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 (54) Title: ANTIBODIES, POLYPEPTIDES AND USES THEREOF

(57) Abrégé/Abstract:

A method of inhibiting angiogenesis in an individual in need thereof comprising administering an antibody that selectively binds to the extracellular region of human magic roundabout (MR) to the individual. An antibody that has the amino acid sequences i) to iii), the amino acid sequences iv) to vi), or the amino acid sequences i) to vi): i) S A S S S V S Y M Y ii) L T S N L A S iii) Q Q W S S N P L T iv) D Y N L N v) V I N P N Y G T T S Y N Q K F K G vi) G R D Y F G Y. A method of inhibiting angiogenesis in an individual in need thereof comprising administering the extracellular domain (residues 1-467) of MR, or a fragment thereof that inhibits angiogenesis, to the individual. A method of inhibiting endothelial cell migration and/or proliferation comprising administering the extracellular domain of MR, or a fragment thereof that inhibits endothelial cell migration and/or proliferation.

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(54) Title: ANTIBODIES BINDING TO HUMAN MAGIC ROUNDABOUT (MR), POLYPEPTIDES AND USES THEREOF FOR INHIBITION ANGIOGENESIS

(57) Abstract: A method of inhibiting angiogenesis in an individual in need thereof comprising administering an antibody that selectively binds to the extracellular region of human magic roundabout (MR) to the individual. An antibody that has the amino acid sequences *i*) to *iii*), the amino acid sequences *iv*) to *vi*), or the amino acid sequences *i*) to *vi*): *i*) S A S S S V S Y M Y *ii*) L T S N L A S *iii*) Q Q W S S N P L T *iv*) D Y N L N *v*) V I N P N Y G T T S Y N Q K F K G *vi*) G R D Y F G Y. A method of inhibiting angiogenesis in an individual in need thereof comprising administering the extracellular domain (residues 1-467) of MR, or a fragment thereof that inhibits angiogenesis, to the individual. A method of inhibiting endothelial cell migration and/or proliferation comprising administering the extracellular domain of MR, or a fragment thereof that inhibits endothelial cell migration and/or proliferation.



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ANTIBODIES, POLYPEPTIDES AND USES THEREOF

The present invention relates to antibodies and polypeptides, and in particular to ECSM4 antibodies and polypeptides that inhibit angiogenesis and their use
5 therefor.

Endothelial cells form a single cell layer that lines all blood vessels and regulates exchanges between the blood stream and the surrounding tissues. New blood vessels develop from the walls of existing small vessels by the
10 outgrowth of these endothelial cells which have the capacity to form hollow capillary tubes even when isolated in culture. *In vivo*, damaged tissues and some tumours attract a blood supply by secreting factors that stimulate nearby endothelial cells to construct new capillary sprouts. Tumours that fail to attract a blood supply are severely limited in their growth.

15

The process whereby new vessels originate as capillaries, which sprout from existing small vessels, is called angiogenesis. It can therefore be seen that angiogenesis plays a major role in normal tissue development and repair and in the progression of some pathological conditions.

20

Once the vascular system is fully developed, endothelial cells of blood vessels normally remain quiescent with no new vessel formation, with the exception of the formation of new blood vessels in natural wound healing. However, a deregulation of blood vessel growth and an abnormal increase in vessel
25 density can occur in diseases or conditions such as tumourigenesis, diabetic retinopathy, psoriasis and inflammation. Therefore the ability to inhibit inappropriate or undesirable angiogenesis may be useful in the treatment of these diseases or conditions.

Human magic roundabout (MR; also known as endothelial cell-specific molecule 4, ECSM4) has previously been shown to have a highly endothelial-cell selective expression profile (Huminiecki & Bicknell (2000), *Genome Research*, **10**, 1796-1806; and WO 02/36771). MR expression *in vivo* was
5 shown to be restricted to sites of active angiogenesis, notably tumour vessels (Huminiecki *et al.* (2002) *Genomics*, **79(4)**, 547-552).

Based on this information it was suggested in WO 02/36771 that compounds comprising a moiety that binds to MR, such as an antibody, and a further
10 functional moiety, may be useful for a variety of medical purposes including imaging the vascular epithelium; diagnosing or prognosing a condition involving the vascular endothelium; assessing the efficacy of anti-angiogenic therapies; detecting endothelial damage; detecting a tumour or tumour neovasculature or cardiac disease or endometriosis or atherosclerosis; treating
15 a proliferative disease involving the vascular endothelium such as cancer, psoriasis, diabetic retinopathy, atherosclerosis or menorrhagia; introducing genetic material into vascular endothelial cells; and modulating angiogenesis.

For example, WO 02 /36771 teaches a compound comprising a moiety that
20 binds to MR, such as an antibody, and a further moiety such as an inhibitor of angiogenesis (page 27). WO 02/36771 also teaches a compound comprising a moiety that binds to MR, such as an antibody, and a further moiety such as a cytotoxic moiety that destroys or slows or reverses the growth of the neovasculature (page 35).

25

However, in each case, the moiety that binds to MR merely directs the functional moiety to a desired endothelial location for use. WO 02/36771 does not suggest that the moiety that binds to MR is itself functional, let alone that it inhibits MR or can be used to inhibit angiogenesis.

30

We have now shown that an antibody that selectively binds to the extracellular region of MR results in inhibition of angiogenesis.

On the paragraph spanning pages 71-72, WO 02/36771 states that both
5 antibodies which stimulate or activate MR and antibodies which prevent stimulation and activation of MR could be used to modulate angiogenesis. However, it does not suggest that an antibody that selectively binds to the extracellular region of MR can be used to inhibit angiogenesis. Moreover, to the best of the inventors' knowledge, neither WO 02/36771 nor any other
10 document shows any evidence that an antibody that selectively binds to the extracellular region of MR does, in fact, inhibit angiogenesis.

There is thus provided in accordance with a first aspect of the invention a method of inhibiting angiogenesis in an individual in need thereof comprising
15 administering an antibody that selectively binds to the extracellular region of human magic roundabout (MR) to the individual.

By "inhibiting angiogenesis" we include the meaning of reducing the rate or level of angiogenesis. The reduction can be a low level reduction of about
20 10%, or about 20%, or about 30%, or about 40% of the rate or level of angiogenesis. Preferably, the reduction is a medium level reduction of about 50%, or about 60%, or about 70%, or about 80% reduction of the rate or level of angiogenesis. More preferably, the reduction is a high level reduction of about 90%, or about 95%, or about 99%, or about 99.9%, or about 99.99% of
25 the rate or level of angiogenesis. Most preferably, inhibition can also include the elimination of angiogenesis or its reduction to an undetectable level.

Methods and assays for determining the rate or level of angiogenesis, and hence for determining whether and to what extent an antibody inhibits
30 angiogenesis, are known in the art.

For example, US Patent No. 6,225,118 B1 to Grant et al, describes a multicellular *in vitro* assay for modelling the combined stages of angiogenesis namely the proliferation, migration and differentiation stages of cell development.

5

The AngioKit™, Catalogue No. ZHA-1000, by TCS CellWorks Ltd, Buckingham MK18 2LR, UK, is a suitable model of human angiogenesis for analysing the angiogenic or anti-angiogenic properties of test compounds.

10

The rate or level of angiogenesis can also be determined using the aortic ring assay described in Example 2.

15

Preferably, the antibody also inhibits angiogenesis *in vivo*, especially in mammals, and most preferably in humans

20

By "MR" we include the gene product of the human magic roundabout gene (also known as ECSM4) and naturally occurring variants thereof. The cDNA and amino acid sequence of MR are found in Genbank Accession Nos. AF361473 and AAL31867, and are shown in Figure 1 (SEQ ID NOs: 1 and 2, respectively).

25

MR is a transmembrane protein and has been predicted to have an extracellular region at residues 1-467 (SEQ ID NO: 3), a transmembrane region at residues 468-490, and an intracellular region at residues 491-1007 (Huminiacki *et al.*, 2002). The extracellular region of MR has an immunoglobulin (Ig) region at residues 46-209 (SEQ ID NO: 4), which can be further subdefined into an IgA domain at residues 46-116 (SEQ ID NO: 5), and an IgB domain at residues 151-209 (SEQ ID NO: 6), and two fibronectin

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type III domains at residues 252-335 (SEQ ID NO: 7) and 347-432 (SEQ ID

NO: 8). The MR amino acid residue numbering is that given in AF361473, AAL31867 and in Figure 1B.

By an antibody that “selectively binds” a specified domain or region of MR, such as an Ig domain, we include the meaning that the antibody binds the specific domain with a greater affinity than for any other region of MR. Preferably, the antibody binds the specified domain of MR with at least 2, or at least 5, or at least 10 or at least 50 times greater affinity than any other region of MR. More preferably, the antibody binds the specific domain of MR with at least 100, or at least 1,000, or at least 10,000 times greater affinity than any other region of MR. Such binding may be determined by methods well known in the art. Preferably, the antibody selectively binds a particular epitope within MR and does not bind other epitopes.

Preferably, when the antibody is administered to an individual, the antibody binds MR at the specified domain with a greater affinity than for any other molecule in the individual. Preferably, the agent binds MR at the specific domain with at least 2, or at least 5, or at least 10 or at least 50 times greater affinity than for any other molecule in the individual. More preferably, the agent binds MR at the specific domain with at least 100, or at least 1,000, or at least 10,000 times greater affinity than any other molecule in the individual.

Inhibition of angiogenesis may be useful in combating any disease or condition involving unwanted, undesirable or inappropriate angiogenesis. Such conditions include tumours/cancer, psoriasis, atherosclerosis, menorrhagia, endometriosis, arthritis (both inflammatory and rheumatoid), macular degeneration, Paget’s disease, retinopathy and its vascular complications (including proliferative and of prematurity, and diabetic retinopathy), benign vascular proliferations, fibroses, obesity and inflammation.

By cancer is included Kaposi's sarcoma, leukaemia, lymphoma, myeloma, solid carcinomas (both primary and secondary (metastasis), vascular tumours including haemangioma (both capillary and juvenile (infantile)),
5 haemangiomatosis and haemangioblastoma.

The tumours that may be treated by the methods of the invention include any tumours which are associated with new blood vessel production.

10 The term "tumour" is to be understood as referring to all forms of neoplastic cell growth, including tumours of the lung, liver, blood cells, skin, pancreas, stomach, colon, prostate, uterus, breast, lymph glands and bladder. Solid tumours are especially suitable. However, blood cancers, including leukaemias and lymphomas are now also believed to involve new blood vessel
15 formation and may be treated by the methods of the invention.

The invention thus includes a method of combating a disease or condition selected from tumours/cancer, psoriasis, atherosclerosis, menorrhagia, endometriosis, arthritis (both inflammatory and rheumatoid), macular
20 degeneration, Paget's disease, retinopathy and its vascular complications (including proliferative and of prematurity, and diabetic retinopathy), benign vascular proliferations, fibroses, obesity and inflammation in an individual, the method comprising administering an antibody that selectively binds to the extracellular region of MR to the individual.

25

By "combating" we include the meaning that the method can be used to alleviate symptoms of the disorder (ie the method is used palliatively), or to treat the disorder, or to prevent the disorder (ie the method is used prophylactically).

30

Thus, the invention comprises a method of treating a patient who has a disease in which angiogenesis contributes to pathology, the method comprising the step of administering to the patient an antibody that selectively binds to the extracellular region of MR.

5

Typically, the disease is associated with undesirable neovasculature formation and the treatment reduces this to a useful extent.

The therapy (treatment) may be on humans or animals. Preferably, the methods of the inventions are used to treat humans.

10

By "antibody" we include not only whole immunoglobulin molecules but also fragments thereof such as Fab, F(ab')₂, Fv and other fragments thereof that retain the antigen-binding site. Similarly the term "antibody" includes genetically engineered derivatives of antibodies such as single chain Fv molecules (scFv) and domain antibodies (dAbs). The term also includes antibody-like molecules which may be produced using phage-display techniques or other random selection techniques for molecules which bind to MR or to specified regions of MR. Thus, the term antibody includes all molecules which contain a structure, preferably a peptide structure, which is part of the recognition site (ie the part of the antibody that binds or combines with the epitope or antigen) of a natural antibody.

15

20

The variable heavy (V_H) and variable light (V_L) domains of the antibody are involved in antigen recognition, a fact first recognised by early protease digestion experiments. Further confirmation was found by "humanisation" of rodent antibodies. Variable domains of rodent origin may be fused to constant domains of human origin such that the resultant antibody retains the antigenic specificity of the rodent parented antibody (Morrison *et al* (1984) *Proc. Natl. Acad. Sci. USA* **81**, 6851-6855).

25

30

That antigenic specificity is conferred by variable domains and is independent of the constant domains is known from experiments involving the bacterial expression of antibody fragments, all containing one or more variable domains. These molecules include Fab-like molecules (Better *et al* (1988) *Science* 240, 1041); Fv molecules (Skerra *et al* (1988) *Science* 240, 1038); single-chain Fv (ScFv) molecules where the V_H and V_L partner domains are linked via a flexible oligopeptide (Bird *et al* (1988) *Science* 242, 423; Huston *et al* (1988) *Proc. Natl. Acad. Sci. USA* 85, 5879) and single domain antibodies (dAbs) comprising isolated V domains (Ward *et al* (1989) *Nature* 341, 544). A general review of the techniques involved in the synthesis of antibody fragments which retain their specific binding sites is to be found in Winter & Milstein (1991) *Nature* 349, 293-299.

By "ScFv molecules" we mean molecules wherein the V_H and V_L partner domains are linked via a flexible oligopeptide. Engineered antibodies, such as ScFv antibodies, can be made using the techniques and approaches described in J. Huston *et al.*, (1988) "Protein engineering of antibody binding sites: recovery of specific activity in an anti-digoxin single chain Fv analogue produced in *E. coli*", *Proc. Natl. Acad. Sci. USA*, 85, pp.5879-5883, and in A. Pluckthun, (June 1991) "Antibody engineering; Advances from use of *E. coli* expression systems", *Bio/technology* vol 9.

The advantages of using antibody fragments, rather than whole antibodies, are several-fold. The smaller size of the fragments may lead to improved pharmacological properties, such as better penetration to the target site. Effector functions of whole antibodies, such as complement binding, are removed. Fab, Fv, ScFv and dAb antibody fragments can all be expressed in and secreted from *E. coli*, thus allowing the facile production of large amounts of the fragments.

Whole antibodies, and F(ab')₂ fragments are "bivalent". By "bivalent" we mean that the antibodies and F(ab')₂ fragments have two antigen combining sites. In contrast, Fab, Fv, ScFv and dAb fragments are monovalent, having only one antigen combining site.

5

Although the antibody may be a polyclonal antibody, it is preferred if it is a monoclonal antibody. In some circumstance, particularly if the antibody is going to be administered repeatedly to a human patient, it is preferred if the monoclonal antibody is a human monoclonal antibody or a humanised monoclonal antibody.

10

Suitable monoclonal antibodies which are reactive as described herein may be prepared by known techniques, for example those disclosed in "*Monoclonal Antibodies; A manual of techniques*", H Zola (CRC Press, 1988) and in
15 "*Monoclonal Hybridoma Antibodies: Techniques and Application*", SGR Hurrell (CRC Press, 1982). Polyclonal antibodies may be produced which are polyspecific or monospecific. It is preferred that they are monospecific.

15

Chimaeric antibodies are discussed by Neuberger *et al* (1998, 8th
20 *International Biotechnology Symposium Part 2*, 792-799).

20

It is preferred if the antibody is a humanised antibody. Suitably prepared non-human antibodies can be "humanised" in known ways, for example by inserting the CDR regions of mouse antibodies into the framework of human
25 antibodies. Humanised antibodies can be made using the techniques and approaches described in M. Verhoeyen, C. Milstein and G. Winter (1988) "Reshaping human antibodies: Grafting an antilysozyme activity", *Science*, 239, 1534-1536, and in C. Kettleborough *et al.*, (1991) "Humanisation of a mouse monoclonal antibody by CDR grafting; The importance of framework

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residues in loop conformation", *Protein Engineering*, 14(7), 773-783.

The antibodies may be human antibodies in the sense that they have the amino
5 acid sequence of human anti-MR antibodies but they may be prepared using
methods known in the art that do not require immunisation of humans. For
example, transgenic mice are available which contain, in essence, human
immunoglobulin genes (see Vaughan *et al* (1998) *Nature Biotechnol.* 16, 535-
539.

10

A second aspect of the invention provides use of an antibody that selectively
binds to the extracellular region of MR in the preparation of a medicament for
inhibiting angiogenesis.

15 The medicament may be useful in combating any disease or condition
involving unwanted or inappropriate angiogenesis. Such conditions include
those described above with reference to the first aspect of the invention.

The invention thus includes the use of an antibody that selectively binds to the
20 extracellular region of MR in the preparation of a medicament for combating a
disease or condition selected from tumours/cancer, especially solid tumours,
psoriasis, atherosclerosis, menorrhagia, endometriosis, arthritis (both
inflammatory and rheumatoid), macular degeneration, Paget's disease,
retinopathy and its vascular complications (including proliferative and of
25 prematurity, and diabetic retinopathy), benign vascular proliferations, fibroses,
obesity and inflammation.

A third aspect of the invention provides an *in vitro* method of inhibiting
angiogenesis comprising administering an antibody that selectively binds to
30 the extracellular region of MR to tissue or cells *in vitro*. The cells may be

established cell lines, or cells that have been removed from an individual. The tissue or cells are preferably mammalian tissue or cells, and most preferably are human tissue or cells.

- 5 In an embodiment of each of the first three aspects of the invention, the antibody selectively binds to the Ig region of MR. The Ig region of MR is located at residues 46-209 of MR (Figure 3, SEQ ID NO: 4).

In one preferred embodiment, the antibody selectively binds to the IgA domain of MR, which is located at residues 46-116 of MR (Figure 4A, SEQ ID NO: 5).

In an alternative preferred embodiment, the antibody selectively binds to the IgB domain of MR, which is located at residues 151-209 of MR (Figure 4B, SEQ ID NO: 6).

In an embodiment of each of the first three aspects of the invention, the antibody has at least one light chain variable region incorporating the following CDRs:

- 20 CDR1: S A S S S V S Y M Y (SEQ ID NO: 9)
 CDR2: L T S N L A S (SEQ ID NO: 10)
 CDR3: Q Q W S S N P L T (SEQ ID NO: 11)

In a more specific embodiment, the antibody may have at least one light chain variable region comprising the amino acid sequence:

25 Q I V L T Q S P A L M S A S P G E K V T M T C S A S S S V S Y M Y W
 Y Q Q K P R S S P K P W I Y L T S N L A S G V P A R F S G S G S G T S
 Y S L T I S S M E A E D A A T Y Y C Q Q W S S N P L T F G A G T K L E
 L K (SEQ ID NO: 12).

Preferably, the light chain is a kappa light chain.

In an embodiment of each of the first three aspects of the invention, the antibody has at least one heavy chain variable region incorporating the following CDRs:

CDR1: D Y N L N (SEQ ID NO: 13)

CDR2: V I N P N Y G T T S Y N Q K F K G (SEQ ID NO: 14)

CDR3: G R D Y F G Y (SEQ ID NO: 15)

In a more specific embodiment, the antibody may have at least one heavy chain variable region comprising the amino acid sequence:

Q V K/Q L Q E S G P E L V K P G A S V K I S C K A S G Y S L T D Y N L
N W V K Q N K G K S L E W I G V I N P N Y G T T S Y N Q K F K G K A
T L T V D Q S S S T T Y M Q L N S L T S E D S A V Y Y C A R G R D Y
F G Y W G Q G T T V T V S S (SEQ ID NOs: 16 and 17),

where K/Q means that either K or Q is present at that position (K is present in SEQ ID NO: 16, while Q is present in SEQ ID NO: 17).

In a yet more specific embodiment, the antibody has at least one light chain variable region as defined above and at least one heavy chain variable region as defined above.

A fourth aspect of the invention provides a method of inhibiting angiogenesis in an individual in need thereof comprising administering a polynucleotide encoding an antibody as defined above to the individual.

A fifth aspect of the invention provides the use of a polynucleotide encoding an antibody as defined above in the preparation of a medicament for inhibiting angiogenesis.

A sixth aspect of the invention provides an *in vitro* method of inhibiting angiogenesis comprising administering a polynucleotide encoding an antibody as defined above to tissue or cells *in vitro*.

5 A seventh aspect of the invention provides an antibody that contains the amino acid sequences *i*) to *iii*), the amino acid sequences *iv*) to *vi*), or preferably the amino acid sequences *i*) to *vi*):

i) S A S S S V S Y M Y (SEQ ID NO: 9)

ii) L T S N L A S (SEQ ID NO: 10)

10 *iii*) Q Q W S S N P L T (SEQ ID NO: 11)

iv) D Y N L N (SEQ ID NO: 13)

v) V I N P N Y G T T S Y N Q K F K G (SEQ ID NO: 14)

vi) G R D Y F G Y (SEQ ID NO: 15).

15 While the CDRs that determine specificity of binding to an antigen may be determined empirically, it has been demonstrated that in a significant number of cases the IgH CDR3 is the most important CDR region. The invention thus includes an antibody with an Ig heavy chain CDR3 region having the amino acid sequence G R D Y F G Y (SEQ ID NO: 15).

20

Preferably, the antibody selectively binds to the extracellular region of MR (residues 1-467 of MR, Figure 2B, SEQ ID NO: 3), and the selective binding to MR is conferred by the presence of these amino acid sequences. Preferably, the antibody inhibits a function of MR. Such functions include the
25 inhibition of ligand binding, the interaction with other cell surface molecules and the inhibition of activation of the receptor.

Preferably, the antibody has at least one light chain variable region incorporating the following CDRs:

30 CDR1: S A S S S V S Y M Y (SEQ ID NO: 9)

CDR2: L T S N L A S (SEQ ID NO: 10)

CDR3: Q Q W S S N P L T (SEQ ID NO: 11)

More preferably, the antibody has at least one light chain variable region
5 comprising the amino acid sequence:

Q I V L T Q S P A L M S A S P G E K V T M T C S A S S S V S Y M Y W
Y Q Q K P R S S P K P W I Y L T S N L A S G V P A R F S G S G S G T S
Y S L T I S S M E A E D A A T Y Y C Q Q W S S N P L T F G A G T K L E
L K (SEQ ID NO: 12).

10

Preferably, the light chain is a kappa light chain.

