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An agency of Industry Canada

CA 2536912 A1 2005/03/10

(21) 2 536 912

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2004/08/26
(87) Date publication PCT/PCT Publication Date: 2005/03/10
(85) Entrée phase nationale/National Entry: 2006/02/24
(86) N° demande PCT/PCT Application No.: US 2004/027612
(87) N° publication PCT/PCT Publication No.: 2005/020972
(30) Priorités/Priorities: 2003/08/27 (US60/498,407); 2004/03/26 (US60/556,837)

(51) Cl.Int./Int.Cl. *C12N 15/11* (2006.01)
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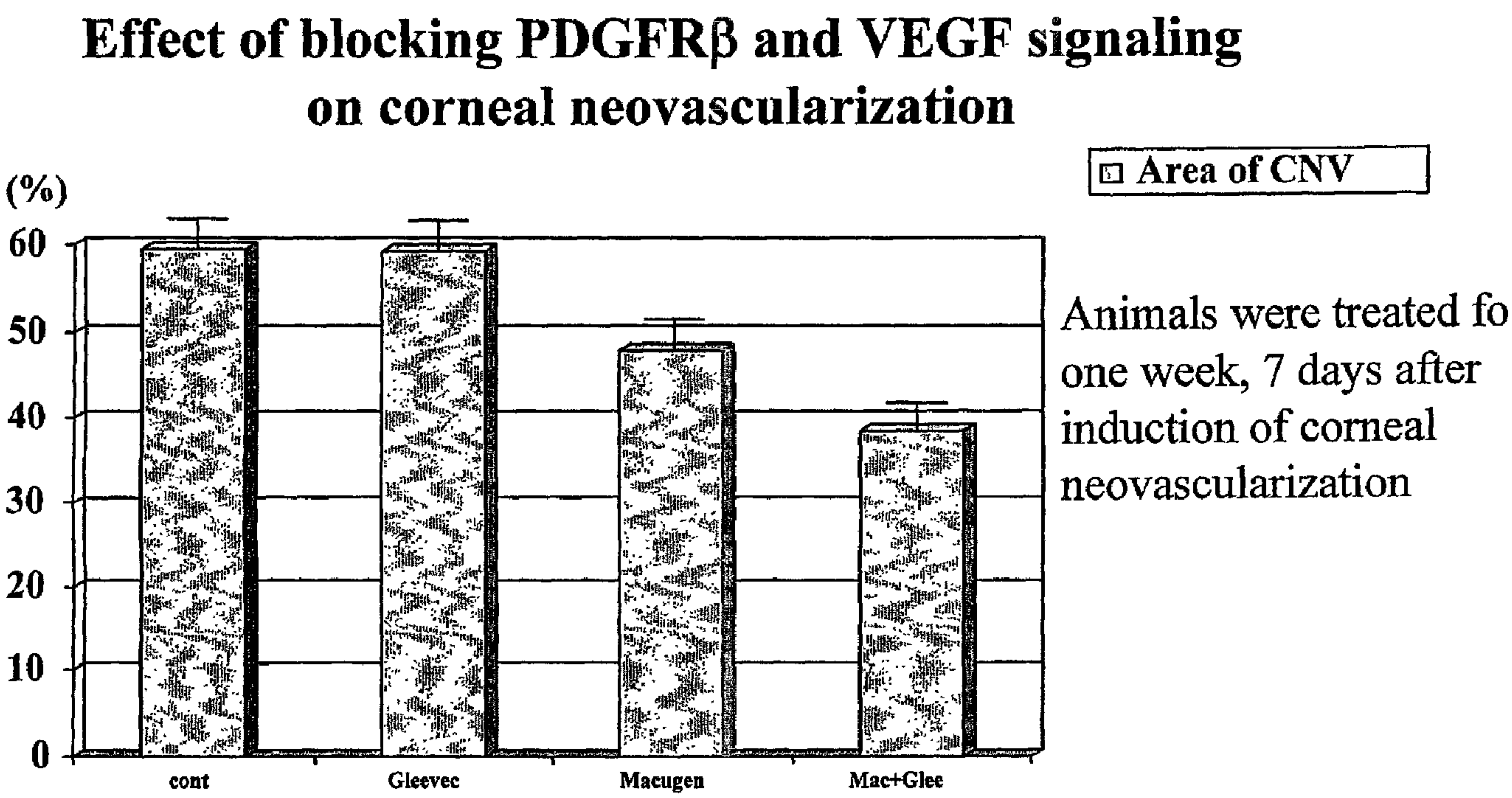
(54) Titre : POLYTHERAPIE POUR LE TRAITEMENT DE TROUBLES NEOVASCULAIRES OCULAIRES
(54) Title: COMBINATION THERAPY FOR THE TREATMENT OF OCULAR NEOVASCULAR DISORDERS



(57) Abrégé/Abstract:
The invention features methods for treating a patient diagnosed with, or at risk of developing, a neovascular disorder by administering a PDGF antagonist and a VEGF antagonist to the patient. The invention also features a pharmaceutical composition containing a PDGF antagonist and a VEGF antagonist for the treatment or prevention of a neovascular disorder.

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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 March 2005 (10.03.2005)

PCT

(10) International Publication Number
WO 2005/020972 A3

(51) International Patent Classification[7]: C12N 15/11

(21) International Application Number: PCT/US2004/027612

(22) International Filing Date: 26 August 2004 (26.08.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/498,407 27 August 2003 (27.08.2003) US
60/556,837 26 March 2004 (26.03.2004) US

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

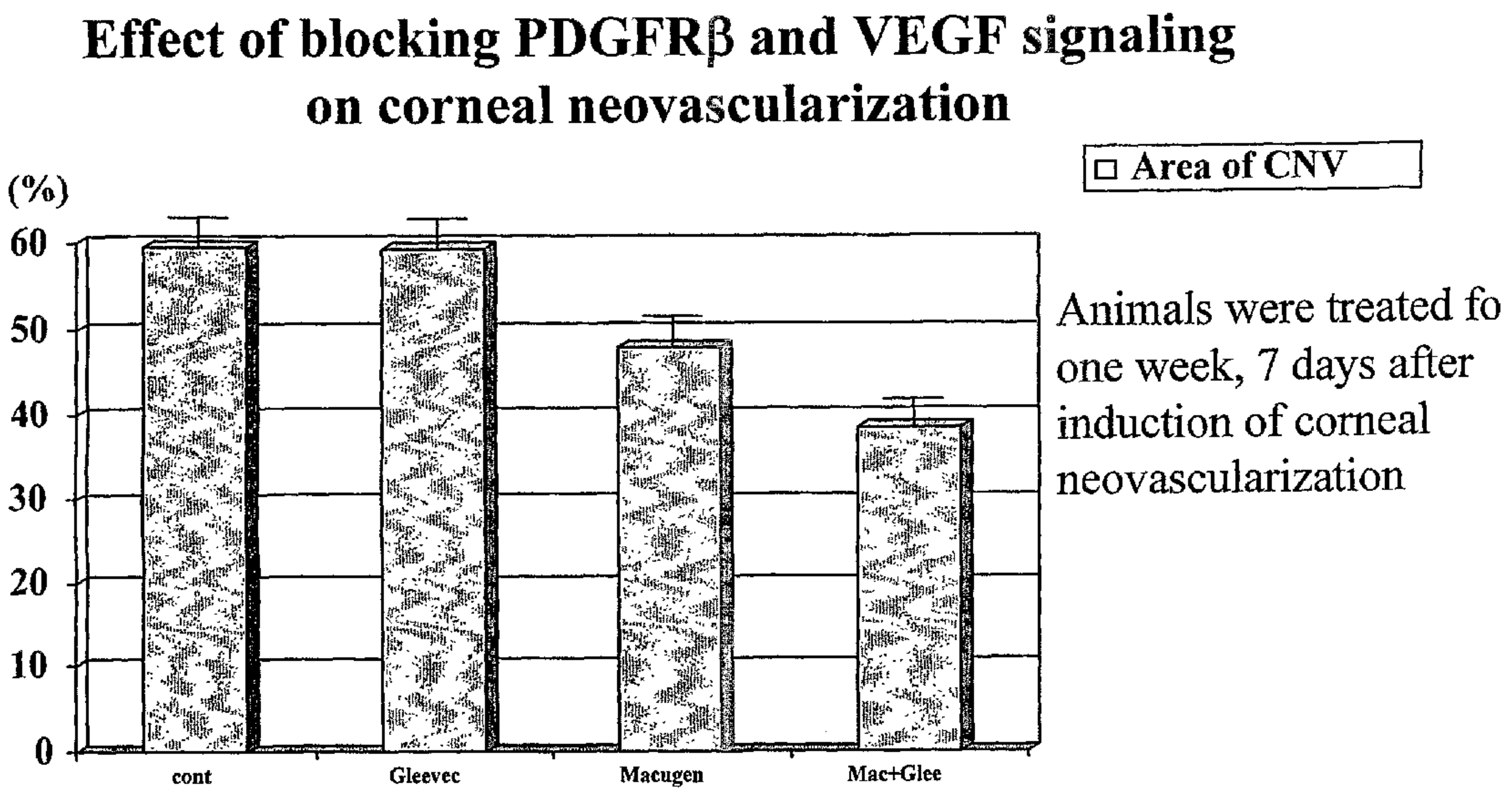
(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU,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

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) Date of publication of the international search report: 17 November 2005

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

(54) **Title:** COMBINATION THERAPY FOR THE TREATMENT OF OCULAR NEOVASCULAR DISORDERS



(57) **Abstract:** The invention features methods for treating a patient diagnosed with, or at risk of developing, a neovascular disorder by administering a PDGF antagonist and a VEGF antagonist to the patient. The invention also features a pharmaceutical composition containing a PDGF antagonist and a VEGF antagonist for the treatment or prevention of a neovascular disorder.

WO 2005/020972 A3

COMBINATION THERAPY FOR THE TREATMENT OF OCULAR NEOVASCULAR DISORDERS

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Serial No. 60/498,407, filed August 27, 2003, Attorney Docket No. EYE-013P, and U.S. Provisional Application Serial No. 60/556,837, filed March 26, 2004, Attorney Docket No. EYE-013P2, both of which are hereby incorporated in its entirety by reference.

FIELD OF THE INVENTION

This invention relates to the fields of ophthalmology and medicine. More specifically, this invention relates to the treatment of neovascular disorders of the eye using a combination of agents that inhibit both platelet-derived growth factor (PDGF) and vascular endothelial growth factor (VEGF).

BACKGROUND OF THE INVENTION

Angiogenesis, also called neovascularization, involves the formation of sprouts from preexistent blood vessels and their invasion into surrounding tissue. A related process, vasculogenesis, involves the differentiation of endothelial cells and angioblasts that are already present throughout a tissue, and their subsequent linking together to form blood vessels.

Angiogenesis occurs extensively during development, and also occurs in the healthy body during wound healing in order to restore blood flow to tissues after injury or insult. Angiogenesis, however, has also been implicated in cancer and tumor formation. Indeed, the quantity of blood vessels in a tumor tissue is a strong negative prognostic indicator in breast cancer (Weidner *et al.*, (1992) J. Natl. Cancer Inst. 84:1875-1887), prostate cancer (Weidner *et al.*, (1993) Am. J. Pathol. 143:401-409), brain tumors (Li *et al.*, (1994) Lancet 344:82-86), and melanoma (Foss *et al.*, (1996) Cancer Res. 56:2900-2903). Angiogenesis has also recently been implicated in other disease states in many areas of medicine, including rheumatology, dermatology, cardiology and ophthalmology. In particular, undesirable or pathological tissue-specific angiogenesis has been associated with certain specific disease states including rheumatoid arthritis, atherosclerosis, and psoriasis (see *e.g.*, Fan *et al.*, (1995) Trends Pharmacol. Sci. 16: 57; and Folkman (1995) Nature Med. 1: 27). Furthermore, the alteration of vascular permeability is thought to play a role in both normal and pathological physiological processes (Cullinan-Bove *et al.*, (1993) Endocrinol. 133: 829; Senger *et al.*, (1993) Cancer and Metastasis Reviews 12: 303). Although the angiogenic process in each of these diseases is likely to share many features with developmental angiogenesis and tumor angiogenesis, each may also have unique aspects conferred by the influence of surrounding cells.

Several ocular disorders involve alterations in angiogenesis. For example, diabetic retinopathy, the third leading cause of adult blindness (accounting for almost 7% of blindness in the USA), is associated with extensive angiogenic events. Nonproliferative retinopathy is accompanied by the selective loss of pericytes within the retina, and their loss results in dilation of associated capillaries dilation and a resulting increase in blood flow. In the dilated capillaries, endothelial cells proliferate and form outpouchings, which become microaneurysms, and the adjacent capillaries become blocked so that the area of retina surrounding these microaneurysms is not perfused. Eventually, shunt vessels appear between adjacent areas of micro aneurysms, and the clinical picture of early diabetic retinopathy with micro aneurysms and areas of nonperfused retina is seen. The microaneurysms leak and capillary vessels may bleed, causing exudates and hemorrhages. Once the initial stages of background diabetic retinopathy are established, the condition progresses over a period of years, developing into proliferative diabetic retinopathy and blindness in about 5% of cases. Proliferative diabetic retinopathy occurs when some areas of the retina continue losing their capillary vessels and become nonperfused, leading to the appearance of new vessels on the disk and elsewhere on the retina. These new blood vessels grow into the vitreous and bleed easily, leading to preretinal hemorrhages. In advanced proliferative diabetic retinopathy, a massive vitreous hemorrhage may fill a major portion of the vitreous cavity. In addition, the new vessels are accompanied by fibrous tissue proliferation that can lead to traction retinal detachment.

Diabetic retinopathy is associated primarily with the duration of diabetes mellitus; therefore, as the population ages and diabetic patients live longer, the prevalence of diabetic retinopathy will increase. Laser therapy is currently used in both nonproliferative and proliferative diabetic retinopathy. Focal laser treatment of the leaking microaneurysms surrounding the macular area reduces visual loss in 50% of patients with clinically significant macular edema. In proliferative diabetic retinopathy, panretinal photocoagulation results in several thousand tiny burns scattered throughout the retina (sparing the macular area); this treatment reduces the rate of blindness by 60 percent. Early treatment of macular edema and proliferative diabetic retinopathy prevents blindness for 5 years in 95% of patients, whereas late treatment prevents blindness in only 50 percent. Therefore, early diagnosis and treatment are essential.

Another ocular disorder involving neovascularization is age-related macular degeneration (AMD), a disease that affects approximately one in ten Americans over the age of 65. AMD is characterized by a series of pathologic changes in the macula, the central region of the retina, which is accompanied by decreased visual acuity, particularly affecting central vision. AMD involves the single layer of cells called the retinal pigment epithelium that lies immediately beneath the sensory retina. These cells nourish and support the portion of the retina in contact with them, *i.e.,* the photoreceptor cells that contain the visual pigments. The retinal pigment epithelium lies on the Bruch membrane, a basement membrane complex which, in AMD, thickens and becomes sclerotic. New blood vessels may break through the Bruch membrane from the underlying choroid, which contains a rich vascular bed. These vessels may in turn leak fluid or bleed beneath the retinal pigment epithelium and also between the retinal pigment epithelium and the sensory retina. Subsequent fibrous scarring disrupts the nourishment of the photoreceptor cells and leads to their death, resulting in a loss of central visual acuity. This type of age-related maculopathy is called the "wet" type because of the leaking vessels and the subretinal edema or blood. The wet type accounts for only 10% of age-related maculopathy cases but results in 90% of cases of legal blindness from macular degeneration in the elderly. The "dry" type of age-related maculopathy involves disintegration of the retinal pigment epithelium along with loss of the overlying photoreceptor cells. The dry type reduces vision but usually only to levels of 20/50 to 20/100.

AMD is accompanied by distortion of central vision with objects appearing larger or smaller or straight lines appearing distorted, bent, or without a central segment. In the wet type of AMD, a small detachment of the sensory retina may be noted in the macular area, but the definitive diagnosis of a subretinal neovascular membrane requires fluorescein angiography. In the dry type, drusen may disturb the pigmentation pattern in the macular area. Drusen are excrescences of the basement membrane of the retinal pigment epithelium that protrude into the cells, causing them to bulge anteriorly; their role as a risk factor in age-related maculopathy is unclear. No treatment currently exists for the dry type of age-related maculopathy. Laser treatment is used in the wet type of age-related maculopathy and initially obliterates the neovascular membrane and prevents further visual loss in about 50% of patients at 18 months. By 60 months, however, only 20% still have a substantial benefit.

Multiple molecular mediators of angiogenesis have been identified including basic and acidic fibroblast growth factors (aFGF, bFGF), transforming growth factors alpha and beta (TGFα, TGFβ), platelet-derived growth factor (PDGF), angiogenin, platelet-derived endothelial cell growth factor (PD-ECGF), interleukin-8 (IL-8), and vascular endothelial growth factor (VEGF). Other stimulators implicated in angiogenesis include angiopoietin-1, Del-1, follistatin, granulocyte colony-stimulating factor (G-CSF), hepatocyte growth factor (HGF), leptin, midkine, placental growth factor, pleiotrophin (PTN), progranulin, proliferin, and tumor necrosis factor-alpha (TNF-alpha). In addition, control of angiogenesis is further mediated by a number of negative regulators of angiogenesis produced by the body including angioarrestin, ngiostatin (plasminogen fragment), antiangiogenic antithrombin III, cartilage-derived inhibitor (CDI), CD59 complement fragment, endostatin (collagen XVIII fragment), fibronectin fragment, gro-beta, heparinases, heparin hexasaccharide fragment, human chorionic gonadotropin (hCG), interferon alpha/beta/gamma, interferon inducible protein (IP-10), interleukin-12, kringle 5 (plasminogen fragment), metalloproteinase inhibitors (TIMPs), 2-methoxyestradiol, placental ribonuclease inhibitor, plasminogen activator inhibitor, platelet factor-4 (PF4), prolactin 16kD fragment, proliferin-related protein (PRP), retinoids, tetrahydrocortisol-S, thrombospondin-1 (TSP-1), vasculostatin, and vasostatin (calreticulin fragment).

Among these angiogenic regulators, VEGF appears to play a key role as a positive regulator of the abnormal angiogenesis accompanying tumor growth (reviewed in Brown *et al.*, (1996) Control of Angiogenesis (Goldberg and Rosen, eds.) Birkhauser, Basel, and Thomas (1996) J. Biol. Chem. 271:603-606). Furthermore, recently the role of the PDGF-B member of the PDGF family of signaling molecules has been under investigation, since it appears to play a role in the formation, expansion and proper function of perivascular cells, sometimes referred to as mural cells, *e.g.*, vascular smooth muscle, mesangial cells, and pericytes.

While much has been learned about angiogenesis, or neovascularization, accompanying development, wound healing and tumor formation, it remains to be determined whether there are differences between these forms of angiogenesis and ocular angiogenesis. Significantly, while angiogenesis accompanying, *e.g.*, collateral blood vessel formation in the heart, may be beneficial and adaptive to the organism, pathological ocular neovascularization accompany, *e.g.*, AMD, has no known benefit and often leads to blindness (for review, see Campochiaro (2000) J. Cell. Physiol. 184: 301-10). Therefore, although advances in the understanding of the molecular events accompanying neovascularization have been made, there exists a need to utilize this understanding to develop further methods for treating neovascular diseases disorders, including ocular neovascular diseases and disorders such as the choroidal neovascularization that occurs with AMD and diabetic retinopathy.

SUMMARY OF THE INVENTION

It has been discovered that the combination of anti-VEGF and anti-PDGF agents surprisingly affords synergistic therapeutic benefits for treating an ocular neovascular disease.

Accordingly, the invention features a method for treating a patient diagnosed with or at risk for developing a neovascular disorder. This method includes administering to the patient an anti-VEGF agent and an anti-PDGF agent as a primary or adjunct therapeutic treatment.

In one aspect, the invention provides a method for suppressing a neovascular disorder in a patient in need thereof, by administering to the patient a PDGF antagonist and a VEGF antagonist, simultaneously, or within about 90 days of each other, in amounts sufficient to suppress the neovascular disorder in the patient.

In another aspect, the invention provides a method for treating a patient diagnosed with, or at risk for developing, a neovascular disorder in a patient in need thereof, by administering to the patient a PDGF antagonist and a VEGF antagonist, simultaneously or within 90 days of each other, in amounts sufficient to treat the patient.

In particular embodiments of these aspects, the method of the invention involves administering the PDGF antagonist and the VEGF antagonist within about 10 days of each other. In another embodiment of the method of the invention, the PDGF antagonist and the VEGF antagonist are administered within 5 days of each other. In yet another embodiment of the method of the invention, the PDGF antagonist and the VEGF antagonist are administered within about 24 hours of each other. In a particular embodiment of the method of the invention, the PDGF antagonist and said VEGF antagonist are administered simultaneously.

In another embodiment, the method of the invention involves administration of a PDGF antagonist that is a PDGF-B antagonist. In still another embodiment, the method of the invention involves administration of a VEGF antagonist that is a VEGF-A antagonist.

In certain embodiments, the method of the invention involves administration of a PDGF antagonist that is a nucleic acid molecule, an aptamer, an antisense RNA molecule, a ribozyme, an RNAi molecule, a protein, a peptide, a cyclic peptide, an antibody, a binding fragment of an antibody fragment, a sugar, a polymer, or a small organic compound. In another embodiment, the method of the invention involves administration of a VEGF antagonist that is a nucleic acid molecule, an aptamer, an antisense RNA molecule, a ribozyme, an RNAi molecule, a protein, a peptide, a cyclic peptide, an antibody, a binding fragment of an antibody fragment, a sugar, a polymer, or a small organic compound.

In a particular embodiment, the method of the invention involves administration of a VEGF antagonist that is an aptamer, such as an EYE001 aptamer. In another embodiment, the method of the invention involves administration of a VEGF antagonist that is an antibody or binding fragment thereof.

In a particular embodiment, the method of the invention involves administration of a PDGF antagonist that is an aptamer, an antibody or a binding fragment thereof. In another particular embodiment, the method of the invention involves administration of a PDGF antagonist that is an antisense oligonucleotide.

In yet another embodiment of this aspect of the invention, the PDGF antagonist and/or the VEGF antagonist are pro-drugs.

In one embodiment, the method of the invention provides a means for suppressing or treating an ocular neovascular disorder. In some embodiments, ocular neovascular disorders amenable to treatment or suppression by the method of the invention include ischemic retinopathy, iris neovascularization, intraocular neovascularization, age-related macular degeneration, corneal neovascularization, retinal neovascularization, choroidal neovascularization, diabetic retinal ischemia, or proliferative diabetic retinopathy. In still another embodiment, the method of the invention provides a means for suppressing or treating psoriasis or rheumatoid arthritis in a patient in need thereof or a patient diagnosed with or at risk for developing such a disorder.

The invention also provides a pharmaceutical composition that includes both a PDGF antagonist and a VEGF antagonist, as well a pharmaceutically acceptable carrier. In this aspect, the PDGF and VEGF antagonists are present both in amounts sufficient to suppress the neovascular disorder in the patient.

In one embodiment of this aspect, the pharmaceutical composition includes a PDGF antagonist that is a PDGF-B antagonist. In another embodiment, the pharmaceutical composition includes a VEGF antagonist that is a VEGF-A antagonist.

In certain embodiments, the pharmaceutical composition of the invention includes a PDGF antagonist that is a nucleic acid molecule, an aptamer, an antisense RNA molecule, a ribozyme, an RNAi molecule, a protein, a peptide, a cyclic peptide, an antibody, a binding fragment of an antibody fragment, a sugar, a polymer or a small organic compound. In another embodiment, the pharmaceutical composition of the invention includes a VEGF antagonist that is a nucleic acid molecule, an aptamer, an antisense RNA molecule, a ribozyme, an RNAi molecule, a protein, a peptide, a cyclic peptide, an antibody, a binding fragment of an antibody fragment, a sugar, a polymer, or a small organic compound.

In other particular embodiments, the pharmaceutical composition of the invention includes a VEGF antagonist that is an aptamer, such as an EYE001 aptamer. In one embodiment, the pharmaceutical composition of the invention includes a VEGF antagonist that is an antibody or binding fragment thereof.

In a particular embodiment, the pharmaceutical composition of the invention includes a PDGF antagonist that is an antibody or binding fragment thereof. In another particular embodiment, the pharmaceutical composition of the invention includes a PDGF antagonist that is an antisense oligonucleotide.

The pharmaceutical composition the invention may include a pharmaceutically acceptable carrier which includes a microsphere or a hydrogel formulation.

