	aaa	ctc	cag	tac	agt	gtg	3792
Gln	Gly	Asp	Gln	Leu	Leu	Ala	Tyr	Gly	Gly	Lys	Leu	Gln	Tyr	Ser	Val	1248
gct	ttc	tac	tct	aca	ctt	ggc	acc	gga	aca	tcc	aat	tat	gag	cct	caa	3840
Ala	Phe	Tyr	Ser	Thr	Leu	Gly	Thr	Gly	Thr	Ser	Asn	Tyr	Glu	Pro	Gln	1264
gtc	ctc	atc	aaa	gga	ggt	cgg	gcc	agg	aag	cac	gtc	att	tat	atg	gat	3888
Val	Leu	Ile	Lys	Gly	Gly	Arg	Ala	Arg	Lys	His	Val	Ile	Tyr	Met	Asp	1280
gcc	cca	gcg	cct	gag	aat	gga	gtg	aga	cag	gat	tac	gaa	gtg	cag	atg	3936
Ala	Pro	Ala	Pro	Glu	Asn	Gly	Val	Arg	Gln	Asp	Tyr	Glu	Val	Gln	Met	1296
aaa	gag	gaa	ttc	tgg	aaa	tat	ttt	aac	tcc	gtg	tct	gag	aaa	cac	gtc	3984
Lys	Glu	Glu	Phe	Trp	Lys	Tyr	Phe	Asn	Ser	Val	Ser	Glu	Lys	His	Val	1312
aca	cac	tct	gat	ttt	atg	tct	ggt	ctc	agc	aat	att	gac	tac	atc	ctc	4032
Thr	His	Ser	Asp	Phe	Met	Ser	Val	Leu	Ser	Asn	Ile	Asp	Tyr	Ile	Leu	1328
atc	aaa	gca	tca	tac	ggc	cag	gga	ctg	cag	cag	agc	aga	att	gcc	aac	4080
Ile	Lys	Ala	Ser	Tyr	Gly	Gln	Gly	Leu	Gln	Gln	Ser	Arg	Ile	Ala	Asn	1344

Fig. 1D

att	tcc	atg	gag	ggt	ggc	cgg	aaa	gct	gtc	gag	ctg	ccc	gct	gag	ggc	4128
Ile	Ser	Met	Glu	Val	Gly	Arg	Lys	Ala	Val	Glu	Leu	Pro	Ala	Glu	Gly	1360
gag	gcg	gca	ttg	ctg	ttg	gag	ctc	tgt	gtc	tgt	cct	cct	ggc	acc	gca	4176
Glu	Ala	Ala	Leu	Leu	Leu	Glu	Leu	Cys	Val	Cys	Pro	Pro	Gly	Thr	Ala	1376
gga	cac	tcc	tgt	cag	gac	tgt	gct	cct	ggg	tac	tac	aga	gaa	aag	ctc	4224
Gly	His	Ser	Cys	Gln	Asp	Cys	Ala	Pro	Gly	Tyr	Tyr	Arg	Glu	Lys	Leu	1392
cca	gaa	agt	ggt	ggc	agg	gga	ccc	cgc	cct	ctg	ctg	gct	cct	tgt	gtg	4272
Pro	Glu	Ser	Gly	Gly	Arg	Gly	Pro	Arg	Pro	Leu	Leu	Ala	Pro	Cys	Val	1408
ccc	tgc	aat	tgc	aac	aac	cac	agt	gat	gtc	tgt	gac	ccc	gaa	act	gga	4320
Pro	Cys	Asn	Cys	Asn	Asn	His	Ser	Asp	Val	Cys	Asp	Pro	Glu	Thr	Gly	1424
aag	tgc	ctg	agc	tgc	agg	gac	cac	aca	tcc	ggg	gac	cac	tgt	gag	ctg	4368
Lys	Cys	Leu	Ser	Cys	Arg	Asp	His	Thr	Ser	Gly	Asp	His	Cys	Glu	Leu	1440
tgt	gct	tct	ggc	tac	tat	ggg	aag	gtg	act	gga	ctg	cct	gga	gac	tgt	4416
Cys	Ala	Ser	Gly	Tyr	Tyr	Gly	Lys	Val	Thr	Gly	Leu	Pro	Gly	Asp	Cys	1456
acc	ccg	tgc	acc	tgt	cct	cat	cac	cct	cct	ttc	agt	ttc	agc	ccc	act	4464
Thr	Pro	Cys	Thr	Cys	Pro	His	His	Pro	Pro	Phe	Ser	Phe	Ser	Pro	Thr	1472
tgt	gtc	gtg	gaa	ggt	gac	agt	gat	ttc	cgg	tgc	aat	gcc	tgc	ctc	ccc	4512
Cys	Val	Val	Glu	Gly	Asp	Ser	Asp	Phe	Arg	Cys	Asn	Ala	Cys	Leu	Pro	1488
ggc	tat	gaa	gga	cag	tac	tgt	gaa	agg	tgc	tct	gca	ggc	tat	cac	ggc	4560
Gly	Tyr	Glu	Gly	Gln	Tyr	Cys	Glu	Arg	Cys	Ser	Ala	Gly	Tyr	His	Gly	1504
aac	cct	cga	gca	gca	ggt	ggt	agc	tgc	caa	acg	tgt	gat	tgc	aac	ccc	4608
Asn	Pro	Arg	Ala	Ala	Gly	Gly	Ser	Cys	Gln	Thr	Cys	Asp	Cys	Asn	Pro	1520
caa	ggc	tct	gtc	cac	agt	gac	tgt	gac	cgt	gca	tcc	ggg	cag	tgt	gtc	4656
Gln	Gly	Ser	Val	His	Ser	Asp	Cys	Asp	Arg	Ala	Ser	Gly	Gln	Cys	Val	1536
tgc	aag	cca	gga	gct	aca	ggg	ctc	cac	tgt	gag	aaa	tgc	ctg	ccg	aga	4704
Cys	Lys	Pro	Gly	Ala	Thr	Gly	Leu	His	Cys	Glu	Lys	Cys	Leu	Pro	Arg	1552
cac	atc	ctg	atg	gag	agc	gac	tgt	ggt	tcc	tgt	gat	gat	gac	tgt	gtg	4752
His	Ile	Leu	Met	Glu	Ser	Asp	Cys	Val	Ser	Cys	Asp	Asp	Asp	Cys	Val	1568
ggt	cct	ttg	ctg	aac	gac	ctg	gat	tct	ggt	ggt	gat	gcc	ggt	ctg	tct	4800
Gly	Pro	Leu	Leu	Asn	Asp	Leu	Asp	Ser	Val	Gly	Asp	Ala	Val	Leu	Ser	1584
ctg	aac	ctc	acg	ggc	ggt	tcc	cct	gct	ccc	tat	gga	atc	ctg	gaa	aat	4848
Leu	Asn	Leu	Thr	Gly	Val	Ser	Pro	Ala	Pro	Tyr	Gly	Ile	Leu	Glu	Asn	1600
ctg	gaa	aat	aca	act	aaa	tat	ttc	cag	agg	tat	tta	ata	aag	gaa	aat	4896
Leu	Glu	Asn	Thr	Thr	Lys	Tyr	Phe	Gln	Arg	Tyr	Leu	Ile	Lys	Glu	Asn	1616
gcc	aag	aag	att	cga	gca	gag	atc	cag	ctc	gaa	ggg	att	gca	gag	caa	4944
Ala	Lys	Lys	Ile	Arg	Ala	Glu	Ile	Gln	Leu	Glu	Gly	Ile	Ala	Glu	Gln	1632
aca	gaa	aat	ctg	caa	aag	gag	ctc	acc	aga	gtg	tta	gca	cgc	cat	cag	4992
Thr	Glu	Asn	Leu	Gln	Lys	Glu	Leu	Thr	Arg	Val	Leu	Ala	Arg	His	Gln	1648
aag	gtg	aac	gct	gaa	atg	gaa	aga	act	tcc	aat	ggg	act	caa	gcc	ctg	5040
Lys	Val	Asn	Ala	Glu	Met	Glu	Arg	Thr	Ser	Asn	Gly	Thr	Gln	Ala	Leu	1664
gcc	acg	ttc	att	gag	cag	cta	cat	gca	aac	atc	aaa	gaa	atc	aca	gaa	5088
Ala	Thr	Phe	Ile	Glu	Gln	Leu	His	Ala	Asn	Ile	Lys	Glu	Ile	Thr	Glu	1680