Preferably, the antibody has at least one heavy chain variable region
incorporating the following CDRs:

15 CDR1: D Y N L N (SEQ ID NO: 13)

CDR2: V I N P N Y G T T S Y N Q K F K G (SEQ ID NO: 14)

CDR3: G R D Y F G Y (SEQ ID NO: 15)

More preferably, the antibody has at least one heavy chain variable region
20 comprising the amino acid sequence:

Q V K / Q L Q E S G P E L V K P G A S V K I S C K A S G Y S L T D Y N L
N W V K Q N K G K S L E W I G V I N P N Y G T T S Y N Q K F K G K A
T L T V D Q S S S T T Y M Q L N S L T S E D S A V Y Y C A R G R D Y
F G Y W G Q G T T V T V S S (SEQ ID NOs: 16 and 17).

25

Yet more preferably, the antibody has at least one light chain variable region
as defined above as defined above in the seventh aspect of the invention and at
least one heavy chain variable region as defined above in the seventh aspect of
the invention.

30

Most preferably, the antibody has at least one light chain variable region comprising the amino acid sequence:

Q I V L T Q S P A L M S A S P G E K V T M T C S A S S S V S Y M Y W
 Y Q Q K P R S S P K P W I Y L T S N L A S G V P A R F S G S G S G T S
 5 Y S L T I S S M E A E D A A T Y Y C Q Q W S S N P L T F G A G T K L E
 L K (SEQ ID NO: 12)

and at least one heavy chain variable region comprising the amino acid sequence:

Q V K / Q L Q E S G P E L V K P G A S V K I S C K A S G Y S L T D Y N L
 10 N W V K Q N K G K S L E W I G V I N P N Y G T T S Y N Q K F K G K A
 T L T V D Q S S S T T Y M Q L N S L T S E D S A V Y Y C A R G R D Y
 F G Y W G Q G T T V T V S S (SEQ ID NOs: 16 and 17).

It is preferred if the antibody is a humanised antibody.

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It is further preferred if the antibody is a humanised antibody having the following CDRs:

light chain CDR1: S A S S S V S Y M Y (SEQ ID NO: 9)

light chain CDR2: L T S N L A S (SEQ ID NO: 10)

20 light chain CDR3: Q Q W S S N P L T (SEQ ID NO: 11)

heavy chain CDR1: D Y N L N (SEQ ID NO: 13)

heavy chain CDR2: V I N P N Y G T T S Y N Q K F K G (SEQ ID NO: 14)

heavy chain CDR3: G R D Y F G Y (SEQ ID NO: 15)

25 An eighth aspect of the invention provides an antibody that selectively binds to the MR epitope selectively bound by an antibody having at least one light chain variable region comprising the amino acid sequence:

Q I V L T Q S P A L M S A S P G E K V T M T C S A S S S V S Y M Y W
 Y Q Q K P R S S P K P W I Y L T S N L A S G V P A R F S G S G S G T S

Y S L T I S S M E A E D A A T Y Y C Q Q W S S N P L T F G A G T K L E
L K (SEQ ID NO: 12)

and at least one heavy chain variable region comprising the amino acid
sequence:

5 Q V K / Q L Q E S G P E L V K P G A S V K I S C K A S G Y S L T D Y N L
N W V K Q N K G K S L E W I G V I N P N Y G T T S Y N Q K F K G K A
T L T V D Q S S S T T Y M Q L N S L T S E D S A V Y Y C A R G R D Y
F G Y W G Q G T T V T V S S (SEQ ID NOs: 16 and 17).

10 By an antibody that selectively binds to an MR epitope selectively bound by
another defined antibody, we include an antibody that competes with the
defined antibody. Such antibodies can be determined, for example, using
competitive binding assays, preferably high throughput binding assays, as are
well known to a person of skill in the art. Suitable assays include a cross-
15 competition ELISA in which an extracellular fragment of MR is incubated
with the defined antibody and a test antibody, to determine whether or not the
test antibody competes with the defined antibody for binding to the MR
epitope.

20 A ninth aspect of the invention provides a polynucleotide encoding an
antibody as defined in the seventh or eighth aspects of the invention.

In an embodiment, the polynucleotide comprises at least one of the nucleotide
sequences:

- 25 *i)* AGT GCC AGC TCA AGT GTA AGT TAC ATG TAC (SEQ ID NO: 18)
ii) TCT CAC ATC CAA CCT GGC TTC T (SEQ ID NO: 19)
iii) CAG CAG TGG AGT AGT AAC CCA CTC ACG (SEQ ID NO: 20)

Preferably, the polynucleotide comprises two or all three of the nucleotide
30 sequences *i)*, *ii)* and *iii)*.

Preferably, the polynucleotide comprises the nucleotide sequence:

CAA ATT GTT CTC ACC CAG TCT CCA GCA CTC ATG TCT GCA TCT
 CCA GGG GAG AAG GTC ACC ATG ACC TGC AGT GCC AGC TCA
 5 AGT GTA AGT TAC ATG TAC TGG TAC CAG CAG AAG CCA AGA
 TCC TCC CCC AAA CCC TGG ATT TAT CTC ACA TCC AAC CTG GCT
 TCT GGA GTC CCT GCT CGC TTC AGT GGC AGT GGG TCT GGG
 ACC TCT TAC TCT CTC ACA ATC AGC AGC ATG GAG GCT GAA
 GAT GCT GCC ACT TAT TAC TGC CAG CAG TGG AGT AGT AAC
 10 CCA CTC ACG TTC GGT GCT GGG ACC AAG CTG GAG CTG AAA
 (SEQ ID NO: 21).

In an alternative or additional embodiment, the polynucleotide comprises at least one of the nucleotide sequences:

- 15 *iv)* GAC TAC AAC CTG AAC (SEQ ID NO: 22)
v) GTA ATT AAT CCA AAC TAT GGT ACT AGT TAC AAT CAG AAG
 TTC AAG GGC (SEQ ID NO: 23), and
vi) GGG AGG GAT TAC TTC GGC TAC (SEQ ID NO: 24)

- 20 Preferably, the polynucleotide comprises two or all three of the nucleotide sequences *iv)*, *v)* and *vi)*.

Preferably, the polynucleotide comprises the nucleotide sequence:

CAG GTC AAG(or A/CAA) CTG CAG GAG TCA GGA CCT GAG CTG
 25 GTG AAG CCT GGC GCT TCA GTG AAG ATA TCC TGC AAG GCT
 TCT GGT TAC TCA CTC ACT GAC TAC AAC CTG AAC TGG GTG
 AAG CAG AAC AAA GGA AAG AGC CTT GAG TGG ATT GGA GTA
 ATT AAT CCA AAC TAT GGT ACT AGT TAC AAT CAG AAG TTC
 AAG GGC AAG GCC ACA TTG ACT GTA GAC CAA TCT TCC AGC
 30 ACA ACC TAC ATG CAG CTC AAC AGC CTG ACA TCT GAG GAC

TCT GCA GTC TAT TAC TGT GCA AGA GGG AGG GAT TAC TTC
GGC TAC TGG GGC CAA GGG ACC ACG GTC ACC GTC TCC TCA.
(The polynucleotide having AAG in the third codon is SEQ ID NO: 25; the
polynucleotide having AAA in the third codon is SEQ ID NO: 26; and the
5 polynucleotide having CAA in the third codon is SEQ ID NO: 27).

Most preferably, the polynucleotide comprises at least one nucleotide
sequence:

CAA ATT GTT CTC ACC CAG TCT CCA GCA CTC ATG TCT GCA TCT
10 CCA GGG GAG AAG GTC ACC ATG ACC TGC AGT GCC AGC TCA
AGT GTA AGT TAC ATG TAC TGG TAC CAG CAG AAG CCA AGA
TCC TCC CCC AAA CCC TGG ATT TAT CTC ACA TCC AAC CTG GCT
TCT GGA GTC CCT GCT CGC TTC AGT GGC AGT GGG TCT GGG
ACC TCT TAC TCT CTC ACA ATC AGC AGC ATG GAG GCT GAA
15 GAT GCT GCC ACT TAT TAC TGC CAG CAG TGG AGT AGT AAC
CCA CTC ACG TTC GGT GCT GGG ACC AAG CTG GAG CTG AAA
(SEQ ID NO: 21),

and at least one nucleotide sequence:

CAG GTC AAG(or A/CAA) CTG CAG GAG TCA GGA CCT GAG CTG
20 GTG AAG CCT GGC GCT TCA GTG AAG ATA TCC TGC AAG GCT
TCT GGT TAC TCA CTC ACT GAC TAC AAC CTG AAC TGG GTG
AAG CAG AAC AAA GGA AAG AGC CTT GAG TGG ATT GGA GTA
ATT AAT CCA AAC TAT GGT ACT AGT TAC AAT CAG AAG TTC
AAG GGC AAG GCC ACA TTG ACT GTA GAC CAA TCT TCC AGC
25 ACA ACC TAC ATG CAG CTC AAC AGC CTG ACA TCT GAG GAC
TCT GCA GTC TAT TAC TGT GCA AGA GGG AGG GAT TAC TTC
GGC TAC TGG GGC CAA GGG ACC ACG GTC ACC GTC TCC TCA
(SEQ ID NOs: 25-27).

In an embodiment, the two coding regions may be on the same polynucleotide, for example on a polynucleotide for expression of a ScFv antibody.

A tenth aspect of the invention provides an antibody that selectively binds the
5 Ig region of MR (residues 46-209, SEQ ID NO: 4) but which does not selectively bind to the peptide LLQPPARGHAHDGQALSTD L (residues 91-109 of MR, SEQ ID NO: 28) or to the peptide LSQSPGAVPQALVAWRA (residues 165-181 of MR, SEQ ID NO: 29).

10 In an embodiment, the invention includes an antibody that selectively binds the IgA region of MR (residues 46-116, SEQ ID NO: 5) but does not selectively bind to the peptide LLQPPARGHAHDGQALSTD L (residues 91-109 of MR, SEQ ID NO: 28).

15 In an alternative embodiment, the invention includes an antibody that selectively binds the IgB region of MR (residues 151-209, SEQ ID NO: 6) but does not selectively bind to the peptide LSQSPGAVPQALVAWRA (residues 165-181 of MR, SEQ ID NO: 29).

20 An eleventh aspect of the invention provides a polynucleotide that encodes an antibody as defined in the tenth aspect of the invention.

A twelfth aspect of the invention provides a compound comprising an antibody as defined above in the seventh, eighth and tenth aspects of the
25 invention, and a cytotoxic moiety.

The cytotoxic moiety is preferably directly or indirectly toxic to cells in neovasculature or cells which are in close proximity to and associated with neovasculature.

By “directly cytotoxic” we include the meaning that the moiety is one which on its own is cytotoxic. By “indirectly cytotoxic” we include the meaning that the moiety is one which, although is not itself cytotoxic, can induce cytotoxicity, for example by its action on a further molecule or by further
5 action on it.

In one embodiment the cytotoxic moiety is a cytotoxic chemotherapeutic agent. Cytotoxic chemotherapeutic agents are well known in the art.

10 Cytotoxic chemotherapeutic agents, such as anticancer agents, include: alkylating agents including nitrogen mustards such as mechlorethamine (HN₂), cyclophosphamide, ifosfamide, melphalan (L-sarcolysin) and chlorambucil; ethylenimines and methylmelamines such as hexamethylmelamine, thiotepa; alkyl sulphonates such as busulfan; nitrosoureas such as carmustine (BCNU),
15 lomustine (CCNU), semustine (methyl-CCNU) and streptozocin (streptozotocin); and triazenes such as decarbazine (DTIC; dimethyltriazenoimidazole-carboxamide); Antimetabolites including folic acid analogues such as methotrexate (amethopterin); pyrimidine analogues such as fluorouracil (5-fluorouracil; 5-FU), floxuridine (fluorodeoxyuridine; FUdR) and
20 cytarabine (cytosine arabinoside); and purine analogues and related inhibitors such as mercaptopurine (6-mercaptopurine; 6-MP), thioguanine (6-thioguanine; TG) and pentostatin (2'-deoxycoformycin). Natural Products including vinca alkaloids such as vinblastine (VLB) and vincristine; epipodophyllotoxins such as etoposide and teniposide; antibiotics such as dactinomycin (actinomycin D),
25 daunorubicin (daunomycin; rubidomycin), doxorubicin, bleomycin, plicamycin (mithramycin) and mitomycin (mitomycin C); enzymes such as L-asparaginase; and biological response modifiers such as interferon alphenomes. Miscellaneous agents including platinum coordination complexes such as cisplatin (*cis*-DDP) and carboplatin; anthracenedione such as mitoxantrone and anthracycline;
30 substituted urea such as hydroxyurea; methyl hydrazine derivative such as

procarbazine (N-methylhydrazine, MIH); and adrenocortical suppressant such as mitotane (*o,p'*-DDD) and aminoglutethimide; taxol™ and analogues/derivatives; and hormone agonists/antagonists such as flutamide and tamoxifen.

5 Various of these agents have previously been attached to antibodies and other target site-delivery agents, and so compounds of the invention comprising these agents may readily be made by the person skilled in the art. For example, carbodiimide conjugation (Bauminger & Wilchek (1980) *Methods Enzymol.* 70,151-159) may be used to conjugate a variety of agents, including doxorubicin, to antibodies.

10

Carbodiimides comprise a group of compounds that have the general formula $R-N=C=N-R'$, where R and R' can be aliphatic or aromatic, and are used for synthesis of peptide bonds. The preparative procedure is simple, relatively fast, and is carried out under mild conditions. Carbodiimide compounds attack carboxylic groups to change them into reactive sites for free amino groups.

15 The water soluble carbodiimide, 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide (EDC) is particularly useful for conjugating a functional moiety to an antibody and may be used to conjugate doxorubicin to tumor homing peptides. The conjugation of doxorubicin and an antibody requires the presence of an amino group, which is provided by doxorubicin, and a carboxyl group, which is provided by the antibody such as an antibody or peptide.

25

In addition to using carbodiimides for the direct formation of peptide bonds, EDC also can be used to prepare active esters such as N-hydroxysuccinimide (NHS) ester. The NHS ester, which binds only to amino groups, then can be used to induce the formation of an amide bond with the single amino group of the doxorubicin. The use of EDC and NHS in combination is commonly used

30

for conjugation in order to increase yield of conjugate formation (Bauminger & Wilchek, *supra*, 1980).

Other methods for conjugating a cytotoxic moiety to an antibody can also be used. For example, sodium periodate oxidation followed by reductive alkylation of appropriate reactants can be used, as can glutaraldehyde cross-linking. However, it is recognised that, regardless of which method of producing a compound of the invention is selected, a determination must be made that the antibody maintains its targeting ability and that the attached moiety maintains its relevant function.

In a further embodiment of the invention, the cytotoxic moiety is a cytotoxic peptide or polypeptide moiety by which we include any moiety which leads to cell death. Cytotoxic peptide and polypeptide moieties are well known in the art and include, for example, ricin, abrin, *Pseudomonas* exotoxin, tissue factor and the like. Methods for linking them to targeting moieties such as antibodies are also known in the art. The use of ricin as a cytotoxic agent is described in Burrows & Thorpe (1993) *Proc. Natl. Acad. Sci. USA* 90, 8996-9000, and the use of tissue factor, which leads to localised blood clotting and infarction of a tumour, has been described by Ran et al (1998) *Cancer Res.* 58, 4646-4653 and Huang et al (1997) *Science* 275,547-550. Tsai et al (1995) *Dis. Colon Rectum* 38, 1067-1074 describes the abrin A chain conjugated to a monoclonal antibody. Other ribosome inactivating proteins are described as cytotoxic agents in WO 96/06641. *Pseudomonas* exotoxin may also be used as the cytotoxic polypeptide moiety (see, for example, Aiello et al (1995) *Proc. Natl. Acad. Sci. USA* 92, 10457-10461).

Certain cytokines, such as TNF α and IL-2, may also be useful as cytotoxic agents.

Certain radioactive atoms may also be cytotoxic if delivered in sufficient
5 doses. Thus, the cytotoxic moiety may comprise a radioactive atom which, in
use, delivers a sufficient quantity of radioactivity to the target site so as to be
cytotoxic. Suitable radioactive atoms include phosphorus-32, iodine-125,
iodine-131, indium-111, rhenium-186, rhenium-188 or yttrium-90, or any
10 other isotope which emits enough energy to destroy neighbouring cells,
organelles or nucleic acid. Preferably, the isotopes and density of radioactive
atoms in the compound of the invention are such that a dose of more than
4000 cGy (preferably at least 6000, 8000 or 10000 cGy) is delivered to the
target site and, preferably, to the cells at the target site and their organelles,
particularly the nucleus.

15

The radioactive atom may be attached to the antibody in known ways. For
example EDTA or another chelating agent may be attached to the antibody
and used to attach ^{111}In or ^{90}Y . Tyrosine residues may be labelled with ^{125}I or
 ^{131}I .

20

The cytotoxic moiety may be a suitable indirectly cytotoxic polypeptide. In a
particularly preferred embodiment, the indirectly cytotoxic polypeptide is a
polypeptide which has enzymatic activity and can convert a relatively non-
toxic prodrug into a cytotoxic drug. When the targeting moiety is an antibody
25 this type of system is often referred to as ADEPT (Antibody-Directed Enzyme
Prodrug Therapy). The system requires that the targeting moiety locates the
enzymatic portion to the desired site in the body of the patient (ie the site
expressing MR, such as new vascular tissue associated with a tumour) and
after allowing time for the enzyme to localise at the site, administering a
30 prodrug which is a substrate for the enzyme, the end product of the catalysis

being a cytotoxic compound. The object of the approach is to maximise the concentration of drug at the desired site and to minimise the concentration of drug in normal tissues (see Senter, P.D. *et al* (1988) "Anti-tumor effects of antibody-alkaline phosphatase conjugates in combination with etoposide phosphate" *Proc. Natl. Acad. Sci. USA* **85**, 4842-4846; Bagshawe (1987) *Br. J. Cancer* **56**, 531-2; and Bagshawe, K.D. *et al* (1988) "A cytotoxic agent can be generated selectively at cancer sites" *Br. J. Cancer.* **58**, 700-703.)

10 The cytotoxic substance may be any existing anti-cancer drug such as an alkylating agent; an agent which intercalates in DNA; an agent which inhibits any key enzymes such as dihydrofolate reductase, thymidine synthetase, ribonucleotide reductase, nucleoside kinases or topoisomerase; or an agent which effects cell death by interacting with any other cellular constituent.

15 Etoposide is an example of a topoisomerase inhibitor.

Reported prodrug systems include: a phenol mustard prodrug activated by an *E. coli* β -glucuronidase (Wang *et al*, 1992 and Roffler *et al*, 1991); a doxorubicin prodrug activated by a human β -glucuronidase (Bosslet *et al*, 1994); further doxorubicin prodrugs activated by coffee bean α -galactosidase (Azoulay *et al*, 1995); daunorubicin prodrugs, activated by coffee bean α -D-galactosidase (Gesson *et al*, 1994); a 5-fluorouridine prodrug activated by an *E. coli* β -D-galactosidase (Abraham *et al*, 1994); and methotrexate prodrugs (eg methotrexate-alanine) activated by carboxypeptidase A (Kuefner *et al*, 1990, Vitols *et al*, 1992 and Vitols *et al*, 1995). These and others are included in Table 1.

Table 1

Enzyme	Prodrug
Carboxypeptidase G2	Derivatives of L-glutamic acid and benzoic acid mustards, aniline mustards, phenol mustards and phenylenediamine mustards; fluorinated derivatives of these
Alkaline phosphatase	Etoposide phosphate
	Mitomycin phosphate
Beta-glucuronidase	<i>p</i> -Hydroxyaniline mustard-glucuronide
	Epirubicin-glucuronide
Penicillin-V-amidase	Adriamycin-N phenoxyacetyl
Penicillin-G-amidase	N-(4'-hydroxyphenyl acetyl) palytoxin
	Doxorubicin and melphalan
Beta-lactamase	Nitrogen mustard-cephalosporin <i>p</i> -phenylenediamine; doxorubicin derivatives; vinblastine derivative-cephalosporin, cephalosporin mustard; a taxol derivative
Beta-glucosidase	Cyanophenylmethyl-beta-D-gluco-pyranosiduronic acid
Nitroreductase	5-(Azaridin-1-yl)-2,4-dinitrobenzamide
Cytosine deaminase	5-Fluorocytosine
Carboxypeptidase A	Methotrexate-alanine

(This table is adapted from Bagshawe (1995) *Drug Dev. Res.* **34**, 220-230, from which full references for these various systems may be obtained; the taxol derivative is described in Rodrigues, M.L. *et al* (1995) *Chemistry & Biology* **2**, 223).

5

Suitable enzymes for forming part of the enzymatic portion of the invention include: exopeptidases, such as carboxypeptidases G, G1 and G2 (for glutamylated mustard prodrugs), carboxypeptidases A and B (for MTX-based prodrugs) and aminopeptidases (for 2- α -aminocyl MTC prodrugs);
10 endopeptidases, such as eg thrombolysin (for thrombin prodrugs); hydrolases, such as phosphatases (eg alkaline phosphatase) or sulphatases (eg aryl sulphatases) (for phosphylated or sulphated prodrugs); amidases, such as penicillin amidases and arylacyl amidase; lactamases, such as β -lactamases; glycosidases, such as β -glucuronidase (for β -glucuronomide anthracyclines),
15 α -galactosidase (for amygdalin) and β -galactosidase (for β -galactose anthracycline); deaminases, such as cytosine deaminase (for 5FC); kinases, such as urokinase and thymidine kinase (for gancyclovir); reductases, such as nitroreductase (for CB1954 and analogues), azoreductase (for azobenzene mustards) and DT-diaphorase (for CB1954); oxidases, such as glucose oxidase
20 (for glucose), xanthine oxidase (for xanthine) and lactoperoxidase; DL-racemases, catalytic antibodies and cyclodextrins.

The prodrug is relatively non-toxic compared to the cytotoxic drug. Typically, it has less than 10% of the toxicity, preferably less than 1% of the
25 toxicity as measured in a suitable *in vitro* cytotoxicity test.

It is likely that the moiety which is able to convert a prodrug to a cytotoxic drug will be active in isolation from the rest of the compound but it is necessary only for it to be active when (a) it is in combination with the rest of

the compound and (b) the compound is attached to, adjacent to or internalised in target cells.

When each moiety of the compound is a polypeptide, the two portions may be
5 linked together by any of the conventional ways of cross-linking polypeptides,
such as those generally described in O'Sullivan *et al* (1979) *Anal. Biochem.*
100, 100-108. For example, the anti-MR antibody may be enriched with thiol
groups and the further moiety reacted with a bifunctional agent capable of
reacting with those thiol groups, for example the N-hydroxysuccinimide ester
10 of iodoacetic acid (NHIA) or N-succinimidyl-3-(2-pyridyldithio)propionate
(SPDP). Amide and thioether bonds, for example achieved with m-
maleimidobenzoyl-N-hydroxysuccinimide ester, are generally more stable *in*
vivo than disulphide bonds.