In yet another embodiment, the PDGF antagonist and/or the VEGF antagonist are pro-drugs.

In another embodiment, the pharmaceutical composition of the invention provides a means for suppressing or treating an ocular neovascular disorder. In some embodiments, ocular neovascular disorders amenable to treatment or suppression by the pharmaceutical composition of the invention include ischemic retinopathy, iris neovascularization, intraocular neovascularization, age-related macular degeneration, corneal neovascularization, retinal neovascularization, choroidal neovascularization, diabetic retinal ischemia, or proliferative diabetic retinopathy. In still other embodiments, the pharmaceutical composition of the invention provides a means for suppressing or treating psoriasis or rheumatoid arthritis in a patient in need thereof, or a patient diagnosed with or at risk for developing such a disorder.

The invention also provides a pharmaceutical pack that includes both a PDGF antagonist and a VEGF antagonist. In one embodiment of this aspect, the pharmaceutical pack includes a PDGF antagonist that is a PDGF-B antagonist. In another embodiment of this aspect, the pharmaceutical pack includes a VEGF antagonist that is a VEGF-A antagonist.

In another embodiment, the PDGF antagonist and VEGF antagonist of the pharmaceutical pack are formulated separately and in individual dosage amounts. In still another embodiment, the PDGF antagonist and VEGF antagonist of the pharmaceutical pack are formulated together.

In some particular embodiments, the pharmaceutical pack of the invention includes a VEGF antagonist that is an aptamer, such as an EYE001 aptamer. In other embodiments, the pharmaceutical pack of the invention includes a VEGF antagonist that is an antibody or binding fragment thereof.

In some embodiments, the pharmaceutical pack of the invention includes a PDGF antagonist that is an antibody or binding fragment thereof. In other particular embodiment, the pharmaceutical pack of the invention includes a PDGF antagonist that is an antisense oligonucleotide. In yet another embodiment of this aspect, the PDGF antagonist and/or the VEGF antagonist are pro-drugs.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 (A) is a schematic representation of the nucleic acid sequence of a human PDGF-B (GenBank Accession No. X02811) (SEQ ID NO: 1).

Figure 1 (B) is a schematic representation of the amino acid sequence of a human PDGF-B (GenBank Accession No. CAA26579) (SEQ ID NO: 2).

Figure 1 (C) is a schematic representation of the nucleic acid sequence of a human PDGF-A (GenBank Accession No. X06374) (SEQ ID NO: 11).

Figure 1 (D) is a schematic representation of the polypeptide sequence of a human PDGF-A (GenBank Accession No. CAA29677) (SEQ ID NO: 12).

Figure 2 (A) is a schematic representation of the nucleic acid sequence of a human VEGF (GenBank Accession No: NM_003376) (SEQ ID NO: 3).

Figure 2 (B) is a schematic representation of the amino acid sequence of a human VEGF polypeptide (GenBank Accession No. NP_003367) (SEQ ID NO: 4).

Figure 3 (A) is a schematic representation of the nucleic acid sequence of a human PDGFR-B (GenBank Accession No. NM_002609) (SEQ ID NO: 5).

Figure 3 (B) is a schematic representation of the polypeptide sequence of a human PDGFR-B (GenBank Accession No. NP_002600) (SEQ ID NO: 6).

Figure 3 (C) is a schematic representation of the nucleic acid sequence of a human PDGFR-A (GenBank Accession No. NM_006206) (SEQ ID NO: 13).

Figure 3 (D) is a schematic representation of the polypeptide sequence of a human PDGFR-A (GenBank Accession No. NP_006197) (SEQ ID NO: 14).

Figure 4 (A) is a schematic representation of the nucleic acid sequence of a human VEGFR-1 (Flt-1) (GenBank Accession No. AF063657) (SEQ ID NO: 7).

Figure 4 (B) is schematic a representation of the polypeptide sequence of a human VEGFR-1 (Flt-1) (GenBank Accession No.) (SEQ ID NO: 8).

Figure 4 (C) is a schematic representation of the nucleic acid sequence of a human VEGFR-2 (KDR/Flk-1) (GenBank Accession No. AF035121) (SEQ ID NO: 9).

Figure 4 (D) is a schematic representation of the polypeptide sequence of a human VEGFR-2 (KDR/Flk-1) (GenBank Accession No. AAB88005) (SEQ ID NO: 10).

Figure 5 is a graphical representation of the results of a corneal neovascularization assay comparing a control treatment (cont), Gleevec treatment (an anti-PDGF agent), and Macugen™ treatment (*i.e.* pegaptanib treatment, an anti-VEGF agent), to the results of a combination treatment with Macugen™ and Gleevec (anti-PDGF/anti-VEGF combination therapy).

Figure 6 (A) is a photographic representation of a fluorescent-microscopic image of corneal neovascularization occurring in control (PEG-treated) mouse cornea.

Figure 6 (B) is a photographic representation of a fluorescent-microscopic image of corneal neovascularization occurring in a Gleevec-treated mouse cornea.

Figure 6 (C) is a photographic representation of a fluorescent-microscopic image of corneal neovascularization occurring in a Macugen™ -treated mouse cornea.

Figure 6 (D) is a photographic representation of a fluorescent-microscopic image of corneal neovascularization occurring in a mouse cornea treated with both Macugen™ and Gleevec.

Figure 7 (A) is a photographic representation of a fluorescent-microscopic image showing that normal corneal vasculature is unaffected by administration of APB5 (PDGFR antibody, an anti-PDGF agent).

Figure 7 (B) is a photographic representation of a fluorescent-microscopic image showing that normal corneal vasculature is unaffected by administration of Gleevec.

Figure 7 (C) is a photographic representation of a fluorescent-microscopic image showing that normal corneal vasculature is unaffected by administration of Macugen™ (Mac) and Gleevec together.

Figure 7 (D) is a photographic representation of a fluorescent-microscopic image showing that normal corneal vasculature is unaffected by administration of PEG.

Figure 8 is a graphical representation of the results of a laser-induced choroidal neovascularization assay comparing a control treatment (cont), Gleevec treatment (an anti-PDGF agent), and Macugen™ treatment (*i.e.* pegaptanib treatment, an anti-VEGF agent), to the results of a combination treatment with Macugen™ and Gleevec (anti-PDGF/anti-VEGF combination therapy).

Figure 9 is a graphical representation of the results of a laser-induced choroidal neovascularization assay comparing a control-treated (cont), APB5-treated (an anti-PGFR antibody, which acts as an anti-PDGF agent), and Macugen treatment (*i.e.* pegaptanib treatment, an anti-VEGF aptamer), to the results of a combination treatment with Macugen and APB5 (Mac+APB5).

Figure 10 is a graphical representation of the results of a retinal developmental model comparing a control treatment (cont), ARC-127 treatment (an anti-PDGF agent), and Macugen treatment (*i.e.* pegaptanib treatment, an anti-VEGF agent), to the results of a combination treatment with Macugen and ARC-127 (anti-PDGF/anti-VEGF combination therapy).

Figure 11 is a graphical representation of the results of a corneal neovascularization assay comparing a control treatment (cont), ARC-127 treatment (an anti-PDGF agent), and Macugen treatment (*i.e.* pegaptanib treatment, an anti-VEGF agent), to the results of a combination treatment with Macugen and ARC-127 (anti-PDGF/anti-VEGF combination therapy).

Figure 12 (A) is a photographic representation of a fluorescent-microscopic image of corneal neovascularization occurring in control mouse cornea.

Figure 12 (B) is a photographic representation of a fluorescent-microscopic image of corneal neovascularization occurring in a ARC-127-treated mouse cornea.

Figure 12 (C) is a photographic representation of a fluorescent-microscopic image of corneal neovascularization occurring in a Macugen-treated mouse cornea.

Figure 12 (D) is a photographic representation of a fluorescent-microscopic image of corneal neovascularization occurring in a mouse cornea treated with both Macugen and ARC-127.

Figure 13 is a graphical representation of the results of a corneal neovascularization assay comparing a control treatment (cont), APB-5 treatment (an anti-PDGF agent), and Macugen treatment (*i.e.* pegaptanib treatment, an anti-VEGF agent), to the results of a combination treatment with Macugen and APB-5 (anti-PDGF/anti-VEGF combination therapy).

Figure 14 is a graphical representation of the results of a corneal neovascularization assay comparing a control treatment (cont), APB-5 treatment (an anti-PDGF agent), and Macugen treatment (*i.e.* pegaptanib treatment, an anti-VEGF agent), to the results of a combination treatment with Macugen and APB-5 (anti-PDGF/anti-VEGF combination therapy).

DETAILED DESCRIPTION OF THE INVENTION

All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference.

Definitions

As used herein, the following terms and phrases shall have the meanings set forth below. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this invention belongs.

By “antagonist” is meant an agent that inhibits, either partially or fully, the activity or production of a target molecule. In particular, the term “antagonist,” as applied selectively herein, means an agent capable of decreasing levels of PDGF, PDGFR, VEGF or VEGFR gene expression, mRNA levels, protein levels or protein activity. Exemplary forms of antagonists include, for example, proteins, polypeptides, peptides (such as cyclic peptides), antibodies or antibody fragments, peptide mimetics, nucleic acid molecules, antisense molecules, ribozymes, aptamers, RNAi molecules, and small organic molecules. Exemplary non-limiting mechanisms of antagonist inhibition of the VEGF/VEGFR and PDGF/PDGFR ligand/receptor targets include repression of ligand synthesis and/or stability (*e.g.,* using, antisense, ribozymes or RNAi compositions targeting the ligand gene/nucleic acid), blocking of binding of the ligand to its cognate receptor (*e.g.,* using anti-ligand aptamers, antibodies or a soluble, decoy cognate receptor), repression of receptor synthesis and/or stability (*e.g.,* using, antisense, ribozymes or RNAi compositions targeting the ligand receptor gene/nucleic acid), blocking of the binding of the receptor to its cognate receptor (*e.g.,* using receptor antibodies) and blocking of the activation of the receptor by its cognate ligand (*e.g.,* using receptor tyrosine kinase inhibitors). In addition, the antagonist may directly or indirectly inhibit the target molecule.

The term "antibody" as used herein is intended to include whole antibodies, *e.g.,* of any isotype (IgG, IgA, IgM, IgE, etc.), and includes fragments thereof which recognize and are also specifically reactive with vertebrate (*e.g.,* mammalian) protein, carbohydrates, etc. Antibodies can be fragmented using conventional techniques and the fragments screened for utility in the same manner as described above for whole antibodies. Thus, the term includes segments of proteolytically cleaved or recombinantly-prepared portions of an antibody molecule that are capable of selectively reacting with a certain protein. Non-limiting examples of such proteolytic and/or recombinant fragments include Fab, F(ab')2, Fab', Fv, and single chain antibodies (scFv) containing a V[L] and/or V[H] domain joined by a peptide linker. The scFv's may be covalently or noncovalently linked to form antibodies having two or more binding sites. The subject invention includes polyclonal, monoclonal, or other purified preparations of antibodies and recombinant antibodies.

The term “aptamer,” used herein interchangeably with the term “nucleic acid ligand,” means a nucleic acid that, through its ability to adopt a specific three dimensional conformation, binds to and has an antagonizing (*i.e.,* inhibitory) effect on a target. The target of the present invention is PDGF or VEGF (or one of their cognate receptors PDGFR or VEGFR), and hence the term PDGF aptamer or nucleic acid ligand or VEGF aptamer or nucleic acid ligand (or PDGFR aptamer or nucleic acid ligand or VEGFR aptamer or nucleic acid ligand) is used. Inhibition of the target by the aptamer may occur by binding of the target, by catalytically altering the target, by reacting with the target in a way which modifies/alters the target or the functional activity of the target, by covalently attaching to the target as in a suicide inhibitor, by facilitating the reaction between the target and another molecule. Aptamers may be comprised of multiple ribonucleotide units, deoxyribonucleotide units, or a mixture of both types of nucleotide residues. Aptamers may further comprise one or more modified bases, sugars or phosphate backbone units as described in further detail herein.

By "antibody antagonist" is meant an antibody molecule as herein defined which is able to block or significantly reduce one or more activities of a target PDGF or VEGF. For example, an VEGF inhibitory antibody may inhibit or reduce the ability of VEGF to stimulate angiogenesis.

A nucleotide sequence is "complementary" to another nucleotide sequence if each of the bases of the two sequences matches, *i.e.*, are capable of forming Watson Crick base pairs. The term "complementary strand" is used herein interchangeably with the term "complement." The complement of a nucleic acid strand can be the complement of a coding strand or the complement of a non-coding strand.

The phrases "conserved residue" "or conservative amino acid substitution" refer to grouping of amino acids on the basis of certain common properties. A functional way to define common properties between individual amino acids is to analyze the normalized frequencies of amino acid changes between corresponding proteins of homologous organisms. According to such analyses, groups of amino acids may be defined where amino acids within a group exchange preferentially with each other, and therefore resemble each other most in their impact on the overall protein structure (Schulz, G. E. and R. H. Schirmer, <u>Principles of Protein Structure</u>, Springer-Verlag). Examples of amino acid groups defined in this manner include:

(i) a charged group, consisting of Glu and Asp, Lys, Arg and His,

(ii) a positively-charged group, consisting of Lys, Arg and His,

(iii) a negatively-charged group, consisting of Glu and Asp,

(iv) an aromatic group, consisting of Phe, Tyr and Trp,

(v) a nitrogen ring group, consisting of His and Trp,
(vi) a large aliphatic nonpolar group, consisting of Val, Leu and Ile,
(vii) a slightly-polar group, consisting of Met and Cys,
(viii) a small-residue group, consisting of Ser, Thr, Asp, Asn, Gly, Ala, Glu, Gln and Pro,
(ix) an aliphatic group consisting of Val, Leu, Ile, Met and Cys, and
(x) a small hydroxyl group consisting of Ser and Thr.

In addition to the groups presented above, each amino acid residue may form its own group, and the group formed by an individual amino acid may be referred to simply by the one and/or three letter abbreviation for that amino acid commonly used in the art.

The term "interact" as used herein is meant to include detectable relationships or association (*e.g.*, biochemical interactions) between molecules, such as interaction between protein-protein, protein-nucleic acid, nucleic acid-nucleic acid, and protein-small molecule or nucleic acid-small molecule in nature.

The term "interacting protein" refers to protein capable of interacting, binding, and/or otherwise associating to a protein of interest, such as for example a PDGF or a VEGF protein, or their corresponding cognate receptors.

The term "isolated" as used herein with respect to nucleic acids, such as DNA or RNA, refers to molecules separated from other DNAs, or RNAs, respectively that are present in the natural source of the macromolecule. Similarly the term "isolated" as used herein with respect to polypeptides refers to protein molecules separated from other proteins that are present in the source of the polypeptide. The term isolated as used herein also refers to a nucleic acid or peptide that is substantially free of cellular material, viral material, or culture medium when produced by recombinant DNA techniques, or chemical precursors or other chemicals when chemically synthesized.

"Isolated nucleic acid" is meant to include nucleic acid fragments, which are not naturally occurring as fragments and would not be found in the natural state. The term "isolated" is also used herein to refer to polypeptides, which are isolated from other cellular proteins and is meant to encompass both purified and recombinant polypeptides.

As used herein, the terms "label" and "detectable label" refer to a molecule capable of detection, including, but not limited to, radioactive isotopes, fluorophores, chemiluminescent moieties, enzymes, enzyme substrates, enzyme cofactors, enzyme inhibitors, dyes, metal ions, ligands (*e.g.*, biotin or haptens) and the like. The term "fluorescer" refers to a substance or a portion thereof, which is capable of exhibiting fluorescence in the detectable range. Particular examples of labels which may be used under the invention include fluorescein, rhodamine, dansyl, umbelliferone, Texas red, luminol, NADPH, alpha - beta -galactosidase and horseradish peroxidase.

The "level of expression of a gene in a cell" refers to the level of mRNA, as well as pre-mRNA nascent transcript(s), transcript processing intermediates, mature mRNA(s) and degradation products, encoded by the gene in the cell, as well as the level of protein translated from that gene.

As used herein, the term "nucleic acid" refers to polynucleotides such as deoxyribonucleic acid (DNA), and, where appropriate, ribonucleic acid (RNA). The term should also be understood to include, as equivalents, analogs of either RNA or DNA made from nucleotide analogs, and, as applicable to the embodiment being described, single (sense or antisense) and double-stranded polynucleotides, ESTs, chromosomes, cDNAs, mRNAs, and rRNAs are representative examples of molecules that may be referred to as nucleic acids.

The term "oligonucleotide" refers to an oligomer or polymer of nucleotide or nucleoside monomers consisting of naturally occurring bases, sugars and intersugar (backbone) linkages. The term also includes modified or substituted oligomers comprising non-naturally occurring monomers or portions thereof, which function similarly. Incorporation of substituted oligomers is based on factors including enhanced cellular uptake, or increased nuclease resistance and are chosen as is known in the art. The entire oligonucleotide or only portions thereof may contain the substituted oligomers.

The term "percent identical" refers to sequence identity between two amino acid sequences or between two nucleotide sequences. Identity can each be determined by comparing a position in each sequence, which may be aligned for purposes of comparison. When an equivalent position in the compared sequences is occupied by the same base or amino acid, then the molecules are identical at that position; when the equivalent site occupied by the same or a similar amino acid residue (*e.g.*, similar in steric and/or electronic nature), then the molecules can be referred to as homologous (similar) at that position. Expression as a percentage of homology, similarity, or identity refers to a function of the number of identical or similar amino acids at positions shared by the compared sequences. Various alignment algorithms and/or programs may be used, including Hidden Markov Model (HMM), FASTA and BLAST. HNiM, FASTA and BLAST are available through the National Center for Biotechnology Information, National Library of Medicine, National Institutes of Health, Bethesda, Md. and the European Bioinformatic Institute EBI. In one embodiment, the percent identity of two sequences that can be determined by these GCG programs with a gap weight of 1, *e.g.*, each amino acid gap is weighted as if it were a single amino acid or nucleotide mismatch between the two sequences. Other techniques for alignment are described in Methods in Enzymology, vol. 266: Computer Methods for Macromolecular

Sequence Analysis (1996), ed. Doolittle, Academic Press, Inc., a division of Harcourt Brace & Co., San Diego, California, USA. Where desirable, an alignment program that permits gaps in the sequence is utilized to align the sequences. The Smith Waterman is one type of algorithm that permits gaps in sequence alignments (see (1997) Meth. Mol. Biol. 70: 173-187). Also, the GAP program using the Needleman and Wunsch alignment method can be utilized to align sequences. More techniques and algorithms including use of the HMM are described in Sequence, Structure, and Databanks: A Practical Approach (2000), ed. Oxford University Press, Incorporated and in Bioinformatics: Databases and Systems (1999) ed. Kluwer Academic Publishers. An alternative search strategy uses MPSRCH software, which runs on a MASPAR computer. MPSRCH uses a Smith-Watermnan algorithm to score sequences on a massively parallel computer. This approach improves ability to pick up distantly related matches, and is especially tolerant of small gaps and nucleotide sequence errors. Nucleic acid-encoded amino acid sequences can be used to search both protein and DNA databases. Databases with individual sequences are described in Methods in Enzymology, ed. Doolittle, *supra*. Databases include Genbank, EMBL, and DNA Database of Japan (DDBJ).

"Perfectly matched" in reference to a duplex means that the poly- or oligonucleotide strands making up the duplex form a double stranded structure with one other such that every nucleotide in each strand undergoes Watson-Crick basepairing with a nucleotide in the other strand. The term also comprehends the pairing of nucleoside analogs, such as deoxyinosine, nucleosides with 2-aminopurine bases, and the like, that may be employed. A mismatch in a duplex between a target polynucleotide and an oligonucleotide or polynucleotide means that a pair of nucleotides in the duplex fails to undergo Watson-Crick bonding. In reference to a triplex, the term means that the triplex consists of a perfectly matched duplex and a third strand in which every nucleotide undergoes Hoogsteen or reverse Hoogsteen association with a base pair of the perfectly matched duplex.

The term "RNA interference," "RNAi," or "siRNA" all refer to any method by which expression of a gene or gene product is decreased by introducing into a target cell one or more double-stranded RNAs, which are homologous to the gene of interest (particularly to the messenger RNA of the gene of interest, *e.g.*, PDGF or VEGF).

Polymorphic variants also may encompass "single nucleotide polymorphisms" (SNPs) in which the polynucleotide sequence varies by one base (*e.g.*, a one base variation in PDGF or VEGF). The presence of SNPs may be indicative of, for example, a certain population, a disease state, or a propensity for a disease state.

The "profile" of an aberrant, *e.g.*, tumor cell's biological state refers to the levels of various constituents of a cell that change in response to the disease state. Constituents of a cell include levels of RNA, levels of protein abundances, or protein activity levels.

The term "protein" is used interchangeably herein with the terms "peptide" and "polypeptide." The term "recombinant protein" refers to a protein of the present invention which is produced by recombinant DNA techniques, wherein generally DNA encoding the expressed protein or RNA is inserted into a suitable expression vector which is in turn used to transform a host cell to produce the heterologous protein or RNA. Moreover, the phrase "derived from," with respect to a recombinant gene encoding the recombinant protein is meant to include within the meaning of "recombinant protein" those proteins having an amino acid sequence of a native protein, or an amino acid sequence similar thereto which is generated by mutations, including substitutions and deletions, of a naturally occurring protein.

As used herein, the term "transgene" means a nucleic acid sequence (encoding, *e.g.*, one of the target nucleic acids, or an antisense transcript thereto), which has been introduced into a cell. A transgene could be partly or entirely heterologous, *i.e.*, foreign, to the transgenic animal or cell into which it is introduced, or, is homologous to an endogenous gene of the transgenic animal or cell into which it is introduced, but which is designed to be inserted, or is inserted, into the animal's genome in such a way as to alter the genome of the cell into which it is inserted (*e.g.*, it is inserted at a location which differs from that of the natural gene or its insertion results in a knockout). A transgene can also be present in a cell in the form of an episome. A transgene can include one or more transcriptional regulatory sequences and any other nucleic acid, such as introns, that may be necessary for optimal expression of a selected nucleic acid.

By "neovascular disorder" is meant a disorder characterized by altered or unregulated angiogenesis other than one accompanying oncogenic or neoplastic transformation, *i.e.*, cancer. Examples of neovascular disorders include psoriasis, rheumatoid arthritis, and ocular neovascular disorders including diabetic retinopathy and age-related macular degeneration.

As used herein, the terms "neovascularization" and "angiogenesis" are used interchangeably. Neovascularization and angiogenesis refer to the generation of new blood vessels into cells, tissue, or organs. The control of angiogenesis is typically altered in certain disease states and, in many cases, the pathological damage associated with the disease is related to altered, unregulated, or uncontrolled angiogenesis. Persistent, unregulated angiogenesis occurs in a multiplicity of disease states, including those characterized by the abnormal growth by endothelial cells, and supports the pathological damage seen in these conditions including leakage and permeability of blood vessels.

By "ocular neovascular disorder" is meant a disorder characterized by altered or unregulated angiogenesis in the eye of a patient. Exemplary ocular neovascular disorders include optic disc neovascularization, iris neovascularization, retinal neovascularization, choroidal neovascularization, corneal neovascularization, vitreal neovascularization, glaucoma, pannus, pterygium, macular edema, diabetic retinopathy, diabetic macular edema, vascular retinopathy, retinal degeneration, uveitis, inflammatory diseases of the retina, and proliferative vitreoretinopathy.

The term "treating" a neovascular disease in a subject or "treating" a subject having a neovascular disease refers to subjecting the subject to a pharmaceutical treatment, *e.g.*, the administration of a drug, such that at least one symptom of the neovascular disease is decreased. Accordingly, the term "treating" as used herein is intended to encompass curing as well as ameliorating at least one symptom of the neovascular condition or disease. Accordingly, "treating" as used herein, includes administering or prescribing a pharmaceutical composition for the treatment or prevention of an ocular neovascular disorder.

By "patient" is meant any animal. The term "animal" includes mammals, including, but is not limited to, humans and other primates. The term also includes domesticated animals, such as cows, hogs, sheep, horses, dogs, and cats.