Fig. 1E

aag	gtg	gca	acg	ttg	aac	cag	acg	gcg	cgt	aaa	gat	ttc	cag	cca	ccc	5136
Lys	Val	Ala	Thr	Leu	Asn	Gln	Thr	Ala	Arg	Lys	Asp	Phe	Gln	Pro	Pro	1696
gtg	tct	gcc	ctt	cag	agc	atg	cac	cag	aac	att	tcg	tct	ctg	ctg	gga	5184
Val	Ser	Ala	Leu	Gln	Ser	Met	His	Gln	Asn	Ile	Ser	Ser	Leu	Leu	Gly	1712
ctc	atc	aag	gaa	agg	aat	ttc	aca	gag	atg	cag	cag	aat	gct	acc	ctt	5232
Leu	Ile	Lys	Glu	Arg	Asn	Phe	Thr	Glu	Met	Gln	Gln	Asn	Ala	Thr	Leu	1728
gag	ctc	aag	gct	gct	aaa	gac	tta	ttg	tca	cgg	att	cag	aaa	agg	ttt	5280
Glu	Leu	Lys	Ala	Ala	Lys	Asp	Leu	Leu	Ser	Arg	Ile	Gln	Lys	Arg	Phe	1744
cag	aag	cct	cag	gaa	aag	ttg	aag	gca	ttg	aag	gag	gcc	aac	agc	ctc	5328
Gln	Lys	Pro	Gln	Glu	Lys	Leu	Lys	Ala	Leu	Lys	Glu	Ala	Asn	Ser	Leu	1760
ctt	tcc	aac	cac	agt	gaa	aaa	ctg	cag	gct	gct	gag	gag	ctc	ctt	aag	5376
Leu	Ser	Asn	His	Ser	Glu	Lys	Leu	Gln	Ala	Ala	Glu	Glu	Leu	Leu	Lys	1776
gaa	gct	gga	agc	aag	acc	cag	gag	agc	aac	ctc	ctg	ctg	ctc	ctt	gtc	5424
Glu	Ala	Gly	Ser	Lys	Thr	Gln	Glu	Ser	Asn	Leu	Leu	Leu	Leu	Leu	Val	1792
aag	gcc	aac	ctg	aaa	gag	gaa	ttc	cag	gag	aaa	aag	ctg	cgt	gtt	caa	5472
Lys	Ala	Asn	Leu	Lys	Glu	Glu	Phe	Gln	Glu	Lys	Lys	Leu	Arg	Val	Gln	1808
gaa	gaa	caa	aat	gtg	acc	tca	gag	ctc	att	gcc	aag	ggt	aga	gaa	tgg	5520
Glu	Glu	Gln	Asn	Val	Thr	Ser	Glu	Leu	Ile	Ala	Lys	Gly	Arg	Glu	Trp	1824
gtg	gat	gct	gcc	ggg	act	cac	aca	gct	gct	gca	caa	gac	acc	cta	aca	5568
Val	Asp	Ala	Ala	Gly	Thr	His	Thr	Ala	Ala	Ala	Gln	Asp	Thr	Leu	Thr	1840
cag	ctg	gag	cat	cac	cga	gat	gaa	ctc	ctt	ctg	tgg	gcc	aga	aaa	atc	5616
Gln	Leu	Glu	His	His	Arg	Asp	Glu	Leu	Leu	Leu	Trp	Ala	Arg	Lys	Ile	1856
agg	agc	cac	gta	gat	gac	ctc	gtc	atg	cag	atg	tcc	aaa	cga	aga	gcc	5664
Arg	Ser	His	Val	Asp	Asp	Leu	Val	Met	Gln	Met	Ser	Lys	Arg	Arg	Ala	1872
cgt	gac	ctg	gtc	cac	agg	gca	gag	cag	cat	gcc	tct	gag	ctg	cag	agc	5712
Arg	Asp	Leu	Val	His	Arg	Ala	Glu	Gln	His	Ala	Ser	Glu	Leu	Gln	Ser	1888
agg	gca	gga	gct	ttg	gac	aga	gac	ctt	gaa	aat	ggt	aga	aac	gtg	tct	5760
Arg	Ala	Gly	Ala	Leu	Asp	Arg	Asp	Leu	Glu	Asn	Val	Arg	Asn	Val	Ser	1904
ttg	aat	gcc	acc	agt	gcg	gca	cac	gtc	cac	agc	aac	atc	cag	aca	ctg	5808
Leu	Asn	Ala	Thr	Ser	Ala	Ala	His	Val	His	Ser	Asn	Ile	Gln	Thr	Leu	1920
aca	gag	gaa	gct	gag	atg	ctg	gct	gct	gat	gct	cac	aag	acg	gcg	aat	5856
Thr	Glu	Glu	Ala	Glu	Met	Leu	Ala	Ala	Asp	Ala	His	Lys	Thr	Ala	Asn	1936
aag	aca	gac	ttg	atc	tcc	gaa	tcc	ctg	gct	tct	cgg	ggg	aaa	gca	gtc	5904
Lys	Thr	Asp	Leu	Ile	Ser	Glu	Ser	Leu	Ala	Ser	Arg	Gly	Lys	Ala	Val	1952
ctt	cag	cgc	tcg	tcc	cgg	ttt	cta	aag	gaa	agt	gtc	ggt	acc	agg	agg	5952
Leu	Gln	Arg	Ser	Ser	Arg	Phe	Leu	Lys	Glu	Ser	Val	Gly	Thr	Arg	Arg	1968
aag	cag	caa	ggc	att	acg	atg	aag	ctg	gat	gag	ttg	aaa	aac	tta	acg	6000
Lys	Gln	Gln	Gly	Ile	Thr	Met	Lys	Leu	Asp	Glu	Leu	Lys	Asn	Leu	Thr	1984
agt	caa	ttt	cag	gag	agc	gtg	gat	aac	att	acg	aag	cag	gcc	aac	gac	6048
Ser	Gln	Phe	Gln	Glu	Ser	Val	Asp	Asn	Ile	Thr	Lys	Gln	Ala	Asn	Asp	2000
tcc	ctt	gcg	atg	ctt	aga	gaa	agc	cct	gga	ggt	atg	aga	gag	aag	ggc	6096
Ser	Leu	Ala	Met	Leu	Arg	Glu	Ser	Pro	Gly	Gly	Met	Arg	Glu	Lys	Gly	2016