15 Alternatively, the compound may be produced as a fusion compound by
recombinant DNA techniques whereby a length of DNA comprises respective
regions encoding the two moieties of the compound of the invention either
adjacent one another or separated by a region encoding a linker peptide which
does not destroy the desired properties of the compound. Conceivably, the
20 two portions of the compound may overlap wholly or partly.

The DNA is then expressed in a suitable host to produce a polypeptide
comprising the compound of the invention.

25 The cytotoxic moiety may be a radiosensitizer. Radiosensitizers include
fluoropyrimidines, thymidine analogues, hydroxyurea, gemcitabine,
fludarabine, nicotinamide, halogenated pyrimidines, 3-aminobenzamide, 3-
aminobenzodiamide, etanixadole, pimonidazole and misonidazole (see, for
example, McGinn *et al* (1996) *J. Natl. Cancer Inst.* **88**, 1193-11203; Shewach
30 & Lawrence (1996) *Invest. New Drugs* **14**, 257-263; Horsman (1995) *Acta*

Oncol. **34**, 571-587; Shenoy & Singh (1992) *Clin. Invest.* **10**, 533-551; Mitchell *et al* (1989) *Int. J. Radiat. Biol.* **56**, 827-836; Iliakis & Kurtzman (1989) *Int. J. Radiat. Oncol. Biol. Phys.* **16**, 1235-1241; Brown (1989) *Int. J. Radiat. Oncol. Biol. Phys.* **16**, 987-993; Brown (1985) *Cancer* **55**, 2222-
5 2228).

Also, delivery of genes into cells can radiosensitise them, for example delivery of the p53 gene or cyclin D (Lang *et al* (1998) *J. Neurosurg.* **89**, 125-132; Coco Martin *et al* (1999) *Cancer Res.* **59**, 1134-1140).

10

The further moiety may be one which becomes cytotoxic, or releases a cytotoxic moiety, upon irradiation. For example, the boron-10 isotope, when appropriately irradiated, releases α particles which are cytotoxic (see for example, US 4,348,376 to Goldenberg; Primus *et al* (1996) *Bioconjug. Chem.*
15 7, 532-535).

Similarly, the cytotoxic moiety may be one which is useful in photodynamic therapy such as photofrin (see, for example, Dougherty *et al* (1998) *J. Natl. Cancer Inst.* **90**, 889-905).

20

The cytotoxic moiety may be a nucleic acid molecule which is directly or indirectly cytotoxic. For example, the nucleic acid molecule may be an antisense oligonucleotide which, upon localisation at the target site is able to enter cells and lead to their death. The oligonucleotide, therefore, may be one
25 which prevents expression of an essential gene, or one which leads to a change in gene expression which causes apoptosis.

Examples of suitable oligonucleotides include those directed at bcl-2 (Ziegler *et al* (1997) *J. Natl. Cancer Inst.* **89**, 1027-1036), and DNA polymerase α and topoisomerase II α (Lee *et al* (1996) *Anticancer Res.* **16**, 1805-1811).
30

Peptide nucleic acids may be useful in place of conventional nucleic acids (see Knudsen & Nielsen (1997) *Anticancer Drugs* 8, 113-118).

5 A thirteenth aspect of the invention provides a polynucleotide encoding a compound as defined above in the twelfth aspect of the invention, wherein the antibody and the cytotoxic moiety are polypeptides which are fused.

A fourteenth aspect of the invention provides a compound comprising an
10 antibody as defined above in the seventh, eighth and tenth aspects of the invention, and a readily detectable moiety.

A compound comprising an anti-MR antibody as defined above and a readily detectable moiety can be used, in combination with an appropriate detection
15 method, to detect the location of the compound in the individual, and hence to identify the sites and extent of angiogenesis in the individual, as well as inhibiting the angiogenesis in the individual.

By a "readily detectable moiety" we include the meaning that the moiety is
20 one which, when located at the target site following administration of the compound of the invention into a patient, may be detected, typically non-invasively from outside the body and the site of the target located. Thus, the compounds of this embodiment of the invention are useful in imaging and diagnosis.

25

Typically, the readily detectable moiety is or comprises a radioactive atom which is useful in imaging. Suitable radioactive atoms include technetium-99m or iodine-123 for scintigraphic studies. Other readily detectable moieties include, for example, spin labels for magnetic resonance imaging (MRI) such
30 as iodine-123 again, iodine-131, indium-111, fluorine-19, carbon-13, nitrogen-

15, oxygen-17, gadolinium, manganese or iron. Clearly, the compound of the invention must have sufficient of the appropriate atomic isotopes in order for the molecule to be readily detectable.

5 The radio- or other labels may be incorporated in the compound of the invention in known ways. For example, if the antibody is a polypeptide it may be biosynthesised or may be synthesised by chemical amino acid synthesis using suitable amino acid precursors involving, for example, fluorine-19 in place of hydrogen. Labels such as ^{99m}Tc , ^{123}I , ^{186}Rh , ^{188}Rh and ^{111}In can, for
10 example, be attached *via* cysteine residues in the antibody. Yttrium-90 can be attached via a lysine residue. The IODOGEN method (Fraker *et al* (1978) *Biochem. Biophys. Res. Comm.* 80, 49-57) can be used to incorporate iodine-123. Reference ("Monoclonal Antibodies in Immunoscintigraphy", J-F Chatal, CRC Press, 1989) describes other methods in detail.

15

A fifteenth aspect of the invention provides a vector comprising a polynucleotide as defined above in the ninth, eleventh and thirteenth aspects of the invention.

20 Typical prokaryotic vector plasmids are: pUC18, pUC19, pBR322 and pBR329 available from Biorad Laboratories (Richmond, CA, USA); pTrc99A, pKK223-3, pKK233-3, pDR540 and pRIT5 available from Pharmacia (Piscataway, NJ, USA); pBS vectors, Phagescript™ vectors, Bluescript™ vectors, pNH8A, pNH16A, pNH18A, pNH46A available from Stratagene Cloning Systems (La Jolla, CA 92037,
25 USA).

25

A typical mammalian cell vector plasmid is pSVL available from Pharmacia (Piscataway, NJ, USA). This vector uses the SV40 late promoter to drive expression of cloned genes, the highest level of expression being found in T
30 antigen-producing cells, such as COS-1 cells. An example of an inducible

mammalian expression vector is pMSG, also available from Pharmacia (Piscataway, NJ, USA). This vector uses the glucocorticoid-inducible promoter of the mouse mammary tumour virus long terminal repeat to drive expression of the cloned gene.

5

Useful yeast plasmid vectors are pRS403-406 and pRS413-416 and are generally available from Stratagene Cloning Systems (La Jolla, CA 92037, USA). Plasmids pRS403, pRS404, pRS405 and pRS406 are Yeast Integrating plasmids (YIps) and incorporate the yeast selectable markers *HIS3*, *TRP1*, *LEU2* and
10 *URA3*. Plasmids pRS413-416 are Yeast Centromere plasmids (YCps).

Methods well known to those skilled in the art can be used to construct expression vectors containing the coding sequence and, for example appropriate transcriptional or translational controls. One such method involves ligation via
15 homopolymer tails. Homopolymer polydA (or polydC) tails are added to exposed 3' -OH groups on the DNA fragment to be cloned by terminal deoxynucleotidyl transferases. The fragment is then capable of annealing to the polydT (or polydG) tails added to the ends of a linearised plasmid vector. Gaps left following annealing can be filled by DNA polymerase and the free ends
20 joined by DNA ligase.

Another method involves ligation via cohesive ends. Compatible cohesive ends can be generated on the DNA fragment and vector by the action of suitable restriction enzymes. These ends will rapidly anneal through complementary
25 base pairing and remaining nicks can be closed by the action of DNA ligase.

A further method uses synthetic molecules called linkers and adaptors. DNA fragments with blunt ends are generated by bacteriophage T4 DNA polymerase or *E. coli* DNA polymerase I which remove protruding 3' termini and fill in
30 recessed 3' ends. Synthetic linkers, pieces of blunt-ended double-stranded DNA

which contain recognition sequences for defined restriction enzymes, can be ligated to blunt-ended DNA fragments by T4 DNA ligase. They are subsequently digested with appropriate restriction enzymes to create cohesive ends and ligated to an expression vector with compatible termini. Adaptors are
5 also chemically synthesised DNA fragments which contain one blunt end used for ligation but which also possess one preformed cohesive end.

Synthetic linkers containing a variety of restriction endonuclease sites are commercially available from a number of sources including International
10 Biotechnologies Inc, New Haven, CN, USA.

A desirable way to modify the DNA encoding the polypeptide of the invention is to use the polymerase chain reaction as disclosed by Saiki *et al* (1988) *Science* **239**, 487-491. In this method the DNA to be enzymatically amplified is flanked
15 by two specific oligonucleotide primers which themselves become incorporated into the amplified DNA. The specific primers may contain restriction endonuclease recognition sites which can be used for cloning into expression vectors using methods known in the art.

20 A sixteenth aspect of the invention provides a host cell comprising a polynucleotide as defined in the ninth, eleventh and thirteenth aspects of the invention, or a vector as defined in the fifteenth aspect of the invention.

Many expression systems are known, including systems employing: bacteria (eg.
25 *E. coli* and *Bacillus subtilis*) transformed with, for example, recombinant bacteriophage, plasmid or cosmid DNA expression vectors; yeasts (eg. *Saccharomyces cerevisiae*) transformed with, for example, yeast expression vectors; insect cell systems transformed with, for example, viral expression vectors (eg. baculovirus); plant cell systems transfected with, for example viral

or bacterial expression vectors; animal cell systems transfected with, for example, adenovirus expression vectors.

The vectors can include a prokaryotic replicon, such as the Col E1 *ori*, for propagation in a prokaryote, even if the vector is to be used for expression in other, non-prokaryotic cell types. The vectors can also include an appropriate promoter such as a prokaryotic promoter capable of directing the expression (transcription and translation) of the genes in a bacterial host cell, such as *E. coli*, transformed therewith.

10

A promoter is an expression control element formed by a DNA sequence that permits binding of RNA polymerase and transcription to occur. Promoter sequences compatible with exemplary bacterial hosts are typically provided in plasmid vectors containing convenient restriction sites for insertion of a DNA segment of the present invention.

15

The polynucleotide in a suitable host cell may be expressed to produce the antibody or compound of the invention. Thus, the polynucleotide may be used in accordance with known techniques, appropriately modified in view of the teachings contained herein, to construct an expression vector, which is then used to transform an appropriate host cell for the expression and production of the antibody or compound of the invention. Such techniques include those disclosed in US Patent Nos. 4,440,859 issued 3 April 1984 to Rutter *et al*, 4,530,901 issued 23 July 1985 to Weissman, 4,582,800 issued 15 April 1986 to Crowl, 4,677,063 issued 30 June 1987 to Mark *et al*, 4,678,751 issued 7 July 1987 to Goeddel, 4,704,362 issued 3 November 1987 to Itakura *et al*, 4,710,463 issued 1 December 1987 to Murray, 4,757,006 issued 12 July 1988 to Toole, Jr. *et al*, 4,766,075 issued 23 August 1988 to Goeddel *et al* and 4,810,648 issued 7 March 1989 to Stalker.

30

The polynucleotide may be joined to a wide variety of other DNA sequences for introduction into an appropriate host. The companion DNA will depend upon the nature of the host, the manner of the introduction of the DNA into the host, and whether episomal maintenance or integration is desired.

5

Generally, the polynucleotide is inserted into an expression vector, such as a plasmid, in proper orientation and correct reading frame for expression. If necessary, the DNA may be linked to the appropriate transcriptional and translational regulatory control nucleotide sequences recognised by the desired
10 host, although such controls are generally available in the expression vector. Thus, the DNA insert may be operatively linked to an appropriate promoter. Bacterial promoters include the *E. coli lacI* and *lacZ* promoters, the T3 and T7 promoters, the *gpt* promoter, the phage λ PR and PL promoters, the *phoA* promoter and the *trp* promoter. Eukaryotic promoters include the CMV
15 immediate early promoter, the HSV thymidine kinase promoter, the early and late SV40 promoters and the promoters of retroviral LTRs. Other suitable promoters will be known to the skilled artisan. The expression constructs will desirably also contain sites for transcription initiation and termination, and in the transcribed region, a ribosome binding site for translation. (Hastings *et al*,
20 International Patent No. WO 98/16643, published 23 April 1998)

The vector is then introduced into the host through standard techniques. Generally, not all of the hosts will be transformed by the vector and it will therefore be necessary to select for transformed host cells. One selection
25 technique involves incorporating into the expression vector a DNA sequence marker, with any necessary control elements, that codes for a selectable trait in the transformed cell. These markers include dihydrofolate reductase, G418 or neomycin resistance for eukaryotic cell culture, and tetracyclin, kanamycin or ampicillin resistance genes for culturing in *E. coli* and other bacteria.

Alternatively, the gene for such selectable trait can be on another vector, which is used to co-transform the desired host cell.

Host cells that have been transformed by the recombinant DNA of the invention
5 are then cultured for a sufficient time and under appropriate conditions known to those skilled in the art in view of the teachings disclosed herein to permit the expression of the polypeptide, which can then be recovered.

The antibody or compound can be recovered and purified from recombinant cell
10 cultures by well-known methods including ammonium sulphate or ethanol precipitation, acid extraction, anion or cation exchange chromatography, phosphocellulose chromatography, hydrophobic interaction chromatography, affinity chromatography, hydroxylapatite chromatography and lectin chromatography. Most preferably, high performance liquid chromatography
15 ("HPLC") is employed for purification.

An seventeenth aspect of the invention provides a stable host cell line producing an antibody as defined in the seventh, eighth or tenth aspects of the invention, or a compound as defined in the twelfth aspect of the invention
20 wherein the antibody and the cytotoxic moiety are polypeptides which are fused, resulting from incorporation in the cell line an exogenous polynucleotide as defined in the ninth, eleventh and thirteenth aspects of the invention, or a vector as defined in the fifteenth aspect of the invention.

25 A eighteenth aspect of the invention provides a pharmaceutical composition or formulation comprising an antibody as defined in the seventh, eighth or tenth aspects of the invention, or a polynucleotide as defined in the ninth, eleventh and thirteenth aspects of the invention, or a compound as defined in the twelfth or fourteenth aspects of the invention, and a pharmaceutically
30 acceptable carrier.

By “pharmaceutically acceptable” is included that the formulation is sterile and pyrogen free. Suitable pharmaceutical carriers are well known in the art of pharmacy.

5

The carrier(s) must be “acceptable” in the sense of being compatible with the compound of the invention and not deleterious to the recipients thereof. Typically, the carriers will be water or saline which will be sterile and pyrogen free; however, other acceptable carriers may be used.

10

In an embodiment, the pharmaceutical compositions or formulations of the invention are for parenteral administration, more particularly for intravenous administration.

15 In a preferred embodiment, the pharmaceutical composition is suitable for intravenous administration to a patient, for example by injection.

Formulations suitable for parenteral administration include aqueous and non-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.

In an alternative preferred embodiment, the pharmaceutical composition is 25 suitable for topical administration to a patient.

Preferably, the formulation is a unit dosage containing a daily dose or unit, daily sub-dose or an appropriate fraction thereof, of the active ingredient.

The antibody, polynucleotide or compound of the invention will normally be administered orally or by any parenteral route, in the form of a pharmaceutical formulation comprising the active ingredient, optionally in the form of a non-toxic organic, or inorganic, acid, or base, addition salt, in a pharmaceutically acceptable dosage form. Depending upon the disorder and patient to be treated, as well as the route of administration, the compositions may be administered at varying doses.

In human therapy, the antibody, polynucleotide or compound of the invention can be administered alone but will generally be administered in admixture with a suitable pharmaceutical excipient, diluent or carrier selected with regard to the intended route of administration and standard pharmaceutical practice.

For example, the antibody, polynucleotide or compound of the invention can be administered orally, buccally or sublingually in the form of tablets, capsules, ovules, elixirs, solutions or suspensions, which may contain flavouring or colouring agents, for immediate-, delayed- or controlled-release applications. The antibody, polynucleotide or compound of invention may also be administered *via* intracavernosal injection.

Such tablets may contain excipients such as microcrystalline cellulose, lactose, sodium citrate, calcium carbonate, dibasic calcium phosphate and glycine, disintegrants such as starch (preferably corn, potato or tapioca starch), sodium starch glycollate, croscarmellose sodium and certain complex silicates, and granulation binders such as polyvinylpyrrolidone, hydroxypropylmethylcellulose (HPMC), hydroxy-propylcellulose (HPC), sucrose, gelatin and acacia. Additionally, lubricating agents such as magnesium stearate, stearic acid, glyceryl behenate and talc may be included.

Solid compositions of a similar type may also be employed as fillers in gelatin capsules. Preferred excipients in this regard include lactose, starch, a cellulose, milk sugar or high molecular weight polyethylene glycols. For aqueous suspensions and/or elixirs, the compounds of the invention may be
5 combined with various sweetening or flavouring agents, colouring matter or dyes, with emulsifying and/or suspending agents and with diluents such as water, ethanol, propylene glycol and glycerin, and combinations thereof.

The antibody, polynucleotide or compound of the invention can also be
10 administered parenterally, for example, intravenously, intra-arterially, intraperitoneally, intrathecally, intraventricularly, intrasternally, intracranially, intra-muscularly or subcutaneously, or they may be administered by infusion techniques. They are best used in the form of a sterile aqueous solution which may contain other substances, for example, enough salts or glucose to make
15 the solution isotonic with blood. The aqueous solutions should be suitably buffered (preferably to a pH of from 3 to 9), if necessary. The preparation of suitable parenteral formulations under sterile conditions is readily accomplished by standard pharmaceutical techniques well-known to those skilled in the art.

20 Formulations suitable for parenteral administration include aqueous and non-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
25 may include suspending agents and thickening agents. The formulations may be presented in unit-dose or multi-dose containers, for example sealed ampoules and vials, and may be stored in a freeze-dried (lyophilised) condition requiring only the 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.

For oral and parenteral administration to human patients, the daily dosage
5 level of the antibody, polynucleotide or compound of the invention will usually be from 1 to 1000 mg per adult (*i.e.* from about 0.015 to 15 mg/kg), administered in single or divided doses.

Thus, for example, the tablets or capsules of the antibody, polynucleotide or
10 compound of the invention may contain from 1 mg to 1000 mg of active agent for administration singly or two or more at a time, as appropriate. The physician in any event will determine the actual dosage which will be most suitable for any individual patient and it will vary with the age, weight and response of the particular patient. The above dosages are exemplary of the
15 average case. There can, of course, be individual instances where higher or lower dosage ranges are merited and such are within the scope of this invention.

The antibody, polynucleotide or compound of the invention can also be
20 administered intranasally or by inhalation and are conveniently delivered in the form of a dry powder inhaler or an aerosol spray presentation from a pressurised container, pump, spray or nebuliser with the use of a suitable propellant, *e.g.* dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoro-ethane, a hydrofluoroalkane such as 1,1,1,2-
25 tetrafluoroethane (HFA 134A, or 1,1,1,2,3,3,3-heptafluoropropane (HFA 227EA), carbon dioxide or other suitable gas. In the case of a pressurised aerosol, the dosage unit may be determined by providing a valve to deliver a metered amount. The pressurised container, pump, spray or nebuliser may contain a solution or suspension of the active compound, *e.g.* using a mixture
30 of ethanol and the propellant as the solvent, which may additionally contain a

lubricant, *e.g.* sorbitan trioleate. Capsules and cartridges (made, for example, from gelatin) for use in an inhaler or insufflator may be formulated to contain a powder mix of a compound of the invention and a suitable powder base such as lactose or starch.

5

Aerosol or dry powder formulations are preferably arranged so that each metered dose or "puff" contains at least 1 mg of an antibody, polynucleotide or compound of the invention for delivery to the patient. It will be appreciated that the overall daily dose with an aerosol will vary from patient to patient, and
10 may be administered in a single dose or, more usually, in divided doses throughout the day.

Alternatively, the antibody, polynucleotide or compound of the invention can be administered in the form of a suppository or pessary, or they may be
15 applied topically in the form of a lotion, solution, cream, ointment or dusting powder. The compounds of the invention may also be transdermally administered, for example, by the use of a skin patch. They may also be administered by the ocular route, particularly for treating diseases of the eye.

20 For ophthalmic use, the antibody, polynucleotide or compound of the invention can be formulated as micronised suspensions in isotonic, pH adjusted, sterile saline, or, preferably, as solutions in isotonic, pH adjusted, sterile saline, optionally in combination with a preservative such as a benzylalkonium chloride. Alternatively, they may be formulated in an
25 ointment such as petrolatum.

For application topically to the skin, the antibody, polynucleotide or compound of the invention can be formulated as a suitable ointment containing the active compound suspended or dissolved in, for example, a
30 mixture with one or more of the following: mineral oil, liquid petrolatum,

white petrolatum, propylene glycol, polyoxyethylene polyoxypropylene compound, emulsifying wax and water. Alternatively, they can be formulated as a suitable lotion or cream, suspended or dissolved in, for example, a mixture of one or more of the following: mineral oil, sorbitan monostearate, a
5 polyethylene glycol, liquid paraffin, polysorbate 60, cetyl esters wax, cetearyl alcohol, 2-octyldodecanol, benzyl alcohol and water.

Formulations suitable for topical administration in the mouth include lozenges comprising the active ingredient in a flavoured basis, usually sucrose and acacia
10 or tragacanth; pastilles comprising the active ingredient in an inert basis such as gelatin and glycerin, or sucrose and acacia; and mouth-washes comprising the active ingredient in a suitable liquid carrier.

For veterinary use, a compound of the invention is administered as a suitably
15 acceptable formulation in accordance with normal veterinary practice and the veterinary surgeon will determine the dosing regimen and route of administration which will be most appropriate for a particular animal.

A nineteenth aspect of the invention provides an antibody as defined in the
20 seventh, eighth or tenth aspects of the invention, or a polynucleotide as defined in the ninth, eleventh and thirteenth aspects of the invention, or a compound as defined in the twelfth or fourteenth aspects of the invention, for use in medicine.

25 A twentieth aspect of the invention provides the use of an antibody as defined in the seventh, eighth, or tenth aspects of the invention, or a polynucleotide as defined in the ninth, eleventh and thirteenth aspects of the invention, or a compound as defined in the twelfth or fourteenth aspects of the invention, in the preparation of a medicament for inhibiting angiogenesis.