By "PDGF" or "platelet-derived growth factor" is meant a mammalian platelet-derived growth factor that affects angiogenesis or an angiogenic process. As used herein, the term "PDGF" includes the various subtypes of PDGF including PDGF-B (see Figure 1 (A) and (B)), and PDGF-A (see Figure 1 (C) and (D)). Further, as used herein, the term "PDGF" refers to PDGF-related angiogenic factors such as PDGF-C and PDGF-D that act through a cognate PDGF receptor to stimulate angiogenesis or an angiogenic process. In particular, the term "PDGF" means any member of the class of growth factors that (i) bind to a PDGF receptor such as PDGFR-B (see Figure 3 (A) and (B)), or PDGFR-A (see Figure 3 (C) and (D)); (ii) activates a tyrosine kinase activity associated with the VEGF receptor; and (iii) thereby affects angiogenesis or an angiogenic process. As used herein, the term "PDGF" generally refers to those members of the class of growth factors that induce DNA synthesis and mitogenesis through the binding and activation of a platelet-derived growth factor cell surface receptor (*i.e.,* PDGFR) on a responsive cell type. PDGFs effect specific biological effects including, for example: directed cell migration (chemotaxis) and cell activation; phospholipase activation; increased phosphatidylinositol turnover and prostaglandin metabolism; stimulation of both collagen and collagenase synthesis by responsive cells; alteration of cellular metabolic activities, including matrix synthesis, cytokine production, and lipoprotein uptake; induction, indirectly, of a proliferative response in cells lacking PDGF receptors; and potent vasoconstrictor activity. The term "PDGF" is meant to include both a “PDGF” polypeptide and its corresponding “PDGF” encoding gene or nucleic acid.

By "PDGF-A" is meant an A chain polypeptide of PDGF and its corresponding encoding gene or nucleic acid.

By "PDGF-B" is meant a B chain polypeptide of PDGF and its corresponding encoding gene or nucleic acid.

By “VEGF,” or "vascular endothelial growth factor," is meant a mammalian vascular endothelial growth factor that affects angiogenesis or an angiogenic process. As used herein, the term “VEGF” includes the various subtypes of VEGF (also known as vascular permeability factor (VPF) and VEGF-A) (see Figure 2(A) and (B)) that arise by, *e.g.*, alternative splicing of the VEGF-A/VPF gene including $VEGF_{121}$, $VEGF_{165}$ and $VEGF_{189}$. Further, as used herein, the term “VEGF” refers to VEGF-related angiogenic factors such as PIGF (placenta growth factor), VEGF-B, VEGF-C, VEGF-D and VEGF-E that act through a cognate VEFG receptor to stimulate angiogenesis or an angiogenic process. In particular, the term "VEGF" means any member of the class of growth factors that (i) bind to a VEGF receptor such as VEGFR-1 (Flt-1) (see Figure 4 (A) and (B)), VEGFR-2 (KDR/Flk-1) (see Figure 4 (C) and (D)), or VEGFR-3 (FLT-4); (ii) activates a tyrosine kinase activity associated with the VEGF receptor; and (iii) thereby affects angiogenesis or an angiogenic process. The term "VEGF" is meant to include both a “VEGF” polypeptide and its corresponding “VEGF” encoding gene or nucleic acid.

By "PDGF antagonist" is meant an agent that reduces, or inhibits, either partially or fully, the activity or production of a PDGF. A PDGF antagonist may directly or indirectly reduce or inhibit a specific PDGF such as PDGF-B. Furthermore, “PDGF antagonists” consistent with the above definition of “antagonist,” may include agents that act on either a PDGF ligand or its cognate receptor so as to reduce or inhibit a PDGF-associated receptor signal. Examples of such “PDGF antagonists” thus include, for example: antisense, ribozymes or RNAi compositions targeting a PDGF nucleic acid; anti-PDGF aptamers, anti-PDGF antibodies or soluble PDGF receptor decoys that prevent binding of a PDGF to its cognate receptor; antisense, ribozymes or RNAi compositions targeting a cognate PDGF receptor (PDGFR) nucleic acid; anti-PDGFR aptamers or anti-PDGFR antibodies that bind to a cognate PDGFR receptor; and PDGFR tyrosine kinase inhibitors.

By "VEGF antagonist" is meant an agent that reduces, or inhibits, either partially or fully, the activity or production of a VEGF. A VEGF antagonist may directly or indirectly reduce or inhibit a specific VEGF such as $VEGF_{165}$. Furthermore, “VEGF antagonists” consistent with the above definition of “antagonist,” may include agents that act on either a VEGF ligand or its cognate receptor so as to reduce or inhibit a VEGF -associated receptor signal. Examples of such

"VEGF antagonists" thus include, for example: antisense, ribozymes or RNAi compositions targeting a VEGF nucleic acid; anti- VEGF aptamers, anti- VEGF antibodies or soluble VEGF receptor decoys that prevent binding of a VEGF to its cognate receptor; antisense, ribozymes, or RNAi compositions targeting a cognate VEGF receptor (VEGFR) nucleic acid; anti- VEGFR aptamers or anti- VEGFR antibodies that bind to a cognate VEGFR receptor; and VEGFR tyrosine kinase inhibitors.

By "an amount sufficient to suppress a neovascular disorder" is meant the effective amount of an antagonist, in a combination of the invention, required to treat or prevent a neovascular disorder or symptom thereof. The "effective amount" of active antagonists used to practice the present invention for therapeutic treatment of conditions caused by or contributing to the neovascular disorder varies depending upon the manner of administration, anatomical location of the neovascular disorder, the age, body weight, and general health of the patient. Ultimately, a physician or veterinarian will decide the appropriate amount and dosage regimen. Such amount is referred to as an amount sufficient to suppress a neovascular disorder.

Other features and advantages of the invention will be apparent from the following detailed description, and from the claims.

A "variant" of polypeptide X refers to a polypeptide having the amino acid sequence of peptide X in which is altered in one or more amino acid residues. The variant may have "conservative" changes, wherein a substituted amino acid has similar structural or chemical properties (*e.g.*, replacement of leucine with isoleucine). More rarely, a variant may have "nonconservative" changes (*e.g.*, replacement of glycine with tryptophan). Analogous minor variations may also include amino acid deletions or insertions, or both. Guidance in determining which amino acid residues may be substituted, inserted, or deleted without abolishing biological or immunological activity may be found using computer programs well known in the art, for example, LASERGENE software (DNASTAR).

The term "variant," when used in the context of a polynucleotide sequence, may encompass a polynucleotide sequence related to that of gene or the coding sequence thereof. This definition may also include, for example, "allelic," "splice," "species," or "polymorphic" variants. A splice variant may have significant identity to a reference molecule, but will generally have a greater or lesser number of polynucleotides due to alternative splicing of exons during mRNA processing. The corresponding polypeptide may possess additional functional domains or an absence of domains. Species variants are polynucleotide sequences that vary from one species to another. The resulting polypeptides generally will have significant amino acid identity relative to each other. A polymorphic variant is a variation in the polynucleotide sequence of a particular gene between individuals of a given species.

The term "vector" refers to a nucleic acid molecule capable of transporting another nucleic acid to which it has been linked. One type of useful vector is an episome, *i.e.,* a nucleic acid capable of extra-chromosomal replication. Useful vectors are those capable of autonomous replication and/or expression of nucleic acids to which they are linked. Vectors capable of directing the expression of genes to which they are operatively linked are referred to herein as "expression vectors". In general, expression vectors of utility in recombinant DNA techniques are often in the form of "plasmids" which refer generally to circular double stranded DNA loops which, in their vector form are not bound to the chromosome. In the present specification, "plasmid" and "vector" are used interchangeably as the plasmid is the most commonly used form of vector. However, the invention is intended to include such other forms of expression vectors which serve equivalent functions and which become known in the art subsequently hereto.

Combination Therapy

The invention is based, in part, upon the specific inhibition of both VEGF and PDGF activities using appropriate growth factor antagonists as a potent treatment for patients having a neovascular disorder. The administration of a combination of a PDGF antagonist and a VEGF antagonist affords greater therapeutic benefits for treating an ocular neovascular disorder than either antagonist administered alone. The combined action of anti-VEGF and anti-PDGF agents is unexpected in light of studies evidencing no apparent cooperation between the two factors in stimulating angiogenesis in a retinal endothelial cell system (see Castellon *et al.,* (2001) Exp. Eye Res. 74: 523-35).

PDGF and VEGF are important stimuli for the growth of new blood vessels throughout the body, especially in the eye. Combination therapy directed at inhibiting both PDGF and VEGF biological activities provides a method for treating or preventing the neovascular disorder.

Accordingly, the invention features methods and compositions for suppressing a neovascular disorder using combination therapy. In particular, the present invention utilizes two distinct intercellular communication signaling pathways operative in vascular cells, namely PDGF and VEGF signaling, as therapeutic targets in the treatment of a neovascular disorder, such as an ocular neovascular disorder. This combination method is especially useful for treating any number of ophthamalogical diseases and disorders marked by the development of ocular neovascularization, including, but not limited to, optic disc neovascularization, iris neovascularization, retinal neovascularization, choroidal neovascularization, corneal neovascularization, vitreal neovascularization, glaucoma, pannus, pterygium, macular edema, diabetic macular edema, vascular retinopathy, retinal degeneration, macular degeneration, uveitis, inflammatory diseases of the retina, and proliferative vitreoretinopathy. The combination therapy, consisting of antagonists that inhibit PDGF (such as PDGF-B) and VEGF (such as VEGF-A) signaling results in an increased treatment efficacy compared to either of the two therapies being used independently. While the examples discussed below describe the combination of a single PDGF antagonist and a single VEGF antagonist, it is understood that the combination of multiple antagonistic agents may be desirable.

Anti-PDGF and anti-VEGF combination therapy according to the invention may be performed alone or in conjunction with another therapy and may be provided at home, the doctor's office, a clinic, a hospital's outpatient department, or a hospital. Treatment generally begins at a hospital so that the doctor can observe the therapy's effects closely and make any adjustments that are needed. The duration of the combination therapy depends on the type of neovascular disorder being treated, the age and condition of the patient, the stage and type of the patient's disease, and how the patient responds to the treatment. Additionally, a person having a greater risk of developing a neovascular disorder (*e.g.*, a diabetic patient) may receive treatment to inhibit or delay the onset of symptoms. One significant advantage provided by the present invention is that the combination of a PDGF antagonist and a VEGF antagonist for the treatment of a neovascular disorder allows for the administration of a low dose of each antagonist and less total active antagonist, thus providing similar efficacy with less toxicity and side effects, and reduced costs.

The dosage and frequency of administration of each component of the combination can be controlled independently. For example, one antagonist may be administered three times per day, while the second antagonist may be administered once per day. Combination therapy may be given in on-and-off cycles that include rest periods so that the patient's body has a chance to recover from any as yet unforeseen side-effects. The antagonists may also be formulated together such that one administration delivers both antagonists.

PDGF and VEGF Antagonist Targets

PDGF was originally isolated from platelet lysates and identified as the major growth-promoting activity present in serum but not in plasma. The mitogenic activity of PDGF was first shown to act on connective tissue cells, such as fibroblasts and smooth muscle cells, and in glial cells in culture. Two homologous PDGF isoforms have been identified, PDGF A and B, which are encoded by separate genes (on chromosomes 7 and 22). The most abundant species from platelets is the AB heterodimer, although all three possible dimers (AA, AB and BB) occur naturally. Following translation, PDGF dimers are processed into approximately 30 kDa secreted proteins.

Two cell surface proteins that bind PDGF with high affinity have been identified, alpha. and beta. (Heldin *et al.*, (1981) Proc. Natl. Acad. Sci. (USA) 78: 3664; Williams *et al.*, (1981) Proc. Natl.

Acad. Sci. (USA) 79: 5867). Both species contain five immunoglobulin-like extracellular domains, a single transmembrane domain and an intracellular tyrosine kinase domain separated by a kinase insert domain. In the last several years, the specificities of the three PDGF isoforms for the three receptor dimers (alpha/alpha, alpha/beta, and beta/beta.) have been elucidated. The alpha-receptor homodimer binds all three PDGF isoforms with high affinity, the beta-receptor homodimer binds only PDGF BB with high affinity and PDGF AB with approximately 10-fold lower affinity, and the alpha/beta.-receptor heterodimer binds PDGF BB and PDGF AB with high affinity (Westermark & Heldin (1993) Acta Oncologica 32:101). The specificity pattern appears to result from the ability of the A-chain to bind only to the alpha-receptor and of the B-chain to bind to both alpha and beta-receptor subunits with high affinity.

In general, the invention provides for agents that inhibit one or more PDGF activities. These PDGF-inhibitory agents, or PDGF antagonists may act on one or more forms of the PDGF ligand. Platelet derived growth factors includes homo- or heterodimers of A-chain (PDGF-A) and B-chain (PDGF-B) that exert their action via binding to and dimerization of two related receptor tyrosine kinases, [alpha]-receptors (PDGFR-[alpha]) and [beta]-receptors (PDGFR-[beta]). In addition, PDGF-C and PDGF-D, two new protease-activated ligands for the PDGFR complexes, have been identified (see Li *et al.,* (2000) Nat. Cell. Biol. 2: 302-9; Bergsten *et al.,* (2001) Nat. Cell. Biol. 3: 512-6; and Uutele *et al.,* (2001) Circulation 103: 2242-47). Due to the different ligand binding specificities of the PDGFRs it is known that PDGFR-[alpha][alpha] binds PDGF-AA, PDGF-BB, PDGF-AB, and PDGF-CC; PDGFR-[beta][beta] binds PDGF-BB and PDGF-DD; whereas PDGFR-[alpha][beta] binds PDGF-AB, PDGF-BB, PDGF-CC, and PDGF-DD (see Betsholtz *et al.*, (2001) BioEssays 23: 494-507).

VEGF is a secreted disulfide-linked homodimer that selectively stimulates endothelial cells to proliferate, migrate, and produce matrix-degrading enzymes (Conn *et al.,* (1990) Proc. Natl. Acad. Sci. (USA) 87:1323-1327); Ferrara and Henzel (1989) Biochem. Biophys. Res. Commun.161: 851-858); Pepper *et al.,* (1991) Biochem. Biophys. Res. Commun. 181:902-906; Unemori *et al.,* (1992) J. Cell. Physiol. 153:557-562), all of which are processes required for the formation of new vessels. VEGF occurs in four forms (VEGF-121, VEGF-165, VEGF-189, VEGF-206) as a result of alternative splicing of the VEGF gene (Houck *et al.,* (1991) Mol. Endocrinol. 5:1806-1814; Tischer *et al.,* (1991) J. Biol. Chem. 266:11947-11954). The two smaller forms are diffusible whereas the larger two forms remain predominantly localized to the cell membrane as a consequence of their high affinity for heparin. VEGF-165 also binds to heparin and is the most abundant form. VEGF-121, the only form that does not bind to heparin, appears to have a lower affinity for VEGF receptors (Gitay-Goren *et al.,* (1996) J. Biol. Chem. 271:5519-5523) as well as lower mitogenic potency (Keyt *et al.,* (1996) J. Biol. Chem. 271:7788-

7795). The biological effects of VEGF are mediated by two tyrosine kinase receptors (Flt-1 and Flk-1/KDR) whose expression is highly restricted to cells of endothelial origin (de Vries *et al.*, (1992) Science 255:989-991; Millauer *et al.*, (1993) Cell 72:835-846; Terman *et al.*, (1991) Oncogene 6:519-524). While the expression of both functional receptors is required for high affinity binding, the chemotactic and mitogenic signaling in endothelial cells appears to occur primarily through the KDR receptor (Park *et al.*, (1994) J. Biol. Chem. 269:25646-25654; Seetharam *et al.*, (1995) Oncogene 10:135-147; Waltenberger *et al.*, (1994) J. Biol. Chem. 26988-26995). The importance of VEGF and VEGF receptors for the development of blood vessels has recently been demonstrated in mice lacking a single allele for the VEGF gene (Carmeliet *et al.*, (1996) Nature 380:435-439; Ferrara *et al.*, (1996) Nature 380:439-442) or both alleles of the Flt-1 (Fong *et al.*, (1995) Nature 376:66-70) or Flk-1 genes (Shalaby *et al.*, (1995) Nature 376:62-66). In each case, distinct abnormalities in vessel formation were observed resulting in embryonic lethality.

Compensatory angiogenesis induced by tissue hypoxia is now known to be mediated by VEGF (Levy *et al.*, (1996) J. Biol. Chem. 2746-2753); Shweiki *et al.*, (1992) Nature 359:843-845). Studies in humans have shown that high concentrations of VEGF are present in the vitreous in angiogenic retinal disorders but not in inactive or non-neovascularization disease states. Human choroidal tissue excised after experimental submacular surgery have also shown high VEGF levels.

In addition to being the only known endothelial cell specific mitogen, VEGF is unique among angiogenic growth factors in its ability to induce a transient increase in blood vessel permeability to macromolecules (hence its original and alternative name, vascular permeability factor, VPF) (see Dvorak *et al.*, (1979) J. Immunol. 122:166-174; Senger *et al.*, (1983) Science 219:983-985; Senger *et al.*, (1986) Cancer Res. 46:5629-5632). Increased vascular permeability and the resulting deposition of plasma proteins in the extravascular space assists the new vessel formation by providing a provisional matrix for the migration of endothelial cells (Dvorak *et al.*, (1995) Am. J. Pathol. 146:1029-1039). Hyperpermeability is indeed a characteristic feature of new vessels, including those associated with tumors.

PDGF and VEGF Antagonists

General

The invention provides antagonists (*i.e.*, inhibitors) of PDGF and VEGF for use together in combination therapy for neovascular disorders. Specific PDGF antagonists and VEGF antagonists are known in the art and are described briefly in the sections that follow. Still other PDGF antagonists and VEGF antagonists that are now, or that have become, available to the skilled artisan include the antibodies, aptamers, antisense oligomers, ribozymes, and RNAi compositions that may be identified and produced using practices that are routine in the art in conjunction with the teachings and guidance of the specification, including the further-provided sections appearing below.

PDGF Antagonists

Generally, inhibition of PDGF (for example, PDGF-B) may be accomplished in a variety of ways. For example, a variety of PDGF antagonists that inhibit the activity or production of PDGF are available and can be used in the methods of the present invention. Exemplary PDGF antagonists include nucleic acid ligands or aptamers of PDGF, such as those described below. Alternatively, the PDGF antagonist may be, for example, an anti-PDGF antibody or antibody fragment. Accordingly, the PDGF molecule is rendered inactive by inhibiting its binding to a receptor. In addition, nucleic acid molecules such as antisense RNA, ribozymes, and RNAi molecules that inhibit PDGF expression at the nucleic acid level are useful as antagonists in the invention. Other PDGF antagonists include peptides, proteins, cyclic peptides, or small organic compounds. Furthermore, the signaling activity of PDGF may be inhibited by disrupting its downstream signaling, for example, by using a number of small molecule tyrosine kinase inhibitory antagonists including those described below. The ability of a compound or agent to serve as a PDGF antagonist may be determined according to the methods known in art and, further, as set forth in, *e.g.*, Dai *et al.*, (2001) Genes & Dev. 15: 1913-25; Zippel, *et al.*, (1989) Eur. J. Cell Biol. 50(2):428-34; and Zwiller, *et al.*, (1991) Oncogene 6: 219-21.

The invention further includes PDGF antagonists known in the art as well as those supported below and any and all equivalents that are within the scope of ordinary skill to create. For example, inhibitory antibodies directed against PDGF are known in the art, *e.g.*, those described in U.S. Patent Nos. 5,976,534, 5,833,986, 5,817,310, 5,882,644, 5,662,904, 5,620,687, 5,468,468, and PCT WO 2003/025019, the contents of which are incorporated by reference in their entirety. In addition, the invention include N-phenyl-2-pyrimidine-amine derivatives that are PDGF antagonists, such as those disclosed in U. S. Patent No. 5,521,184, as well as WO2003/013541, WO2003/078404, WO2003/099771, WO2003/015282, and WO2004/05282 which are hereby incorporated in their entirety by reference.

Small molecules that block the action of PDGF are known in the art, *e.g.*, those described in U.S. Patent Nos. 6,528,526 (PDGFR tyrosine kinase inhibitors), 6,524,347 (PDGFR tyrosine kinase inhibitors), 6,482,834 (PDGFR tyrosine kinase inhibitors), 6,472,391 (PDGFR tyrosine kinase inhibitors), 6,696,434, 6,331,555, 6,251,905, 6,245,760, 6,207,667, 5,990,141, 5,700,822, 5,618,837 and 5,731,326, the contents of which are incorporated by reference in their entirety.

Proteins and polypeptides that block the action of PDGF are known in the art, *e.g.*, those described in U.S. Patent Nos. 6,350,731 (PDGF peptide analogs), 5,952,304, the contents of which are incorporated by reference in their entirety.

Bis mono- and bicyclic aryl and heteroaryl compounds which inhibit EGF and/or PDGF receptor tyrosine kinase are known in the art, *e.g.*, those described in, *e.g.* U.S. Patent Nos. 5,476,851, 5,480,883, 5,656,643, 5,795,889, and 6,057,320, the contents of which are incorporated by reference in their entirety.

Antisense oligonucleotides for the inhibition of PDGF are known in the art, *e.g.*, those described in U.S. Patent Nos. 5,869,462, and 5,821,234, the contents of each of which are incorporated by reference in their entirety.

Aptamers (also known as nucleic acid ligands) for the inhibition of PDGF are known in the art, *e.g.*, those described in, *e.g.*, U.S. Patent Nos. 6,582,918, 6,229,002, 6,207,816, 5,668,264, 5,674,685, and 5,723,594, the contents of each of which are incorporated by reference in their entirety.

Other compounds for inhibiting PDGF known in the art include those described in U.S. Patent Nos. 5,238,950, 5,418,135, 5,674,892, 5,693,610, 5,700,822, 5,700,823, 5,728,726, 5,795,910, 5,817,310, 5,872,218, 5,932,580, 5,932,602, 5,958,959, 5,990,141, 6,358,954, 6,537,988 and 6,673,798, the contents of each of which are incorporated by reference in their entirety.

VEGF Antagonists

Inhibition of VEGF (for example, VEGF-A) is accomplished in a variety of ways. For example, a variety of VEGF antagonists that inhibit the activity or production of VEGF, including nucleic acid molecules such as aptamers, antisense RNA, ribozymes, RNAi molecules, and VEGF antibodies, are available and can be used in the methods of the present invention. Exemplary VEGF antagonists include nucleic acid ligands or aptamers of VEGF, such as those described below. A particularly useful antagonist to VEGF-A is EYE001 (previously referred to as NX1838), which is a modified, PEGylated aptamer that binds with high and specific affinity to the major soluble human VEGF isoform (see, U.S. Patent Nos. 6,011,020; 6,051,698; and 6,147,204). The aptamer binds and inactivates VEGF in a manner similar to that of a high-affinity antibody directed towards VEGF. Another useful VEGF aptamer is EYE001 in its non-pegylated form. Alternatively, the VEGF antagonist may be, for example, an anti-VEGF antibody or antibody fragment. Accordingly, the VEGF molecule is rendered inactive by inhibiting its binding to a receptor. In addition, nucleic acid molecules such as antisense RNA, ribozymes, and RNAi molecules that inhibit VEGF expression or RNA stability at the nucleic acid level are useful antagonists in the methods and compositions of the invention. Other VEGF antagonists include peptides, proteins, cyclic peptides, and small organic compound. For example, soluble truncated forms of VEGF that bind to the VEGF receptor without concomitant signaling activity also serve as antagonists. Furthermore, the signaling activity of VEGF may be inhibited by disrupting its downstream signaling, for example, by using a number of antagonists including small molecule inhibitors of a VEGF receptor tyrosine kinase activity, as described further below.

The ability of a compound or agent to serve as a VEGF antagonist may be determined according to any number of standard methods well known in the art. For example, one of the biological activities of VEGF is to increase vascular permeability through specific binding to receptors on vascular endothelial cells. The interaction results in relaxation of the tight endothelial junctions with subsequent leakage of vascular fluid. Vascular leakage induced by VEGF can be measured *in vivo* by following the leakage of Evans Blue Dye from the vasculature of the guinea pig as a consequence of an intradermal injection of VEGF (Dvorak *et al.,* in Vascular Permeability Factor/Vascular Endothelial Growth Factor, Microvascular Hyperpermeability, and Angiogenesis; and (1995) Am. J. Pathol. 146:1029). Similarly, the assay can be used to measure the ability of an antagonist to block this biological activity of VEGF.

In one useful example of a vascular permeability assay, $VEGF_{165}$ (20-30 nM) is premixed *ex vivo* with EYE001 (30 nM to 1 μM) or a candidate VEGF antagonist and subsequently administered by intradermal injection into the shaved skin on the dorsum of guinea pigs. Thirty minutes following injection, the Evans Blue dye leakage around the injection sites is quantified according to standard methods by use of a computerized morphometric analysis system. A compound that inhibits VEGF-induced leakage of the indicator dye from the vasculature is taken as being a useful antagonist in the methods and compositions of the invention.