Fig. 1F

agg	aaa	gcc	aga	gag	ctg	gcg	gca	gca	gcc	aac	gag	agt	gcg	gtg	aag	6144
Arg	Lys	Ala	Arg	Glu	Leu	Ala	Ala	Ala	Ala	Asn	Glu	Ser	Ala	Val	Lys	2032
aca	ctg	gag	gat	gtg	ctg	gct	ttg	agc	ctg	agg	gtc	ttc	aat	aca	tca	6192
Thr	Leu	Glu	Asp	Val	Leu	Ala	Leu	Ser	Leu	Arg	Val	Phe	Asn	Thr	Ser	2048
gag	gac	ctg	tcc	aga	gtg	aat	gcc	aca	gtc	cag	gag	aca	aac	gac	ctt	6240
Glu	Asp	Leu	Ser	Arg	Val	Asn	Ala	Thr	Val	Gln	Glu	Thr	Asn	Asp	Leu	2064
ctg	cat	aac	tcc	acg	atg	acc	act	ctg	ttg	gct	gga	aga	aaa	atg	aaa	6288
Leu	His	Asn	Ser	Thr	Met	Thr	Thr	Leu	Leu	Ala	Gly	Arg	Lys	Met	Lys	2080
gac	atg	gaa	atg	caa	gcc	aac	ctt	tta	ttg	gat	cga	ttg	aaa	cct	ttg	6336
Asp	Met	Glu	Met	Gln	Ala	Asn	Leu	Leu	Leu	Asp	Arg	Leu	Lys	Pro	Leu	2096
aaa	acc	ctg	gag	gag	aac	ctg	agc	aga	aac	ctg	tcg	gag	atc	aag	ctg	6384
Lys	Thr	Leu	Glu	Glu	Asn	Leu	Ser	Arg	Asn	Leu	Ser	Glu	Ile	Lys	Leu	2112
ctg	atc	agc	cgg	gcc	cgg	aaa	caa	gcg	gcg	tcg	atc	aaa	gtc	gcc	gtg	6432
Leu	Ile	Ser	Arg	Ala	Arg	Lys	Gln	Ala	Ala	Ser	Ile	Lys	Val	Ala	Val	2128
tct	gca	gac	<u>AGA</u>	<u>GAC</u>	<u>TGC</u>	<u>ATC</u>	<u>CGC</u>	<u>GCC</u>	<u>TAT</u>	cag	cct	cag	act	tca	tct	6480
Ser	Ala	Asp	Arg	Asp	Cys	Ile	Arg	Ala	Tyr	Gln	Pro	Gln	Thr	Ser	Ser	2144
acc	aat	tac	aac	acc	ttg	atc	ctg	aac	gtg	aag	acg	cag	gag	ccc	gac	6528
Thr	Asn	Tyr	Asn	Thr	Leu	Ile	Leu	Asn	Val	Lys	Thr	Gln	Glu	Pro	Asp	2160
aac	ctc	ctc	ttc	tac	ctc	ggc	agc	agc	agc	agt	tct	gac	ttt	ctc	gca	6576
Asn	Leu	Leu	Phe	Tyr	Leu	Gly	Ser	Ser	Ser	Ser	Ser	Asp	Phe	Leu	Ala	2176
gtg	gag	atg	cgg	cgg	ggg	aag	gtc	gcc	ttt	ctc	tgg	gac	ctg	ggc	tcc	6624
Val	Glu	Met	Arg	Arg	Gly	Lys	Val	Ala	Phe	Leu	Trp	Asp	Leu	Gly	Ser	2192
ggg	tcc	aca	agg	ttg	gaa	ttc	cca	gag	gtc	tcc	atc	aat	aac	aac	aga	6672
Gly	Ser	Thr	Arg	Leu	Glu	Phe	Pro	Glu	Val	Ser	Ile	Asn	Asn	Asn	Arg	2208
tgg	cac	agc	atc	tac	ata	acc	agg	ttt	gga	aac	atg	ggg	tcc	ctg	agt	6720
Trp	His	Ser	Ile	Tyr	Ile	Thr	Arg	Phe	Gly	Asn	Met	Gly	Ser	Leu	Ser	2224
gta	aag	gaa	gca	agc	gct	gcc	gag	aac	cca	ccg	gtc	agg	aca	agc	aaa	6768
Val	Lys	Glu	Ala	Ser	Ala	Ala	Glu	Asn	Pro	Pro	Val	Arg	Thr	Ser	Lys	2240
tct	cct	gga	ccg	tcg	aag	gtt	ctg	gac	ata	aac	aat	tca	acg	ctg	atg	6816
Ser	Pro	Gly	Pro	Ser	Lys	Val	Leu	Asp	Ile	Asn	Asn	Ser	Thr	Leu	Met	2256
ttt	gtt	gga	ggg	ctc	gga	ggt	cag	atc	aag	aaa	tcc	ccg	gct	gtg	aag	6864
Phe	Val	Gly	Gly	Leu	Gly	Gly	Gln	Ile	Lys	Lys	Ser	Pro	Ala	Val	Lys	2272
gtt	act	cat	ttt	aag	ggc	tgc	atg	gga	gag	gcc	ttc	ttg	aat	ggc	aaa	6912
Val	Thr	His	Phe	Lys	Gly	Cys	Met	Gly	Glu	Ala	Phe	Leu	Asn	Gly	Lys	2288
tcg	att	ggc	ctg	tgg	aat	tac	atc	gag	aga	gag	ggg	aag	tgc	aat	ggc	6960
Ser	Ile	Gly	Leu	Trp	Asn	Tyr	Ile	Glu	Arg	Glu	Gly	Lys	Cys	Asn	Gly	2304
tgc	ttt	gga	agc	tcc	cag	aac	gaa	gat	tcc	tcc	ttc	cat	ttc	gat	gga	7008
Cys	Phe	Gly	Ser	Ser	Gln	Asn	Glu	Asp	Ser	Ser	Phe	His	Phe	Asp	Gly	2320
agc	ggg	tac	gcc	atg	gtg	gag	aag	acg	ctc	cgg	<u>ccc</u>	<u>acc</u>	<u>gtg</u>	<u>acg</u>	<u>CAG</u>	7056
Ser	Gly	Tyr	Ala	Met	Val	Glu	Lys	Thr	Leu	Arg	Pro	Thr	Val	Thr	Gln	2336
<u>ATA</u>	<u>GTA</u>	<u>ATT</u>	<u>CTC</u>	<u>TTC</u>	<u>AGC</u>	<u>ACC</u>	ttc	tcc	ccg	aat	ggc	ctt	ctt	ttc	tac	7104
Ile	Val	Ile	Leu	Phe	Ser	Thr	Phe	Ser	Pro	Asn	Gly	Leu	Leu	Phe	Tyr	2352