Conditions which involve unwanted or undesirable angiogenesis are described above.

A twenty-first aspect of the invention provides a method of inhibiting angiogenesis in an individual in need thereof comprising administering an antibody as defined in the seventh, eighth, or tenth aspects of the invention, or a polynucleotide as defined in the ninth, eleventh and thirteenth aspects of the invention, or a compound as defined in the twelfth or fourteenth aspects of the invention, to the individual.

10

In an embodiment, polypeptides, such as antibodies, may be delivered using an injectable sustained-release drug delivery system. These are designed specifically to reduce the frequency of injections. An example of such a system is Nutropin Depot™ which encapsulates recombinant human growth hormone (rhGH) in biodegradable microspheres that, once injected, release rhGH slowly over a sustained period.

15

The polypeptide can be administered by a surgically implanted device that releases the drug directly to the required site. For example, Vitrasert™ releases ganciclovir directly into the eye to treat CMV retinitis. The direct application of this toxic agent to the site of disease achieves effective therapy without the drug's significant systemic side-effects.

20

Electroporation therapy (EPT) systems can also be employed for the administration of polypeptides. A device which delivers a pulsed electric field to cells increases the permeability of the cell membranes to the drug, resulting in a significant enhancement of intracellular drug delivery.

25

Polypeptides can also be delivered by electroincorporation (EI). EI occurs when small particles of up to 30 microns in diameter on the surface of the skin

30

experience electrical pulses identical or similar to those used in electroporation. In EI, these particles are driven through the stratum corneum and into deeper layers of the skin. The particles can be loaded or coated with drugs or genes or can simply act as "bullets" that generate pores in the skin
5 through which the drugs can enter.

**An alternative method of polypeptide delivery is the ReGel™ injectable system that is thermo-sensitive. Below body temperature, ReGel™ is an injectable liquid while at body temperature it immediately forms a gel reservoir that slowly erodes and dissolves into known, safe, biodegradable polymers. The active drug is delivered over
10 time as the biopolymers dissolve.**

Polypeptide pharmaceuticals can also be delivered orally. The process employs a natural process for oral uptake of vitamin B₁₂ in the body to co-
15 deliver proteins and peptides. By riding the vitamin B₁₂ uptake system, the protein or peptide can move through the intestinal wall. Complexes are synthesised between vitamin B₁₂ analogues and the drug that retain both significant affinity for intrinsic factor (IF) in the vitamin B₁₂ portion of the complex and significant bioactivity of the drug portion of the complex.

20 Polynucleotides may be administered by any effective method, for example, parenterally (eg intravenously, subcutaneously, intramuscularly) or by oral, nasal or other means which permit the oligonucleotides to access and circulate in the patient's bloodstream. Polynucleotides administered systemically preferably are
25 given in addition to locally administered polynucleotides, but also have utility in the absence of local administration. A dosage in the range of from about 0.1 to about 10 grams per administration to an adult human generally will be effective for this purpose.

The polynucleotide may be administered as a suitable genetic construct as is described below and delivered to the patient where it is expressed. Typically, the polynucleotide in the genetic construct is operatively linked to a promoter which can express the antibody or compound in the cell.

5

Although genetic constructs for delivery of polynucleotides can be DNA or RNA it is preferred if it is DNA.

Preferably, the genetic construct is adapted for delivery to a human cell.

10

Means and methods of introducing a genetic construct into a cell in an animal body are known in the art. For example, the constructs of the invention may be introduced into cells by any convenient method, for example methods involving retroviruses, so that the construct is inserted into the genome of the cell. For example, in Kuriyama *et al* (1991) *Cell Struc. and Func.* 16, 503-510 purified retroviruses are administered. Retroviral DNA constructs comprising a polynucleotide as described above may be made using methods well known in the art. To produce active retrovirus from such a construct it is usual to use an ecotropic psi2 packaging cell line grown in Dulbecco's modified Eagle's medium (DMEM) containing 10% foetal calf serum (FCS).

20

Transfection of the cell line is conveniently by calcium phosphate coprecipitation, and stable transformants are selected by addition of G418 to a final concentration of 1 mg/ml (assuming the retroviral construct contains a *neo*^R gene). Independent colonies are isolated and expanded and the culture supernatant removed, filtered through a 0.45 µm pore-size filter and stored at -70°C. For the introduction of the retrovirus into the tumour cells, it is convenient to inject directly retroviral supernatant to which 10 µg/ml PolybreneTM has been added. For tumours exceeding 10 mm in diameter it is appropriate to inject between 0.1 ml and 1 ml of retroviral supernatant; preferably 0.5 ml.

25

Alternatively, as described in Culver *et al* (1992) *Science* **256**, 1550-1552, cells which produce retroviruses are injected. The retrovirus-producing cells so introduced are engineered to actively produce retroviral vector particles so that continuous productions of the vector occurred within the tumour mass *in situ*. Thus, proliferating epidermal cells can be successfully transduced *in vivo* if mixed with retroviral vector-producing cells.

Targeted retroviruses are also available for use in the invention; for example, sequences conferring specific binding affinities may be engineered into pre-existing viral *env* genes (see Miller & Vile (1995) *Faseb J.* **9**, 190-199 for a review of this and other targeted vectors for gene therapy).

Other methods involve simple delivery of the construct into the cell for expression therein either for a limited time or, following integration into the genome, for a longer time. An example of the latter approach includes liposomes (Nässander *et al* (1992) *Cancer Res.* **52**, 646-653).

For the preparation of immuno-liposomes MPB-PE (N-[4-(p-maleimidophenyl)butyryl]-phosphatidylethanolamine) is synthesised according to the method of Martin & Papahadjopoulos (1982) *J. Biol. Chem.* **257**, 286-288. MPB-PE is incorporated into the liposomal bilayers to allow a covalent coupling of the antibody, or fragment thereof, to the liposomal surface. The liposome is conveniently loaded with the DNA or other genetic construct of the invention for delivery to the target cells, for example, by forming the said liposomes in a solution of the DNA or other genetic construct, followed by sequential extrusion through polycarbonate membrane filters with 0.6 μm and 0.2 μm pore size under nitrogen pressures up to 0.8 MPa. After extrusion, entrapped DNA construct is separated from free DNA construct by ultracentrifugation at 80 000 x g for 45 min. Freshly prepared

MPB-PE-liposomes in deoxygenated buffer are mixed with freshly prepared antibody (or fragment thereof) and the coupling reactions are carried out in a nitrogen atmosphere at 4°C under constant end over end rotation overnight. The immunoliposomes are separated from unconjugated antibodies by
5 ultracentrifugation at 80 000 x g for 45 min. Immunoliposomes may be injected intraperitoneally or directly into a tumour.

Other methods of delivery include adenoviruses carrying external DNA via an antibody-polylysine bridge (see Curiel *Prog. Med. Virol.* **40**, 1-18) and
10 transferrin-polycation conjugates as carriers (Wagner *et al* (1990) *Proc. Natl. Acad. Sci. USA* **87**, 3410-3414). In the first of these methods a polycation-antibody complex is formed with the DNA construct or other genetic construct of the invention, wherein the antibody is specific for either wild-type
15 adenovirus or a variant adenovirus in which a new epitope has been introduced which binds the antibody. The polycation moiety binds the DNA *via* electrostatic interactions with the phosphate backbone. The adenovirus, because it contains unaltered fibre and penton proteins, is internalised into the cell and carries into the cell with it the DNA construct of the invention. It is preferred if the polycation is polylysine.

20

The polynucleotide may also be delivered by adenovirus wherein it is present within the adenovirus particle, for example, as described below.

In an alternative method, a high-efficiency nucleic acid delivery system that
25 uses receptor-mediated endocytosis to carry DNA macromolecules into cells is employed. This is accomplished by conjugating the iron-transport protein transferrin to polycations that bind nucleic acids. Human transferrin, or the chicken homologue conalbumin, or combinations thereof is covalently linked to the small DNA-binding protein protamine or to polylysines of various sizes
30 through a disulfide linkage. These modified transferrin molecules maintain

their ability to bind their cognate receptor and to mediate efficient iron transport into the cell. The transferrin-polycation molecules form electrophoretically stable complexes with DNA constructs or other genetic constructs of the invention independent of nucleic acid size (from short
5 oligonucleotides to DNA of 21 kilobase pairs). When complexes of transferrin-polycation and the DNA constructs or other genetic constructs of the invention are supplied to the tumour cells, a high level of expression from the construct in the cells is expected.

10 High-efficiency receptor-mediated delivery of the DNA constructs or other genetic constructs of the invention using the endosome-disruption activity of defective or chemically inactivated adenovirus particles produced by the methods of Cotten *et al* (1992) *Proc. Natl. Acad. Sci. USA* **89**, 6094-6098 may also be used. This approach appears to rely on the fact that adenoviruses are
15 adapted to allow release of their DNA from an endosome without passage through the lysosome, and in the presence of, for example transferrin linked to the DNA construct or other genetic construct of the invention, the construct is taken up by the cell by the same route as the adenovirus particle.

20 This approach has the advantages that there is no need to use complex retroviral constructs; there is no permanent modification of the genome as occurs with retroviral infection; and the targeted expression system is coupled with a targeted delivery system, thus reducing toxicity to other cell types.

25 It will be appreciated that "naked DNA" and DNA complexed with cationic and neutral lipids may also be useful in introducing the DNA of the invention into cells of the individual to be treated. Non-viral approaches to gene therapy are described in Ledley (1995) *Human Gene Therapy* **6**, 1129-1144.

Alternative targeted delivery systems are also known such as the modified adenovirus system described in WO 94/10323 wherein, typically, the DNA is carried within the adenovirus, or adenovirus-like, particle. Michael *et al* (1995) *Gene Therapy* **2**, 660-668 describes modification of adenovirus to add
5 a cell-selective moiety into a fibre protein. Mutant adenoviruses which replicate selectively in p53-deficient human tumour cells, such as those described in Bischoff *et al* (1996) *Science* **274**, 373-376 are also useful for delivering the genetic construct of the invention to a cell. Thus, it will be appreciated that a further aspect of the invention provides a virus or virus-like
10 particle comprising a genetic construct of the invention. Other suitable viruses, viral vectors or virus-like particles include lentivirus and lentiviral vectors, HSV, adeno-assisted virus (AAV) and AAV-based vectors, vaccinia and parvovirus.

15 The genetic constructs of the invention can be prepared using methods well known in the art.

A twenty-second aspect of the invention provides an *in vitro* method of inhibiting angiogenesis comprising administering an antibody as defined in
20 the seventh, eighth, or tenth aspects of the invention, or a polynucleotide as defined in the ninth, eleventh and thirteenth aspects of the invention, or a compound as defined in the twelfth or fourteenth aspects of the invention, to tissue or cells *in vitro*.

25 A twenty-third aspect of the invention provides a method of producing an antibody as defined in the seventh, eighth or tenth aspects of the invention, or a compound as defined in the twelfth aspect of the invention wherein the antibody and the cytotoxic moiety are polypeptides which are fused, the method comprising expressing a polynucleotide as defined in the ninth,

eleventh and thirteenth aspects of the invention, or culturing a stable host cell line as defined in the seventeenth aspect of the invention.

We have also shown that the extracellular fragment of MR (residues 1-467, 5 Figure 2B, SEQ ID NO: 3, also known as the MR ectodomain) inhibits migration of endothelial cells, including bFGF- and VEGF-induced migration. Interestingly, the MR ectodomain does not appear to affect endothelial cell attachment (data not shown). The MR ectodomain, and fragments of it that show inhibitory activity in the HUVEC migration assay, would be predicted to 10 be therapeutically useful in conditions in which unwanted, undesirable or inappropriate endothelial cell migration contributes to the pathology.

We have also shown that the MR ectodomain inhibits proliferation of endothelial cells. The MR ectodomain, and fragments of it that show anti- 15 proliferative activity in an assay such as that described in Example 5, would be predicted to be therapeutically useful in conditions in which unwanted, undesirable or inappropriate endothelial cell proliferation contributes to the pathology.

20 A twenty-fourth aspect of the invention provides the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation.

It is appreciated that, in an embodiment, “a fragment of the MR ectodomain that inhibits endothelial cell migration and/or proliferation” may inhibit 25 endothelial cell migration and not endothelial cell proliferation, or may inhibit endothelial cell proliferation and not endothelial cell migration. In an alternative embodiment, “a fragment of the MR ectodomain that inhibits endothelial cell migration and/or proliferation” may inhibit both endothelial cell migration and endothelial cell proliferation. In this embodiment, the

fragment of the MR ectodomain does not necessarily inhibit both endothelial cell migration and/or proliferation to the same extent.

By “inhibiting endothelial cell migration and/or proliferation” we include the
5 meaning of reducing the rate or level of endothelial cell migration and/or
proliferation. The reduction can be a low level reduction of about 10%, or
about 20%, or about 30%, or about 40% of the rate or level of endothelial cell
migration and/or proliferation. Preferably, the reduction is a medium level
10 reduction of about 50%, or about 60%, or about 70%, or about 80% reduction
of the rate or level of endothelial cell migration and/or proliferation. More
preferably, the reduction is a high level reduction of about 90%, or about 95%,
or about 99%, or about 99.9%, or about 99.99% of the rate or level of
endothelial cell migration and/or proliferation. Most preferably, inhibition can
15 also include the elimination of endothelial cell migration and/or proliferation,
or its reduction to an undetectable level.

Methods and assays for determining the rate or level of endothelial cell
migration, and hence for determining whether and to what extent any
particular fragment of the MR ectodomain inhibits endothelial cell migration,
20 are known in the art and include the HUVEC assay described in Example 4.
Similarly, methods and assays for determining the rate or level of endothelial
cell proliferation, and hence for determining whether and to what extent any
particular fragment of the MR ectodomain inhibits endothelial cell
proliferation, are well known in the art and include the HUVEC assay
25 described in Example 5.

By “a fragment of the MR ectodomain that inhibits endothelial cell migration
and/or proliferation” we include the MR ectodomain that has been truncated
or deleted, or a polypeptide comprising at least 450 contiguous amino acid
30 residues of the MR ectodomain, which is sufficient to inhibit endothelial cell

migration and/or proliferation. More preferably, a fragment of the ectodomain which is sufficient to inhibit endothelial cell migration and/or proliferation comprises at least 400, or at least 350, or at least 300, or at least 250, or at least 200, or at least 150, or at least 100, or at least 90, or at least 80, or at least 5
70, or at least 60, or at least 50, or at least 40, or at least 30, or at least 20, or at least 15, or at least 10 contiguous amino acid residues of the MR ectodomain. It is more particularly preferred if the fragment of the ectodomain which is sufficient to inhibit endothelial cell migration and/or proliferation comprises at least 60 contiguous amino acid residues of the MR ectodomain. The
10 inhibition of endothelial cell migration and/or proliferation can be tested, for example, using the HUVEC assays as described in Examples 4 and 5.

In an embodiment, the fragment of the ectodomain which is sufficient to inhibit endothelial cell migration and/or proliferation consists of or comprises
15 the Ig region of MR (residues 46-209, SEQ ID NO: 4).

In another embodiment, the fragment of the ectodomain which is sufficient to inhibit endothelial cell migration and/or proliferation consists of or comprises the IgA domain of MR (residues 46-116, SEQ ID NO: 5) or the IgB domain of
20 MR (residues 151-209, SEQ ID NO: 6).

We have shown that the MR ectodomain does not appear to inhibit endothelial cell attachment (data not shown) and, preferably, the fragment of the ectodomain which is sufficient to inhibit endothelial cell migration and/or
25 proliferation does not inhibit endothelial cell attachment.

Thus the MR ectodomain, or fragment thereof which inhibits endothelial cell migration, can be used to inhibit endothelial cell migration and/or proliferation without inhibiting endothelial cell attachment.

A twenty-fifth aspect of the invention provides the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation, for use in medicine.

- 5 A twenty-sixth aspect of the invention provides a method of combating any disease or condition involving unwanted, undesirable or inappropriate endothelial cell migration and/or proliferation in an individual, the method comprising administering the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation, to the individual.

10

Thus, the invention includes a method of treating a patient who has a disease or condition in which endothelial cell migration and/or proliferation contributes to the pathology, the method comprising the step of administering to the patient the MR ectodomain, or a fragment thereof that inhibits
15 endothelial cell migration and/or proliferation.

- A twenty-seventh aspect of the invention provides the use of the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation, in the preparation of a medicament for combating any
20 disease or condition involving unwanted, undesirable or inappropriate endothelial cell migration and/or proliferation.

It has been shown that adipose tissue mass can be regulated by its vasculature (Rupnick, M.A. *et al* (2002) *PNAS USA* **99(16)**: 10730-10735). Furthermore,
25 leptin, a known regulator of appetite and metabolism, is also known to modulate both migration of endothelial cells (Goetze, S. *et al* (2002) *Hypertension* **40(5)**: 748-754) and angiogenesis (Sierra-Honigmann, M.R. *et al* (1998) *Science* **281**: 1683). Hence inhibition of migration of endothelial cells may reduce adipose tissue mass and be useful in treating obesity.

30

Diseases or conditions involving unwanted, undesirable or inappropriate endothelial cell migration and/or proliferation include tumours/cancer, psoriasis, atherosclerosis, menorrhagia, endometriosis, arthritis (both inflammatory and rheumatoid), macular degeneration, Paget's disease, 5 retinopathy and its vascular complications (including proliferative and of prematurity, and diabetic retinopathy), benign vascular proliferations, fibroses, obesity and inflammation.

The invention thus includes a method of combating a disease or condition 10 selected from tumours/cancer, psoriasis, atherosclerosis, menorrhagia, endometriosis, arthritis (both inflammatory and rheumatoid), macular degeneration, Paget's disease, retinopathy and its vascular complications (including proliferative and of prematurity, and diabetic retinopathy), benign vascular proliferations, fibroses, obesity and inflammation in an individual, 15 the method comprising administering the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation, to the individual.

The invention also includes the use of the MR ectodomain, or a fragment 20 thereof that inhibits endothelial cell migration and/or proliferation, in the preparation of a medicament for combating a disease or condition selected from tumours/cancer, psoriasis, atherosclerosis, menorrhagia, endometriosis, arthritis (both inflammatory and rheumatoid), macular degeneration, Paget's disease, retinopathy and its vascular complications (including proliferative and 25 of prematurity, and diabetic retinopathy), benign vascular proliferations, fibroses, obesity and inflammation in an individual.

A yet further aspect of the invention provides an *in vitro* method of inhibiting endothelial cell migration and/or proliferation comprising administering the 30 MR ectodomain, or a fragment thereof that inhibits endothelial cell migration

and/or proliferation, to tissue or cells *in vitro*. The cells may be established cell lines, or cells that have been removed from an individual. The tissue or cells are preferably mammalian tissue or cells, and most preferably are human tissue or cells.

5

Furthermore, it is appreciated that administration of nucleic acid encoding the extracellular fragment of MR or active fragments thereof, might also be therapeutically useful.

10 A further aspect of the invention provides a polynucleotide encoding the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation, for use in medicine.

A further aspect of the invention thus provides a method of combating any
15 disease or condition involving unwanted, undesirable or inappropriate endothelial cell migration and/or proliferation in an individual comprising administering a polynucleotide encoding the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation, to the individual.

20

A still further aspect of the invention provides the use of a polynucleotide encoding the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation, in the preparation of a medicament for combating any disease or condition involving unwanted, undesirable or
25 inappropriate endothelial cell migration and/or proliferation.

A yet further aspect of the invention provides an *in vitro* method of inhibiting endothelial cell migration and/or proliferation comprising administering a polynucleotide encoding the MR ectodomain, or a fragment thereof that
30 inhibits endothelial cell migration and/or proliferation, to tissue or cells *in*

vitro. The cells may be established cell lines, or cells that have been removed from an individual. The tissue or cells are preferably mammalian tissue or cells, and most preferably are human tissue or cells.

5 An additional aspect of the invention provides a vector comprising a polynucleotide that encodes the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation. The invention also includes a host cell comprising a polynucleotide that encodes the MR
10 ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation, or a vector comprising such a polynucleotide.

A further aspect of the invention provides a pharmaceutical composition comprising the MR ectodomain, or a fragment thereof that inhibits endothelial cell migration and/or proliferation, or a polynucleotide encoding the MR
15 ectodomain or the fragment thereof, and a pharmaceutically acceptable carrier.

Preferably, the pharmaceutical composition is suitable for intravenous administration to a patient.

20 The preferences for pharmaceutical formulations, routes of administration, vectors, cell lines and so on, are the same in the aspects of the invention directed to inhibiting endothelial cell migration and/or proliferation using the MR ectodomain or a fragment thereof as the preferences described above for the aspects of the invention directed to anti-MR antibodies.

25

We have also shown that the MR ectodomain is sufficient to inhibit formation of vessel sprouts *in vitro* in the aortic ring assay, and *in vivo* in the sponge angiogenesis assay, and would be predicted to be therapeutically useful in the inhibition of angiogenesis. Furthermore, fragments (for example ones made
30 recombinantly or by *de novo* peptide synthesis) of the extracellular region of

MR that show inhibitory activity in the rat aortic ring assay or the sponge angiogenesis assay would also be predicted to be useful in the inhibition of angiogenesis.

5 A further aspect of the invention thus provides a method of inhibiting angiogenesis in an individual in need thereof comprising administering the MR ectodomain, or a fragment thereof that inhibits angiogenesis, to the individual.

10 By "a fragment of the MR ectodomain that inhibits angiogenesis" we include the MR ectodomain that has been truncated or deleted, or a polypeptide comprising at least 450 contiguous amino acid residues of the MR ectodomain, which is sufficient to inhibit angiogenesis. More preferably, a fragment of the ectodomain which is sufficient to inhibit angiogenesis
15 comprises at least 400, or at least 350, or at least 300, or at least 250, or at least 200, or at least 150, or at least 100, or at least 90, or at least 80, or at least 70, or at least 60, or at least 50, or at least 40, or at least 30, or at least 20, or at least 15, or at least 10 contiguous amino acid residues of the MR ectodomain. It is more particularly preferred if the fragment of the ectodomain which is
20 sufficient to inhibit angiogenesis comprises at least 60 contiguous amino acid residues of the MR ectodomain. The inhibition of angiogenesis can be tested, for example, using the aortic ring assay as described in Example 2 or the sponge angiogenesis assay as described in Example 3.

25 In an embodiment, the fragment of the ectodomain which is sufficient to inhibit angiogenesis consists of or comprises the Ig region of MR (residues 46-209, SEQ ID NO: 4).