Another assay for determining whether a compound is a VEGF antagonist is the so-called corneal angiogenesis assay. In this assay, methacyrate polymer pellets containing $VEGF_{165}$ (3 pmol) are implanted into the corneal stroma of rats to induce blood vessel growth into the normally avascular cornea. A candidate VEGF antagonist is then administered intravenously to the rats at doses of 1mg/kg, 3 mg/kg, and 10 mg/kg either once or twice daily for 5 days. At the end of the treatment period, all of the individual corneas are photomicrographed. The extent to which new blood vessels develop in the corneal tissue, and their inhibition by the candidate compound, are then quantified by standardized morphometric analysis of the photomicrographs. A compound that inhibits VEGF-dependent angiogenesis in the cornea when compared to treatment with phosphate buffered saline (PBS) is taken as being a useful antagonist in the methods and compositions of the invention.

Candidate VEGF antagonists are also identified using the mouse model of retinopathy of prematurity. In one useful example, litters of 9, 8, 8, 7, and 7 mice, respectively, are left in room air or made hyperoxic and are treated intraperitoneally with phosphate buffered saline (PBS) or a candidate VEGF antagonist (for example, at 1 mg/kg, 3 mg/kg, or 10 mg/kg/day). The endpoint of the assay, outgrowth of new capillaries through the inner limiting membrane of the retina into the vitreous humor, is then assessed by microscopic identification and counting of the neovascular buds in 20 histologic sections of each eye from all of the treated and control mice. A reduction in retinal neovasculature in the treated mice relative to the untreated control is taken as identifying a useful VEGF antagonist.

In still another exemplary screening assay, candidate VEGF antagonists are identified using an *in vivo* human tumor xenograft assay. In this screening assay, *in vivo* efficacy of a candidate VEGF antagonist is tested in human tumor xenografts (A673 rhabdomyosarcoma and Wilms tumor) implanted in nude mice. Mice are then treated with the candidate VEGF antagonist (*e.g.*, 10 mg/kg given intraperitoneally once a day following development of established tumors (200 mg)). Control groups are treated with a control agent. Candidate compounds identified as inhibiting A673 rhabdomyosarcoma tumor growth and Wilms tumor relative to the control are taken as being useful antagonists in the methods and compositions of the invention.

Additional methods of assaying for a VEGF antagonist activity are known in the art and described in further detail below.

The invention further includes VEGF antagonists known in the art as well as those supported below and any and all equivalents that are within the scope of ordinary skill to create. For example, inhibitory antibodies directed against VEGF are known in the art, *e.g.*, those described in U.S. Patent Nos. 6,524,583, 6,451,764 (VRP antibodies), 6,448,077, 6,416,758, 6,403,088 (to VEGF-C), 6,383,484 (to VEGF-D), 6,342,221 (anti-VEGF antibodies), 6,342,219 6,331,301 (VEGF-B antibodies), and 5,730,977, and PCT publications WO96/30046, WO 97/44453, and WO 98/45331, the contents of which are incorporated by reference in their entirety.

Antibodies to VEGF receptors are also known in the art, such as those described in, for example, U.S. Patent Nos. 5,840,301, 5,874,542, 5,955,311, 6,365,157, and PCT publication WO 04/003211, the contents of which are incorporated by reference in their entirety.

Small molecules that block the action of VEGF by, *e.g.*, inhibiting a VEGFR-associated tyrosine kinase activity, are known in the art, *e.g.*, those described in U.S. Patent Nos. 6,514,971, 6,448,277 , 6,414,148, 6,362,336, 6,291,455, 6,284,751, 6,177,401, 6071,921, and 6001,885 (retinoid inhibitors of VEGF expression), the contents of each of which are incorporated by reference in their entirety.

Proteins and polypeptides that block the action of VEGF are known in the art, *e.g.*, those described in U.S. Patent Nos. 6,576,608, 6,559,126, 6,541,008, 6,515,105, 6,383,486 (VEGF decoy receptor), 6,375,929 (VEGF decoy receptor), 6,361,946 (VEFG peptide analog inhibitors), 6,348,333 (VEGF decoy receptor), 6,559,126 (polypeptides that bind VEGF and block binding to VEGFR), 6,100,071 (VEGF decoy receptor), and 5,952,199, the contents of each of which are incorporated by reference in their entirety.

Short interfering nucleic acids (siNA), short interfering RNA (siRNA), double stranded RNA (dsRNA), microRNA (miRNA) and short hairpin RNA (shRNA) capable of mediating RNA interference (RNAi) against VEGF and/or VEGFR gene expression and/or activity are known in the art, for example, as disclosed in PCT publication WO 03/070910, the contents of which is incorporated by reference in its entirety.

Antisense oligonucleotides for the inhibition of VEGF are known in the art, *e.g.*, those described in, *e.g.*, U.S. Patent Nos. 5,611,135, 5,814,620, 6,399,586, 6,410,322, and 6,291,667, the contents of each of which are incorporated by reference in their entirety.

Aptamers (also known as nucleic acid ligands) for the inhibition of VEGF are known in the art, *e.g.*, those described in, *e.g.*, U.S. Patent Nos. 6,762,290, 6,426,335, 6,168,778, 6,051,698, and 5,859,228, the contents of each of which are incorporated by reference in their entirety.

Antibody Antagonists

The invention includes antagonist antibodies directed against PDGF and VEGF as well as their cognate receptors PDGFR and VEGFR. The antibody antagonists of the invention block binding of a ligand with its cognate receptor. Accordingly, a PDGF antagonist antibody of the invention includes antibodies directed against a PDGF as well as a PDGFR target.

The antagonist antibodies of the invention include monoclonal inhibitory antibodies. Monoclonal antibodies, or fragments thereof, encompass all immunoglobulin classes such as IgM, IgG, IgD, IgE, IgA, or their subclasses, such as the IgG subclasses or mixtures thereof. IgG and its subclasses are useful, such as IgG_1, IgG_2, IgG_{2a}, IgG_{2b}, IgG_3 or IgG_M. The IgG subtypes $IgG_{1/kappa}$ and $IgG_{2b/kapp}$ are included as useful embodiments. Fragments which may be mentioned are all truncated or modified antibody fragments with one or two antigen-complementary binding sites which show high binding and neutralizing activity toward mammalian PDGF or VEGF (or their cognate receptors), such as parts of antibodies having a binding site which corresponds to the antibody and is formed by light and heavy chains, such as Fv, Fab or $F(ab')_2$ fragments, or single-stranded fragments. Truncated double-stranded fragments such as Fv, Fab or $F(ab')_2$ are particularly useful. These fragments can be obtained, for example, by enzymatic means by eliminating the Fc part of the antibody with enzymes such as papain or pepsin, by chemical oxidation or by genetic manipulation of the antibody genes. It is also possible and advantageous to use genetically manipulated, non-truncated fragments. The anti-PDGF or VEGF antibodies or fragments thereof can be used alone or in mixtures.

The novel antibodies, antibody fragments, mixtures or derivatives thereof advantageously have a binding affinity for PDGF or VEGF (or their cognate receptors) in a range from $1x10^{-7}$ M to $1x10^{-12}$ M, or from $1x10^{-8}$ M to $1x10^{-11}$ M, or from $1x10^{-9}$ M to $5x10^{-10}$ M.

The antibody genes for the genetic manipulations can be isolated, for example from hybridoma cells, in a manner known to the skilled worker. For this purpose, antibody-producing cells are cultured and, when the optical density of the cells is sufficient, the mRNA is isolated from the cells in a known manner by lysing the cells with guanidinium thiocyanate, acidifying with sodium acetate, extracting with phenol, chloroform/isoamyl alcohol, precipitating with isopropanol and washing with ethanol. cDNA is then synthesized from the mRNA using reverse transcriptase. The synthesized cDNA can be inserted, directly or after genetic manipulation, for example, by site-directed mutagenesis, introduction of insertions, inversions, deletions, or base exchanges, into suitable animal, fungal, bacterial or viral vectors and be expressed in appropriate host organisms. Useful bacterial or yeast vectors are pBR322, pUC18/19, pACYC184, lambda or yeast mu vectors for the cloning of the genes and expression in bacteria such as *E. coli* or in yeasts such as *Saccharomyces cerevisiae*.

The invention furthermore relates to cells that synthesize PDGF or VEGF antibodies. These include animal, fungal, bacterial cells or yeast cells after transformation as mentioned above. They are advantageously hybridoma cells or trioma cells, typically hybridoma cells. These hybridoma cells can be produced, for example, in a known manner from animals immunized with PDGF or VEGF (or their cognate receptors) and isolation of their antibody-producing B cells, selecting these cells for PDGF or VEGF-binding antibodies and subsequently fusing these cells to, for example, human or animal, for example, mouse myeloma cells, human lymphoblastoid cells or heterohybridoma cells (see, *e.g.*, Koehler *et al.*, (1975) Nature 256: 496) or by infecting these cells with appropriate viruses to produce immortalized cell lines. Hybridoma cell lines produced by fusion are useful and mouse hybridoma cell lines are particularly useful. The hybridoma cell lines of the invention secrete useful antibodies of the IgG type. The binding of the mAb antibodies of the invention bind with high affinity and reduce or neutralize the biological (*e.g.*, angiogenic) activity of PDGF or VEGF.

The invention further includes derivatives of these anti-PDGF or VEGF antibodies which retain their PDGF or VEGF-inhibiting activity while altering one or more other properties related to their use as a pharmaceutical agent, *e.g.*, serum stability or efficiency of production. Examples of such anti-PDGF or VEGF antibody derivatives include peptides, peptidomimetics derived from the antigen-binding regions of the antibodies, and antibodies, antibody fragments or peptides bound to solid or liquid carriers such as polyethylene glycol, glass, synthetic polymers such as polyacrylamide, polystyrene, polypropylene, polyethylene or natural polymers such as cellulose, Sepharose or agarose, or conjugates with enzymes, toxins or radioactive or nonradioactive markers such as ^{3}H, ^{123}I, ^{125}I, ^{131}I, ^{32}P, ^{35}S, ^{14}C, ^{51}Cr, ^{36}Cl, ^{57}Co, ^{55}Fe, ^{59}Fe, ^{90}Y, ^{99m}Tc, ^{75}Se, or antibodies, fragments, or peptides covalently bonded to fluorescent/chemiluminescent labels such as rhodamine, fluorescein, isothiocyanate, phycoerythrin, phycocyanin, fluorescamine, metal chelates, avidin, streptavidin or biotin.

The novel antibodies, antibody fragments, mixtures, and derivatives thereof can be used directly, after drying, for example freeze drying, after attachment to the abovementioned carriers or after formulation with other pharmaceutical active and ancillary substances for producing pharmaceutical preparations. Examples of active and ancillary substances which may be mentioned are other antibodies, antimicrobial active substances with a microbiocidal or microbiostatic action such as antibiotics in general or sulfonamides, antitumor agents, water, buffers, salines, alcohols, fats, waxes, inert vehicles or other substances customary for parenteral products, such as amino acids, thickeners or sugars. These pharmaceutical preparations are used to control diseases, and are useful to control ocular neovascular disorders and diseases including AMD and diabetic retinopathy.

The novel antibodies, antibody fragments, mixtures or derivatives thereof can be used in therapy or diagnosis directly or after coupling to solid or liquid carriers, enzymes, toxins, radioactive or nonradioactive labels or to fluorescent/chemiluminescent labels as described above.

The human PDGF or VEGF monoclonal antibodies of the present invention may be obtained by any means known in the art. For example, a mammal is immunized with human PDGF or VEGF (or their cognate receptors). Purified human PDGF and VEGF is commercially available (*e.g.,* from Cell Sciences, Norwood, MA, as well as other commercial vendors). Alternatively, human PDGF or VEGF (or their cognate receptors) may be readily purified from human placental tissue. The mammal used for raising anti-human PDGF or VEGF antibody is not restricted and may be a primate, a rodent (such as mouse, rat or rabbit), bovine, sheep, goat or dog.

Next, antibody-producing cells such as spleen cells are removed from the immunized animal and are fused with myeloma cells. The myeloma cells are well-known in the art (*e.g.,* p3x63-Ag8-653, NS-0, NS-1 or P3U1 cells may be used). The cell fusion operation may be carried out by any conventional method known in the art.

The cells, after being subjected to the cell fusion operation, are then cultured in HAT selection medium so as to select hybridomas. Hybridomas which produce antihuman monoclonal antibodies are then screened. This screening may be carried out by, for example, sandwich enzyme-linked immunosorbent assay (ELISA) or the like in which the produced monoclonal antibodies are bound to the wells to which human PDGF or VEGF (or their cognate receptor) is immobilized. In this case, as the secondary antibody, an antibody specific to the immunoglobulin of the immunized animal, which is labeled with an enzyme such as peroxidase, alkaline phosphatase, glucose oxidase, beta-D-galactosidase, or the like, may be employed. The label may be detected by reacting the labeling enzyme with its substrate and measuring the generated color. As the substrate, 3,3-diaminobenzidine, 2,2-diaminobis-o-dianisidine, 4-chloronaphthol, 4-aminoantipyrine, o-phenylenediamine or the like may be produced.

By the above-described operation, hybridomas which produce anti-human PDGF or VEGF antibodies can be selected. The selected hybridomas are then cloned by the conventional limiting dilution method or soft agar method. If desired, the cloned hybridomas may be cultured on a large scale using a serum-containing or a serum free medium, or may be inoculated into the abdominal cavity of mice and recovered from ascites, thereby a large number of the cloned hybridomas may be obtained.

From among the selected anti-human PDGF or VEGF monoclonal antibodies, those that have an ability to prevent binding and activation of the corresponding ligand/ receptor pair (*e.g.*, in a cell-based PDGF or VEGF assay system (see above)) are then chosen for further analysis and manipulation. If the antibody blocks receptor/ligand binding and/or activation, it means that the monoclonal antibody tested has an ability to reduce or neutralize the PDGF or VEGF activity of human PDGF or VEGF. That is, the monoclonal antibody specifically recognizes and/or interferes with the critical binding site of human PDGF or VEGF (or their cognate receptors).

The monoclonal antibodies herein further include hybrid and recombinant antibodies produced by splicing a variable (including hypervariable) domain of an anti-PDGF or VEGF antibody with a constant domain (*e.g.*, "humanized" antibodies), or a light chain with a heavy chain, or a chain from one species with a chain from another species, or fusions with heterologous proteins, regardless of species of origin or immunoglobulin class or subclass designation, as well as antibody fragments [*e.g.*, Fab, $F(ab)_2$, and Fv], so long as they exhibit the desired biological activity. [See, *e.g.*, U.S. Patent No. 4,816,567 and Mage & Lamoyi, in Monoclonal Antibody Production Techniques and Applications, pp.79-97 (Marcel Dekker, Inc.), New York (1987)].

Thus, the term "monoclonal" indicates that the character of the antibody obtained is from a substantially homogeneous population of antibodies, and is not to be construed as requiring production of the antibody by any particular method. For example, the monoclonal antibodies to be used in accordance with the present invention may be made by the hybridoma method first described by Kohler & Milstein, Nature 256:495 (1975), or may be made by recombinant DNA methods (U.S. Patent No. 4,816,567). The "monoclonal antibodies" may also be isolated from phage libraries generated using the techniques described in McCafferty *et al.*, Nature 348:552-554 (1990), for example.

"Humanized" forms of non-human (*e.g.*, murine) antibodies are specific chimeric immunoglobulins, immunoglobulin chains or fragments thereof (such as Fv, Fab, Fab', $F(ab)_2$ or other antigen-binding subsequences of antibodies) which contain minimal sequence derived from non-human immunoglobulin. For the most part, humanized antibodies are human immunoglobulins (recipient antibody) in which residues from the complementary determining regions (CDRs) of the recipient antibody are replaced by residues from the CDRs of a non-human species (donor antibody) such as mouse, rat or rabbit having the desired specificity, affinity and capacity. In some instances, Fv framework region (FR) residues of the human immunoglobulin are replaced by corresponding non-human FR residues. Furthermore, the humanized antibody may comprise residues that are found neither in the recipient antibody nor in the imported CDR or FR sequences. These modifications are made to further refine and optimize antibody performance. In general, the humanized antibody will comprise substantially all of at least one, and typically two, variable domains, in which all or substantially all of the CDR regions correspond to those of a non-human immunoglobulin and all or substantially all of the FR residues are those of a human immunoglobulin consensus sequence. The humanized antibody optimally also will comprise at least a portion of an inununoglobulin constant region (Fc), typically that of a human immunoglobulin.

Methods for humanizing non-human antibodies are well known in the art. Generally, a humanized antibody has one or more amino acid residues introduced into it from a source which is non-human. These non-human amino acid residues are often referred to as "import" residues, which are typically taken from an "import" variable domain. Humanization can be essentially performed following the method of Winter and co-workers (Jones *et al.*, (1986) Nature 321: 522-525; Riechmann *et al.,* (1988) Nature 332: 323-327; and Verhoeyen *et al.,* (1988) Science 239: 1534-1536), by substituting rodent CDRs or CDR sequences for the corresponding sequences of a human antibody. Accordingly, such "humanized" antibodies are chimeric antibodies, wherein substantially less than an intact human variable domain has been substituted by the corresponding sequence from a non-human species. In practice, humanized antibodies are typically human antibodies in which some CDR residues and possibly some FR residues are substituted by residues from analogous sites in rodent antibodies.

The choice of human variable domains, both light and heavy, to be used in making the humanized antibodies is very important to reduce antigenicity. According to the so-called "best-fit" method, the sequence of the variable domain of a rodent antibody is screened against the entire library of known human variable-domain sequences. The human sequence which is closest to that of the rodent is then accepted as the human framework (FR) for the humanized antibody (Sims *et al.,* (1993) J. Immunol., 151:2296; and Chothia and Lesk (1987) J. Mol. Biol., 196:901). Another method uses a particular framework derived from the consensus sequence of all human antibodies of a particular subgroup of light or heavy chains. The same framework may be used for several different humanized antibodies (Carter *et al.*, (1992) Proc. Natl. Acad. Sci. (USA), 89: 4285; and Presta *et al.,* (1993) J. Immnol., 151:2623).

It is further important that antibodies be humanized with retention of high affinity for the antigen and other favorable biological properties. To achieve this goal, according to one useful method, humanized antibodies are prepared by a process of analysis of the parental sequences and various conceptual humanized products using three-dimensional models of the parental and humanized sequences. Three-dimensional immunoglobulin models are commonly available and are familiar to those skilled in the art. Computer programs are available which illustrate and display probable three-dimensional conformational structures of selected candidate immunoglobulin sequences. Inspection of these displays permits analysis of the likely role of the residues in the functioning of the candidate immunoglobulin sequence, i.e., the analysis of residues that influence the ability of the candidate immunoglobulin to bind its antigen. In this way, FR residues can be selected and combined from the consensus and import sequences so that the desired antibody characteristic, such as increased affinity for the target antigen(s), is achieved. In general, the CDR residues are directly and most substantially involved in influencing antigen binding.

Human monoclonal antibodies directed against PDGF or VEGF are also included in the invention. Such antibodies can be made by the hybridoma method. Human myeloma and mouse-human heteromyeloma cell lines for the production of human monoclonal antibodies have been described, for example, by Kozbor (1984) J. Immunol., 133, 3001; Brodeur, *et al.,* Monoclonal Antibody Production Techniques and Applications, pp.51-63 (Marcel Dekker, Inc., New York, 1987); and Boerner *et al.,* (1991) J. Immunol., 147:86-95.

It is now possible to produce transgenic animals (*e.g.*, mice) that are capable, upon immunization, of producing a full repertoire of human antibodies in the absence of endogenous immunoglobulin production. For example, it has been described that the homozygous deletion of the antibody heavy-chain joining region (J_H) gene in chimeric and germ-line mutant mice results in complete inhibition of endogenous antibody production. Transfer of the human germ-line immunoglobulin gene array in such gem-line mutant mice will result in the production of human antibodies upon antigen challenge (see, *e.g.*, Jakobovits *et al.,* (1993) Proc. Natl. Acad. Sci.

(USA), 90: 2551; Jakobovits *et al.,* (1993) Nature, 362:255-258; and Bruggermann *et al.,* (1993) Year in Immuno., 7:33).

Alternatively, phage display technology (McCafferty *et al.*, (1990) Nature, 348: 552-553) can be used to produce human antibodies and antibody fragments *in vitro*, from immunoglobulin variable (V) domain gene repertoires from unimmunized donors (for review see, *e.g.,* Johnson *et al.*, (1993) Current Opinion in Structural Biology, 3:564-571). Several sources of V-gene segments can be used for phage display. For example, Clackson *et al.,* ((1991) Nature, 352: 624-628) isolated a diverse array of anti-oxazolone antibodies from a small random combinatorial library of V genes derived from the spleens of immunized mice. A repertoire of V genes from unimmunized human donors can be constructed and antibodies to a diverse array of antigens (including self-antigens) can be isolated essentially following the techniques described by Marks *et al.,* ((1991) J. Mol. Biol., 222:581-597, or Griffith *et al.,* (1993) EMBO J., 12:725-734).

In a natural immune response, antibody genes accumulate mutations at a high rate (somatic hypermutation). Some of the changes introduced will confer higher affinity, and B cells displaying high-affinity surface immunoglobulin are preferentially replicated and differentiated during subsequent antigen challenge. This natural process can be mimicked by employing the technique known as "chain shuffling" (see Marks *et al.,* (1992) Bio. Technol., 10:779-783). In this method, the affinity of "primary" human antibodies obtained by phage display can be improved by sequentially replacing the heavy and light chain V region genes with repertoires of naturally occurring variants (repertoires) of V domain genes obtained from unimmunized donors. This technique allows the production of antibodies and antibody fragments with affinities in the nM range. A strategy for making very large phage antibody repertoires has been described by Waterhouse *et al.,* ((1993) Nucl. Acids Res., 21:2265-2266).

Gene shuffling can also be used to derive human antibodies from rodent antibodies, where the human antibody has similar affinities and specificities to the starting rodent antibody. According to this method, which is also referred to as "epitope imprinting", the heavy or light chain V domain gene of rodent antibodies obtained by phage display technique is replaced with a repertoire of human V domain genes, creating rodent-human chimeras. Selection on antigen results in isolation of human variable capable of restoring a functional antigen-binding site, *i.e.*, the epitope governs (imprints) the choice of partner. When the process is repeated in order to replace the remaining rodent V domain, a human antibody is obtained (see PCT WO 93/06213, published 1 Apr. 1993). Unlike traditional humanization of rodent antibodies by CDR grafting, this technique provides completely human antibodies, which have no framework or CDR residues of rodent origin.

Aptamer Antagonists

The invention provides aptamer antagonists directed against PDGF and/or VEGF (or their cognate receptors). Aptamers, also known as nucleic acid ligands, are non-naturally occurring nucleic acids that bind to and, generally, antagonize (*i.e.*, inhibit) a pre-selected target.

Aptamers can be made by any known method of producing oligomers or oligonucleotides. Many synthesis methods are known in the art. For example, 2'-O-allyl modified oligomers that contain residual purine ribonucleotides, and bearing a suitable 3'-terminus such as an inverted thymidine residue (Ortigao *et al.*, Antisense Research and Development, 2:129-146 (1992)) or two phosphorothioate linkages at the 3'-terminus to prevent eventual degradation by 3'-exonucleases, can be synthesized by solid phase beta-cyanoethyl phosphoramidite chemistry (Sinha *et al.*, Nucleic Acids Res., 12:4539-4557 (1984)) on any commercially available DNA/RNA synthesizer. One method is the 2'-O-tert-butyldimethylsilyl (TBDMS) protection strategy for the ribonucleotides (Usman *et al.*, J. Am. Chem. Soc., 109:7845-7854 (1987)), and all the required 3'-O-phosphoramidites are commercially available. In addition, aminomethylpolystyrene may be used as the support material due to its advantageous properties (McCollum and Andrus (1991) Tetrahedron Lett., 32:4069-4072). Fluorescein can be added to the 5'-end of a substrate RNA during the synthesis by using commercially available fluorescein phosphoramidites. In general, an aptamer oligomer can be synthesized using a standard RNA cycle. Upon completion of the assembly, all base labile protecting groups are removed by an eight hour treatment at 55° C with concentrated aqueous ammonia/ethanol (3:1 v/v) in a sealed vial. The ethanol suppresses premature removal of the 2'-O-TBDMS groups that would otherwise lead to appreciable strand cleavage at the resulting ribonucleotide positions under the basic conditions of the deprotection (Usman *et al.*, (1987) J. Am. Chem. Soc., 109:7845-7854). After lyophilization, the TBDMS protected oligomer is treated with a mixture of triethylamine trihydrofluoride/triethylamine/N-methylpyrrolidinone for 2 hours at 60° C to afford fast and efficient removal of the silyl protecting groups under neutral conditions (see Wincott *et al.*, (1995) Nucleic Acids Res., 23:2677-2684). The fully deprotected oligomer can then be precipitated with butanol according to the procedure of Cathala and Brunel ((1990) Nucleic Acids Res., 18:201). Purification can be performed either by denaturing polyacrylamide gel electrophoresis or by a combination of ion-exchange HPLC (Sproat *et al.*, (1995) Nucleosides and Nucleotides, 14:255-273) and reversed phase HPLC. For use in cells, synthesized oligomers are converted to their sodium salts by precipitation with sodium perchlorate in acetone. Traces of residual salts may then be removed using small disposable gel filtration columns that are commercially available. As a final step the authenticity of the isolated oligomers may be checked by matrix assisted laser desorption mass spectrometry (Pieles *et al.*, (1993) Nucleic Acids Res., 21:3191-3196) and by nucleoside base composition analysis.