Fig. 1G

ctg gct tca aac ggc acc aag gac ttc cta tcc atc gag ctg gtc cgt	7152
Leu Ala Ser Asn Gly Thr Lys Asp Phe Leu Ser Ile Glu Leu Val Arg	2368
ggc agg gtc aaa gtg atg gtg gac cta ggg tca gga ccc ctc act ctt	7200
Gly Arg Val Lys Val Met Val Asp Leu Gly Ser Gly Pro Leu Thr Leu	2384
atg aca gac agg cgg tat aac aac gga acc tgg tat aaa atc gcc ttc	7248
Met Thr Asp Arg Arg Tyr Asn Asn Gly Thr Trp Tyr Lys Ile Ala Phe	2400
cag cgg aac cgg aag caa gga ctg cta gct gtc ttc gat gca tat gac	7296
Gln Arg Asn Arg Lys Gln Gly Leu Leu Ala Val Phe Asp Ala Tyr Asp	2416
acc agt gac aag gag aca aag caa gga gag act cca gga gcc gct tcc	7344
Thr Ser Asp Lys Glu Thr Lys Gln Gly Glu Thr Pro Gly Ala Ala Ser	2432
gac ctc aat cgg ctg gag aaa gac ctg att tac gtg ggt gga ttg cct	7392
Asp Leu Asn Arg Leu Glu Lys Asp Leu Ile Tyr Val Gly Gly Leu Pro	2448
cat tct aag gct gtg agg aaa ggg gtc agc agc aga agc tat gtg ggc	7440
His Ser Lys Ala Val Arg Lys Gly Val Ser Ser Arg Ser Tyr Val Gly	2464
tgt atc aag aac cta gag ata tcc agg tcc acc ttt gat ttg ctg aga	7488
Cys Ile Lys Asn Leu Glu Ile Ser Arg Ser Thr Phe Asp Leu Leu Arg	2480
aat tcc tac gga gtg aga aaa ggc tgc gca ctg gag cct atc cag agt	7536
Asn Ser Tyr Gly Val Arg Lys Gly Cys Ala Leu Glu Pro Ile Gln Ser	2496
gtg agt ttc ctg aga ggc ggc tat gtg gag atg cca ccc aag <u>tct ctc</u>	7584
Val Ser Phe Leu Arg Gly Gly Tyr Val Glu Met Pro Pro Lys Ser Leu	2512
<u>tca cct gag tca tcc</u> CTG CTG GCC ACA TTC GCC Acc aag aac agc agc	7632
Ser Pro Glu Ser Ser Leu Leu Ala Thr Phe Ala Thr Lys Asn Ser Ser	2528
gga atc ctc ctg gtt gcc ctg ggc aag gat gcg gag gag gct ggt ggg	7680
Gly Ile Leu Leu Val Ala Leu Gly Lys Asp Ala Glu Glu Ala Gly Gly	2544
gct cag gca cat gtg ccc ttc ttt tcc atc atg ctg ctt gag gga cga	7728
Ala Gln Ala His Val Pro Phe Phe Ser Ile Met Leu Leu Glu Gly Arg	2560
att gaa gtg cat gtc aac tct ggg gac ggg acc agt ctg agg aag gcc	7776
Ile Glu Val His Val Asn Ser Gly Asp Gly Thr Ser Leu Arg Lys Ala	2576
ctc ctg cat gcc ccc acc ggc tcc tac agt gat gga cag gaa cac tcc	7824
Leu Leu His Ala Pro Thr Gly Ser Tyr Ser Asp Gly Gln Glu His Ser	2592
atc tcc ctg gtt agg aat cgg aga gtt atc acc ata caa gtg gat gag	7872
Ile Ser Leu Val Arg Asn Arg Arg Val Ile Thr Ile Gln Val Asp Glu	2608
aac agt ccc gta gaa atg aag ttg ggt cca tta aca gaa gga aag acg	7920
Asn Ser Pro Val Glu Met Lys Leu Gly Pro Leu Thr Glu Gly Lys Thr	2624
atc gac ata tcc aac ctg tac ata ggg gga ctt ccg gag gac aag gcg	7968
Ile Asp Ile Ser Asn Leu Tyr Ile Gly Gly Leu Pro Glu Asp Lys Ala	2640
acc ccg atg ctc aag atg cgg act tcg ttc cat ggg tgt att aaa aac	8016
Thr Pro Met Leu Lys Met Arg Thr Ser Phe His Gly Cys Ile Lys Asn	2656
gtg gtc ctt gac gct caa ctt ttg gac ttc acc cat gcg act ggc tct	8064
Val Val Leu Asp Ala Gln Leu Leu Asp Phe Thr His Ala Thr Gly Ser	2672
gag caa gta gag ctg gac aca tgc ttg ctg gca gaa gag ccc atg cag	8112
Glu Gln Val Glu Leu Asp Thr Cys Leu Leu Ala Glu Glu Pro Met Gln	2688

Fig. 1H