In another embodiment, the fragment of the ectodomain which is sufficient to
30 inhibit angiogenesis consists of or comprises the IgA domain of MR (residues

46-116, SEQ ID NO: 5) or the IgB domain of MR (residues 151-209, SEQ ID NO: 6).

Another aspect of the invention provides the MR ectodomain, or a fragment
5 thereof that inhibits angiogenesis.

A further aspect of the invention provides the MR ectodomain, or a fragment thereof that inhibits angiogenesis, for use in medicine.

10 A still further aspect of the invention provides the use of the MR ectodomain, or a fragment thereof that inhibits angiogenesis, in the preparation of a medicament for inhibiting angiogenesis.

A yet further aspect of the invention provides an *in vitro* method of inhibiting
15 angiogenesis comprising administering the MR ectodomain, or a fragment thereof that inhibits angiogenesis, to tissue or cells *in vitro*.

Furthermore, it is appreciated that administration of nucleic acid encoding the extracellular fragment of MR or active fragments thereof, would also be a
20 useful mode of anti-angiogenesis therapy.

A further aspect of the invention thus provides a method of inhibiting angiogenesis in an individual in need thereof comprising administering a polynucleotide encoding the MR ectodomain, or a fragment thereof that
25 inhibits angiogenesis.

A further aspect of the invention provides a polynucleotide encoding the MR ectodomain, or a fragment thereof that inhibits angiogenesis, for use in medicine.

A still further aspect of the invention provides the use of a polynucleotide encoding the MR ectodomain, or a fragment thereof that inhibits angiogenesis, in the preparation of a medicament for inhibiting angiogenesis.

5 A yet further aspect of the invention provides an *in vitro* method of inhibiting angiogenesis comprising administering a polynucleotide encoding the MR ectodomain, or a fragment thereof that inhibits angiogenesis, to tissue or cells *in vitro*.

10 An additional aspect of the invention provides a vector comprising a polynucleotide that encodes the MR ectodomain, or a fragment thereof that inhibits angiogenesis.

Another aspect of the invention provides a host cell comprising a
15 polynucleotide that encodes the MR ectodomain, or a fragment thereof that inhibits angiogenesis, or a vector comprising such a polynucleotide.

A further aspect of the invention provides a pharmaceutical composition comprising the MR ectodomain, or a fragment thereof that inhibits
20 angiogenesis, or a polynucleotide encoding the MR ectodomain or the fragment thereof, and a pharmaceutically acceptable carrier.

Preferably, the pharmaceutical composition is suitable for intravenous administration to a patient.

25

The preferences for diseases or conditions to be combated, pharmaceutical formulations, routes of administration, vectors, cell lines and so on, are the same in the aspects of the invention directed to the MR ectodomain, or a fragment thereof that inhibits angiogenesis, as the preferences described above
30 for the aspects of the invention directed to anti-MR antibodies.

5 The listing or discussion of a prior-published document in this specification should not necessarily be taken as an acknowledgement that the document is part of the state of the art or is common general knowledge

The invention will now be described in more detail by reference to the
10 following Examples and Figures.

Figure 1A shows the DNA sequence of the insert used to generate plasmid N1 (SEQ ID NO: 1). Figure 1B shows the amino acid sequence encoded by the insert (SEQ ID NO: 2). This sequence is the full length MR amino acid
15 sequence.

Figure 2A shows the DNA sequence of the insert used to generate plasmid NH10 (SEQ ID NO: 30). Figure 2B shows the amino acid sequence encoded by the insert used for generating plasmid NH10. This sequence is designated
20 as the MR ectodomain and is the amino acid sequence of the entire extracellular fragment of MR (residues 1-467, SEQ ID NO: 3).

Figure 3 shows the amino acid sequence of the Ig region of MR (residues 46-209, SEQ ID NO: 4).

25

Figure 4A shows the amino acid sequence of the IgA domain of MR (residues 46-116, SEQ ID NO: 5). Figure 4B shows the amino acid sequence of the IgB domain of MR (residues 151-209, SEQ ID NO: 5).

30 Figure 5 shows a pictorial representation of the structure of MR.

Figure 6A is a graph and a table showing the effect of the antibody (MR-7) and the soluble extracellular domain of MR (MR Ecto) on formation of new vessels in the aortic ring assay.

5

Figure 6B is a graph and a table showing the effect of the soluble extracellular domain of MR (MR ectodomain, MR Ecto) on formation of new vessels in the aortic ring assay with a human IgG control.

10 Figure 7 shows sprout formation from rat aorta in the presence of antibody or soluble MR extracellular domain. Rat aorta sections were cultured for 5 days in the presence of media alone (A), or in media containing 100 $\mu\text{g/ml}$ MR-7 antibody (B), or 15 $\mu\text{g/ml}$ soluble MR extracellular domain (residues 1-467) (C). Four pictures are shown for each treatment group and are representative
15 of sprouting levels from duplicate aortas.

Figure 8 is a graph and a table showing the effect of the soluble extracellular domain of MR (MR ectodomain) on formation of new blood vessels in the sponge angiogenesis assay.

20

Figure 9A is a graph and a table showing that the vascular endothelial growth factor (VEGF) induced migration of primary human endothelial cells is inhibited by the MR extracellular domain.

25 Figure 9B is a graph and a table showing that the basic fibroblast growth factor (bFGF) induced migration of primary human endothelial cells is inhibited by the MR extracellular domain.

Figure 10 is a graph and a table showing that the MR ectodomain (Robo4-Fc) inhibits proliferation of primary human endothelial cells.

Example 1: Preparation of antibodies

5

The cDNA constructs that were used were as described in Table 2:

Table 2

Full length MR cDNA	Figure 1
MR ectodomain-Fc	Figure 2
MR IgA+B-Fc	Figure 3
MR IgA-Fc	Figure 4

10 “Fc” refers to the Fc region of the pIG vector. It is human IgG constant domains hinge, CH1, CH2, within the ends of the vector (multiple cloning site and splice acceptor region included). The nucleotide sequence of the vector is:

AAGCTTGATATCGAATTCTGCAGCCCGGGGGATCCGGAGGGAGGG
 15 TGTCTGCTGGAAGCAGGCTCAGCGCTCCTGCCTGGACGCATCCCGG
 CTATGCAGCCCCAGTCCAGGGCAGCAAGGCAGGCCCCGTCTGCCTC
 TTCACCCGGAGGCCTCTGCCCCGCCCCACTCATGCTCAGGGAGAGGG
 TCTTCTGGCTTTTTCCCCAGGCTCTGGGCAGGCACAGGCTAGGTGC
 CCCTAACCCAGGCCCTGCACACAAAGGGGCAGGTGCTGGGCTCAG
 20 ACCTGCCAAGAGCCATATCCGGGAGGACCCTGCCCCTGACCTAAGC
 CCACCCCAAAGGCCAAACTCTCCACTCCCTCAGCTCGGACACCTTC
 TCTCCTCCCAGATTCCAGTAACTCCCAATCTTCTCTCTGCAGAGCCC
 AAATCTTGTGACAAAACCTCACACATGCCACCGTGCCCAGGTAAGC
 CAGCCCAGGCCTCGCCCTCCAGCTCAAGGCGGGACAGGTGCCCTA

GAGTAGCCTGCATCCAGGGACAGGCCCCAGCCGGGTGCTGACACG
TCCACCTCCATCTCTTCCTCAGCACCTCAACTCCTGGGGGGACCGTC
AGTCTTCCTCTTCCCCC AAAACCCAAGGACACCCTCATGATCTCC
CGGACCCCTGAGGTCACATGCGTGGTGGTGGACGTGAGCCACGAA
5 GACCCTGAGGTCAAGTTCAACTGGTACGTGGACGGCGTGGAGGTG
CATAATGCCAAGACAAAGCCGCGGGAGGAGCAGTACAACAGCACG
TACCGGGTGGTCAGCGTCCTCACCGTCCTGCACCAGGACTGGCTGA
ATGGCAAGGAGTACAAGTGCAAGGTCTCCAACAAAGCCCTCCCAG
CCCCATCGAGAAAACCATCTCCAAGCCAAAGGTGGGACCCGTG
10 GGGTGCGAGGGCCACATGGACAGAGGCCGGCTCGGCCACCCTCT
GCCCTGAGAGTGACCGCTGTACCAACCTCTGTCCTACAGGGCAGCC
CCGAGAACCACAGGTGTACACCCTGCCCCCATCCCGCCATGACCTG
ACCAAGAACCAGGTCAGCCTGACCTGCCTGGTCAAAGGCTTCTATC
CCAGCGACATCGCCGTGGAGTGGGAGAGCAATGGGCAGCCGGAGA
15 ACAACTACAAGACCACGCCTCCCGTGCTGGACTCCGACGGCTCCTT
CTTCCTCTACAGCAAGCTCACCGTGGACAAGAGCAGGTGGCAGCA
GGGGAACGTCTTCTCATGCTCCGTGATGCATGAGGCTCTGCACAAC
CACTACACGCAGAAGAGCCTCTCCCTGTCTCCGGGTAAATGAGTGC
GACGGCCGGCAAGCCCCGCTCCCCGGGCTCTCGCGGTTCGCACGACC
20 ATGCTTGGCACGTACCCCCTGTACATACTTCCCGGGCGCCCAGCAT
GGAAATAAAGCACCCAGCGCTGCCCTGGGCCCCTGCGAGACTGTG
ATGGTTCTTCCACGGGTCACCCCGAGTCTGAGGCCTGAGTGGCAT
GAGGGAGGCAGCGGCCGCGACTCTAG (SEQ ID NO: 31).

25 Generation of plasmid vectors N1 and NH10 for generation of anti-MR antibodies using genetic immunisation was carried out as follows. The plasmid vectors N1 and NH10, encoding N1 (membrane bound) and NH10 (soluble), were generated as follows:

N1 was generated by removal of the full length MR pBluescript KS+ by a *NotI* digest. The product was cleaned from a gel and ligated into pcDNA3 (which had been digested with *NotI*).

5 NH10 was generated by amplifying the extracellular domain of MR using primers which incorporated a 5' *HinDIII* site and a 3' *NotI* site. This was ligated into a pcDNA3 vector which had been digested with the same enzymes.

10 Genetic immunisation of mice to generate anti-MR antibodies was carried out as follows:

The constructs N1 and NH10 were used to immunise mice from three different genetic background according to the method reported in (Boyle, J.S., A. Silva,
15 *et al* (1997) "DNA immunization: induction of higher avidity antibody and effect of route on T cell cytotoxicity." *Proc Natl Acad Sci USA* 94(26): 14626-31). The mice were immunised with an intramuscular injection of 100µg of endotoxin free plasmid once every two weeks. Following the immunisation with the DNA constructs, the mice were each injected with 200µl of purified
20 MR ectodomain intravenously as a final boost before harvesting the spleen for generating the hybridomas. Three different genetic strains of mice were tested for their ability to generate suitable immune response to genetic immunisation, as shown in Table 3.

Table 3

Group	Immunisation with N1	Immunisation with NH10
Group B – Balb/c mice	B1-B5	B6-B10
Group C – C57B1 mice	C1-C5	C6-C10
Group M – MFI outbred mice	M1-M5	M6-M10

The schedule for immunisation is shown in Table 4.

5 Table 4

	<u>Day</u>
Pre Bleed	-2
1 st Immunisation I/M	0
2 nd Immunisation I/M	14
3 rd Immunisation I/M	28
Test Bleed	35
I/V boost with cells or protein 200µl of 129µg/ml purified ECSM4 protein I/V in PBSa	59
Sacrifice the mice and remove spleens for fusion.	63

During the course of immunisation, the test bleed were assayed for anti-MR antibodies using the following capture ELISA. This ELISA is a robust and flexible assay which can be used to measure level of fusion protein in supernatant or presence/level of antibody to the fusion protein in hybridoma supernatant. It is very sensitive, detecting human IgG in the range 0.001 to

0.5 μ g/ml. It has a low background, typically in the region of OD405 = 0.07. In comparison, neat hybridoma supernatants in this system (MR-pIG) give positive results of OD405 > 1.0 (and in some cases >2.0).

5 Summary of ELISA method

Coat plate with 5 μ g/ml goat anti-human IgG Fc-specific; block with 1% BSA in PBS; add fusion protein supernatant or human IgG control; add detection antibody or goat anti human alkaline phosphatase conjugate; add secondary conjugate if unconjugated detection antibody used; add pNPP substrate; stop
10 with 3M NaOH after 20-30 min.

Detailed protocol for capture ELISA for pIG fusion proteins

- (1) Coat plate with 2 to 5 μ g/ml goat-anti-human IgG (Fc-specific) purified unconjugated antibody diluted in PBS, e.g. Sigma I-2136. 50 μ l/well, tap plate
15 gently to ensure even coverage of base of wells.
- (2) Incubate overnight at +4°C. Plates can be stored like this for at least a week, as long as they are kept in a humidified container to prevent drying out.
- (3) Wash 3x with PBS-Tween™ 20 (0.04% Tween™ 20) by flooding plate and tapping dry on tissue paper each time.
- 20 (4) Block with 1% BSA in PBS, 200 μ l/well. Incubate at room temperature for 1-2 hours, or overnight at +4°C. Plates can be stored blocked at +4°C, as for point (2) above.
- (5) Repeat wash step (step 3).
- (6) Coat plate with the fusion protein supernatant e.g. MR-ecto-pIG.
25 Supernatant containing 0.5 to 1.0 μ g/ml fusion protein gives a very strong result, so there is no need to purify or concentrate. Incubate 1 hour at room temperature. Human IgG can be used instead of supernatant as a positive control for detecting the Fc domain and titrated for quantifying the amount of NABA-pIG fusion protein present in the supernatant.
- 30 (7) Repeat wash step (step 3)

(8) Detect the pIG domain using goat anti-human IgG-alkaline phosphatase conjugate, 1/5000 dilution in PBS (positive control), or mouse serum from test bleed, various dilutions in PBS (1/10 to 1/1000). Incubate 1 hour at room temperature. This is followed by an additional step of a secondary conjugate
5 (anti-mouse-alkaline phosphatase). Incubate for a further 1 hour at room temperature.

(9) Repeat wash step (step 3). (Also between use of detection antibody and secondary conjugate, if alternative method used)

(10) Measure colour change using Sigma pNPP substrate made up from
10 tablets, 50µl/well. Incubate for 20-30 min. in the dark then stop the reaction by the addition of 50µl/well 3M NaOH. Read the colour change at 405nm.

Anti-MR antibodies were generated as follows: The spleens harvested from the above mentioned immunised mice were fused to NSO cells. The resulting
15 hybridomas were tested for their ability generate antibodies that recognise MR using ELISA. Of the antibodies identified, one was chosen for further studies – MR7.

The MR7 antibody was characterised as follows:

20 MR7 was tested for its ability to recognise various domains of MR using ELISA. It was found that MR7 recognises the MR IgA domain. The DNA sequence encoding the Complementary Determining Regions (CDRs) of MR7 was determined by PCR amplification and standard sequencing techniques using the primers shown below.

25

Primers

A mixture of eleven 5' primers (listed in Table 5) was used to amplify the kappa chain CDRs.

Table 5

Primer	Sequence
MKV1	ACTAGTCGACATGAAGTTGCCTGTTAGGCTGTTGGTGCTG (SEQ ID NO: 32)
MKV2	ACTAGTCGACATGGAGWCAGACACACTCCTGYTATGGGT (SEQ ID NO: 33)
MKV3	ACTAGTCGACATGAGTGTGGCTCACTCAGGTCCTGGSGTTG (SEQ ID NO: 34)
MKV4	ACTAGTCGACATGAGGRCCCCTGCTCAGWTTYTTGGMWTCT TG (SEQ ID NO: 35)
MKV5	ACTAGTCGACATGGATTTWCAGGTGCAGATTWTCAGCTTC (SEQ ID NO: 36)
MKV6	ACTAGTCGACATGAGGTKCCYTG YTCAGYTYCTGRGG (SEQ ID NO: 37)
MKV7	ACTAGTCGACATGGGCWTCAAGATGGAGTCACAKWYYCWG G (SEQ ID NO: 38)
MKV8	ACTAGTCGACATGTGGGGAYCTTKTTYAMMTTTTCAATTG (SEQ ID NO: 39)
MKV9	ACTAGTCGACATGGTRTCCWCASCTCAGTTCCTTG (SEQ ID NO: 40)
MKV10	ACTAGTCGACATGTATATATGTTTGTGTCTATTTCT (SEQ ID NO: 41)
MKV11	ACTAGTCGACATGGAAGCCCCATGCTCAGCTTCTCTTCC (SEQ ID NO: 42)

The primer sequence which amplified the MR7 kappa chain 5' end was MK5

The sequence of the 3' primer was GTTTGATCTAGAGCTTGGTCCC (SEQ
 5 ID NO: 43) which amplifies from after CDR3 and adds an *Xba*I restriction site
 on the end of the product if you need to clone the product. The same product
 was also produced when the 5' mix was used with the 3' constant region
 primer TTGGAGGGCGTTATCCACCT (SEQ ID NO: 44).

10 Heavy chain primers

The 5' primer was:

ATCGGATCCAGGTSMARCTGCAGSAGTCWGG (SEQ ID NO: 45),

and the 3' primer was:

15 CTCGAATTCTGAGGAGACGGTGACCGTGGTCCCTTGGCCCC (SEQ
 ID NO: 46).

The redundancy code for these primers is shown in Table 6.

Table 6: IUB ambiguity code

<u>Nucleotides</u>	<u>Code</u>	
A+C	M	aMino
A+G	R	puRine
A+T	W	Weak
C+G	S	Strong
C+T	Y	pYrimidine
G+T	K	Keto
A+G+C	V	not T

A+C+T	H	not G
A+G+T	D	not C
C+G+T	B	not A
A+G+C+T	N	aNy

MR7 Sequence

The amino acid sequence of the light and heavy V regions of MR7 antibody is given below. The CDRs are underlined.

5

MR7 kappa V region:

Q I V L T Q S P A L M S A S P G E K V T M T C S A S S S
V S Y M Y W Y Q Q K P R S S P K P W I Y L T S N L A S
 G V P A R F S G S G S G T S Y S L T I S S M E A E D A A
 10 T Y Y C Q Q W S S N P L T F G A G T K L E L K (SEQ ID
 NO: 12).

MR7 heavy V region:

Q V K/Q L Q E S G P E L V K P G A S V K I S C K A S G
 15 Y S L T D Y N L N W V K Q N K G K S L E W I G V I N P
N Y G T T S Y N Q K F K G K A T L T V D Q S S S T T Y
 M Q L N S L T S E D S A V Y Y C A R G R D Y F G Y W
 G Q G T T V T V S S (SEQ ID NOs: 16-17),

20 The nucleotide sequence encoding the light and heavy V regions of MR7 antibody. The CDRs are underlined.

MR7 kappa V region:

CAA,ATT,GTT,CTC,ACC,CAG,TCT,CCA,GCA,CTC,ATG,TCT,GCA,TCT,
 CCA,GGG,GAG,AAG,GTC,ACC,ATG,ACC,TGC,AGT,GCC,AGC,TCA.A
GT,GTA,AGT,TAC,ATG,TAC,TGG,TAC,CAG,CAG,AAG,CCA,AGA,TCC
 ,TCC,CCC,AAA,CCC,TGG,ATT,TAT,CTC,ACA,TCC,AAC,CTG,GCT,TCT
 5 GGA,GTC,CCT,GCT,CGC,TTC,AGT,GGC,AGT,GGG,TCT,GGG,ACC,TC
 T,TAC,TCT,CTC,ACA,ATC,AGC,AGC,ATG,GAG,GCT,GAA,GAT,GCT,G
 CC,ACT,TAT,TAC,TGC,CAG,CAG,TGG,AGT,AGT,AAC,CCA,CTC,ACG,
 TTC,GGT,GCT,GGG,ACC,AAG,CTG,GAG,CTG,AAA (SEQ ID NO: 21).

10 MR7 heavy V region:

CAG,GTC,AAG(orA/CAA),CTG,CAG,GAG,TCA,GGA,CCT,GAG,CTG,GT
 G,AAG,CCT,GGC,GCT,TCA,GTG,AAG,ATA,TCC,TGC,AAG,GCT,TCT,G
 GT,TAC,TCA,CTC,ACT,GAC,TAC,AAC,CTG,AAC,TGG,GTG,AAG,CAG,
 AAC,AAA,GGA,AAG,AGC,CTT,GAG,TGG,ATT,GGA,GTA,ATT,AAT,C
 15 CA,AAC,TAT,GGT,ACT,AGT,TAC,AAT,CAG,AAG,TTC,AAG,GGC,AAG
 ,GCC,ACA,TTG,ACT,GTA,GAC,CAA,TCT,TCC,AGC,ACA,ACC,TAC,AT
 G,CAG,CTC,AAC,AGC,CTG,ACA,TCT,GAG,GAC,TCT,GCA,GTC,TAT,T
 AC,TGT,GCA,AGA,GGG,AGG,GAT,TAC,TTC,GGC,TAC,TGG,GGC,CAA
 ,GGG,ACC,ACG,GTC,ACC,GTC,TCC,TCA (SEQ ID NOS: 25-27).

20

**Example 2: The antibody MR7 and the MR ectodomain (extracellular
 fragment of MR residues 1-467) inhibit formation of vessel sprouts in the
 aortic ring assay**

25 Summary

The role of MR in angiogenesis was investigated using the rat aortic ring
 assay. Segments of rat aorta were embedded in MatrigelTM and treated with
 either antibody MR7 or purified MR ectodomain protein. The sprouting
 vessels were allowed to develop over five day before scoring by three
 30 independent observers. The averaged scores over 20-25 separate experiments

are shown in Figures 6A and 6B. Inter-scorer reliability was assessed using the method of Landis and Koch. The weighted kappa values calculated were 0.96 for MR7 and 0.93 for MR ectodomain. These kappa values show that there was a high degree of consistency between independent scorers.

5

Methods

Aortas were harvested from 200g - 300g rats (6-8 weeks old) and immediately placed in MCDB 131 media. Connective tissue was removed and aortas cut into 1 mm - 1.5 mm rings. 48-well plates were coated with 110 μ l of Matrigel (BD Biosciences) diluted 1:1 with PBS and allowed to gel at 37°C for 30 min. The rings were placed in the wells and sealed in place with an overlay of 40 μ l of Matrigel. Antibodies (100 μ g/ml) or MR ectodomain (soluble robo4 extracellular domain) (15 μ g/ml) were added to wells in a final volume of 250 μ l of MCDB 131 media containing 20% foetal bovine serum and 50 μ g/ml endothelial cell growth supplement. Media was changed after two days and aortas analysed and photographed after five days.