The disclosed aptamers can also be produced through enzymatic methods, when the nucleotide subunits are available for enzymatic manipulation. For example, the RNA molecules can be made through *in vitro* RNA polymerase T7 reactions. They can also be made by strains of bacteria or cell lines expressing T7, and then subsequently isolated from these cells. As discussed below, the disclosed aptamers can also be expressed in cells directly using vectors and promoters.

The aptamers, like other nucleic acid molecules of the invention, may further contain chemically modified nucleotides. One issue to be addressed in the diagnostic or therapeutic use of nucleic acids is the potential rapid degration of oligonucleotides in their phosphodiester form in body fluids by intracellular and extracellular enzymes such as endonucleases and exonucleases before the desired effect is manifest. Certain chemical modifications of the nucleic acid ligand can be made to increase the *in vivo* stability of the nucleic acid ligand or to enhance or to mediate the delivery of the nucleic acid ligand (see, *e.g.,* U.S. Patent Application No. 5,660,985, entitled "High Affinity Nucleic Acid Ligands Containing Modified Nucleotides") which is specifically incorporated herein by reference.

Modifications of the nucleic acid ligands contemplated in this invention include, but are not limited to, those which provide other chemical groups that incorporate additional charge, polarizability, hydrophobicity, hydrogen bonding, electrostatic interaction, and fluxionality to the nucleic acid ligand bases or to the nucleic acid ligand as a whole. Such modifications include, but are not limited to, 2'-position sugar modifications, 5-position pyrimidine modifications, 8-position purine modifications, modifications at exocyclic amines, substitution of 4-thiouridine, substitution of 5-bromo or 5-iodo-uracil; backbone modifications, phosphorothioate or alkyl phosphate modifications, methylations, unusual base-pairing combinations such as the isobases isocytidine and isoguanidine and the like. Modifications can also include 3' and 5' modifications such as capping or modification with sugar moieties. In some embodiments of the instant invention, the nucleic acid ligands are RNA molecules that are 2'-fluoro (2'-F) modified on the sugar moiety of pyrimidine residues.

The stability of the aptamer can be greatly increased by the introduction of such modifications and as well as by modifications and substitutions along the phosphate backbone of the RNA. In addition, a variety of modifications can be made on the nucleobases themselves which both inhibit degradation and which can increase desired nucleotide interactions or decrease undesired nucleotide interactions. Accordingly, once the sequence of an aptamer is known, modifications or substitutions can be made by the synthetic procedures described below or by procedures known to those of skill in the art.

Other modifications include the incorporation of modified bases (or modified nucleoside or modified nucleotides) that are variations of standard bases, sugars and/or phosphate backbone chemical structures occurring in ribonucleic (*i.e.,* A, C, G and U) and deoxyribonucleic (*i.e.,* A, C, G and T) acids. Included within this scope are, for example: Gm (2'-methoxyguanylic acid), Am (2'-methoxyadenylic acid), Cf (2'-fluorocytidylic acid), Uf (2'-fluorouridylic acid), Ar (riboadenylic acid). The aptamers may also include cytosine or any cytosine-related base including 5-methylcytosine, 4-acetylcytosine, 3-methylcytosine, 5-hydroxymethyl cytosine, 2-thiocytosine, 5-halocytosine (*e.g.*, 5-fluorocytosine, 5-bromocytosine, 5-chlorocytosine, and 5-iodocytosine), 5-propynyl cytosine, 6-azocytosine, 5-trifluoromethylcytosine, N4, N4-ethanocytosine, phenoxazine cytidine, phenothiazine cytidine, carbazole cytidine or pyridoindole cytidine. The aptamer may further include guanine or any guanine-related base including 6-methylguanine, 1-methylguanine, 2,2-dimethylguanine, 2-methylguanine, 7-methylguanine, 2-propylguanine, 6-propylguanine, 8-haloguanine (*e.g.*, 8-fluoroguanine, 8-bromoguanine, 8-chloroguanine, and 8-iodoguanine), 8-aminoguanine, 8-sulfhydrylguanine, 8-thioalkylguanine, 8-hydroxylguanine, 7-methylguanine, 8-azaguanine, 7-deazaguanine or 3-deazaguanine. The aptamer may still further include adenine or any adenine-related base including 6-methyladenine, N6-isopentenyladenine, N6-methyladenine, 1-methyladenine, 2-methyladenine, 2-methylthio-N6-isopentenyladenine, 8-haloadenine (*e.g.*, 8-fluoroadenine, 8-bromoadenine, 8-chloroadenine, and 8-iodoadenine), 8-aminoadenine, 8-sulfhydryladenine, 8-thioalkyladenine, 8-hydroxyladenine, 7-methyladenine, 2-haloadenine (*e.g.*, 2-fluoroadenine, 2-bromoadenine, 2-chloroadenine, and 2-iodoadenine), 2-aminoadenine, 8-azaadenine, 7-deazaadenine or 3-deazaadenine. Also included are uracil or any uracil-related base including 5-halouracil (*e.g.*, 5-fluorouracil, 5-bromouracil, 5-chlorouracil, 5-iodouracil), 5-(carboxyhydroxylmethyl)uracil, 5-carboxymethylaminomethyl-2-thiouracil, 5-carboxymethylaminomethyluracil, dihydrouracil, 1-methylpseudouracil, 5-methoxyaminomethyl-2-thiouracil, 5'-methoxycarbonylmethyluracil, 5-methoxyuracil, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-methyluracil, uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid, pseudouracil, 5-methyl-2-thiouracil, 2-thiouracil, 3-(3-amino-3-N-2-carboxypropyl)uracil, 5-methylaminomethyluracil, 5-propynyl uracil, 6-azouracil, or 4-thiouracil.

Examples of other modified base variants known in the art include, without limitation, those listed at 37 C.F.R. §1.822(p) (1), *e.g.*, 4-acetylcytidine, 5-(carboxyhydroxylmethyl) uridine, 2'-methoxycytidine, 5-carboxymethylaminomethyl-2-thioridine, 5-carboxymethylaminomethyluridine, dihydrouridine, 2'-O-methylpseudouridine, b-D-galactosylqueosine, inosine, N6-isopentenyladenosine, 1-methyladenosine, 1-methylpseudouridine, 1-methylguanosine, 1-methylinosine, 2,2-dimethylguanosine, 2-methyladenosine, 2-methylguanosine, 3-methylcytidine, 5-methylcytidine, N6-methyladenosine, 7-methylguanosine, 5-methylaminomethyluridine, 5-methoxyaminomethyl-2-thiouridine, b-D-mannosylqueosine, 5-methoxycarbonylmethyluridine, 5-methoxyuridine, 2-methylthio-N6-isopentenyladenosine, N-((9-b-D-ribofuranosyl-2-methylthiopurine-6-yl)carbamoyl)threonine, N-((9-b-D-ribofuranosylpurine-6-yl)N-methyl-carbamoyl)threonine, urdine-5-oxyacetic acid methylester, uridine-5-oxyacetic acid (v), wybutoxosine, pseudouridine, queosine, 2-thiocytidine, 5-methyl-2-thiouridine, 2-thiouridine, 4-thiouridine, 5-methyluridine, N-((9-b-D-ribofuranosylpurine-6-y1)carbamoyl)threonine, 2'-O-methyl-5-methyluridine, 2'-O-methyluridine, wybutosine, 3-(3-amino-3-carboxypropyl)uridine.

Also included are the modified nucleobases described in U.S. Patent Nos. 3,687,808, 3,687,808, 4,845,205, 5,130,302, 5,134,066, 5,175,273, 5,367,066, 5,432,272, 5,457,187, 5,459,255, 5,484,908, 5,502,177, 5,525,711, 5,552,540, 5,587,469, 5,594,121, 5,596,091, 5,614,617, 5,645,985, 5,830,653, 5,763,588, 6,005,096, and 5,681,941. Examples of modified nucleoside and nucleotide sugar backbone variants known in the art include, without limitation, those having, *e.g.*, 2' ribosyl substituents such as F, SH, SCH3, OCN, Cl, Br, CN, CF3, OCF3, SOCH3, SO2, CH3, ONO2, NO2, N3, NH2, OCH2CH2OCH3, O(CH2)2ON(CH3)2, OCH2OCH2N(CH3)2, O(C1-10 alkyl), O(C2-10 alkenyl), O(C2-10 alkynyl), S(C1-10 alkyl), S(C2-10 alkenyl), S(C2-10 alkynyl), NH(C1-10 alkyl), NH(C2-10 alkenyl), NH(C2-10 alkynyl), and O-alkyl-O-alkyl. Desirable 2' ribosyl substituents include 2'-methoxy (2'-OCH3), 2'-aminopropoxy (2' OCH2CH2CH2NH2), 2'-allyl (2'-CH2-CH=CH2), 2'-O-allyl (2'-O-CH2-CH=CH2), 2'-amino (2'-NH2), and 2'-fluoro (2'-F). The 2'-substituent may be in the arabino (up) position or ribo (down) position.

The aptamers of the invention may be made up of nucleotides and/or nucleotide analogs such as described above, or a combination of both, or are oligonucleotide analogs. The aptamers of the invention may contain nucleotide analogs at positions which do not effect the function of the oligomer to bind PDGF or VEGF (or their cognate receptors).

There are several techniques that can be adapted for refinement or strengthening of the nucleic acid Ligands binding to a particular target molecule or the selection of additional aptamers. One technique, generally referred to as "*in vitro* genetics" (see Szostak (1992) TIBS, 19:89), involves isolation of aptamer antagonists by selection from a pool of random sequences. The pool of nucleic acid molecules from which the disclosed aptamers may be isolated may include invariant sequences flanking a variable sequence of approximately twenty to forty nucleotides. This method has been termed Selective Evolution of Ligands by EXponential Enrichment (SELEX). Compositions and methods for generating aptamer antagonists of the invention by SELEX and related methods are known in the art and taught in, for example, U.S. Patent No. 5,475,096 entitled "Nucleic Acid Ligands," and U.S. Patent No. 5,270,163, entitled

"Methods for Identifying Nucleic Acid Ligands," each of which is specifically incorporated by reference herein in its entirety. The SELEX process in general, and VEGF and PDGF aptamers and formulations in particular, are further described in, *e.g.*, U.S. Patent. Nos. 5,668,264, 5,696,249, 5,670,637, 5,674,685, 5,723,594, 5,756,291, 5,811,533, 5,817,785, 5,958,691, 6,011,020, 6,051,698, 6,147,204, 6,168,778, 6,207,816, 6,229,002, 6,426,335, 6,582,918, the contents of each of which is specifically incorporated by reference herein.

Briefly, the SELEX method involves selection from a mixture of candidate oligonucleotides and step-wise iterations of binding to a selected target, partitioning and amplification, using the same general selection scheme, to achieve virtually any desired criterion of binding affinity and selectivity. Starting from a mixture of nucleic acids, typically comprising a segment of randomized sequence, the SELEX method includes steps of contacting the mixture with the target under conditions favorable for binding, partitioning unbound nucleic acids from those nucleic acids which have bound specifically to target molecules, dissociating the nucleic acid-target complexes, amplifying the nucleic acids dissociated from the nucleic acid-target complexes to yield a ligand-enriched mixture of nucleic acids, then reiterating the steps of binding, partitioning, dissociating and amplifying through as many cycles as desired to yield highly specific high affinity nucleic acid ligands to the target molecule.

The basic SELEX method has been modified to achieve a number of specific objectives. For example, U.S. Patent No. 5,707,796, entitled "Method for Selecting Nucleic Acids on the Basis of Structure," describes the use of the SELEX process in conjunction with gel electrophoresis to select nucleic acid molecules with specific structural characteristics, such as bent DNA. U.S. Patent No. 5,763,177 entitled "Systematic Evolution of Ligands by Exponential Enrichment: Photoselection of Nucleic Acid Ligands and Solution SELEX" describe a SELEX based method for selecting nucleic acid ligands containing photoreactive groups capable of binding and/or photocrosslinking to and/or photoinactivating a target molecule. U.S. Patent No. 5,580,737 entitled "High-Affinity Nucleic Acid Ligands That Discriminate Between Theophylline and Caffeine," describes a method for identifying highly specific nucleic acid ligands able to discriminate between closely related molecules, which can be non-peptidic, termed Counter-SELEX. U.S. Patent No. 5,567,588 entitled "Systematic Evolution of Ligands by EXponential Enrichment: Solution SELEX," describes a SELEX-based method which achieves highly efficient partitioning between oligonucleotides having high and low affinity for a target molecule.

The SELEX method encompasses the identification of high-affinity nucleic acid ligands containing modified nucleotides conferring improved characteristics on the ligand, such as improved *in vivo* stability or improved delivery characteristics. Examples of such modifications include chemical substitutions at the ribose and/or phosphate and/or base positions. SELEX process-identified nucleic acid ligands containing modified nucleotides are described in U.S. Patent No. 5,660,985 entitled "High Affinity Nucleic Acid Ligands Containing Modified Nucleotides," that describes oligonucleotides containing nucleotide derivatives chemically modified at the 5- and 2'-positions of pyrimidines. U.S. Patent No. 5,580,737, *supra*, describes highly specific nucleic acid ligands containing one or more nucleotides modified with 2'-amino (2'-NH_2), 2'-fluoro (2'-F), and/or 2'-O-methyl (2'-OMe). U.S. Patent Application No. 08/264,029, filed Jun. 22, 1994, entitled "Novel Method of Preparation of Known and Novel 2' Modified Nucleosides by Intramolecular Nucleophilic Displacement," now abandoned, describes oligonucleotides containing various 2'-modified pyrimidines.

The SELEX method encompasses combining selected oligonucleotides with other selected oligonucleotides and non-oligonucleotide functional units as described in U.S. Patent No. 5,637,459 entitled "Systematic Evolution of Ligands by EXponential Enrichment: Chimeric SELEX," and U.S. Patent No. 5,683,867 entitled "Systematic Evolution of Ligands by EXponential Enrichment: Blended SELEX," respectively. These patents allow for the combination of the broad array of shapes and other properties, and the efficient amplification and replication properties, of oligonucleotides with the desirable properties of other molecules.

The SELEX method further encompasses combining selected nucleic acid ligands with lipophilic compounds or non-immunogenic, high molecular weight compounds in a diagnostic or therapeutic complex as described in U.S. Patent No. 6,011,020, entitled "Nucleic Acid Ligand Complexes," which is specifically incorporated by reference herein in their entirety.

The aptamer antagonists can also be refined through the use of computer modeling techniques. Examples of molecular modeling systems are the CHARMm and QUANTA programs, Polygen Corporation (Waltham, Mass.). CHARMm performs the energy minimization and molecular dynamics functions. QUANTA performs the construction, graphic modeling and analysis of molecular structure. QUANTA allows interactive construction, modification, visualization, and analysis of the behavior of molecules with each other. These applications can be adapted to define and display the secondary structure of RNA and DNA molecules.

Aptamers with these various modifications can then be tested for function using any suitable assay for the PDGF or VEGF function of interest, such as a PDGF cell-based proliferation activity assay.

The modifications can be pre- or post-SELEX process modifications. Pre-SELEX process modifications yield nucleic acid ligands with both specificity for their SELEX target and improved *in vivo* stability. Post-SELEX process modifications made to 2'-OH nucleic acid ligands can result in improved *in vivo* stability without adversely affecting the binding capacity of the nucleic acid ligand.

Other modifications useful for producing aptamers of the invention are known to one of ordinary skill in the art. Such modifications may be made post-SELEX process (modification of previously identified unmodified ligands) or by incorporation into the SELEX process.

It has been observed that aptamers, or nucleic acid ligands, in general, and VEGF aptamers in particular, are most stable, and therefore efficacious when 5'-capped and 3'-capped in a manner which decreases susceptibility to exonucleases and increases overall stability. Accordingly, the invention is based in one embodiment, upon the capping of aptamers in general, and anti-VEGF aptamers in particular, with a 5'-5' inverted nucleoside cap structure at the 5' end and a 3'-3' inverted nucleoside cap structure at the 3' end. Accordingly, the invention provides anti-VEGF and/or anti-PDGF aptamers, *i.e.*, nucleic acid ligands, that are capped at the 5' end with a 5'-5- inverted nucleoside cap and at the 3' end with a 3'-3' inverted nucleoside cap.

Certain particularly useful aptamers of the invention are anti-VEGF aptamer compositions, including, but not limited to, those having both 5'-5' and 3'-3' inverted nucleotide cap structures at their ends. Such anti-VEGF capped aptamers may be RNA aptamers, DNA aptamers or aptamers having a mixed (*i.e.*, both RNA and DNA) composition. Suitable anti-VEGF aptamer sequences of the invention include the nucleotide sequence GAAGAAUUGG (SEQ ID NO: 15); or the nucleotide sequence UUGGACGC (SEQ ID NO: 16); or the nucleotide sequence GUGAAUGC (SEQ ID NO: 17). Particularly useful are capped anti-VEGF aptamers of the invention have the sequence:

X-5'-5'-CGGAAUCAGUGAAUGCUUAUACAUCCG-3'-3'-X (SEQ ID NO: 18)

where each C, G, A, and U represents, respectively, the naturally-occurring nucleotides cytidine, guanidine, adenine, and uridine, or modified nucleotides corresponding thereto; X-5'-5' is an inverted nucleotide capping the 5' terminus of the aptamer; 3'-3'-X is an inverted nucleotide capping the 3' terminus of the aptamer; and the remaining nucleotides or modified nucleotides are sequentially linked via 5'-3' phosphodiester linkages. In some embodiments, each of the nucleotides of the capped anti-VEGF aptamer, individually carries a 2' ribosyl substitution, such as -OH (which is standard for ribonucleic acids (RNAs)), or -H (which is standard for deoxyribonucleic acids (DNAs)). In other embodiments the 2' ribosyl position is substituted with an O(C_{1-10} alkyl), an O(C_{1-10} alkenyl), a F, an N_3, or an NH_2 substituent.

In a still more particular non-limiting example, the 5'-5' capped anti-VEGF aptamer may have the structure:

T_d-5'-5'-$C_fG_mG_mA_rA_rU_fC_fA_mG_mU_fG_mA_mA_mU_fG_mC_fU_fU_fA_mU_fA_mC_fA_mU_fC_fC_fG_m$ 3'-3'-T_d

(SEQ ID NO: 19)

where "G_m" represents 2'-methoxyguanylic acid, "A_m" represents 2'-methoxyadenylic acid, "C_f" represents 2'-fluorocytidylic acid, "U_f" represents 2'-fluorouridylic acid, "A_r" represents riboadenylic acid, and "T_d" represents deoxyribothymidylic acid.

Antisense, Ribozymes, and DNA Enzyme Antagonists

Antisense oligonucleotides and ribozymes that are targeted to PDGF and VEGF effect PDGF /VEGF inhibition by inhibiting protein translation from these messenger RNAs or by targeting degradation of the corresponding PDGF or VEGF mRNs, respectively. These PDGF- and VEGF-targeted nucleic acids described above provide useful sequences for the design and synthesis of these PDGF and VEGF ribozymes and antisense oligonucleotides. Methods of design and synthesis of antisense oligonucleotides and ribozymes are known in the art. Additional guidance is provided herein.

One issue in designing specific and effective mRNA-targeted oligonucleotides (antisense ODNs) and ribozymes and antisense is that of identifying accessible sites of antisense pairing within the target mRNA (which is itself folded into a partially self-paired secondary structure). A combination of computer-aided algorithms for predicting RNA pairing accessibility and molecular screening allow for the creation of specific and effective ribozymes and/or antisense oligonucleotides directed against most mRNA targets. Indeed several approaches have been described to determine the accessibility of a target RNA molecule to antisense or ribozyme inhibitors. One approach uses an *in vitro* screening assay applying as many antisense oligodeoxynucleotides as possible (see Monia *et al.*, (1996) Nature Med., 2:668-675; and Milner *et al.*, (1997) Nature Biotechnol., 15:537-541). Another utilizes random libraries of ODNs (Ho *et al.*, (1996) Nucleic Acids Res., 24:1901-1907; Birikh *et al.*, (1997) RNA 3:429-437; and Lima *et al.*, (1997) J. Biol. Chem., 272:626-638). The accessible sites can be monitored by RNase H cleavage (see Birikh *et al.*, *supra*; and Ho *et al.*, (1998) Nature Biotechnol., 16:59-63). RNase H catalyzes the hydrolytic cleavage of the phosphodiester backbone of the RNA strand of a DNA-RNA duplex.

In another approach, involving the use of a pool of semi-random, chimeric chemically synthesized ODNs, is used to identify accessible sites cleaved by RNase H on an *in vitro* synthesized RNA target. Primer extension analyses are then used to identify these sites in the target molecule (see Lima *et al.*, supra). Other approaches for designing antisense targets in RNA are based upon computer assisted folding models for RNA. Several reports have been published on the use of random ribozyme libraries to screen effective cleavage (see Campbell *et al.*, (1995) RNA 1:598-609; Lieber *et al.*, (1995) Mol. Cell Biol., 15: 540-551; and Vaish *et al.*, (1997) Biochem., 36:6459-6501).

Other *in vitro* approaches, which utilize random or semi-random libraries of ODNs and RNase H may be more useful than computer simulations (Lima *et al*., *supra*). However, use of *in vitro* synthesized RNA does not predict the accessibility of antisense ODNs *in vivo* because recent observations suggest that annealing interactions of polynucleotides are influenced by RNA-binding proteins (see Tsuchihashi *et al*., (1993) Science, 267:99-102; Portman *et al*., (1994) EMBO J., 13:213-221; and Bertrand and Rossi (1994) EMBO J., 13:2904-2912). U.S. Patent No. 6,562,570, the contents of which are incorporated herein by reference, provides compositions and methods for determining accessible sites within an mRNA in the presence of a cell extract, which mimics *in vivo* conditions.

Briefly, this method involves incubation of native or *in vitro*-synthesized RNAs with defined antisense ODNs, ribozymes, or DNAzymes, or with a random or semi-random ODN, ribozyme or DNAzyme library, under hybridization conditions in a reaction medium which includes a cell extract containing endogenous RNA-binding proteins, or which mimics a cell extract due to presence of one or more RNA-binding proteins. Any antisense ODN, Ribozyme, or DNAzyme, which is complementary to an accessible site in the target RNA will hybridize to that site. When defined ODNs or an ODN library is used, RNase H is present during hybridization or is added after hybridization to cleave the RNA where hybridization has occurred. RNase H can be present when ribozymes or DNAzymes are used, but is not required, since the ribozymes and DNAzymes cleave RNA where hybridization has occurred. In some instances, a random or semi-random ODN library in cell extracts containing endogenous mRNA, RNA-binding proteins and RNase H is used.

Next, various methods can be used to identify those sites on target RNA to which antisense ODNs, ribozymes or DNAzymes have bound and cleavage has occurred. For example, terminal deoxynucleotidyl transferase-dependent polymerase chain reaction (TDPCR) may be used for this purpose (see Komura and Riggs (1998) Nucleic Acids Res., 26:1807-11). A reverse transcription step is used to convert the RNA template to DNA, followed by TDPCR. In this invention, the 3' termini needed for the TDPCR method is created by reverse transcribing the target RNA of interest with any suitable RNA dependent DNA polymerase (*e.g.*, reverse transcriptase). This is achieved by hybridizing a first ODN primer (P1) to the RNA in a region which is downstream (*i.e.*, in the 5' to 3' direction on the RNA molecule) from the portion of the target RNA molecule which is under study. The polymerase in the presence of dNTPs copies the RNA into DNA from the 3' end of P1 and terminates copying at the site of cleavage created by either an antisense ODN/RNase H, a ribozyme or a DNAzyme. The new DNA molecule (referred to as the first strand DNA) serves as first template for the PCR portion of the TDPCR method, which is used to identify the corresponding accessible target sequence present on the RNA.