agt ctg cac aga gaa cac ggg gaa ctc cct ccg gag ccc cca act cta	8160
Ser Leu His Arg Glu His Gly Glu Leu Pro Pro Glu Pro Pro Thr Leu	2704
cca cag cct gaa ctg tgc gca gta gac acg gct ccg ggg tat gtg gca	8208
Pro Gln Pro Glu Leu Cys Ala Val Asp Thr Ala Pro Gly Tyr Val Ala	2720
ggg gct cac cag ttt ggc ctc tcg cag aac agc cac ttg gtg ctc cct	8256
Gly Ala His Gln Phe Gly Leu Ser Gln Asn Ser His Leu Val Leu Pro	2736
ctg aat cag tct gat gtc ccg aag agg <u>CTC CAG GTG CAG CTG AGC ATT</u>	8304
Leu Asn Gln Ser Asp Val Arg Lys Arg Leu Gln Val Gln Leu Ser Ile	2752
cgg aca ttt gcc tcc agt ggc ctc att tac tat gtg gct cat cag aac	8352
Arg Thr Phe Ala Ser Ser Gly Leu Ile Tyr Tyr Val Ala His Gln Asn	2768
caa atg gac tac gcc acg ctc cag ctc caa gag ggc cgc ctg cac ttc	8400
Gln Met Asp Tyr Ala Thr Leu Gln Leu Gln Glu Gly Arg Leu His Phe	2784
atg ttt gat ctc ggc aag ggc cgg acc aag gtc tcc cac cct gcc ctg	8448
Met Phe Asp Leu Gly Lys Gly Arg Thr Lys Val Ser His Pro Ala Leu	2800
ctc agt gat ggc aag tgg cac aca gtc aag aca gaa tac att aaa agg	8496
Leu Ser Asp Gly Lys Trp His Thr Val Lys Thr Glu Tyr Ile Lys Arg	2816
aag gcg ttc atg act gtt gac ggc caa gag tcc ccc agt gtg act gtg	8544
Lys Ala Phe Met Thr Val Asp Gly Gln Glu Ser Pro Ser Val Thr Val	2832
gtg ggc aat gca acc acg ctg gat gtg gaa agg aaa ctg tac ctc gga	8592
Val Gly Asn Ala Thr Thr Leu Asp Val Glu Arg Lys Leu Tyr Leu Gly	2848
ggc ctt ccc agc cac tac agg gcc agg aac atc ggg act atc acc cac	8640
Gly Leu Pro Ser His Tyr Arg Ala Arg Asn Ile Gly Thr Ile Thr His	2864
agc atc cct gcc tgc att ggg gaa <u>atc atg gtt aat ggc caa cag</u> <u>CTG</u>	8688
Ser Ile Pro Ala Cys Ile Gly Glu Ile Met Val Asn Gly Gln Gln Leu	2880
<u>GAT AAA GAC AGG CCC TTG</u> tct gcc tct gct gtg gac agg tgc tat gtc	8736
Asp Lys Asp Arg Pro Leu Ser Ala Ser Ala Val Asp Arg Cys Tyr Val	2896
gtg gct cag gaa gga act ttc ttt gaa gga agc gga tat gca gct ctt	8784
Val Ala Gln Glu Gly Thr Phe Phe Glu Gly Ser Gly Tyr Ala Ala Leu	2912
gtc aag gaa ggt tac aaa gtt cga ttg gat tta aat atc aca ctg gag	8832
Val Lys Glu Gly Tyr Lys Val Arg Leu Asp Leu Asn Ile Thr Leu Glu	2928
ttc cgt act acc tct aag aat ggc gtc ctc ctg gga atc agc agt gcc	8880
Phe Arg Thr Thr Ser Lys Asn Gly Val Leu Leu Gly Ile Ser Ser Ala	2944
aaa gtg gat gcc att ggc cta gag att gta gat ggc aag gtc tta ttt	8928
Lys Val Asp Ala Ile Gly Leu Glu Ile Val Asp Gly Lys Val Leu Phe	2960
cac gtc aac aac ggt gcc gga agg ata aca gcc acc tac cag ccc aga	8976
His Val Asn Asn Gly Ala Gly Arg Ile Thr Ala Thr Tyr Gln Pro Arg	2976
gcc gcc aga gct ctc tgt gat ggc aag tgg cac aca ctc caa gcc cac	9024
Ala Ala Arg Ala Leu Cys Asp Gly Lys Trp His Thr Leu Gln Ala His	2992
aaa agc aag cac cgc atc gtc ctg act gtg gac ggg aat tcc gtt agg	9072
Lys Ser Lys His Arg Ile Val Leu Thr Val Asp Gly Asn Ser Val Arg	3008
gct gaa agc ccc cac acc cat tcc acc tcg gca gac acc aac gat ccc	9120
Ala Glu Ser Pro His Thr His Ser Thr Ser Ala Asp Thr Asn Asp Pro	3024