10

15

Results

Representative photomicrographs of segments of the aortic rings are shown in Figure 7 A-C. As the figure shows, treatment of the aortic rings with either MR7 or MR ectodomain resulted in significant decrease in sprouting of vessels from the aortic segment.

20

Statistical Analysis of aortic ring assay

Aortic rings were scored according to the vessel growth on a scale of 0 (low) to 4 (high) as follows: 0 = no growth, 1 = few vessels, 2 = intermediate vessels, 3 = many vessels but sporadic sprouting centres around the ring and 4 = many vessels sprouting from all regions of the ring.

25

All experiments were scored blind by three independent researchers. Inter-scorer reliability was assessed using the method of Landis and Koch (*Biometrics*, 1977, **33(1)**, 159-174). Weighted kappa was calculated in order to establish the inter-rater reliability of the examiners. Weighted kappa is
 5 given by:

$$k_w = \frac{p_{o(w)} - p_{e(w)}}{1 - p_{e(w)}}$$

where $p_{o(w)}$ and $p_{e(w)}$ are the weighted observed and expected agreement calculated with the formulas:

$$p_{o(w)} = \frac{1}{n} \sum_{i=1}^g \sum_{j=1}^g w_{ij} f_{ij}$$

$$10 \quad p_{e(w)} = \frac{1}{n^2} \sum_{i=1}^g \sum_{j=1}^g w_{ij} r_i c_j$$

The i represents the category for one examiner and j represent the category for the second examiner. The r_i represents the grand total of cases in category i for one examiner, and c_j represents the grand total of cases in category j for the other examiner.

15

The difference between the categories considered to be 1, therefore with the introduction of the new categories for the description of the additional transition categories the difference to one category to another was considered to be 0.5 points. The total number of categories therefore $g = 9$. The number
 20 of cases is $n = 80$.

The weight w_{ij} for the observed frequency f_{ij} of cases which were in category i by one examiner and in category j for the second examiner is calculated as:

$$w_{ij} = 1 - \frac{|i - j|}{g - 1}$$

25

The strength of the agreement was regarded as poor if the Kappa statistics was < 0.00, slight for values 0.00-0.20, fair for 0.21-0.40, moderate for 0.41-0.60, substantial for 0.61-0.80 and high for 0.81-1.00.

5 The data was then collated together and analysed by ANOVA and the Kruskal Wallis method. The resulting p values show a highly significant difference between the control group and those treated with either MR7 or the ectodomain.

10 Example 3: The MR ectodomain (extracellular fragment of MR residues 1-467) inhibits formation of vessel sprouts *in vivo*.

The ability of the MR ectodomain to inhibit angiogenesis *in vivo* was tested using a sponge angiogenesis assay (Hori Y. *et al* (1996) "Differential effects
15 of angiostatic steroids and dexamethasone on angiogenesis and cytokine levels in rat sponge implants" *Br. J. Pharmacol.* 118(7): 1584-1591) performed on female C57 black mice. All mice received a subcutaneous sterile polyether sponge (type 611-9) disc (15 x 5 x 5 mm) under the dorsal skin at day 0. Test reagents were injected through the skin directly into the sponges every second
20 day for 21 days (100 µl injection volume). Groups of 2 mice received either PBS control; 10 ng/ml basic fibroblast growth factor (bFGF); or 10 ng/ml bFGF + 100 µg/ml MR ectodomain. Animals were scarified on day 21 and sponges were removed, fixed in 3.7% paraformaldehyde and paraffin embedded. 5 micron sections were stained with haematoxylin and eosin and
25 digital photos taken using a Zeiss Axioskop 2 *plus*TM microscope with an AxiocamTM digital camera at 20x magnification. The number of vessels invading the sponges were counted as a measure of angiogenesis.

There were clear differences between the sponges from the mice who were injected with bFGF alone (controls) and those who were injected with both bFGF and the MR ectodomain. The differences were:

- a) significantly fewer vessel numbers in the MR ectodomain treated sponges compared to control (Figure 8; $p=0.0014$ using the Student t-test);
- b) an absence of very large vessels from the MR ectodomain treated sponges; and
- c) much lower fibroblast cell density in the MR ectodomain treated sponges.

Example 4: The MR ectodomain (extracellular fragment of MR residues 1-467) inhibits migration of primary human vascular endothelial cells.

A primary human vascular endothelial cell (HUVEC) migration assay was performed using the BD BioCoat™ Angiogenesis System for Endothelial Cell Migration which is available as Catalog No. 354143 from BD Biosciences, Bedford, MA, USA. This system uses a 24-multiwell insert system and consists of a BD Falcon FluoroBlok PET membrane with 3 micron pore size coated uniformly on the top side with fibronectin. Quantitation of cell migration is achieved by post-labelling of cells with the fluorescent dye Calcein AM and measuring the fluorescence of migrating cells in a fluorescence plate reader. The FluoroBlok™ membrane effectively blocks the passage of light from 490-700 nm at >99% efficiency meaning labelled cells that have not migrated are blocked from detection.

The upper chamber was seeded with 50,000 HUVEC/well in MCDB 131 medium supplemented with 1% heat-inactivated foetal calf serum (FCS). The bottom chambers were loaded with or without bFGF (5 ng/ml), VEGF (10 ng/ml) and MR ectodomain (100 µg/ml) in 750 µl of MCDB 131 + 1% FCS.

5 After 22 hr incubation at 37°C the insert membranes were stained with 4 µg/ml Calcein AM (Molecular Probes) in Hanks Balanced Salt Solution (HBSS) for 90 min. Fluorescence on the bottom side of the membrane was measured at excitation/emission wavelengths of 485/530 nm. Images were taken using a Zeiss Axiovert 135TM microscope with an AxioCam digital camera

10 at 10x magnification.

Both bFGF and VEGF are known to stimulate migration of endothelial cells (Cross & Claesson-Welsh, 2001 *Trends Pharmacol Sci.* 22(4): 201-207). As shown in Figures 9A and 9B, the MR ectodomain was shown to significantly

15 inhibit migration of HUVEC cells induced by either bFGF or VEGF.

Example 5: The MR ectodomain (extracellular fragment of MR residues 1-467) inhibits endothelial cell proliferation.

20 5×10^4 primary human vascular endothelial cells (HUVEC) were seeded per well of a 6-well plate in 1.5 ml full growth media containing treatment (6.25, 12.5, 25, 50 or 100 µg/ml of the MR ectodomain (Robo4-Fc) or 100 µg/ml human IgG), or no treatment as a control. After four days incubation at 37°C, the cells were washed in PBS and detached from the wells by addition of 1 ml

25 trypsin solution. After all the cells had detached, 400 µl of the cell suspension was transferred to 19.6 ml IsotonTM buffer (Beckman Coulter), and the number of cells in each sample was determined in a Coulter Particle Count and Size Analyser (Beckman Coulter). The experiment was carried out in triplicate, and replicated three times.

As shown in Figure 10, incubation in the presence of 12.5 µg/ml MR ectodomain decreased proliferation of the HUVEC cells to about 75% of the control levels, and higher concentrations of MR ectodomain had an increasingly strong anti-proliferative effect.

Example 6: Treatment of a patient exhibiting undesirable angiogenesis by administering an antibody that specifically binds to the extracellular region of MR

10

A patient exhibiting undesirable angiogenesis is treated with intravenous infusions of saline solutions of a pharmaceutical composition comprising an antibody that specifically binds to the extracellular region of MR. The infusions are administered weekly for a time of 3 to 6 months.

15

Example 7: Treatment of a patient exhibiting undesirable angiogenesis by administering the extracellular region of MR

A patient exhibiting undesirable angiogenesis is treated with intravenous infusions of saline solutions of a pharmaceutical composition comprising the MR ectodomain. The infusions are administered weekly, typically for 3 to 6 months.

20

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tcctccccca aaccctggat ttatctcaca tccaacctgg cttctggagt ccctgctcgc 180

ttcagtggca gtgggtctgg gacctttac tctctcacia tcagcagcat ggaggctgaa 240

gatgctgcca cttattactg ccagcagtgg agtagtaacc cactcacggt cggtgctggg 300

accaagctgg agctgaaa

318

110

<210> 22

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<223> Polynucleotide encoding MR7 Ab CDR

<400> 22

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15

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48

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tcttgcaagg cttctggtta ctcaactcact gactacaacc tgaactgggt gaagcagaac 120

aaaggaaaga gccttgagtg gattggagta attaatccaa actatggtag tagttacaat 180

cagaagttca agggcaaggc cacattgact gtagaccaat cttccagcac aacctacatg 240

cagctcaaca gcctgacatc tgaggactct gcagtctatt actgtgcaag agggagggat 300

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112

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<220>

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<400> 26

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tcctgcaagg cttctgggta ctcactcact gactacaacc tgaactgggt gaagcagaac 120

aaaggaaaga gccttgagtg gattggagta attaatccaa actatggtac tagttacaat 180

cagaagttca agggcaaggc cacattgact gtagaccaat cttccagcac aacctacatg 240

cagctcaaca gcctgacatc tgaggactct gcagtctatt actgtgcaag agggagggat 300

tacttcggct actggggcca agggaccacg gtcaccgtct cctca 345

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<400> 27

113

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 aaaggaaaga gccttgagtg gattggagta attaatccaa actatgggtac tagttacaat 180
 cagaagttca agggcaaggc cacattgact gtagaccaat cttccagcac aacctacatg 240
 cagctcaaca gcctgacatc tgaggactct gcagtctatt actgtgcaag agggagggat 300
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<213> Homo sapiens

<400> 28

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1

5

10

15

Ser Thr Asp Leu

20

<210> 29

114

<211> 17

<212> PRT

<213> Homo sapiens

<400> 29

Leu Ser Gln Ser Pro Gly Ala Val Pro Gln Ala Leu Val Ala Trp Arg

1

5

10

15

Ala

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tggtcagga ctccccgcc cagatcctag tccaccccca ggaccagctg ttccagggcc 180

ctggcctgc caggatgagc tgccaagcct caggccagcc acctcccacc atccgctggt 240

tgctgaatgg gcagcccctg agcatggtgc ccccagacct acaccacctc ctgcctgatg 300

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ccacagacct ggggtgtctac acatgtgagg ccagcaaccg gcttggcacg gcagtcagca 420

gaggcgctcg gctgtctgtg gctgtcctcc gggaggattt ccagatccag cctcgggaca 480

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cagtgctcgg ggggtccctg ctgatggcaa gagcagagaa gagtgacgaa gggacctaca 660

tgtgtgtggc caccaacagc gcaggacata gggagagccg cgcagcccgg gtttccatcc 720

aggagcccca ggactacacg gagcctgtgg agcttctggc tgtgcgaatt cagctggaaa 780

atgtgacact gctgaaccgg gatcctgcag agggcccaaa gcctagaccg gcggtgtggc 840

tcagctggaa ggtcagtggc cctgctgcgc ctgcccaatc ttacacggcc ttgttcagga 900

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116

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gggtcttctg gctttttccc caggctctgg gcaggcacag gctaggtgcc cctaaccag 240

gccctgcaca caaaggggca ggtgctgggc tcagacctgc caagagccat atccgggagg 300

accctgcccc tgacctaaagc ccaccccaaa ggccaaactc tccactccct cagctcggac 360

accttctctc ctcccagatt ccagtaactc ccaatcttct ctctgcagag cccaaatctt 420

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ttcctcttcc ccccaaaacc caaggacacc ctcatgatct ccgggacccc tgaggtcaca 660

tgcgtgggtg tggacgtgag ccacgaagac cctgagggtca agttcaactg gtacgtggac 720

ggcgtggagg tgcataatgc caagacaaag ccgcgggagg agcagtacaa cagcacgtac 780

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cctgagagtg accgctgtac caacctctgt cctacagggc agccccgaga accacaggtg 1020

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118

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<210> 32

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<223> Kappa light chain 5' oligonucleotide primer

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<210> 33

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41

<210> 36

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40

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<400> 37

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37

121

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41

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35

<210> 41

<211> 37

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<400> 41

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37

<210> 42

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<223> Kappa light chain 5' oligonucleotide primer

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123

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<223> Kappa light chain 3' oligonucleotide primer

<400> 43

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22

<210> 44

<211> 20

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<223> Kappa light chain constant region 3' oligonucleotide primer

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20

<210> 45

<211> 31

<212> DNA

124

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<223> Heavy chain 5' primer

<400> 45

atcggatcca ggtsmarctg cagsagtcwg g

31

<210> 46

<211> 41

<212> DNA

<213> Artificial

<220>

<223> Heavy chain 3' primer

<400> 46

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41

CLAIMS

1. Use of an antibody that selectively binds to the IgA region (residues 46-116, SEQ ID NO: 5) of human magic roundabout (MR) for inhibiting
5 angiogenesis.

2. An *in vitro* method of inhibiting angiogenesis comprising administering an antibody that selectively binds to the IgA region (residues 46-116, SEQ ID NO: 5) of human magic roundabout (MR) to tissue or cells *in vitro*.

10

3. A method or a use according to Claim 1 or 2 wherein the antibody has a light chain variable region incorporating the following CDRs:

CDR1: S A S S S V S Y M Y (SEQ ID NO: 9),

CDR2: L T S N L A S (SEQ ID NO: 10), and

15 CDR3: Q Q W S S N P L T (SEQ ID NO: 11),

and a heavy chain variable region incorporating the following CDRs:

CDR1: D Y N L N (SEQ ID NO: 13),

CDR2: V I N P N Y G T T S Y N Q K F K G (SEQ ID NO: 14), and

CDR3: G R D Y F G Y (SEQ ID NO: 15).

20

4. A method or a use according to Claim 3 wherein the antibody has a light chain variable region comprising the amino acid sequence Q I V L T Q S P A L M S A S P G E K V T M T C S A S S S V S Y M Y W Y Q Q K P R S S P K P W I Y L T S N L A S G V P A R F S G S G S G T S Y S L T I S S M E A E D A A T
25 Y Y C Q Q W S S N P L T F G A G T K L E L K (SEQ ID NO: 12).

5. A method or a use according to Claim 3 wherein the antibody has a heavy chain variable region comprising the amino acid sequence Q V K/Q L Q E S G P E L V K P G A S V K I S C K A S G Y S L T D Y N L N W V K Q N K G
30 K S L E W I G V I N P N Y G T T S Y N Q K F K G K A T L T V D Q S S S T T Y M Q L N S L T S E D S A V Y Y C A R G R D Y F G Y W G Q G T T V T V S S (SEQ ID NOs: 16-17).

6. A method or a use according to Claim 1 or 2 wherein the antibody has a light chain variable region as defined in Claim 4 and a heavy chain variable region as defined in Claim 5.
- 5 7. Use of a polynucleotide encoding an antibody as defined in any one of Claims 1 to 6 for inhibiting angiogenesis.
8. An *in vitro* method of inhibiting angiogenesis comprising administering a polynucleotide encoding an antibody as defined in any one of Claims 1 to 6 to
10 tissue or cells *in vitro*.
9. An antibody that selectively binds to the IgA region (residues 46-116, SEQ ID NO: 5) of human magic roundabout (MR) having a light chain variable region that contains the following CDR sequences:
15 CDR1: S A S S S V S Y M Y (SEQ ID NO: 9),
CDR2: L T S N L A S (SEQ ID NO: 10), and
CDR3: Q Q W S S N P L T (SEQ ID NO: 11),
and a heavy chain variable region that contains the following CDR sequences:
CDR1: D Y N L N (SEQ ID NO: 13),
20 CDR1: V I N P N Y G T T S Y N Q K F K G (SEQ ID NO: 14), and
CDR1: G R D Y F G Y (SEQ ID NO: 15).
10. An antibody according to Claim 9 having a light chain variable region comprising the amino acid sequence Q I V L T Q S P A L M S A S P G E K V T
25 M T C S A S S S V S Y M Y W Y Q Q K P R S S P K P W I Y L T S N L A S G
V P A R F S G S G S G T S Y S L T I S S M E A E D A A T Y Y C Q Q W S S N
P L T F G A G T K L E L K (SEQ ID NO: 12).
11. An antibody according to Claim 9 having a heavy chain variable region
30 comprising the amino acid sequence Q V K / Q L Q E S G P E L V K P G A S V
K I S C K A S G Y S L T D Y N L N W V K Q N K G K S L E W I G V I N P N Y
G T T S Y N Q K F K G K A T L T V D Q S S S T T Y M Q L N S L T S E D S A
V Y Y C A R G R D Y F G Y W G Q G T T V T V S S (SEQ ID NOs: 16-17).

12. An antibody according to Claim 9 having a light chain variable region according to Claim 10 and a heavy chain variable region according to Claim 11.
- 5 13. An antibody that selectively binds to the magic roundabout (MR) epitope bound by an antibody having a light chain variable region according to Claim 10 and a heavy chain variable region according to Claim 11.
14. A polynucleotide encoding an antibody according to any one of Claims 9
10 to 13.
15. A polynucleotide according to Claim 14 comprising the following nucleotide sequences:
- i) AGT GCC AGC TCA AGT GTA AGT TAC ATG TAC (SEQ ID NO: 18),
15 ii) TCT CAC ATC CAA CCT GGC TTC T (SEQ ID NO: 19),
iii) CAG CAG TGG AGT AGT AAC CCA CTC ACG (SEQ ID NO: 20),
iv) GAC TAC AAC CTG AAC (SEQ ID NO: 22),
v) GTA ATT AAT CCA AAC TAT GGT ACT AGT TAC AAT CAG AAG TTC
AAG GGC (SEQ ID NO: 23), and
20 vi) GGG AGG GAT TAC TTC GGC TAC (SEQ ID NO: 24).
16. A polynucleotide according to Claim 14 or 15 comprising the nucleotide sequence CAA ATT GTT CTC ACC CAG TCT CCA GCA CTC ATG TCT GCA
TCT CCA GGG GAG AAG GTC ACC ATG ACC TGC AGT GCC AGC TCA
25 AGT GTA AGT TAC ATG TAC TGG TAC CAG CAG AAG CCA AGA TCC TCC
CCC AAA CCC TGG ATT TAT CTC ACA TCC AAC CTG GCT TCT GGA GTC
CCT GCT CGC TTC AGT GGC AGT GGG TCT GGG ACC TCT TAC TCT
CTC ACA ATC AGC AGC ATG GAG GCT GAA GAT GCT GCC ACT TAT TAC
TGC CAG CAG TGG AGT AGT AAC CCA CTC ACG TTC GGT GCT GGG
30 ACC AAG CTG GAG CTG AAA (SEQ ID NO: 21).
17. A polynucleotide according to Claim 14 or 15 comprising the nucleotide sequence CAG GTC AAG(or A/CAA) CTG CAG GAG TCA GGA CCT GAG

CTG GTG AAG CCT GGC GCT TCA GTG AAG ATA TCC TGC AAG GCT
TCT GGT TAC TCA CTC ACT GAC TAC AAC CTG AAC TGG GTG AAG CAG
AAC AAA GGA AAG AGC CTT GAG TGG ATT GGA GTA ATT AAT CCA AAC
TAT GGT ACT AGT TAC AAT CAG AAG TTC AAG GGC AAG GCC ACA TTG
5 ACT GTA GAC CAA TCT TCC AGC ACA ACC TAC ATG CAG CTC AAC AGC
CTG ACA TCT GAG GAC TCT GCA GTC TAT TAC TGT GCA AGA GGG
AGG GAT TAC TTC GGC TAC TGG GGC CAA GGG ACC ACG GTC ACC
GTC TCC TCA (SEQ ID NOs: 25-27).

10 18. A polynucleotide according to Claim 14 or 15 comprising the nucleotide
sequence as defined in Claim 16 and the nucleotide sequence as defined in
Claim 17.

15 19. An antibody that selectively binds the IgA region (residues 46-116, SEQ
ID NO: 5) of human magic roundabout (MR) but does not selectively bind to the
peptide LLQPPARGHAHDGQALSTDL (SEQ ID NO: 28).

20 20. A compound comprising an antibody according to any one of Claims 9 to
13 and a directly or indirectly cytotoxic moiety.

21. A compound comprising an antibody according to Claim 19 and a
directly or indirectly cytotoxic moiety.

25 22. A compound according to Claim 20 or 21 wherein the cytotoxic moiety is
selected from a directly cytotoxic chemotherapeutic agent, a directly cytotoxic
polypeptide, a moiety which is able to convert a relatively non-toxic prodrug into
a cytotoxic drug, a radiosensitizer, a directly cytotoxic nucleic acid, a nucleic
acid molecule that encodes a directly or indirectly cytotoxic polypeptide, a
nucleic acid molecule that encodes a therapeutic polypeptide, and a radioactive
30 atom.

23. A compound according to Claim 22 wherein the radioactive atom is any one of phosphorus-32, iodine-125, iodine-131, indium-111, rhenium-186, rhenium-188 or yttrium-90.
- 5 24. A compound according to Claim 20 wherein the antibody and the cytotoxic moiety are polypeptides which are fused.
25. A polynucleotide encoding a compound according to Claim 24.
- 10 26. A compound comprising an antibody according to any one of Claims 9 to 13 or 19 and a readily detectable moiety.
- 15 27. A compound according to Claim 26 wherein the readily detectable moiety comprises a suitable amount of any one of iodine-123, iodine-131, indium-111, fluorine-19, carbon-13, nitrogen-15, oxygen-17, technitium-99m, gadolinium, manganese or iron.
28. A vector comprising the polynucleotide of any one of Claims 14 to 18 or 25.
- 20 29. A host cell comprising the polynucleotide of any one of Claims 14 to 18 or 25, or the vector of Claim 28.
- 25 30. A stable host cell line producing an antibody according to any one of Claims 9 to 13 or a compound according to Claim 24 resulting from incorporation in the cell line of an exogenous polynucleotide according to any of Claims 14 to 18 or 25, or a vector according to Claim 28.
- 30 31. A pharmaceutical composition comprising an antibody according to any one of Claims 9 to 13 or 19, or a polynucleotide according to any of Claims 14 to 18 or 25, or a compound according to any of Claims 21 to 24 or 26 to 27, and a pharmaceutically acceptable carrier.

32. A pharmaceutical composition according to Claim 31 suitable for use by injection.

33. Use of an antibody according to any one of Claims 9 to 13 or 19, or a polynucleotide according to any one of Claims 14 to 18 or 25, or a compound according to any one of Claims 21 to 24 or 26 to 27, for inhibiting angiogenesis.

34. An *in vitro* method of inhibiting angiogenesis comprising administering an antibody according to any one of Claims 9 to 13 or 19, or a polynucleotide according to any one of Claims 14 to 18 or 25, or a compound according to any one of Claims 21 to 24 or 26 to 27, to tissue or cells *in vitro*.