For example, the TDPCR procedure may then be used, *i.e.*, the reverse-transcribed DNA with guanosine triphosphate (rGTP) is reacted in the presence of terminal deoxynucleotidyl transferase (TdT) to add an (rG)2-4 tail on the 3' termini of the DNA molecules. Next is ligated a double-stranded ODN linker having a 3'2-4 overhang on one strand that base-pairs with the (rG)2-4 tail. Then two PCR primers are added. The first is a linker primer (LP) that is complementary to the strand of the TDPCR linker which is ligated to the (rG)2-4 tail (sometimes referred to as the lower strand). The other primer (P2) can be the same as P1, but may be nested with respect to P1, *i.e.,* it is complementary to the target RNA in a region which is at least partially upstream (*i.e.*, in the 3' to 5' direction on the RNA molecule) from the region which is bound by P1, but it is downstream of the portion of the target RNA molecule which is under study. That is, the portion of the target RNA molecule, which is under study to determine whether it has accessible binding sites is that portion which is upstream of the region that is complementary to P2. Then PCR is carried out in the known manner in presence of a DNA polymerase and dNTPs to amplify DNA segments defined by primers LP and P2. The amplified product can then be captured by any of various known methods and subsequently sequenced on an automated DNA sequencer, providing precise identification of the cleavage site. Once this identity has been determined, defined sequence antisense DNA or ribozymes can be synthesized for use *in vitro* or *in vivo*.

Antisense intervention in the expression of specific genes can be achieved by the use of synthetic antisense oligonucleotide sequences (see, *e.g.*, Lefebvre-d'Hellencourt *et al.,* (1995) Eur. Cyokine Netw., 6:7; Agrawal (1996) TIBTECH, 14: 376; and Lev-Lehman *et al.,* (1997) Antisense Therap. Cohen and Smicek, eds. (Plenum Press, New York)). Briefly, antisense oligonucleotide sequences may be short sequences of DNA, typically 15-30mer but may be as small as 7mer (see Wagner *et al.,* (1994) Nature, 372: 333) designed to complement a target mRNA of interest and form an RNA:AS duplex. This duplex formation can prevent processing, splicing, transport or translation of the relevant mRNA. Moreover, certain AS nucleotide sequences can elicit cellular RNase H activity when hybridized with their target mRNA, resulting in mRNA degradation (see Calabretta *et al.,* (1996) Semin. Oncol., 23:78). In that case, RNase H will cleave the RNA component of the duplex and can potentially release the AS to further hybridize with additional molecules of the target RNA. An additional mode of action results from the interaction of AS with genomic DNA to form a triple helix that may be transcriptionally inactive.

In as a non-limiting example of, addition to, or substituted for, an antisense sequence as discussed herein above, ribozymes may be utilized for suppression of gene function. This is particularly necessary in cases where antisense therapy is limited by stoichiometric considerations. Ribozymes can then be used that will target the same sequence. Ribozymes are

RNA molecules that possess RNA catalytic ability that cleave a specific site in a target RNA. The number of RNA molecules that are cleaved by a ribozyme is greater than the number predicted by a 1:1 stoichiometry (see Hampel and Tritz (1989) Biochem., 28: 4929-33; and Uhlenbeck (1987) Nature, 328: 596-600). Therefore, the present invention also allows for the use of the ribozyme sequences targeted to an accessible domain of an PDGF or VEGF mRNA species and containing the appropriate catalytic center. The ribozymes are made and delivered as known in the art and discussed further herein. The ribozymes may be used in combination with the antisense sequences.

Ribozymes catalyze the phosphodiester bond cleavage of RNA. Several ribozyme structural families have been identified including Group I introns, RNase P, the hepatitis delta virus ribozyme, hammerhead ribozymes and the hairpin ribozyme originally derived from the negative strand of the tobacco ringspot virus satellite RNA (sTRSV) (see Sullivan (1994) Investig. Dermatolog., (Suppl.) 103: 95S; and U.S. Patent No. 5,225,347). The latter two families are derived from viroids and virusoids, in which the ribozyme is believed to separate monomers from oligomers created during rolling circle replication (see Symons (1989) TIBS, 14: 445-50; Symons (1992) Ann. Rev. Biochem., 61: 641-71). Hammerhead and hairpin ribozyme motifs are most commonly adapted for trans-cleavage of mRNAs for gene therapy. The ribozyme type utilized in the present invention is selected as is known in the art. Hairpin ribozymes are now in clinical trial and are a particularly useful type. In general the ribozyme is from 30-100 nucleotides in length.

Ribozyme molecules designed to catalytically cleave a target mRNA transcript are known in the art (*e.g.*, PDGF (SEQ ID NO:1) or VEGF (SEQ ID NO:3) and can also be used to prevent translation of mRNA (see, *e.g.*, PCT International Pub. WO90/11364; Sarver *et al.*, (1990) Science, 247:1222-1225 and U.S. Patent No. 5,093,246). While ribozymes that cleave mRNA at site specific recognition sequences can be used to destroy particular mRNAs, the use of hammerhead ribozymes is particularly useful. Hammerhead ribozymes cleave mRNAs at locations dictated by flanking regions that form complementary base pairs with the target mRNA. The sole requirement is that the target mRNA have the following sequence of two bases: 5'-UG-3'. The construction and production of hammerhead ribozymes is well known in the art and is described more fully in Haseloff and Gerlach ((1988) Nature, 334: 585).

The ribozymes of the present invention also include RNA endoribonucleases (hereinafter "Cech-type ribozymes") such as the one which occurs naturally in Tetrahymena thermophila (known as the IVS, or L-19 IVS RNA), and which has been extensively described by Thomas Cech and collaborators (see Zaug *et al.*, (1984) Science, 224:574-578; Zaug and Cech (1986) Science, 231:470-475; Zaug, *et al.*, (1986) Nature, 324:429-433; International patent application

No. W088/04300; Been and Cech (1986) Cell, 47:207-216). The Cech-type ribozymes have an eight base pair active site, which hybridizes to a target RNA sequence where after cleavage of the target RNA takes place. The invention encompasses those Cech-type ribozymes, which target eight base-pair active site sequences. While the invention is not limited to a particular theory of operative mechanism, the use of hammerhead ribozymes in the invention may have an advantage over the use of PDGF /VEGF-directed antisense, as recent reports indicate that hammerhead ribozymes operate by blocking RNA translation and/or specific cleavage of the mRNA target.

As in the antisense approach, the ribozymes can be composed of modified oligonucleotides (*e.g.*, for improved stability, targeting, etc.) and are delivered to cells expressing the target mRNA. A useful method of delivery involves using a DNA construct "encoding" the ribozyme under the control of a strong constitutive pol III or pol II promoter, so that transfected cells will produce sufficient quantities of the ribozyme to destroy targeted messages and inhibit translation. Because ribozymes, unlike antisense molecules, are catalytic, a lower intracellular concentration is required for efficiency.

As described above, nuclease resistance, where needed, is provided by any method known in the art that does not substantially interfere with biological activity of the antisense oligodeoxynucleotides or ribozymes as needed for the method of use and delivery (Iyer *et al.*, (1990) J. Org. Chem., 55: 4693-99; Eckstein (1985) Ann. Rev. Biochem., 54: 367-402; Spitzer and Eckstein (1988) Nucleic Acids Res., 18: 11691-704; Woolf *et al.*, (1990) Nucleic Acids Res., 18: 1763-69; and Shaw *et al.*, (1991) Nucleic Acids Res., 18: 11691-704). As described above for aptamers, non-limiting representative modifications that can be made to antisense oligonucleotides or ribozymes in order to enhance nuclease resistance include modifying the phosphorous or oxygen heteroatom in the phosphate backbone, short chain alkyl or cycloalkyl intersugar linkages or short chain heteroatomic or heterocyclic intersugar linkages. These include, *e.g.*, preparing 2'-fluoridated, O-methylated, methyl phosphonates, phosphorothioates, phosphorodithioates and morpholino oligomers. For example, the antisense oligonucleotide or ribozyme may have phosphorothioate bonds linking between four to six 3'-terminus nucleotide bases. Alternatively, phosphorothioate bonds may link all the nucleotide bases. Phosphorothioate antisense oligonucleotides do not normally show significant toxicity at concentrations that are effective and exhibit sufficient pharmacodynamic half-lives in animals (see Agarwal *et al.*, (1996) TIBTECH, 14: 376) and are nuclease resistant. Alternatively the nuclease resistance for the AS-ODN can be provided by having a 9 nucleotide loop forming sequence at the 3'-terminus having the nucleotide sequence CGCGAAGCG. The use of avidin-biotin conjugation reaction can also be used for improved protection of AS-ODNs against serum nuclease degradation (see Boado and Pardridge (1992) Bioconj. Chem., 3: 519-23). According to this concept the AS-ODN agents are monobiotinylated at their 3'-end. When reacted with avidin, they form tight, nuclease-resistant complexes with 6-fold improved stability over non-conjugated ODNs.

Other studies have shown extension *in vivo* of antisense oligodeoxynucleotides (Agarwal *et al.,* (1991) Proc. Natl. Acad. Sci. (USA) 88: 7595). This process, presumably useful as a scavenging mechanism to remove alien AS-oligonucleotides from the circulation, depends upon the existence of free 3'-termini in the attached oligonucleotides on which the extension occurs. Therefore partial phosphorothioate, loop protection or biotin-avidin at this important position should be sufficient to ensure stability of these AS-oligodeoxynucleotides.

In addition to using modified bases as described above, analogs of nucleotides can be prepared wherein the structure of the nucleotide is fundamentally altered and that are better suited as therapeutic or experimental reagents. An example of a nucleotide analog is a peptide nucleic acid (PNA) wherein the deoxyribose (or ribose) phosphate backbone in DNA (or RNA) is replaced with a polyamide backbone, which is similar to that found in peptides. PNA analogs have been shown to be resistant to degradation by enzymes and to have extended lives *in vivo* and *in vitro*. Further, PNAs have been shown to bind stronger to a complementary DNA sequence than a DNA molecule. This observation is attributed to the lack of charge repulsion between the PNA strand and the DNA strand. Other modifications that can be made to oligonucleotides include polymer backbones, morpholino polymer backbones (see, *e.g.,* U.S. Patent No. 5,034,506, the contents of which are incorporated herein by reference), cyclic backbones, or acyclic backbones, sugar mimetics or any other modification including which can improve the pharmacodynamics properties of the oligonucleotide.

A further aspect of the invention relates to the use of DNA enzymes to decrease expression of the target mRNA as, *e.g.,* PDGF or VEGF. DNA enzymes incorporate some of the mechanistic features of both antisense and ribozyme technologies. DNA enzymes axe designed so that they recognize a particular target nucleic acid sequence, much like an antisense oligonucleotide, however much like a ribozyme they are catalytic and specifically cleave the target nucleic acid.

There are currently two basic types of DNA enzymes, and both of these were identified by Santoro and Joyce (see, for example, U.S. Patent No. 6,110,462). The 10-23 DNA enzyme comprises a loop structure which connect two arms. The two arms provide specificity by recognizing the particular target nucleic acid sequence while the loop structure provides catalytic function under physiological conditions.

Briefly, to design DNA enzyme that specifically recognizes and cleaves a target nucleic acid, one of skill in the art must first identify the unique target sequence. This can be done using the same approach as outlined for antisense oligonucleotides. In certain instances, the unique or substantially sequence is a G/C rich of approximately 18 to 22 nucleotides. High G/C content helps insure a stronger interaction between the DNA enzyme and the target sequence.

When synthesizing the DNA enzyme, the specific antisense recognition sequence that targets the enzyme to the message is divided so that it comprises the two arms of the DNA enzyme, and the DNA enzyme loop is placed between the two specific arms.

Methods of making and administering DNA enzymes can be found, for example, in U.S. 6110462. Similarly, methods of delivery DNA ribozymes *in vitro* or *in vivo* include methods of delivery RNA ribozyrne, as outlined herein. Additionally, one of skill in the art will recognize that, like antisense oligonucleotides, DNA enzymes can be optionally modified to improve stability and improve resistance to degradation.

RNAi antagonists

Some embodiments of the invention make use of materials and methods for effecting repression of VEGF and PDGF by means of RNA interference (RNAi). RNAi is a process of sequence-specific post-transcriptional gene repression that can occur in eukaryotic cells. In general, this process involves degradation of an mRNA of a particular sequence induced by double-stranded RNA (dsRNA) that is homologous to that sequence. For example, the expression of a long dsRNA corresponding to the sequence of a particular single-stranded mRNA (ss mRNA) will labilize that message, thereby "interfering" with expression of the corresponding gene. Accordingly, any selected gene may be repressed by introducing a dsRNA which corresponds to all or a substantial part of the mRNA for that gene. It appears that when a long dsRNA is expressed, it is initially processed by a ribonuclease III into shorter dsRNA oligonucleotides of as few as 21 to 22 base pairs in length. Accordingly, RNAi may be effected by introduction or expression of relatively short homologous dsRNAs. Indeed the use of relatively short homologous dsRNAs may have certain advantages as discussed below.

Mammalian cells have at least two pathways that are affected by double-stranded RNA (dsRNA). In the RNAi (sequence-specific) pathway, the initiating dsRNA is first broken into short interfering (si) RNAs, as described above. The siRNAs have sense and antisense strands of about 21 nucleotides that form approximately 19 nucleotide si RNAs with overhangs of two nucleotides at each 3' end. Short interfering RNAs are thought to provide the sequence information that allows a specific messenger RNA to be targeted for degradation. In contrast, the nonspecific pathway is triggered by dsRNA of any sequence, as long as it is at least about 30 base pairs in length. The nonspecific effects occur because dsRNA activates two enzymes: PKR (double-stranded RNA-activated protein kinase), which in its active form phosphorylates the translation initiation factor eIF2 to shut down all protein synthesis, and 2', 5' oligoadenylate synthetase (2', 5'-AS), which synthesizes a molecule that activates RNase L, a nonspecific enzyme that targets all mRNAs. The nonspecific pathway may represent a host response to stress or viral infection, and, in general, the effects of the nonspecific pathway are minimized in particularly useful methods of the present invention. Significantly, longer dsRNAs appear to be required to induce the nonspecific pathway and, accordingly, dsRNAs shorter than about 30 bases pairs are particular useful to effect gene repression by RNAi (see, *e.g.*, Hunter *et al.*, (1975) J. Biol. Chem., 250: 409-17; Manche *et al.*, (1992) Mol. Cell Biol., 12: 5239-48; Minks *et al.*, (1979) J. Biol. Chem., 254: 10180-3; and Elbashir *et al.*, (2001) Nature, 411: 494-8).

Certain double stranded oligonucleotides used to effect RNAi are less than 30 base pairs in length and may comprise about 25, 24, 23, 22, 21, 20, 19, 18 or 17 base pairs of ribonucleic acid. Optionally, the dsRNA oligonucleotides of the invention may include 3' overhang ends. Non-limiting exemplary 2-nucleotide 3' overhangs may be composed of ribonucleotide residues of any type and may even be composed of 2'-deoxythymidine resides, which lowers the cost of RNA synthesis and may enhance nuclease resistance of siRNAs in the cell culture medium and within transfected cells (see Elbashi *et al.*, (2001) Nature, 411: 494-8).

Longer dsRNAs of 50, 75, 100 or even 500 base pairs or more may also be utilized in certain embodiments of the invention. Exemplary concentrations of dsRNAs for effecting RNAi are about 0.05 nM, 0.1 nM, 0.5 nM, 1.0 nM, 1.5 nM, 25 nM or 100 nM, although other concentrations may be utilized depending upon the nature of the cells treated, the gene target and other factors readily discernable the skilled artisan. Exemplary dsRNAs may be synthesized chemically or produced *in vitro* or *in vivo* using appropriate expression vectors. Exemplary synthetic RNAs include 21 nucleotide RNAs chemically synthesized using methods known in the art (*e.g.*, Expedite RNA phophoramidites and thymidine phosphoramidite (Proligo, Germany)). Synthetic oligonucleotides may be deprotected and gel-purified using methods known in the art (see *e.g.*, Elbashir *et al.*, (2001) Genes Dev., 15: 188-200). Longer RNAs may be transcribed from promoters, such as T7 RNA polymerase promoters, known in the art. A single RNA target, placed in both possible orientations downstream of an *in vitro* promoter, will transcribe both strands of the target to create a dsRNA oligonucleotide of the desired target sequence.

The specific sequence utilized in design of the oligonucleotides may be any contiguous sequence of nucleotides contained within the expressed gene message of the target (*e.g.*, of PDGF (*e.g.*, SEQ ID NO:2) or VEGF (*e.g.*, SEQ ID NO: 4). Programs and algorithms, known in the art, may be used to select appropriate target sequences. In addition, optimal sequences may be selected, as described additionally above, utilizing programs designed to predict the secondary structure of a specified single stranded nucleic acid sequence and allow selection of those sequences likely to occur in exposed single stranded regions of a folded mRNA. Methods and compositions for designing appropriate oligonucleotides may be found in, for example, U.S. Patent No. 6,251,588, the contents of which are incorporated herein by reference. mRNA is generally thought of as a linear molecule that contains the information for directing protein synthesis within the sequence of ribonucleotides. However, studies have revealed a number of secondary and tertiary structures exist in most mRNAs. Secondary structure elements in RNA are formed largely by Watson-Crick type interactions between different regions of the same RNA molecule. Important secondary structural elements include intramolecular double stranded regions, hairpin loops, bulges in duplex RNA and internal loops. Tertiary structural elements are formed when secondary structural elements come in contact with each other or with single stranded regions to produce a more complex three-dimensional structure. A number of researchers have measured the binding energies of a large number of RNA duplex structures and have derived a set of rules which can be used to predict the secondary structure of RNA (see *e.g.,* Jaeger *et al.*, (1989) Proc. Natl. Acad. Sci. (USA) 86:7706 (1989); and Turner *et al.*, (1988) Ann. Rev. Biophys. Biophys. Chem., 17:167). The rules are useful in identification of RNA structural elements and, in particular, for identifying single stranded RNA regions, which may represent particularly useful segments of the mRNA to target for silencing RNAi, ribozyme or antisense technologies. Accordingly, particular segments of the mRNA target can be identified for design of the RNAi mediating dsRNA oligonucleotides as well as for design of appropriate ribozyme and hammerheadribozyme compositions of the invention.

The dsRNA oligonucleotides may be introduced into the cell by transfection with an heterologous target gene using carrier compositions such as liposomes, which are known in the art, *e.g.*, Lipofectamine 2000 (Life Technologies, Rockville MD) as described by the manufacturer for adherent cell lines. Transfection of dsRNA oligonucleotides for targeting endogenous genes may be carried out using Oligofectamine (Life Technologies). Transfection efficiency may be checked using fluorescence microscopy for mammalian cell lines after co-transfection of hGFP encoding pAD3 (Kehlenback *et al.*, (1998) J. Cell. Biol., 141: 863-74). The effectiveness of the RNAi may be assessed by any of a number of assays following introduction of the dsRNAs. These include, but are not limited to, Western blot analysis using antibodies which recognize the targeted gene product following sufficient time for turnover of the endogenous pool after new protein synthesis is repressed, and Northern blot analysis to determine the level of existing target mRNA.

Still further compositions, methods and applications of RNAi technology for use in the invention are provided in U.S. Patent Nos. 6,278,039, 5,723,750 and 5,244,805, which are incorporated herein by reference.

Receptor Tyrosine Kinase Inhibitor Antagonists

Also included in the invention are tyrosine kinase antagonists known in the art and variants and alternatives thereto that may be obtained using routine skill in the art and the teachings of the art incorporated herein by reference. The extracellular signal of PDGF (and VEGF) is communicated to other parts of the cell via a tyrosine kinase mediated phosphorylation event effected by the PDGF receptor (and VEGF receptor) and which affects substrate proteins downstream of the cell membrane bound signaling complex. Accordingly, antagonists acting at the receptor kinase stage of PDGF (and/or VEGF) signaling are also effective in the method of the invention.

A number of types of tyrosine kinase inhibitors that are selective for tyrosine kinase receptor enzymes such as PDGFR or VEGFR, are known (see, *e.g.*, Spada and Myers ((1995) Exp. Opin. Ther. Patents, 5: 805) and Bridges ((1995) Exp. Opin. Ther. Patents, 5: 1245). Additionally Law and Lydon have summarized the anticancer potential of tyrosine kinase inhibitors ((1996) Emerging Drugs: The Prospect For Improved Medicines, 241-260). For example, U.S. Patent No. 6,528,526 describes substituted quinoxaline compounds that exhibit selectively inhibit platelet-derived growth factor-receptor (PDGFR) tyrosine kinase activity. The known inhibitors of PDGFR tyrosine kinase activity includes quinoline-based inhibitors reported by Maguire *et al.*, ((1994) J. Med. Chem., 37: 2129), and by Dolle, *et al.*, ((1994) J. Med. Chem., 37: 2627). A class of phenylamino-pyrimidine-based inhibitors was recently reported by Traxler, *et al.*, in EP 564409 and by Zimmerman *et al.*, ((1996) Biorg. Med. Chem. Lett., 6: 1221-1226) and by Buchdunger, *et al.*, ((1995) Proc. Nat. Acad. Sci. (USA), 92: 2558). Quinazoline derivatives that are useful in inhibiting PDGF receptor tyrosine kinase activity include bismono- and bicyclic aryl compounds and heteroaryl compounds (see, *e.g.*, WO 92/20642), quinoxaline derivatives (see (1994) Cancer Res., 54: 6106-6114), pyrimidine derivatives (Japanese Published Patent Application No. 87834/94) and dimethoxyquinoline derivatives (see Abstracts of the 116th Annual Meeting of the Pharmaceutical Society of Japan (Kanazawa), (1996), 2, p. 275, 29(C2) 15-2).

Examples of VEGFR tyrosine kinase inhibitors include cinnoline derivatives, *e.g.*, those described in U.S. Patent No. 6,514,971, the contents of which are incorporated herein in their entirety. Other such cinnoline derivatives are also known. For example, (1995) J. Med Chem., 38: 3482-7 discloses 4-(3-bromoanilino)cinnoline; (1968) J. Chem. Soc. C, (9):1152-5 discloses 6-chloro-4-phenoxycinnoline; (1984) J. Karnatak Univ., Sci., 29: 82-6 discloses certain 4-anilinocinnolines; and (1973) Indian J. Chem., 11: 211-13 discloses certain 4-phenylthiocinnolines. Furthermore, (1973) J. Karnatak Univ., 18: 25-30 discloses certain 4-phenoxycinnolines, (1984) J. Karnatak Univ., Sci., 29: 82-6 discloses two compounds: 4-(4-

methoxyanilino)-6,7-dimethoxycinnoline and 4-(3-chloroanilino)-6,7-dimethoxycinnoline. Furthermore, certain cinnolines with a phenyl ring linked via a group selected from --O--, --S--, --NH-- and --CH_2 -- at the 4-position are described in U.S. Patent No. 5,017,579, U.S. Patent No. 4,957,925, U.S. Patent No. 4,994,474, and EP 0302793 A2.

Still other related compounds for inhibition of VEGFR and/or PDGFR are available by screening novel compounds for their effect on the receptor tyrosine kinase activity of interest using a convention assay. Effective inhibition by a candidate PDGFR or VEGFR small molecule organic inhibitor can be monitored using a cell-based assay system as well as other assay systems known in the art.