Fig. 11

att tat gtg ggt ggc tat cct gcc cac atc aaa cag aac tgc ctg agc 9168
 Ile Tyr Val Gly Gly Tyr Pro Ala His Ile Lys Gln Asn Cys Leu Ser 3040
 agc cgg gcc tca ttc cgg ggc tgt gtg agg aac ctc agg ctg agc agg 9216
 Ser Arg Ala Ser Phe Arg Gly Cys Val Arg Asn Leu Arg Leu Ser Arg 3056
 ggc tca caa gtg cag tcc ttg gac ctg agc cga gcc ttt gac cta caa 9264
 Gly Ser Gln Val Gln Ser Leu Asp Leu Ser Arg Ala Phe Asp Leu Gln 3072
 gga gtc ttc cct cat tcc tgc ccc ggg cct gag ccc taa act gtc gcc 9312
 Gly Val Phe Pro His Ser Cys Pro Gly Pro Glu Pro (SEQ ID NO:2)
 agc ctc tgc cct tgg aat cat cgc caa cgc atg gaa gag agc agt ttg 9360
 tga act caa gca gct cag ctc cca ttc cca tcc cat tgc cat ctc agg 9408
 tta tgt ttc cag agg aaa atg ctg tat tta tgt tga act aaa gcc aca 9456
 cgg aca aca gat acc tct att aaa tgg ttt aaa acg tca 9495
 gtg gaa tt 9503 (SEQ ID NO:1)