35. A method of producing an antibody according to any one of Claims 9 to 13, or a compound according to Claim 24, the method comprising expressing a polynucleotide according to any one of Claims 14 to 18 or 25, or culturing a stable host cell line according to Claim 30.

36. Use of an antibody that selectively binds to the IgA region (residues 46-116, SEQ ID NO: 5) of human magic roundabout (MR) for combating a disease or condition selected from tumours/cancer, psoriasis, atherosclerosis, menorrhagia, endometriosis, inflammatory arthritis, rheumatoid arthritis, macular degeneration, Paget's disease, retinopathy and its vascular complications, benign vascular proliferations, fibroses, obesity and inflammation.

25

37. Use according to Claim 36 wherein the retinopathy is proliferative retinopathy, retinopathy of prematurity or diabetic retinopathy.

1/15

Figure 1A

NotI site

GCGGCCGCGAATTCGGCACGAGCAGCAGGACAAAGTGCTCGGGACAAGGACATAG
GGCTGAGAGTAGCCATGGGCTCTGGAGGAGACAGCCTCCTGGGGGGCAGGGGTTC
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CTGGGACTCCCGAAGCCCCGGCGTGCCCCCTGCTTCCAGACACCAGCACTTTTTAT
GGCTCCCTCATCGCTGAGCTGCCCTCCAGTACCCAGCCAGGCCAAGTCCCAGG
TCCCAGCTGTCAGGCGCCTCCCACCCCAGCTGGCCCAGCTCTCCAGCCCCTGTTC

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CAGCTCAGACAGCCTCTGCAGCCGCAGGGGACTCTCTTCTCCCCGCTTGCTCTCTG
GCCCCCTGCAGAGGCTTGGAAAGGCCAAAAAGAAGCAGGAGCTGCAGCATGCCAACA
GTTCCCCACTGCTCCGGGGCAGCCACTCCTTGGAGCTCCGGGCCTGTGAGTTAGG
AAATAGAGGTTCCAAGAACCCTTTCCCAAAGCCCAGGAGCTGTGCCCAAGCTCTG
GTTGCCTGGCGGGCCCTGGGACCGAAACTCCTCAGCTCCTCAAATGAGCTGGTTA
CTCGTCATCTCCCTCCAGCACCCCTCTTTCCTCATGAAACTCCCCCAACTCAGAG
TCAACAGACCCAGCCTCCGGTGGCACCACAGGCTCCCTCCTCCATCCTGCTGCCA
GCAGCCCCCATCCCCATCCTTAGCCCCCTGCAGTCCCCCTAGCCCCCAGGCCTCTT
CCCTCTCTGGCCCCAGCCAGCTTCCAGTCGCCTGTCCAGCTCCTCACTGTCATC
CCTGGGGGAGGATCAAGACAGCGTGCTGACCCCTGAGGAGGTAGCCCTGTGCTTG
GAACTCAGTGAGGGTGAGGAGACTCCCAGGAACAGCGTCTCTCCCATGCCAAGGG
CTCCTTCACCCCCCACCACCTATGGGTACATCAGCGTCCCAACAGCCTCAGAGTT
CACGGACATGGGCAGGACTGGAGGAGGGGTGGGGCCCAAGGGGGGAGTCTTGCTG
TGCCACCTCGGCCCTGCCTCACCCCCACCCCCAGCGAGGGCTCCTTAGCCAATG
GTTGGGGCTCAGCCTCTGAGGACAATGCCGCCAGCGCCAGAGCCAGCCTTGTCAG
CTCCTCCGATGGCTCCTTCCTCGCTGATGCTCACTTTGCCCGGGCCCTGGCAGTG
GCTGTGGATAGCTTTGGTTTCGGTCTAGAGCCAGGGAGGCAGACTGCGTCTTCA
TAGATGCCTCATCACCTCCCTCCCCACGGGATGAGATCTTCCTGACCCCCAACCT
CTCCCTGCCCTGTGGGAGTGGAGGCCAGACTGGTTGGAAGACATGGAGGTCAGC
CACACCCAGCGGCTGGGAAGGGGGATGCCTCCCTGGCCCCCTGACTCTCAGATCT
CTTCCCAGAGAAGTCAGCTCCTACTGTCGTATGCCCAAGGCTGGTGCTTCTCCTGT
AGATTACTCCTGAACCGTGTCCCTGAGACTTCCCAGACGGGAATCAGAACCCTT
CTCCTGTCCACCCACAAGACCTGGGCTGTGGTGTGTGGGTCTTGGCCTGTGTTTC
TCTGCAGCTGGGGTCCACCTTCCCAAGCCTCCAGAGAGTTCTCCCTCCACGATTG
TGAAAACAAATGAAAACAAAATTAGAGCAAAGCTGACCTGGAGCCCTCAGGGAGC
AAAACATCATCTCCACCTGACTCCTAGCCACTGCTTTCTCCTCTGTGCCATCCAC
TCCCACCACCAGGTTGTTTTGGCCTGAGGAGCAGCCCTGCCTGCTGCTCTTCCCC
CACCATTTGGATCACAGGAAGTGGAGGAGCCAGAGGTGCCTTTGTGGAGGACAGC
AGTGGCTGCTGGGAGAGGGCTGTGGAGGAAGGAGCTTCTCGGAGCCCCCTCTCAG
CCTTACCTGGGCCCTCCTCTAGAGAAGAGCTCAACTCTCTCCCAACCTCACCAT
GGAAAGAAAATAATTATGAATGCCACTGAGGCACTGAGGCCCTACCTCATGCCAA
ACAAAGGGTTCAAGGCTGGGTCTAGCGAGGATGCTGAAGGAAGGGAGGTATGAGA
CCGTAGGTCAAAGCACCATCCTCGTACTGTTGTCACTATGAGCTTAAGAAATTT
GATACCATAAAATGGTAAAGACTTGAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAA
AAAAAAAAAAAAAAAAAAAAAAAAA

NotI site downstream of polyA tail

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Figure 1B

1 MGS GGDSLLG GRGSLPLLLL LIMGGMAQDS PPQILVHPQD QLFQGP GPAR
51 MSCQASGQPP PTIRWLLNGQ PLSMVPPDPH HLLPDGTLLL LQPPARGHAH
101 DGQALSTD LG VYTCEASNRL GTAVSRGARL SVAVLREDFQ IQPRDMVAVV
151 GEQFTLECGP PWGHPEPTVS WWKDGKPLAL QPGRHTVSSG SLLMARA EKS
201 DEGTVMCVAT NSAGHRESRA ARVSIQEPQD YTEPVELLAV RIQLENTLL
251 NPDPAEGPKP RPAVWLSWKV SGPAAPAQSY TALFRTQTAP GGQGAPWAE E
301 LLAGWQSAEL GGLHWGQDYE FKVRPSSGRA RGPDSNVLLL RLPEKVP SAP
351 PQEVTLKPGN GTVFVSWVPP PAENHNGIIR GYQVWSLGNT SLPPANWTVV
401 GEQTQLEIAT HMPGSYCVQV AAVTGAGAGE PSRPVCLLLE QAMERATQEP
451 SEHGPWTLEQ LRATLKRPEV IATCGVALWL LLLGTAVCIH RRRRARVHLG
501 PGLYRYTSED AILKHRMDHS DSQWLADTWR STSGSRDLSS SSSLSSRLGA
551 DARDPLDCRR SLLSWDSRSP GVPLLPDTST FYGSLIAELP SSTPARPSPQ
601 VPAVRRLLPPQ LAQLSSPCSS SDSLCSRRGL SSPRLSLAPA EAWKAKKKQE
651 LQHANS SPLL RGS HSLELRA CELGNRGSKN LSQSPGAVPQ ALVAWRALGP
701 KLLSSSNELV TRHLPPAPLF PHETPPTQSQ QTQPPVAPQA PSSILLPAAP
751 IPILSPCSPP SPQASSLSGP SPASSRLSSS SLSSLGEDQD SVLTPEEVAL
801 CLELSEGEET PRNSVSPMPR APSPPTYGY ISVPTASEFT DMGRTGGGVG
851 PKGGVLLCPP RPCLTPTPSE GSLANGW GSA SEDNAASARA SLVSSSDGSF
901 LADAHFARAL AVAVDSFGFG LEPREADCVF IDASSPPSPR DEIFLTPNLS
951 LPLWEWRPDW LEDMEVSHTQ RLG RGMPPWP PDSQISSQRS QLHCRMPKAG
1001 ASPVDYS

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Figure 2A

HindIII site

AAGCTTAAAGTGCTCGGGACAAGGACATAGGGCTGAGAGTAGCCATGGGCTCTGG
AGGAGACAGCCTCCTGGGGGGCAGGGGTTCCCTGCCTCTGCTGCTCCTGCTCATC
ATGGGAGGCATGGCTCAGGACTCCCCGCCCCAGATCCTAGTCCACCCCCAGGACC
AGCTGTTCCAGGGCCCTGGCCCTGCCAGGATGAGCTGCCAAGCCTCAGGCCAGCC
ACCTCCCACCATCCGCTGGTTGCTGAATGGGCAGCCCCTGAGCATGGTGCCCCCA
GACCACACCACCTCCTGCCTGATGGGACCCTTCTGCTGCTACAGCCCCCTGCC
GGGACATGCCACGATGGCCAGGCCCTGTCCACAGACCTGGGTGTCTACACATG
TGAGGCCAGCAACCGGCTTGGCACGGCAGTCAGCAGAGGCGCTCGGCTGTCTGTG
GCTGTCCTCCGGGAGGATTTCCAGATCCAGCCTCGGGACATGGTGGCTGTGGTGG
GTGAGCAGTTTACTCTGGAATGTGGGCCGCCCTGGGGCCACCCAGAGCCCACAGT
CTCATGGTGGAAAGATGGGAAACCCCTGGCCCTCCAGCCCAGGACACACAGTG
TCCGGGGGGTCCCTGCTGATGGCAAGAGCAGAGAAGAGTGACGAAGGGACCTACA
TGTGTGTGGCCACCAACAGCGCAGGACATAGGGAGAGCCGCGCAGCCCAGGGTTTC
CATCCAGGAGCCCCAGGACTACACGGAGCCTGTGGAGCTTCTGGCTGTGCGAATT
CAGCTGGAAAATGTGACACTGCTGAACCCGGATCCTGCAGAGGGCCCCAAGCCTA
GACCGGCGGTGTGGCTCAGCTGGAAGGTCAGTGGCCCTGCTGCGCCTGCCCAATC
TTACACGGCCTTGTTTCAGGACCCAGACTGCCCCGGGAGGCCAGGGAGCTCCGTGG
GCAGAGGAGCTGCTGGCCGGCTGGCAGAGCGCAGAGCTTGGAGGCCTCCACTGGG
GCCAAGACTACGAGTTCAAAGTGAGACCATCCTCTGGCCGGGCTCGAGGCCCTGA
CAGCAACGTGCTGCTCCTGAGGCTGCCGGAAAAAGTGCCCAGTGCCCCACCTCAG
GAAGTGACTCTAAAGCCTGGCAATGGCACTGTCTTTGTGAGCTGGGTCCCACCAC
CTGCTGAAAACCACAATGGCATCATCCGTGGCTACCAGGTCTGGAGCCTGGGCAA
CACATCACTGCCACCAGCCAACCTGGACTGTAGTTGGTGAGCAGACCCAGCTGGAA
ATCGCCACCCATATGCCAGGCTCCTACTGCGTGCAAGTGGCTGCAGTCACTGGTG
CTGGAGCTGGGGAGCCCAGTAGACCTGTCTGCCTCCTTTTAGAGCAGGCCATGGA
GCGAGCCACCCAAGAACCAGTGAGCATGGTCCCTGGACCCTGGAGCAGCTGAGG
GCTACCTTGAAGCGGTAGTAAGCGGCCGC

(STOP, STOP NotI Site)

Figure 2B

MSGGDSLLGGRGSLPLLLLLLIMGGMAQDSPQILVHPQDQLFQGP GPARMSCQA
SGQPPPTIRWLLNGQPLSMVPPDPHLLPDGTLLLLLQPPARGHAHDGQALSTD LG
VYTCEASNRLGTAVSRGARLSVAVLREDFQIQPRDMVAVVGEQFTLECGPPWGHP
EPTVSWWKDGKPLALQPGRHTVSGGSLLMARA EKSDEGTYM CVATNSAGHRESRA
ARVSIQEPQDYTEPV ELLAVRIQLENV TLLNPDP AEGPKPRPA VWLSWKVSGPAA
PAQSYTALFRTQTAPGGQGAPWAEELLAGWQSAELGGLHWGQDYEFKVRPSSGRA
RGPDSNVLLLLRLPEKVPSAPPQEVTLKPGNGTVFVSWVPPPAENHNGIIRGYQVW
SLGNTSLPPANWTVVGEQTQLEIATHMPGSYCVQVA AVTGAGAGEPSRPVCLLLE
QAMERATQEPSEHG PWTLEQLRATLKR

Figure 3

PGPARMSCQASGQPPPTIRWLLNGQPLSMVPPDPHLLPDGTLLLLQPPARGHAH
DGQALSTD LGVYTCEASNRLGTAVSRGARLSVAVLREDFQIQPRDMVAVVGEQFT
LECGPPWGHPEPTVSWWKDGKPLALQPGRHTVSGGSLLMARA EKSD EGT YMCVA

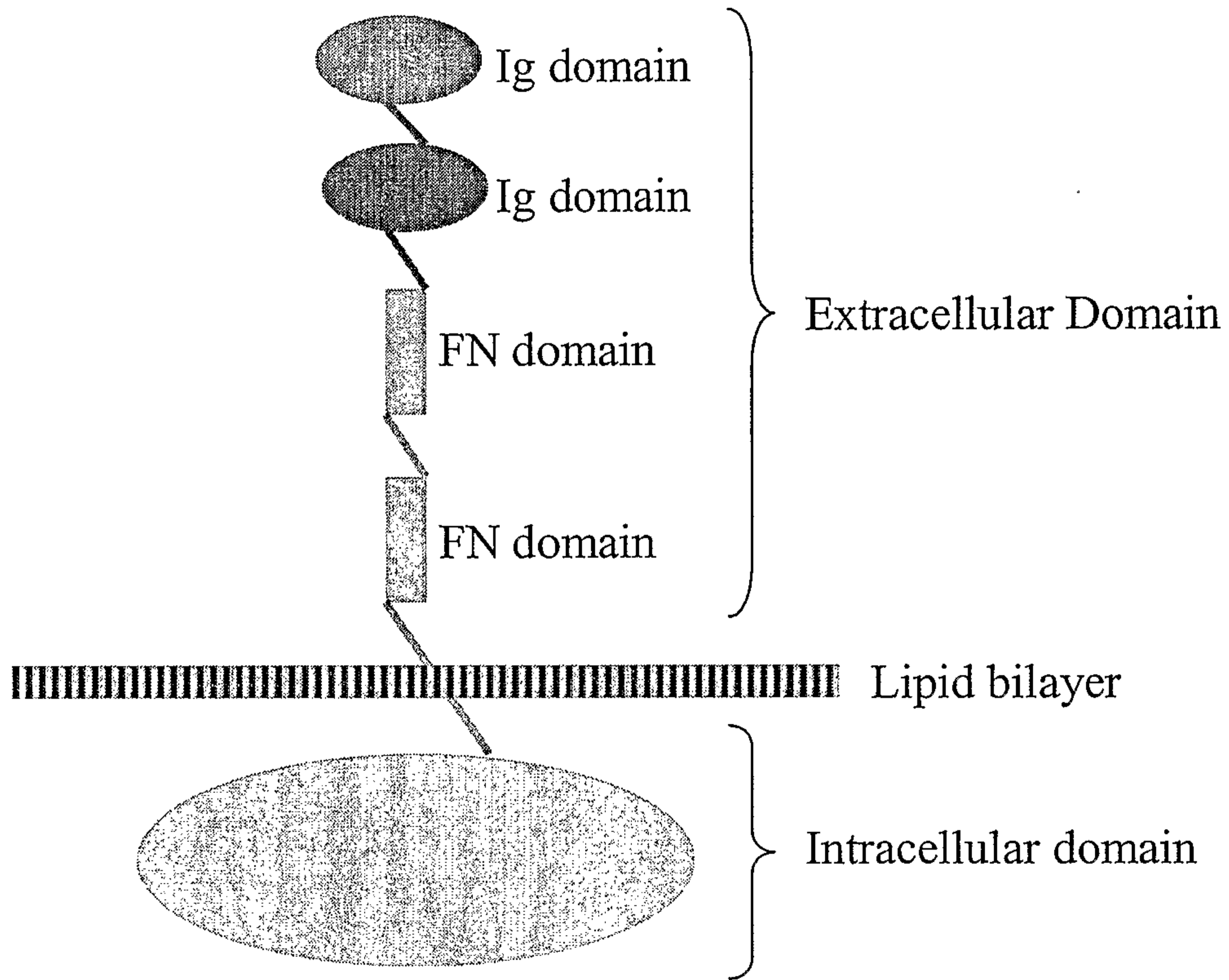
Figure 4A

PGPARMSCQASGQPPPTIRWLLNGQPLSMVPPDPHLLPDGTLLLLQPPARGHAH
DGQALSTD LGVYTCEA

Figure 4B

GEQFTLECGPPWGHPEPTVSWWKDGKPLALQPGRHTVSGGSLLMARA EKSD EGT Y
MCVA

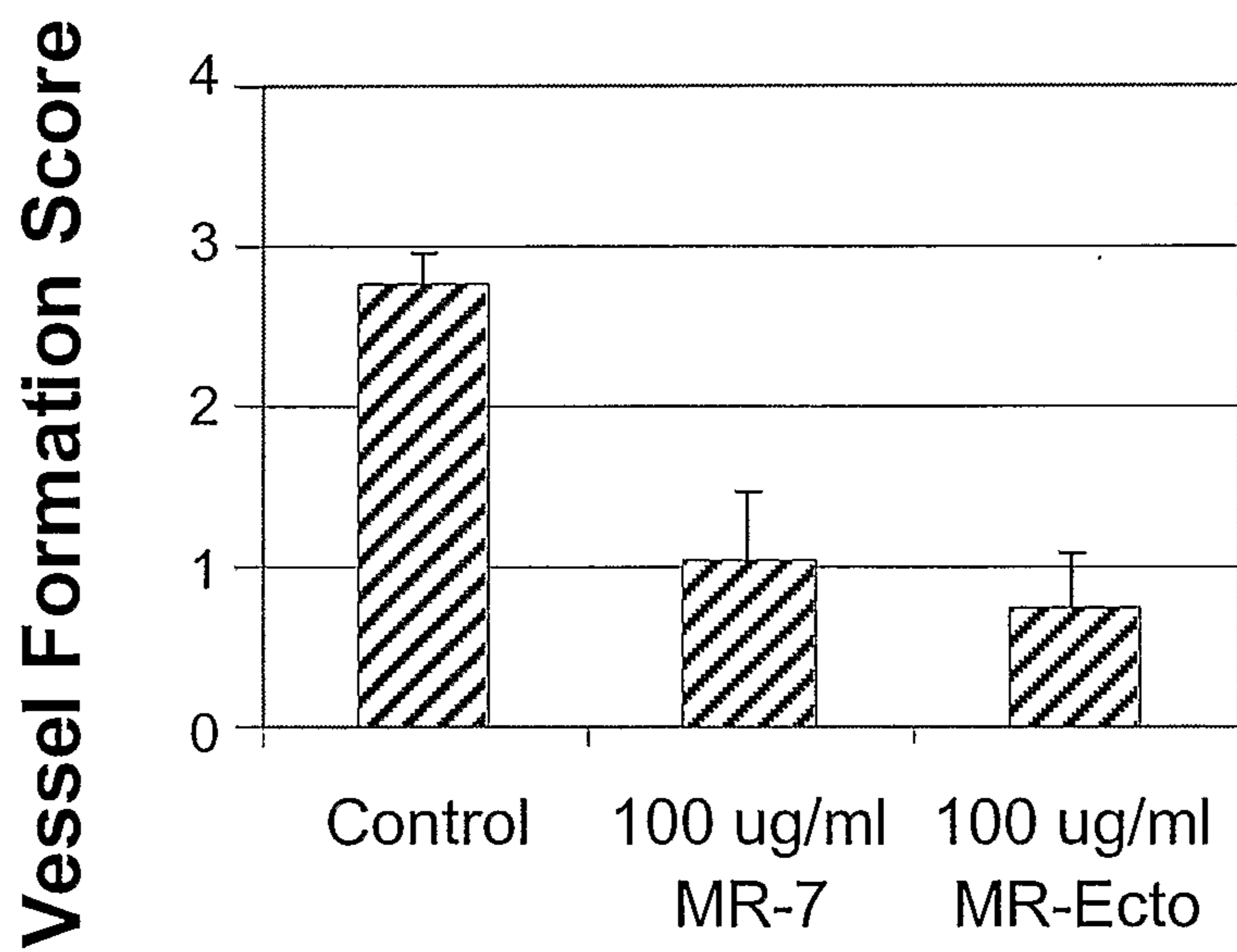
Figure 5



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Figure 6A

Treatment	Average	Variance
Control	2.77	0.18
100 ug/ml MR-7	1.04	0.43
100 ug/ml MR-Ecto	0.74	0.34



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Figure 6B

Treatment	Mean	Standard Deviation
Control	2.91489	0.1579
Human IgG	3.42857	0.409303
MR ectodomain	0.632258	0.194497