For example, one test for activity against VEGF-receptor tyrosine kinase is as follows. The test is conducted using Flt-1 VEGF-receptor tyrosine kinase. The detailed procedure is as follows: 30 µl kinase solution (10 ng of the kinase domain of Flt-1 (see Shibuya, *et al.,* (1990) Oncogene, 5: 519-24) in 20 mM Tris.HCl pH 7.5, 3 mM manganese dichloride ($MnCl_2$), 3 mM magnesium chloride ($MgCl_2$), 10 uM sodium vanadate, 0.25 mg/ml polyethylenglycol (PEG) 20000, 1 mM dithiothreitol and 3 ug/.mu.l poly(Glu,Tyr) 4:1 (Sigma, Buchs, Switzerland), 8 uM [^{33} P]-ATP (0.2 uCi), 1% dimethyl sulfoxide, and 0 to 100 µM of the compound to be tested are incubated together for 10 minutes at room temperature. The reaction is then terminated by the addition of 10 µl 0.25 M ethylenediaminetetraacetate (EDTA) pH 7. Using a multichannel dispenser (LAB SYSTEMS, USA), an aliquot of 20 µl is applied to a PVDF (=polyvinyl difluoride) Immobilon P membrane (Millipore, USA), through a microtiter filter manifold and connected to a vacuum. Following complete elimination of the liquid, the membrane is washed 4 times successively in a bath containing 0.5% phosphoric acid (H_3PO_4) and once with ethanol, incubated for 10 minutes each time while shaking, then mounted in a Hewlett Packard TopCount Manifold and the radioactivity measured after the addition of 10 µl Microscint.RTM. (beta-scintillation counter liquid). IC_{50} -values are determined by linear regression analysis of the percentages for the inhibition of each compound in three concentrations (as a rule 0.01 µmol, 0.1 µmol, and 1 µmol). The IC_{50} -values of active tyrosine inhibitor compounds may be in the range of 0.01 µM to 100 µM.

Furthermore, inhibition of a VEGF-induced VEGFR tyrosine kinase/ autophosphorylation activity can be confirmed with a further experiment on cells. Briefly, transfected CHO cells, which permanently express human VEGF receptor (VEGFR/KDR), are seeded in complete culture medium (with 10% fetal call serum (FCS) in 6-well cell-culture plates and incubated at 37°C. under 5% CO_2 until they show about 80% confluency. The compounds to be tested are then diluted in culture medium (without FCS, with 0.1% bovine serum albumin) and added to the cells. (Controls comprise medium without test compounds). After a two hour incubation at 37°C, recombinant VEGF is added; the final VEGF concentration is 20 ng/ml). After a further five minutes incubation at 37°C, the cells are washed twice with ice-cold PBS) and immediately lysed in 100 µl lysis buffer per well. The lysates are then centrifuged to remove the cell nuclei, and the protein concentrations of the supernatants are determined using a commercial protein assay (BIORAD). The lysates can then either be immediately used or, if necessary, stored at –200 °C.

A sandwich ELISA is then carried out to measure the KDR-receptor phosphorylation: a monoclonal antibody to KDR is immobilized on black ELISA plates (OptiPlate™, HTRF-96 from Packard). The plates are then washed and the remaining free protein-binding sites are saturated with 1% BSA in PBS. The cell lysates (20 µg protein per well) are then incubated in these plates overnight at 4°C. together with an antiphosphotyrosine antibody coupled with alkaline phosphatase (*e.g.*, PY20:AP from Transduction Laboratories, Lexington, KY). The plates are washed again and the binding of the antiphosphotyrosine antibody to the captured phosphorylated receptor is then demonstrated using a luminescent AP substrate (CDP-Star, ready to use, with Emerald II; Applied-Biosystems TROPIX Bedford, MA). The luminescence is measured in a Packard Top Count Microplate Scintillation Counter. The difference between the signal of the positive control (stimulated with VEGF or PDGF) and that of the negative control (not stimulated with VEGF or PDGF) corresponds to VEGF-induced KDR-receptor phosphorylation (=100%). The activity of the tested substances is calculated as % inhibition of VEGF-induced KDR-receptor phosphorylation, wherein the concentration of substance that induces half the maximum inhibition is defined as the ED_{50} (effective dose for 50% inhibition). Active tyrosine inhibitor compound have ED_{50} values in the range of 0.001 µM to 6 µM, typically 0.005 µM to 0.5 µM.

Pharmaceutical Formulations and Therapeutic Administration

The anti-VEGF and anti-PDGF agents are useful in the treatment of a neovascular disorder, including psoriasis, rheumatoid arthritis, and ocular neovascular disorders. Of particular interest are therapies using a PDGF-B antagonist compound in combination with a VEGF-A antagonist to suppress an ocular neovascular disorder such as macular degeneration or diabetic retinopathy. Accordingly, once a patient has been diagnosed to be at risk at developing or having a neovascular disorder, the patient is treated by administration of a PDGF antagonist in combination with a VEGF antagonist in order to block respectively the negative effects of PDGF and VEGF, thereby suppressing the development of a neovascular disorder and alleviating deleterious effects associated with neovascularization. The practice of the methods according to the present invention does not result in corneal edema. As is discussed above, a wide variety of PDGF and VEGF antagonists may be used in the present invention.

Anti-PDGF and anti-VEGF combination therapy according to the invention may be performed alone or in conjunction with another therapy and may be provided at home, the doctor's office, a clinic, a hospital's outpatient department, or a hospital. Treatment generally begins at a hospital so that the doctor can observe the therapy's effects closely and make any adjustments that are needed. The duration of the combination therapy depends on the type of neovascular disorder being treated, the age and condition of the patient, the stage and type of the patient's disease, and how the patient responds to the treatment. Additionally, a person having a greater risk of developing a neovascular disorder (*e.g.*, a diabetic patient) may receive treatment to inhibit or delay the onset of symptoms. One significant advantage provided by the present invention is that the combination of a PDGF antagonist and a VEGF antagonist for the treatment of a neovascular disorder allows for the administration of a low dose of each antagonist and less total active antagonist, thus providing similar efficacy with less toxicity and side effects, and reduced costs.

Administration of each antagonist of the combination therapy may be by any suitable means that results in a concentration of the antagonist that, combined with the other antagonist, is effective for the treatment of a neovascular disorder. Each antagonist, for example, may be admixed with a suitable carrier substance, and is generally present in an amount of 1-95% by weight of the total weight of the composition. The composition may be provided in a dosage form that is suitable for ophthalmic, oral, parenteral (*e.g.*, intravenous, intramuscular, subcutaneous), rectal, transdermal, nasal, or inhalant administration. Accordingly, the composition may be in form of, *e.g.*, tablets, capsules, pills, powders, granulates, suspensions, emulsions, solutions, gels including hydrogels, pastes, ointments, creams, plasters, delivery devices, suppositories, enemas, injectables, implants, sprays, or aerosols. The pharmaceutical compositions containing a single antagonist or two or more antagonists may be formulated according to conventional pharmaceutical practice (see, *e.g.*, Remington: The Science and Practice of Pharmacy, (20th ed.) ed. A.R. Gennaro, 2000, Lippincott Williams & Wilkins, Philadelphia, PA. and Encyclopedia of Pharmaceutical Technology, eds., J. Swarbrick and J. C. Boylan, 1988-2002, Marcel Dekker, New York).

Combinations of PDGF and VEGF antagonists are, in one useful aspect, administered parenterally (*e.g.*, by intramuscular, intraperitoneal, intravenous, intraocular, intravitreal, retro-bulbar, subconjunctival, subtenon or subcutaneous injection or implant) or systemically. Formulations for parenteral or systemic administration include sterile aqueous or non-aqueous solutions, suspensions, or emulsions. A variety of aqueous carriers can be used, *e.g.*, water, buffered water, saline, and the like. Examples of other suitable vehicles include polypropylene glycol, polyethylene glycol, vegetable oils, gelatin, hydrogels, hydrogenated naphalenes, and injectable organic esters, such as ethyl oleate. Such formulations may also contain auxiliary substances, such as preserving, wetting, buffering, emulsifying, and/or dispersing agents. Biocompatible, biodegradable lactide polymer, lactide/glycolide copolymer, or polyoxyethylene-polyoxypropylene copolymers may be used to control the release of the active ingredients.

Alternatively, combinations of PDGF and VEGF antagonists can be administered by oral ingestion. Compositions intended for oral use can be prepared in solid or liquid forms, according to any method known to the art for the manufacture of pharmaceutical compositions.

Solid dosage forms for oral administration include capsules, tablets, pills, powders, and granules. Generally, these pharmaceutical preparations contain active ingredients (such as a PDGF small organic molecule antagonist and a VEGF small organic molecule antagonist) admixed with non-toxic pharmaceutically acceptable excipients. These may include, for example, inert diluents, such as calcium carbonate, sodium carbonate, lactose, sucrose, glucose, mannitol, cellulose, starch, calcium phosphate, sodium phosphate, kaolin and the like. Binding agents, buffering agents, and/or lubricating agents (*e.g.*, magnesium stearate) may also be used. Tablets and pills can additionally be prepared with enteric coatings. The compositions may optionally contain sweetening, flavoring, coloring, perfuming, and preserving agents in order to provide a more palatable preparation.

For example, the PDGF and VEGF antagonists may be administer intraocullary by intravitreal injection into the eye as well as subconjunctival and subtenon injections. Other routes of administration include transcleral, retro bulbar, intraperoteneal, intramuscular, and intravenous. Alternatively, a combination of antagonists may be delivered using a drug delivery device or an intraocular implant (see below).

Liquid dosage forms for oral administration include pharmaceutically acceptable emulsions, solutions, suspensions, syrups, and soft gelatin capsules. These forms contain inert diluents commonly used in the art, such as water or an oil medium, and can also include adjuvants, such as wetting agents, emulsifying agents, and suspending agents.

In some instances, the combination of PDGF and VEGF antagonists can also be administered topically, for example, by patch or by direct application to a region, such as the epidermis or the eye, susceptible to or affected by a neovascular disorder, or by iontophoresis.

Formulations for ophthalmic use include tablets containing the active ingredient(s) in a mixture with non-toxic pharmaceutically acceptable excipients. These excipients may be, for example, inert diluents or fillers (*e.g.*, sucrose and sorbitol), lubricating agents, glidants, and antiadhesives (*e.g.*, magnesium stearate, zinc stearate, stearic acid, silicas, hydrogenated vegetable oils, or talc).

The PDGF and VEGF antagonists may be mixed together in a tablet or other vehicle, or may be partitioned. In one example, the first antagonist is contained on the inside of the tablet, and the second antagonist is on the outside, such that a substantial portion of the second antagonist is released prior to the release of the first antagonist. If desired, antagonists in a tablet form may be delivered using a drug delivery device (see below).

Generally, each of the antagonists should be administered in an amount sufficient to suppress or reduce or eliminate a deleterious effect or a symptom of a neovascular disorder. The amount of an active antagonist ingredient that is combined with the carrier materials to produce a single dosage will vary depending upon the subject being treated and the particular mode of administration.

The dosage of each antagonist of the claimed combinations depends on several factors including the severity of the condition, whether the condition is to be treated or prevented, and the age, weight, and health of the person to be treated. Additionally, pharmacogenomic (the effect of genotype on the pharmacokinetic, pharmacodynamic or efficacy profile of a therapeutic) information about a particular patient may affect dosage used. Furthermore, one skilled in the art will appreciate that the exact individual dosages may be adjusted somewhat depending on a variety of factors, including the specific combination of PDGF and VEGF antagonists being administered, the time of administration, the route of administration, the nature of the formulation, the rate of excretion, the particular neovascular disorder being treated, the severity of the disorder, and the anatomical location of the neovascular disorder (for example, the eye versus the body cavity). Wide variations in the needed dosage are to be expected in view of the differing efficiencies of the various routes of administration. For instance, oral administration generally would be expected to require higher dosage levels than administration by intravenous or intravitreal injection. Variations in these dosage levels can be adjusted using standard empirical routines for optimization, which are well-known in the art. The precise therapeutically effective dosage levels and patterns are typically determined by the attending physician such as an ophthalmologist in consideration of the above-identified factors.

Generally, when orally administered to a human, the dosage of the PDGF antagonist or VEGF antagonist is normally about 0.001 mg to about 200 mg per day, desirably about 1 mg to 100 mg per day, and more desirably about 5 mg to about 50 mg per day. Dosages up to about 200 mg per day may be necessary. For administration of the PDGF antagonist or VEGF antagonist by injection, the dosage is normally about 0.1 mg to about 250 mg per day, desirably about 1 mg to about 20 mg per day, or about 3 mg to about 5 mg per day. Injections may be given up to about four times daily. Generally, when parenterally or systemically administered to a human, the dosage of the VEGF antagonist for use in combination with the PDGF antagonist is normally about 0.1 mg to about 1500 mg per day, or about 0.5 mg to 10 about mg per day, or about 0.5 mg to about 5 mg per day. Dosages up to about 3000 mg per day may be necessary.

When ophthalmologically administered to a human, the dosage of the VEGF antagonist for use in combination with the PDGF antagonist is normally about 0.15 mg to about 3.0 mg per day, or at about 0.3 mg to about 3.0 mg per day, or at about 0.1 mg to 1.0 mg per day.

For example, for ophthalmic uses, PDGF-B and VEGF-A aptamer drug substances are formulated in phosphate buffered saline at pH 5-7. Sodium hydroxide or hydrochloric acid may be added for pH adjustment. In one working formulation, a PDGF-B aptamer and a VEGF-A aptamer, such as EYE001, are individually formulated at three different concentrations: 3 mg/100 µl, 2 mg/100 µl and 1 mg/100 µl packaged in a sterile 1ml, USP Type I graduated glass syringe fitted with a sterile 27-gauge needle. The combination drug product is preservative-free and intended for single use by intravitreous injection only. The active ingredient is PDGF-B and VEGF-A drug substances, at 30 mg/ml, 20 mg/ml and 10 mg/ml concentrations. The excipients are Sodium Chloride, USP; Sodium Phosphate Monobasic, Monohydrate, USP; Sodium Phosphate Dibasic, Heptahydrate, USP; Sodium Hydroxide, USP; Hydrochloric acid, USP; and Water for injection, USP. In this form the PDGF-B and VEGF-A aptamer drug products are in a ready-to-use sterile solution provided in a single-use glass syringe. The syringe is removed from refrigerated storage at least 30 minutes (but not longer than 4 hours) prior to use to allow the solution to reach room temperature. Administration of the syringe contents involves attaching the threaded plastic plunger rod to the rubber stopper inside the barrel of the syringe. The rubber end cap is then removed to allow administration of the product. PDGF-B and VEGF-A aptamers are administered as a 100 µl intravitreal injections on three occasions at 28 day intervals. Patients receive 3 mg/injection per visit. The dose is reduced to 2 mg or 1 mg, and further to 0.1 mg if necessary.

The specific amounts of drugs administered depend on the specific combination of components. In a desired dose combination, the ratio of PDGF antagonist to VEGF antagonist is about 50:1 by weight, about 20:1 by weight, about 10:1 by weight, or about 4:1, about 2:1, or about 1:1 by weight.

A useful combination therapy includes a PDGF-B aptamer antagonist and a VEGF-A aptamer antagonist. The antagonists are used in combination in a weight ratio range from about 0.1 to about 5.0 to about 5.0 to 0.1 of the PDGF-B aptamer antagonist to VEGF-A aptamer antagonist. A useful range of these two antagonists (PDGF-B to VEGF-A antagonist) is from about 0.5 to about 2.0, or from about 2.0 to 0.5, while another useful ratio is from about 1.0 to about 1.0, depending ultimately on the selection of the PDGF-B aptamer antagonist and the VEGF-A aptamer antagonist.

Administration of each drug in the combination therapy can, independently, be one to four times daily for one day to one year, and may even be for the life of the patient. Chronic, long-term administration will be indicated in many cases. The dosage may be administered as a single dose or divided into multiple doses. In general, the desired dosage should be administered at set intervals for a prolonged period, usually at least over several weeks, although longer periods of administration of several months or more may be needed.

In addition to treating pre-existing neovascular disorders, the combination therapy that includes a PDGF antagonist and VEGF antagonist can be administered prophylactically in order to prevent or slow the onset of these disorders. In prophylactic applications, the PDGF and VEGF antagonists are administered to a patient susceptible to or otherwise at risk of a particular neovascular disorder. Again, the precise timing of the administration and amounts that are administered depend on various factors such as the patient's state of health, weight, etc.

In one working example, the combination of the PDGF antagonist and the VEGF antagonist is administered to a mammal in need of treatment therewith, typically in the form of an injectable pharmaceutical composition. In the combination aspect, for example, a PDGF-B aptamer and a VEGF-A aptamer may be administered either separately or in the pharmaceutical composition comprising both. It is generally preferred that such administration be by injection or by using a drug delivery device. Parenteral, systemic, or transdermal administration is also acceptable.

As discussed above, when the PDGF antagonist and VEGF antagonist are administered together, such administration can be sequential in time or simultaneous with the sequential method being one mode of administration. When the PDGF and VEGF antagonists are administered sequentially, the administration of each can be by the same or different methods. For sequential administration, however, it is useful that the method employ administration of the PDGF antagonist over about five seconds (up to about three injections) followed by sustained administration every six weeks for up to about nine injections per year of a VEGF antagonist. The PDGF antagonist may be administered at the time of each VEGF antagonist injection or may be given less often, as determined by the physician. Sequential administration also includes a combination where the individual antagonists may be administered at different times or by different routes or both but which act in combination to provide a beneficial effect, for example, to suppress a neovascular disorder. It is also noted that administration by injection is particularly useful.

Pharmaceutical compositions according to the invention may be formulated to release the active PDGF and VEGF antagonists substantially immediately upon administration or at any predetermined time period after administration, using controlled release formulations. For example, a pharmaceutical composition that includes at least one of each of a PDGF antagonist and a VEGF antagonist may be provided in sustained release compositions. The use of immediate or sustained release compositions depends on the nature of the condition being treated. If the condition consists of an acute or over-acute disorder, treatment with an immediate release form will be typically utilized over a prolonged release composition. For certain preventative or long-term treatments, a sustained released composition may also be appropriate.

Administration of each of the antagonists in controlled release formulations is useful where the antagonist, either alone or in combination, has (i) a narrow therapeutic index (*e.g.*, the difference between the plasma concentration leading to harmful side effects or toxic reactions and the plasma concentration leading to a therapeutic effect is small; generally, the therapeutic index, TI, is defined as the ratio of median lethal dose (LD_{50}) to median effective dose (ED_{50})); (ii) a narrow absorption window in the gastro-intestinal tract; or (iii) a short biological half-life, so that frequent dosing during a day is required in order to sustain the plasma level at a therapeutic level.

Many strategies can be pursued to obtain controlled release in which the rate of release outweighs the rate of degradation or metabolism of the therapeutic antagonist. For example, controlled release can be obtained by the appropriate selection of formulation parameters and ingredients, including, *e.g.*, appropriate controlled release compositions and coatings. Examples include single or multiple unit tablet or capsule compositions, oil solutions, suspensions, emulsions, microcapsules, microspheres, nanoparticles, patches, and liposomes. Methods for preparing such sustained or controlled release formulations are well known in the art.

Pharmaceutical compositions that include a PDGF antagonist and/or a VEGF antagonist or both may also be delivered using a drug delivery device such as an implant. Such implants may be biodegradable and/or biocompatible implants, or may be non-biodegradable implants. The implants may be permeable or impermeable to the active agent. Ophthalmic drug delivery devices may be inserted into a chamber of the eye, such as the anterior or posterior chambers or may be implanted in or on the scelra, choroidal space, or an avascularized region exterior to the vitreous. In one embodiment, the implant may be positioned over an avascular region, such as on the sclera, so as to allow for transcleral diffusion of the drug to the desired site of treatment, *e.g.*, the intraocular space and macula of the eye. Furthermore, the site of transcleral diffusion may be proximity to a site of neovascularization such as a site proximal to the macula.

As noted above, the invention relates to combining separate pharmaceutical compositions in a pharmaceutical pack. The combination of the invention is therefore provided as components of a pharmaceutical pack. At least two antagonists can be formulated together or separately and in individual dosage amounts. The antagonists of the invention are also useful when formulated as salts.

The pharmaceutical pack, in general, includes (1) an amount of a PDGF antagonist, and a pharmaceutically acceptable carrier, vehicle, or diluent in a first unit dosage form; (2) an amount of a VEGF antagonist, and a pharmaceutically acceptable carrier, vehicle, or diluent in a second unit dosage form; and (3) a container. The container is used to separate components and may include, for example, a divided bottle or a divided foil packet. The separate antagonist compositions may also, if desired, be contained within a single, undivided container. The pharmaceutical pack may also include directions for the administration of the separate PDGF and VEGF antagonists. The pharmaceutical pack is particularly advantageous when the separate components are administered in different dosage forms, are administered at different dosage levels, or when titration of the individual components of the combination is desired by the prescribing physician. In one embodiment, the pharmaceutical pack is designed to dispense doses of the PDGF and VEGF antagonists one at a time in the order of their intended use. In another example, a pharmaceutical pack is designed to contain rows of a PDGF antagonist and a VEGF antagonist placed side by side in the pack, with instructions on the pack to convey to the user that one pair of antagonists is to be administered. An exemplary pharmaceutical pack is the so-called blister pack that is well known in the pharmaceutical packaging industry.

Effectiveness

Suppression of a neovascular disorder is evaluated by any accepted method of measuring whether angiogenesis is slowed or diminished. This includes direct observation and indirect evaluation such as by evaluating subjective symptoms or objective physiological indicators. Treatment efficacy, for example, may be evaluated based on the prevention or reversal of neovascularization, microangiopathy, vascular leakage or vascular edema or any combination thereof. Treatment efficacy for evaluating suppression of an ocular neovascular disorder may also be defined in terms of stabilizing or improving visual acuity.

In determining the effectiveness of a particular combination therapy in treating or preventing an ocular neovascular disorder, patients may also be clinically evaluated by an ophthalmologist several days after injection and at least one-month later just prior to the next injection. ETDRS visual acuities, kodachrome photography, and fluorescein angiography are also performed monthly for the first 4 months as required by the ophthalmologist.

For example, in order to assess the effectiveness of combination PDGF antagonist and VEGF antagonist therapy to treat ocular neovascularization, studies are conducted involving the administration of either single or multiple intravitreal injections of a PDGF-B aptamer in combination with a VEGF-A aptamer (for example, a PEGylated form of EYE001) in patients suffering from subfoveal choroidal neovascularization secondary to age-related macular degeneration according to standard methods well known in the ophthalmologic arts. In one working study, patients with subfoveal choroidal neovascularization (CNV) secondary to age-related macular degeneration (AMD) receive a single intravitreal injection of a PDGF-B aptamer and a VEGF-A aptamer. Effectiveness of the combination is monitored, for example, by ophthalmic evaluation. Patients showing stable or improved vision three months after treatment, for example, demonstrating a 3-line or greater improvement in vision on the ETDRS chart, are taken as receiving an effective dosage combination of the PDGF-B aptamer and VEGF-A aptamer that suppresses an ocular neovascular disorder.

In a working study example, patients with subfoveal CNV secondary to age-related macular degeneration and with a visual acuity worse than 20/200 on the ETDRS chart receive a single intravitreous injection of the PDGF-B aptamer and VEGF-A aptamer. The starting dose is 0.25 mg of each antagonist injected once intravitreously. Dosages of 0.5 mg, 1, 2 mg and 3 mg of each antagonist are also tested. Complete ophthalmic examination with fundus photography and fluorescein angiography is also performed. The combination drug product is a ready-to-use sterile solution composed of the PDGF-B aptamer and VEGF-A aptamer dissolved in 10 mM sodium phosphate and 0.9% sodium chloride buffer injection in a sterile and pyrogen free 1 cc glass body syringe barrel, with a coated stopper attached to a plastic plunger, and a rubber end cap on the pre-attached 27 gauge needle. The PDGF-B and VEGF-A aptamers are supplied at drug concentrations of 1 mg/ml, 2.5 mg/ml, 5 mg/ml, 10 mg/ml, 20 mg/ml, or 30 mg/ml for each aptamer (expressed as oligonucleotide content) to provide a 100 μl delivery volume. At approximately 3 months after injection of the PDGF-B and VEGF-A aptamers, acuity studies are performed to evaluate effectiveness of the treatment. Patients showing stable or improved vision after treatment, for example, those showing as a 3-line, or greater, increase in vision on the ETDRS chart, are taken as receiving an effective dosage combination of PDGF-B and VEGF-A aptamers that suppresses an ocular neovascular disorder.

EXAMPLES

The following examples illustrate certain modes of making and practicing the present invention, but are not meant to limit the scope of the invention since alternative methods may be used to obtain similar results.