Fig. 1J

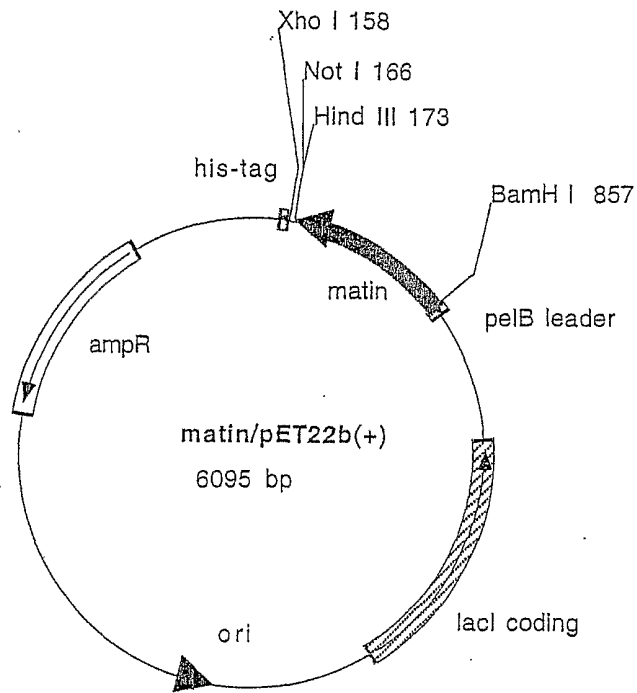


FIG. 2

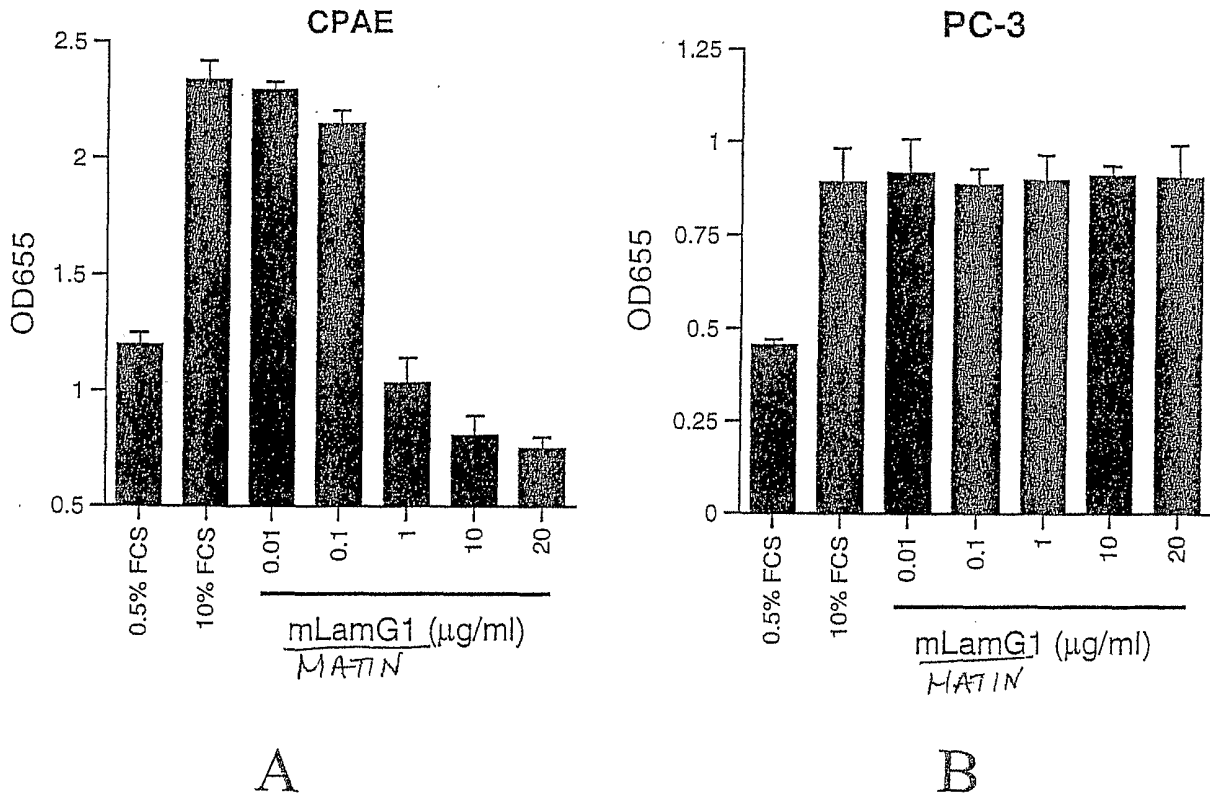


FIG. 3

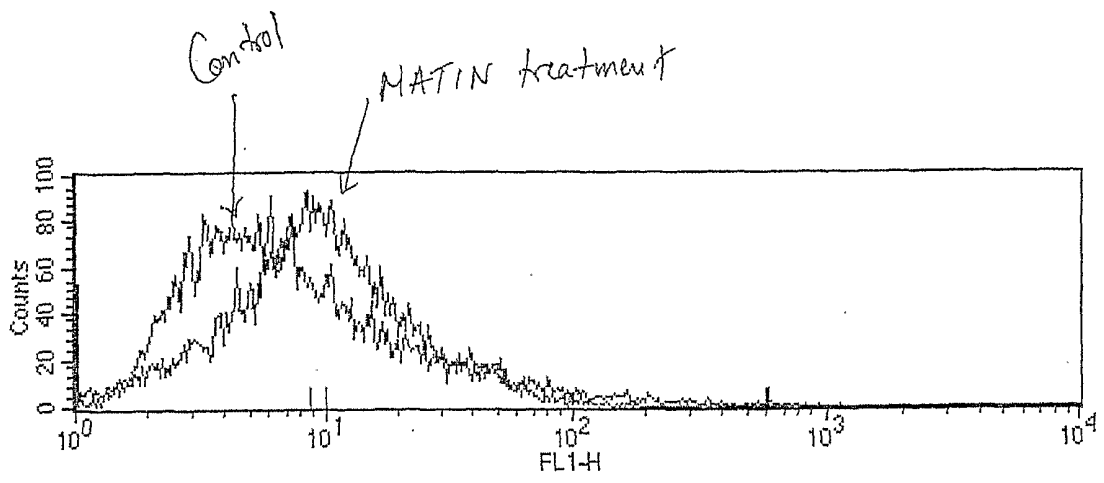


FIG. 4