Aortic Ring Sprouting

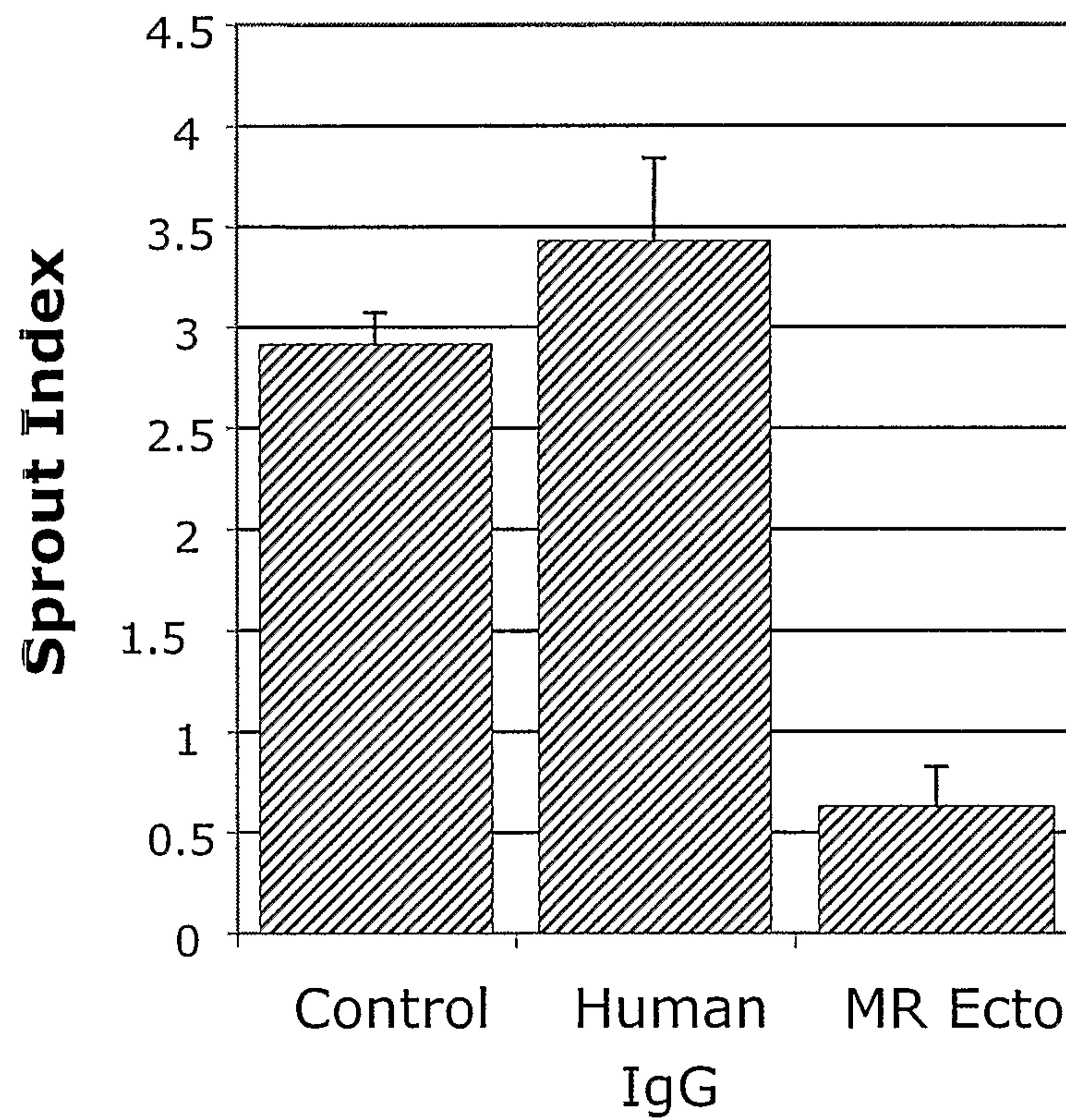
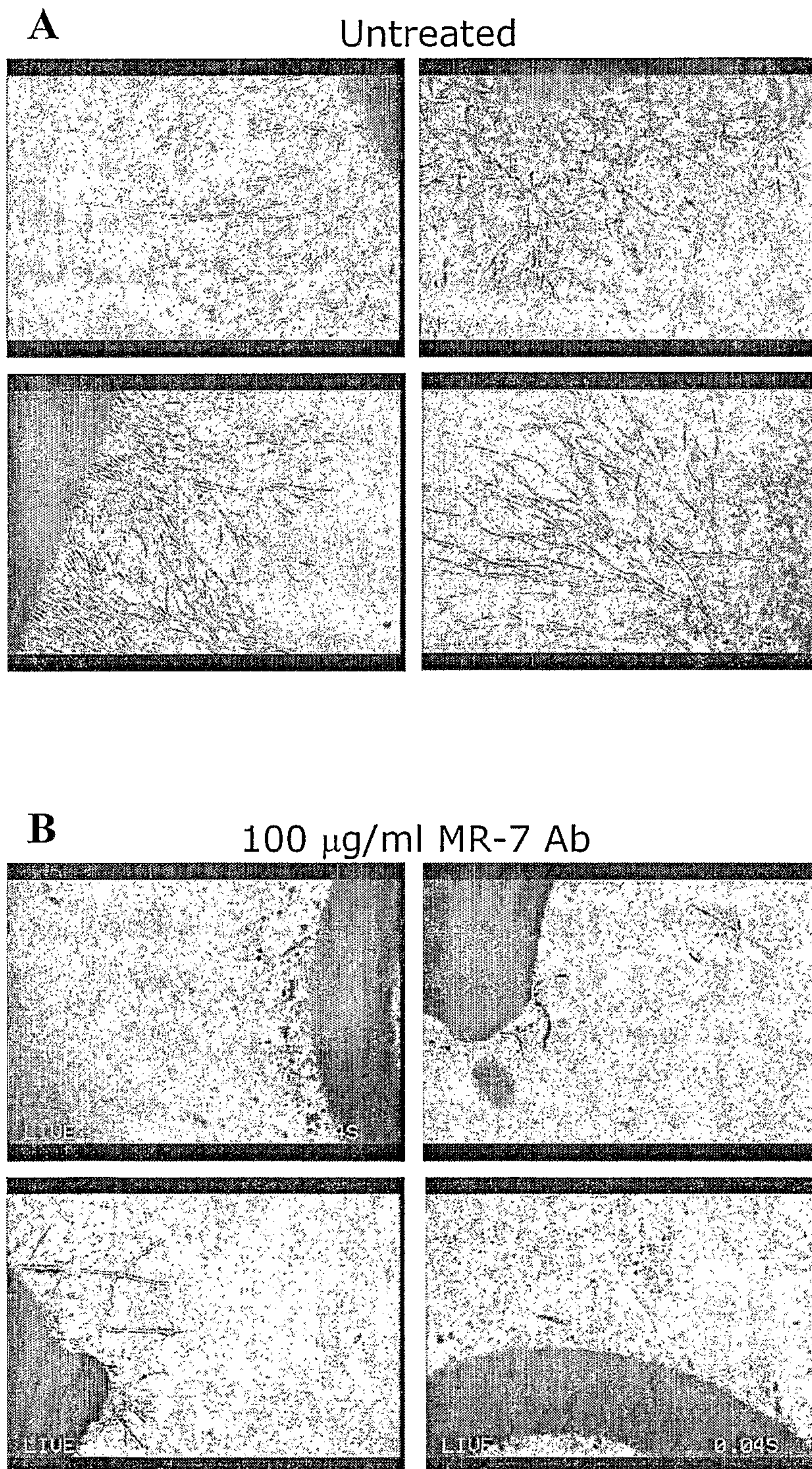
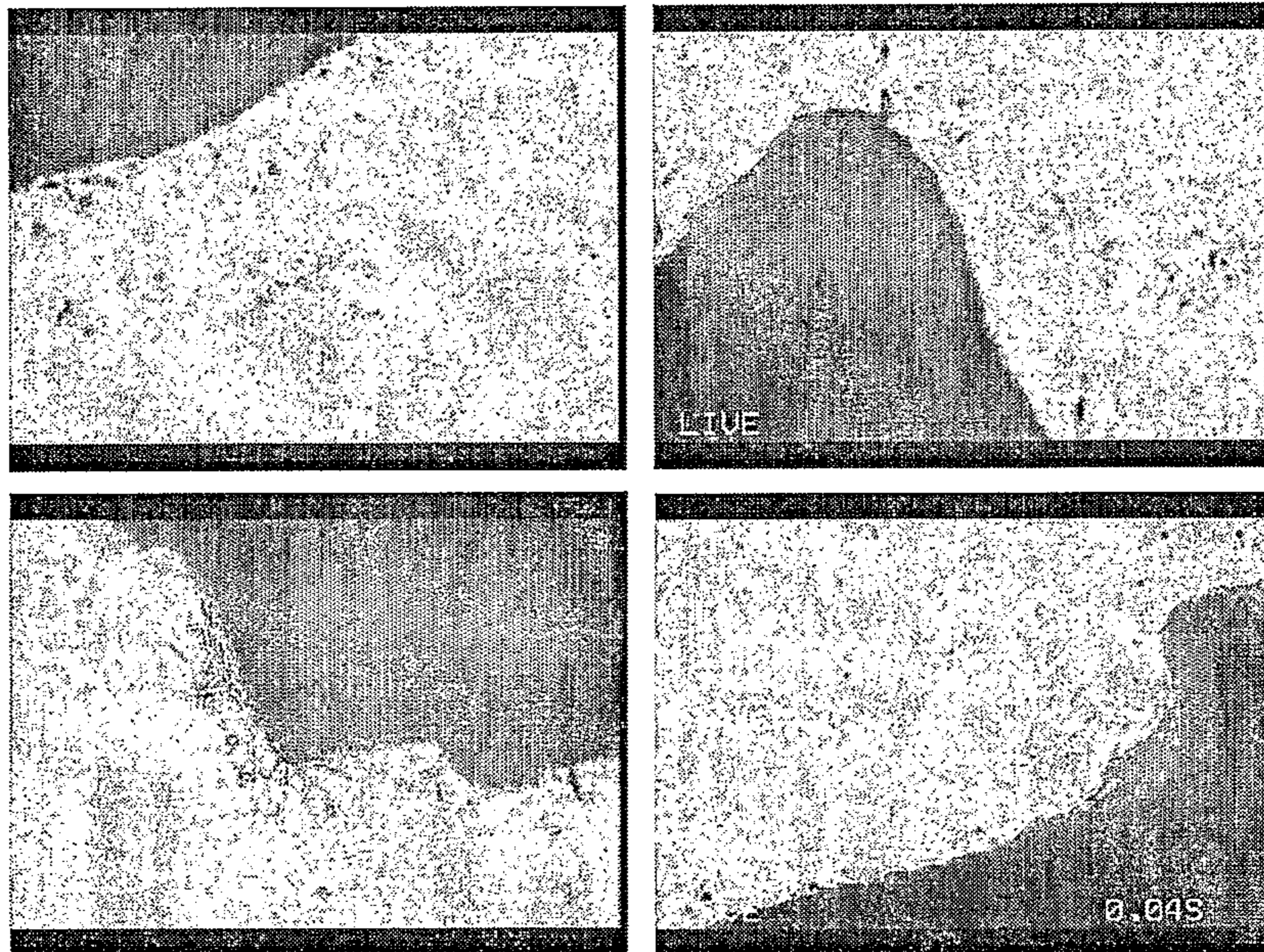


Figure 7



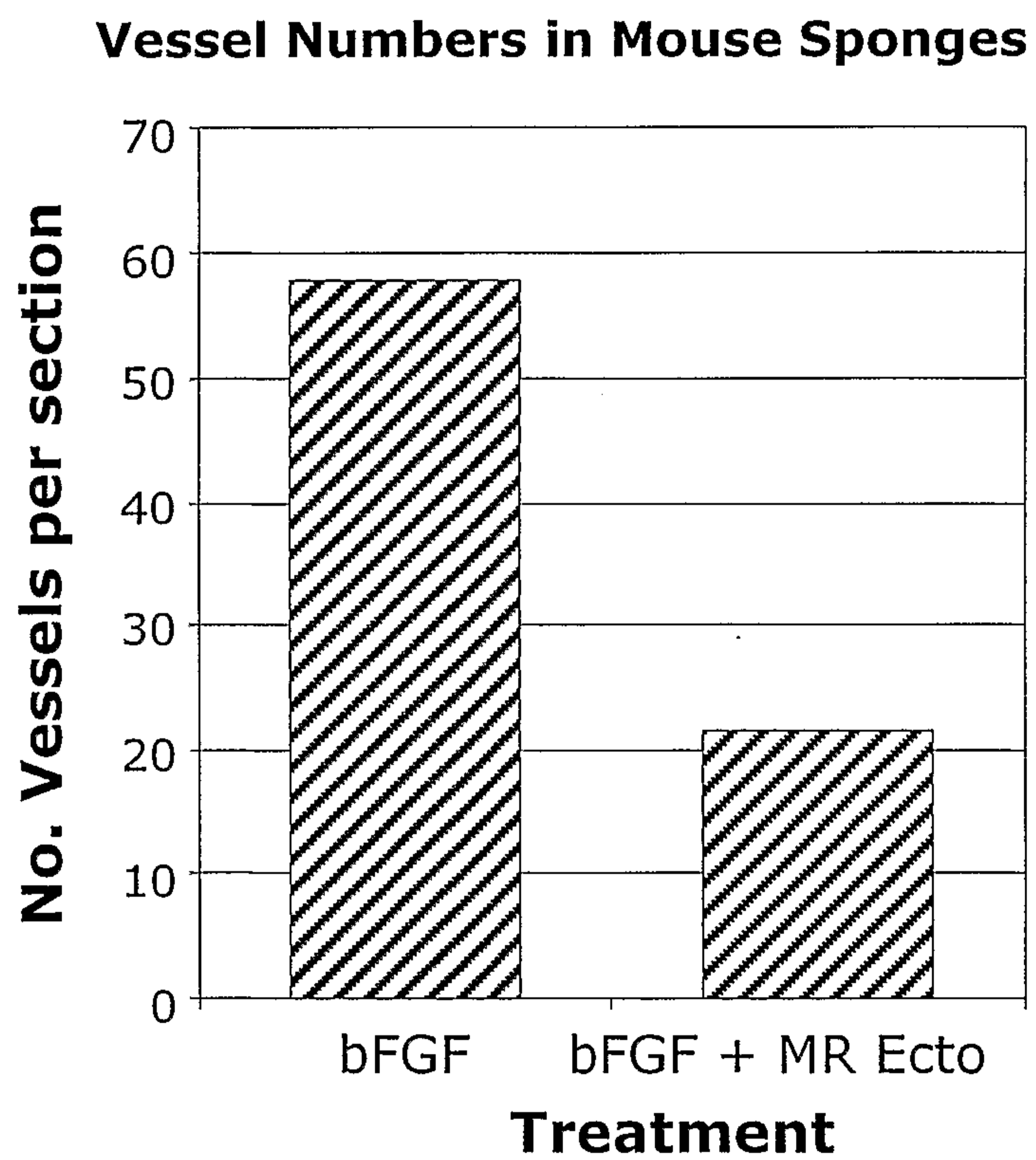
C 15 μ g/ml MR Ectodomain



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Figure 8

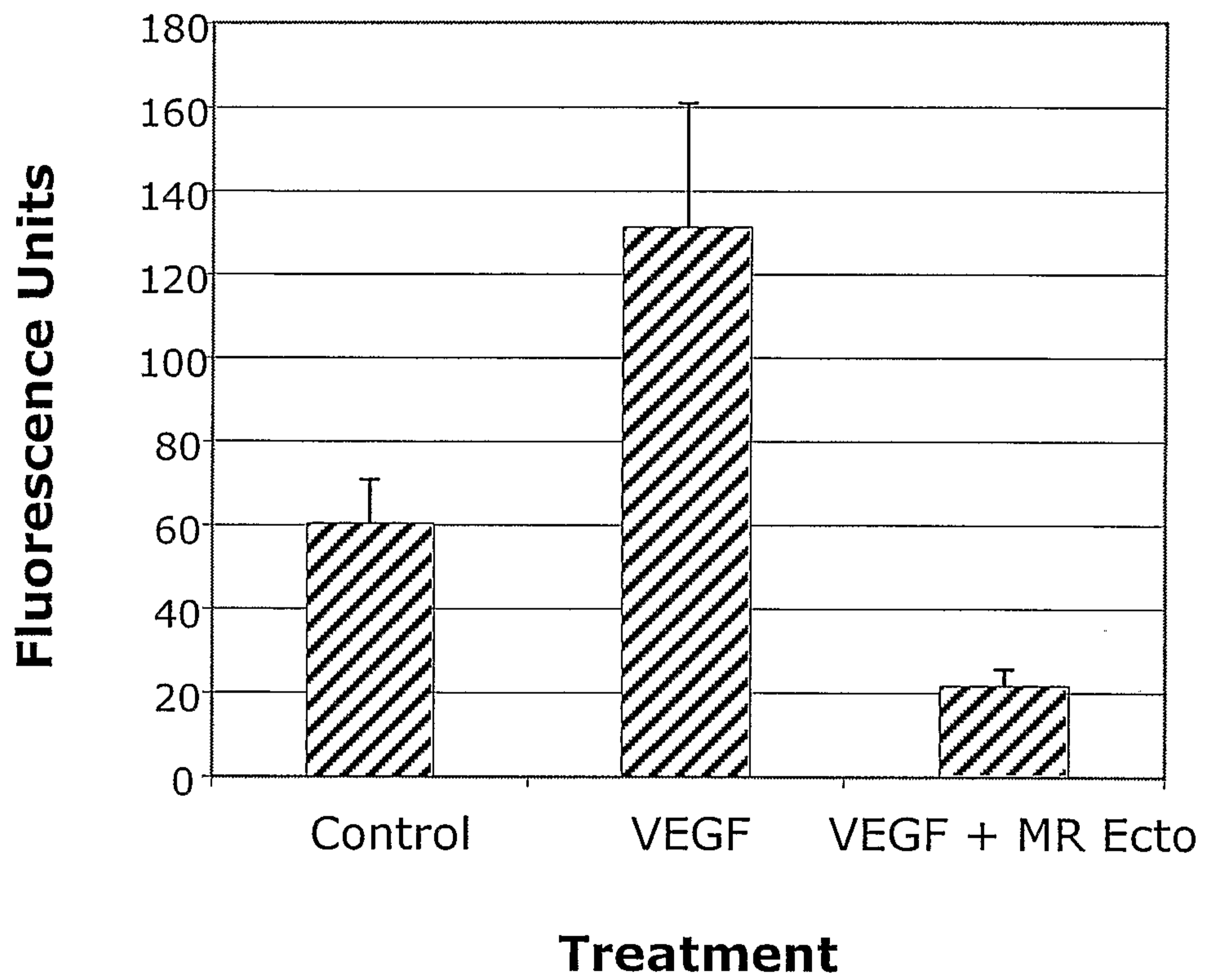
Group	Mean	Standard deviation
bFGF	57.63	19.01
bFGF + MR ectodomain	21.5	10.89



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Figure 9A

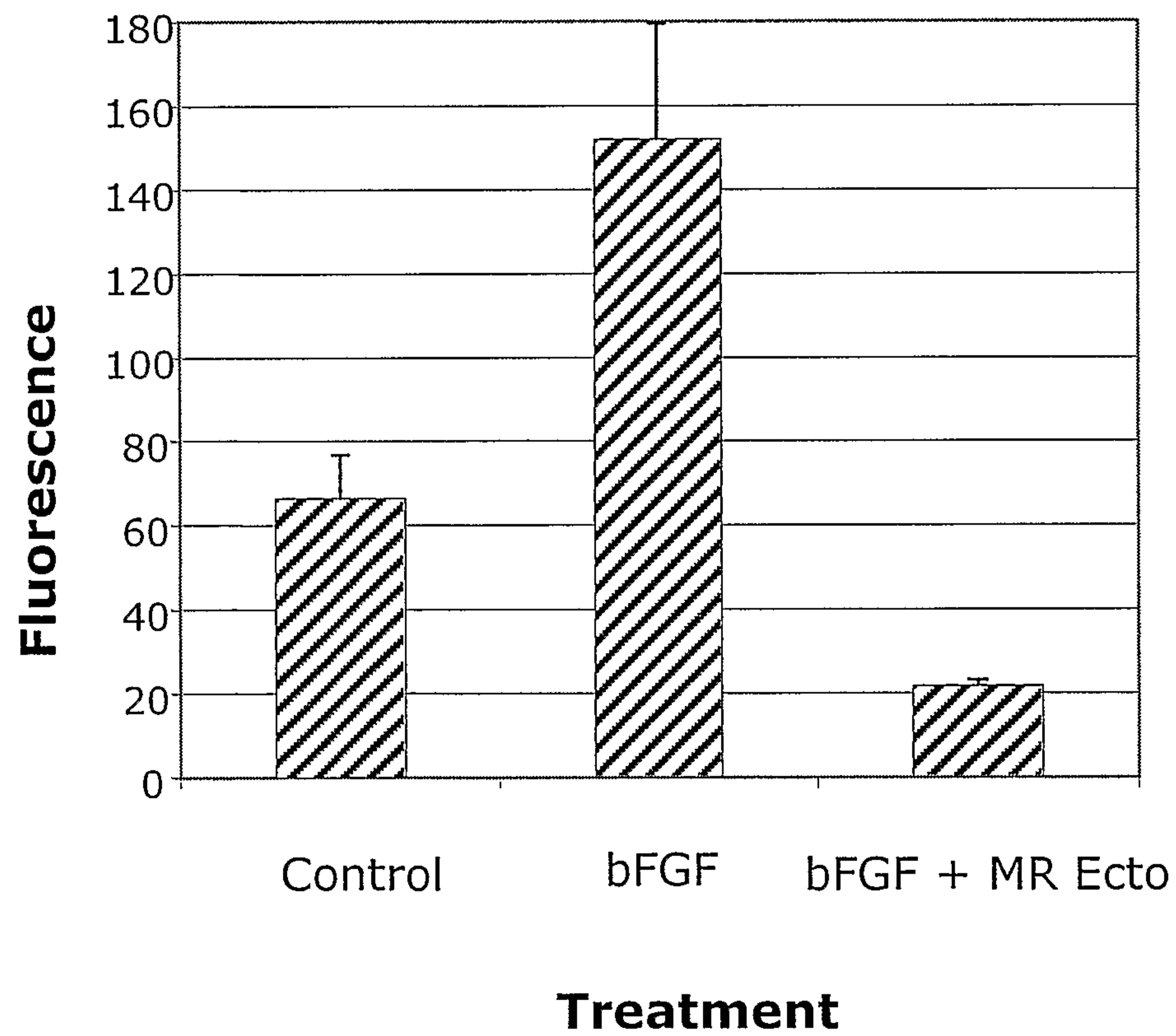
Treatment	Mean	Standard Deviation
Control	60.5	10.41
VEGF	131.33	29.70
VEGF + MR ectodomain	21.67	4.04



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Figure 9B

Treatment	Mean	Standard deviation
Control	66.33	10.41
BFGF	152.00	27.62
bFGF + MR ectodomain	21.67	1.53



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Figure 10

<u>Treatment</u>	<u>Average of Replicates</u>	<u>Standard Deviation</u>
Control	1957	57
100 µg/ml Robo4-Fc	683	73
50 µg/ml Robo4-Fc	1122	92
25 µg/ml Robo4-Fc	1401	134
12.5 µg/ml Robo4-Fc	1483	54
6.25 µg/ml Robo4-Fc	1991	596
100 µg/ml Human IgG	2015	93

HUVEC Proliferation 4 days