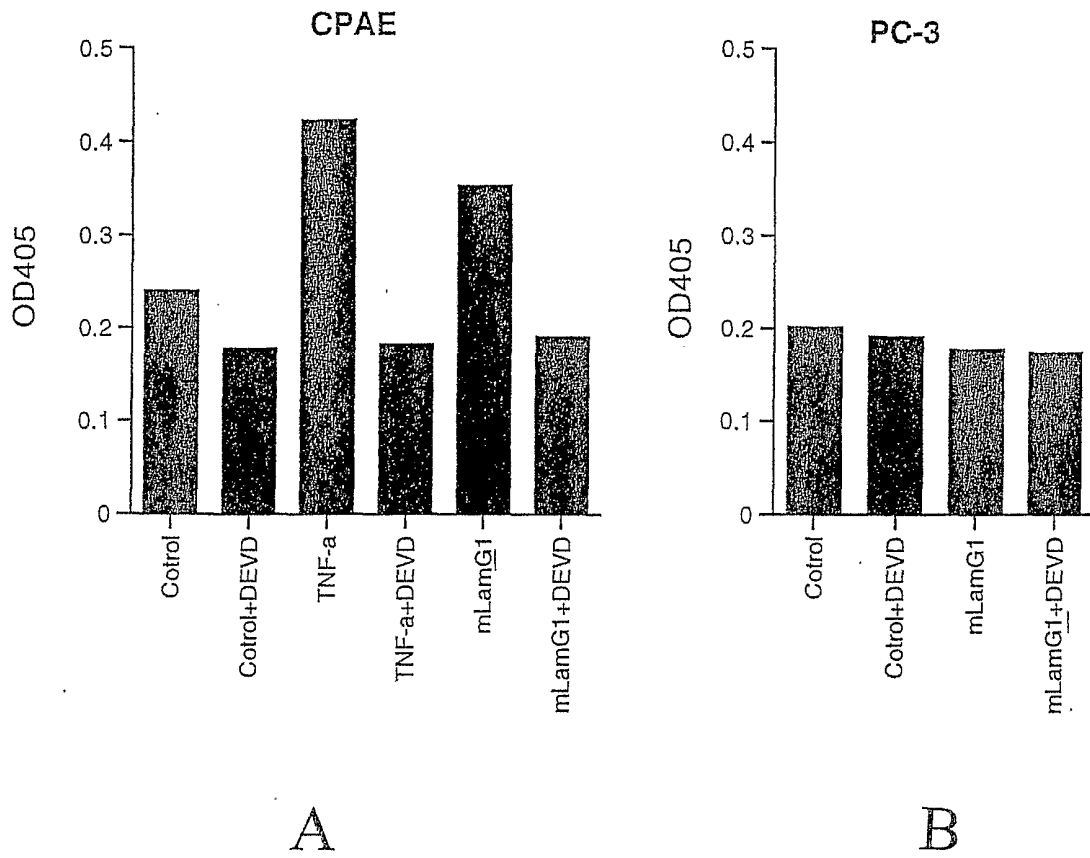
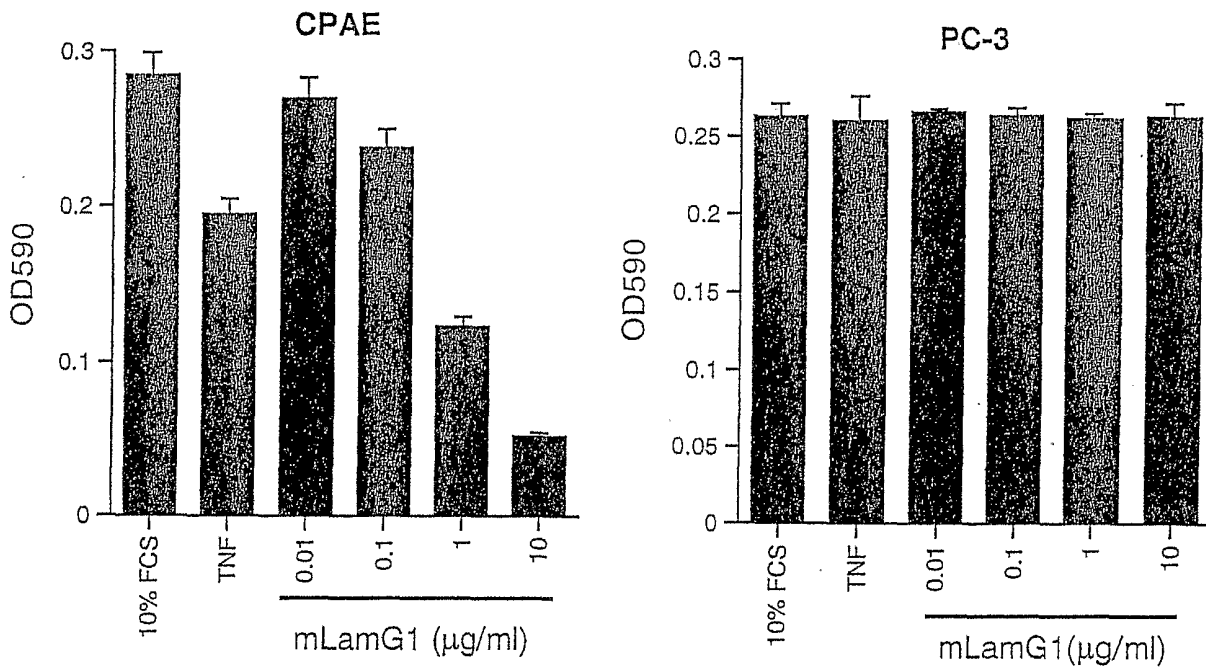


FIG. 5



A

B

FIG. 6

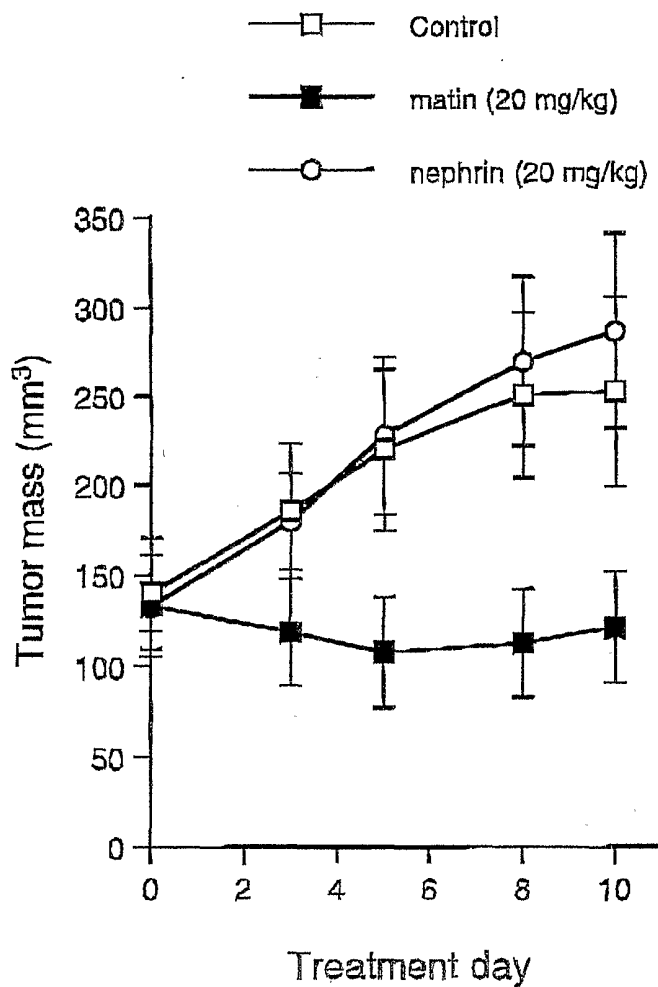


Fig. 7