Example 1: Corneal Neovascularization (Corneal NV)

Corneal Neovascularization is a widely used animal model that allows clear visualization of abnormal vascular growth in the eye. The vessels that grow into the normally avascular cornea, can become well established, making this an attractive model to study vessel regression. To induce experimental corneal NV, male C57BL/6 mice (18-20 g; Charles River, Wilmington, MA) were anesthetized with intramuscular ketamine hydrochloride (25 mg/kg) and xylazine (10 mg/kg). NaOH (2ul of 0.2 mM) was applied topically. The corneal and limbal epithelia were removed by applying a rotary motion parallel to the limbus using #21 blade (Feather, Osaka, Japan). After 7 days, mice were treated with intra-peritoneal injections of 25 mg/kg of pegaptanib sodium (Macugen™ (Eyetech Pharmaceuticals, New York, NY), an anti-VEGF aptamer agent also known as EYE001) twice a day or by oral administration of 50 mg/kg of Gleevec®/STI57 ((also known as CGP57148B) a 2-phenylaminopyrimidine-related, tyrosine kinase-inhibiting anti-PDGF agent from Novartis Pharma AG, Basel, Switzerland) by gavage twice a day or both for 7 days. At day 14 following corneal NV induction, mice received 20 ug/g of fluorescein-isothiocyanate coupled concanavalin A lectin (Vector Laboratories, Burlingame, CA) intravenously whilst deeply anesthetized with xylazine hydrochloride and ketamine hydrochloride. Thirty minutes later, mice eyes were enucleated, and the corneas flat-mounted. Corneal NV was visualized using fluorescence microscopy and quantified using Openlab software. The percent of cornea covered by vessels was calculated as a percentage of total corneal area.

The effects of pegaptanib sodium and Gleevec on neovascularization of the cornea following NaOH application and injury to the epithilia of the limbus and cornea were investigated. Animals treated with pegaptanib sodium (Macugen) showed a 19.6% ($p=0.0014$) decrease in vessel growth as compared to both untreated and Gleevec treated eyes (Figure 5). Animals treated with pegaptanib sodium and Gleevec (Mac+Glee) exhibited significantly less neovascular growth on the cornea (35.6% $p<0.0001$) as compared to controls and animals treated with Gleevec alone (Figure 5). Combination treatment was also more effective than pegaptanib sodium (Macugen) alone at reducing vessel growth (16% $p<0.0145$).

The results of representative corneal neovascularization experiments are also shown in Figures 6 and 7. Figure 6 (D) is a photographic representation of a fluorescent-microscopic image showing effective inhibition of new blood vessel formation in combination (Mac+Gleevec)-treated corneas, as compared to individual treatments with Macugen (Figure 6 (C)) or Gleevec (Figure 6 (B)). Figure 6 (A) is a photographic representation of a fluorescent-microscopic image showing the extent of neovascularization in a control (PEG-treated) cornea. Figure 7 is a photographic representation of a fluorescent-microscopic image showing that the individual (Figure 7(A) (APB5-treated) and Figure 7(B) (Gleevec-treated)) and combined treatments (Figure 7 (C)) inhibited only new vessel growth, and did not affect established blood vessels. Figure 7 (D) is a photographic representation of a fluorescent-microscopic image showing the extent of neovascularization in a control (PEG-treated) cornea.

Example 2: Choroidal Neovascularization (CNV)

Experimental CNV is often used as a model for Age-related Macular degeneration (AMD). In this model, vessels of the choroid grow through breaks in Bruch's membrane and into the retina, similar to what is observed in AMD patients. To induce experimental CNV, male C57BL/6 mice (18-20 g; Charles River, Wilmington, MA) were anesthetized with intramuscular ketamine hydrochloride (25 mg/kg) and xylazine (10 mg/kg) and the pupils were dilated with 1% tropicamide. Four burns were generated using diode laser photocoagulation (75-µm spot size, 0.1-second duration, 90mW, Oculight SL laser, IRIDEX, Mountain View, CA) and a hand-held cover slide as a contact lens. Burns localized to the 3, 6, 9 and 12 o'clock positions of the posterior pole of the retina. Production of a bubble at the time of laser, which indicates rupture of Bruch's membrane, is an important factor in obtaining choroidal neovascularization, so only mice in which a bubble was produced for all four burns were included in the study. After 7 days, mice were treated with intraperitoneal injections of 25 mg/kg of pegaptanib sodium twice a day or 50 mg/kg of Gleevec®/STI57 (Novartis Pharma AG, Basel, Switzerland) by gavage twice a day or both for 7 days. In experiments using APB5 (an anti-mouse PDGFRb (CD140b) antibody (anti-PDGF agent) from eBioscience, San Diego, CA), 5 mg/kg of antibody was administered using intra-peritoneal injections of twice a day. The area of choroidal NV lesions was measured in flat-mounted choroid stained with PECAM. Flat-mounts were examined by fluorescence microscopy and quantified using Openlab software.

Eyes treated with pegaptanib sodium (Macugen™) showed a 24% ($p=0.007$) decrease in CNV area compared to untreated controls (Figure 8). In contrast, APB5-treated eyes were not significantly different to controls (6.5% decrease in CNV area compared to control). Eyes treated with both pegaptanib sodium and APB5 showed significantly less (46% $p=0.001$) CNV area as compared to control eyes or to eyes treated with either pegaptanib sodium (22% $p=0.011$) or APB5 (39.5% $p<0.0001$) alone (Figure 8)

A similar trend was observed when using the PDGFRβ inhibitor. Gleevec® treated eyes showed no significant difference to control eyes (4.2%) (Figure 9). The area of CNV in pegaptanib sodium (Macugen™) treated eyes, however, was significantly different to that of controls (27% less $p=0.0034$). Importantly, animals treated with both pegaptanib sodium and Gleevec (Macugen+Gleevec) exhibited the least amount of CNV (46% $p<0.0001$) compared to control eyes and a 19% decrease in the CNV area as compared to pegaptanib sodium alone treated eyes ($p=0.0407$) (Figure 9).

Example 3: Neonatal mouse model

The effect of administering pegaptanib sodium (Macugen™), and ARC-127 (Archemix Corp., Cambridge, MA), a PEGylated, anti-PDGF aptamer having the sequence CAGGCUACGN

CGTAGAGCAU CANTGATCCU GT (see SEQ ID NO: 146 from U.S. 6,582,918, incorporated herein by reference in its entirety) having 2'-fluoro-2'-deoxyuridine at positions 6, 20 and 30, 2'-fluoro-2'-deoxycytidine at positions 8, 21, 28, and 29, 2'-O-Methyl-2'-deoxyguanosine at positions 9, 15, 17, and 31, 2'-O-Methyl-2'-deoxyadenosine at position 22, hexaethylene-glycol phosphoramidite at "N" in positions 10 and 23, and an inverted orientation T (i.e., 3'-3'-linked) at position 32, or both on the developing vessels of the retina was investigated. Neonatal C57BL/6 mice were injected daily (in the intra-peritoneal cavity) with 100 μg of ARC-127 or 100 μg of Macugen or both, starting on postnatal day 0 (P0). Mice eyes were enucleated at P4. The retinal vasculature was visualized in flatmounted retinas by immunostaining with PECAM and NG-2 or by perfusion with ConA-FITC and analyzed by fluorescence microscopy.

Injection of ARC-127 completely blocked mural cell recruitment to the developing vessels of the retina. In addition, less vessel growth was observed at P4 as compared to the control non-treated retina. In contrast, Macugen did not interfere with normal blood vessel development. However, mice treated with both Macugen and ARC-127 exhibited similar but significantly more severe defects than mice treated with ARC-127 alone.

These results, depicted in Figure 10, show that Macugen has no effect on the blood vessels of the developing retina. PDGFR-B antagonist ARC-127 affects vessels outgrowth and morphology. However, Macugen in combination with ARC-127 affects blood vessels more severely than either of them alone.

Example 4: Combination Therapy with anti-PDGF aptamer and anti-VEGF antibody

In this example, effectiveness of a combination therapy using anti-PDGF aptamers and an anti-VEGF antibody is demonstrated using the corneal neovascularization model described above. To induce experimental corneal NV, male C57BL/6 mice (18-20 g; Charles River, Wilmington, MA) are anesthetized with intramuscular ketamine hydrochloride (25 mg/kg) and xylazine (10 mg/kg). NaOH (2ul of 0.2 mM) are applied topically. The corneal and limbal epithelia are removed by applying a rotary motion parallel to the limbus using #21 blade (Feather, Osaka, Japan). After 7 days, mice are treated with intra-peritoneal injections of 25 mg/kg of an anti-PDGF aptamer having the structure 40Kd PEG-5'-CAGGCTACGCGTAG-AGCATCATGATCCTG(iT)-3' (in which iT represents that the final nucleotide is in the inverted orientation (3'-3' linked)) in combination with 100 μg of the anti-VEGF antibody 2C3 described in U.S. 6,342,221 (incorporated herein by reference). At day 14 following corneal NV induction, mice receive 20 μg/g of fluorescein-isothiocyanate coupled concanavalin A lectin (Vector Laboratories, Burlingame, CA) intravenously whilst deeply anesthetized with xylazine hydrochloride and ketamine hydrochloride. Thirty minutes later, mice eyes are enucleated, and the corneas flat-mounted. Corneal NV is visualized using fluorescence microscopy and quantified using Openlab software. The percent of cornea covered by vessels is calculated as a percentage of total corneal area. The results demonstrate the efficacy of the combination therapy over individual treatments with the anti-PDGF aptamer or anti-VEGF antibody alone.

In separate experiments, the effects of two related anti-PDGF aptamers are tested in combination with 100 μg of the anti-VEGF antibody 2C3 described in U.S. 6,342,221. PEGylated and un-PEGylated versions of the following two anti-PDGF aptamers are tested: (i) CAGGCUACGN CGTAGAGCAU CANTGATCCU GT (see SEQ ID NO: 146 from U.S. 6,582,918, incorporated herein by reference in its entirety) having 2'-fluoro-2'-deoxyuridine at positions 6, 20 and 30, 2'-fluoro-2'-deoxycytidine at positions 8, 21, 28, and 29, 2'-O-Methyl-2'-deoxyguanosine at positions 9, 15, 17, and 31, 2'-O-Methyl-2'-deoxyadenosine at position 22, hexaethylene-glycol phosphoramidite at "N" in positions 10 and 23, and an inverted orientation T (i.e., 3'-3'-linked) at position 32; and (ii) CAGGCUACGN CGTAGAGCAU CANTGATCCU GT (see SEQ ID NO: 87 from U.S. 5,723,594, incorporated herein by reference in its entirety) having O-methyl-2 – deoxycytidine at C at position 8, 2 - O-methyl-2 –deoxyguanosine at Gs at positions 9, 17 and 31, 2 -O-methyl- 2 – deoxyadenine at A at position 22, 2-O-methyl-2 – deoxyuridine at position 30, 2 - fluoro-2 – deoxyuridine at U at positions 6 and 20, 2 - fluoro-2 –deoxycytidine at C at positions 21, 28 and 29, a pentaethylene glycol phosphoramidite spacer at N at positions 10 and 23, and an inverted orientation T (i.e., 3'-3'-linked) at position 32. Appropriate controls are provided to detect the improved anti-neovascular effect of the combination therapy over individual anti-PDGF aptamer or anti-VEGF antibody treatments. The results demonstrate the efficacy of the combination therapy over individual treatments with the anti-PDGF aptamer or anti-VEGF antibody alone.

<u>*Example 5: Combination of anti-PDGF aptamer and anti-VEGF aptamer Block Choroidal Neovascularization (CNV)*</u>

In this example, effectiveness of a combination therapy using anti-PDGF aptamers and anti-VEGF aptamers in blocking chorodial neovascularization is demonstrated using the choroidal neovascularization model described above. Experimental CNV is often used as a model for Age-related Macular degeneration (AMD). In this model, vessels of the choroid grow through breaks in Bruch's membrane and into the retina, similar to what is observed in AMD patients. To induce experimental CNV, male C57BL/6 mice (18-20 g; Charles River, Wilmington, MA) are anesthetized with intramuscular ketamine hydrochloride (25 mg/kg) and xylazine (10 mg/kg) and the pupils are dilated with 1% tropicamide. Four burns are generated using diode laser photocoagulation (75-μm spot size, 0.1-second duration, 90mW, Oculight SL laser, IRIDEX, Mountain View, CA) and a hand-held cover slide as a contact lens. Burns localized to the 3, 6, 9 and 12 o'clock positions of the posterior pole of the retina. Production of a bubble at the time of laser, which indicates rupture of Bruch's membrane, is an important factor in obtaining choroidal neovascularization, so only mice in which a bubble was produced for all four burns are included in the study. After 7 days, mice are treated with intraperitoneal injections of 25 mg/kg of pegaptanib sodium twice a day. In experiments using anti-PDGF aptamer, 25 mg/kg of an anti-PDGF aptamer having the structure 40Kd PEG-5'-CAGGCTACGCGTAGAGCATCATGA-TCCTG(iT)-3' (in which iT represents that the final nucleotide is in the inverted orientation (3'-3' linked)) is co-administered with pegaptanib sodium. The area of choroidal NV lesions is measured in flat-mounted choroid stained with PECAM. Flat-mounts are examined by fluorescence microscopy and quantified using Openlab software. The results demonstrate that eyes treated with the combination therapy showed significantly less CNV area as compared to control eyes or to eyes treated with either pegaptanib sodium or the anti-PDGF aptamer alone.

In separate experiments, the effects of two related anti-PDGF aptamers are tested in combination with the anti-VEGF treatment by intraperitoneal injections of 25 mg/kg of pegaptanib sodium twice a day. PEGylated and un-PEGylated versions of the following two anti-PDGF aptamers are tested: (i) CAGGCUACGN CGTAGAGCAU CANTGATCCU GT (see SEQ ID NO: 146 from U.S. 6,582,918, incorporated herein by reference in its entirety) having 2'-fluoro-2'-deoxyuridine at positions 6, 20 and 30, 2'-fluoro-2'-deoxycytidine at positions 8, 21, 28, and 29, 2'-O-Methyl-2'-deoxyguanosine at positions 9, 15, 17, and 31, 2'-O-Methyl-2'-deoxyadenosine at position 22, hexaethylene-glycol phosphoramidite at "N" in positions 10 and 23, and an inverted orientation T (i.e., 3'-3'-linked) at position 32; and
(ii) CAGGCUACGN CGTAGAGCAU CANTGATCCU GT (see SEQ ID NO: 87 from U.S. 5,723,594, incorporated herein by reference in its entirety) having O-methyl-2 – deoxycytidine at C at position 8, 2 - O-methyl-2 –deoxyguanosine at Gs at positions 9, 17 and 31, 2 -O-methyl- 2 – deoxyadenine at A at position 22, 2-O-methyl-2 – deoxyuridine at position 30, 2 - fluoro-2 – deoxyuridine at U at positions 6 and 20, 2 - fluoro-2 –deoxycytidine at C at positions 21, 28 and 29, a pentaethylene glycol phosphoramidite spacer at N at positions 10 and 23, and an inverted orientation T (i.e., 3'-3'-linked) at position 32. Appropriate controls are provided to detect the improved anti-neovascular effect of the combination therapy over individual anti-PDGF aptamer or anti-VEGF aptamer treatments. The results demonstrate the efficacy of the combination therapy in blocking choroidal neovascularization over individual treatments with either of the anti-PDGF aptamers or the anti-VEGF aptamer alone.

Example 6: Corneal Neovasclarization (Corneal NV) - Regression

The corneal NV model of Example 1 was used to investigate the combination of an anti-VEGF aptamer and anti-PDGF aptamer. After 10 days, mice were treated with intra-peritoneal injections of 25 mg/kg of pegaptanib sodium (Macugen™, Eyetech Pharmaceuticals, New York, NY), an anti-VEGF aptamer agent) twice a day and/or of 50 mg/kg of ARC-127 (Archemix Corp., Cambridge, MA, an anti-PDGF aptamer having the structure 40Kd PEG-5'-CAGGCTACGCGTAGAGCATCATGA-TCCTG(iT)-3' (in which iT represents that the final nucleotide is in the inverted orientation (3'-3' linked)) once a day for 10 days. At day 20 following corneal NV induction, eyes were enucleated, and the corneas flat-mounted. Corneal NV was visualized using CD31 staining (BD Biosciences Pharmingen, San Diego, CA) and quantified using Metamorph software. The percent of cornea covered by vessels was calculated as a percentage of total corneal area.

The effects of pegaptanib sodium and/or ARC-127 on the regression of neovascularization of the cornea following NaOH application and injury to the epithilia of the limbus and cornea are depicted in Figures 11 and 12. Animals treated with ARC-127 did not show a significant decrease in vessel growth as compared to the day 20 control. The day 20 controls showed a 12.92% increase in corneal neovascularization when compared with the day 10 controls. Animals treated with pegaptanib sodium (Macugen) alone showed a 13.81% ($p \leq .016$) decrease in vessel growth as compared to day 20 controls. Animals treated with pegaptanib sodium and ARC-127 exhibited significantly less neovascular growth on the cornea (26.85%, $p \leq .002$) as compared to control.

Example 7: Corneal Neovasclarization (Corneal NV) - Regression

The corneal NV model of Example 1 was used to investigate the combination of an anti-VEGF aptamer and an antibody against the PDGFB receptor. After 14 days, mice were treated with intra-peritoneal injections of 25 mg/kg of pegaptanib sodium (Macugen, an anti-VEGF aptamer agent) twice a day and/or by oral administration of 50 mg/kg of APB5 (a polyclonal antibody against the PDGFB receptor) by gavage twice a day for 14 days. At day 28 following corneal NV induction, mice received 20 ug/g of fluorescein-isothiocyanate coupled concanavalin A lectin (Vector Laboratories, Burlingame, CA) intravenously whilst deeply anesthetized with xylazine hydrochloride and ketamine hydrochloride. Thirty minutes later, mice eyes were enucleated, and the corneas flat-mounted. Corneal NV was visualized using fluorescence microscopy and quantified using Openlab software. The percent of cornea covered by vessels was calculated as a percentage of total corneal area.

The effects of pegaptanib sodium and/or APB5 on the regression of neovascularization of the cornea following NaOH application and injury to the epithilia of the limbus and cornea are depicted in Figure 13. Animals treated with pegaptanib sodium (Macugen) showed an 8.3%

decrease in vessel growth as compared to control. Animals treated with pegaptanib sodium and APB5 exhibited significantly less neovascular growth on the cornea (21.4%) as compared to control.

Example 8: Corneal Neovasclarization (Corneal NV) – Regression (Order of Addition of Therapeutic Agent)

The corneal NV model of Example 1 was used to investigate the effect of order of addition of the combination therapy using an anti-VEGF aptamer and an antibody against the PDGFB receptor. After 14 days, mice were treated with intra-peritoneal injections of 25 mg/kg of pegaptanib sodium (Macugen, an anti-VEGF aptamer agent) twice a day and/or by oral administration of 50 mg/kg of APB5 (eBioscience, San Diego, CA), a polyclonal antibody against the PDGFB receptor, by gavage twice a day for 7 days at different timepoints. At day 28 following corneal NV induction, mice received 20 ug/g of fluorescein-isothiocyanate coupled concanavalin A lectin (Vector Laboratories, Burlingame, CA) intravenously whilst deeply anesthetized with xylazine hydrochloride and ketamine hydrochloride. Thirty minutes later, mice eyes were enucleated, and the corneas flat-mounted. Corneal NV was visualized using fluorescence microscopy and quantified using Openlab software. The percent of cornea covered by vessels was calculated as a percentage of total corneal area and the results are depicted in Figure 14.

The effects of pegaptanib sodium alone from day 21-28 or APB5 alone from day 14-21 followed by no treatment showed little effect compared with control on the regression of neovascularization of the cornea following NaOH application and injury to the epithelia of the limbus and cornea . Animals treated with APB5 from day 14-21 and pegaptanib sodium from day 21-28 exhibited less neovascular growth on the cornea (13.4%) as compared to control.

Equivalents

Various modifications and variations of the described method and system of the invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific desired embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Those skilled in the art will recognize or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. Such equivalents are intended to be encompassed in the scope of the present invention.

We claim:

1. A method for suppressing a neovascular disorder in a patient in need thereof, the method comprising administering to the patient:

(i) a PDGF antagonist; and

(ii) a VEGF antagonist,

wherein the PDGF antagonist and the VEGF antagonist are administered simultaneously or within 90 days of each other, in amounts sufficient to suppress the neovascular disorder in the patient.

2. A method for treating a patient diagnosed with or at risk for developing a neovascular disorder, the method comprising administering to the patient:

(i) a PDGF antagonist; and

(ii) a VEGF antagonist,

wherein the PDGF antagonist and the VEGF antagonist are administered simultaneously or within 90 days of each other, in amounts sufficient to treat the patient.

3. The method of claim 1 or 2, wherein said PDGF antagonist and said VEGF antagonist are administered within 10 days of each other.

4. The method of claim 3, wherein the PDGF antagonist and said VEGF antagonist are administered within 5 days of each other.

5. The method of claim 4, wherein the PDGF antagonist and said VEGF antagonist are administered within 24 hours of each other.

6. The method of claim 5, wherein the PDGF antagonist and said VEGF antagonist are administered simultaneously.

7. The method of claim 1 or 2, wherein the PDGF antagonist is a PDGF-B antagonist.

8. The method of claim 1 or 2, wherein the VEGF antagonist is a VEGF-A antagonist.

9. The method of claim 1 or 2, wherein the PDGF antagonist is a nucleic acid molecule, an aptamer, an antisense RNA molecule, a ribozyme, an RNAi molecule, a protein, a peptide, a cyclic peptide, an antibody, a binding fragment of an antibody, or a small organic compound.

10. The method claim 1 or 2, wherein the VEGF antagonist is a nucleic acid molecule, an aptamer, an antisense RNA molecule, a ribozyme, an RNAi molecule, a protein, a peptide, a cyclic peptide, an antibody or antibody fragment, a sugar, a polymer or a small organic compound.

11. The method of claim 10, wherein the VEGF antagonist is an aptamer.

12. The method of claim 11, wherein the aptamer is EYE001.

13. The method of claim 10, wherein the VEGF antagonist is an antibody or binding fragment thereof.

14. The method of claim 1 or 2, wherein the PDGF antagonist is a nucleic acid molecule, an aptamer, an antisense RNA molecule, a ribozyme, an RNAi molecule, a protein, a peptide, a cyclic peptide, an antibody or antibody fragment, a sugar, a polymer or a small organic compound.

15. The method of claim 14, wherein the PDGF antagonist is an antibody or binding fragment thereof.

16. The method of claim 14, wherein the PDGF antagonist is an antisense oligonucleotide.

17. The method of claim 1 or 2, wherein said neovascular disorder is an ocular neovascular disorder.

18. The method of claim 17, wherein the ocular neovascular disorder is ischemic retinopathy, iris neovascularization, intraocular neovascularization, age-related macular degeneration, corneal neovascularization, retinal neovascularization, choroidal neovascularization, diabetic retinal ischemia, and proliferative diabetic retinopathy.

19. The method of claim 1 or 2, wherein said neovascular disorder is psoriasis or rheumatoid arthritis.

20. A pharmaceutical composition comprising:

(i) a PDGF antagonist;

(ii) a VEGF antagonist; and

(iii) a pharmaceutically acceptable carrier,

wherein the PDGF antagonist and the VEGF antagonist are present in an amount sufficient to suppress a neovascular disorder in a patient.

21. The composition of claim 20, wherein the PDGF antagonist is a PDGF-B antagonist.

22. The composition of claim 20, wherein the VEGF antagonist is a VEGF-A antagonist.

23. The composition of claim 20, wherein the PDGF antagonist is a nucleic acid molecule, an aptamer, an antisense RNA molecule, a ribozyme, an RNAi molecule, a protein, a peptide, a cyclic peptide, an antibody or antibody fragment, a sugar, a polymer, or a small organic compound.

24. The composition of claim 20, wherein the VEGF antagonist is a nucleic acid molecule, an aptamer, an antisense RNA molecule, a ribozyme, an RNAi molecule, a protein, a

peptide, a cyclic peptide, an antibody or antibody, a binding fragment of an antibody or a small organic compound.

25. The composition of claim 23, wherein the PDGF antagonist is an antibody or binding fragment thereof.

26. The composition of claim 23, wherein the PDGF antagonist is an antisense oligonucleotide.

27. The composition of claim 24, wherein the VEGF antagonist is an aptamer.

28. The composition of claim 27, wherein the aptamer is EYE001.

29. The composition of claim 24, wherein the VEGF antagonist is an antibody or binding fragment thereof.

30. A pharmaceutical pack comprising:

(i) a PDGF antagonist; and

(ii) a VEGF antagonist.

31. The pharmaceutical pack of claim 30, wherein the PDGF antagonist is a PDGF-B antagonist.

32. The pharmaceutical pack of claim 30, wherein said VEGF antagonist is a VEGF-A antagonist.

33. The pharmaceutical pack of claim 30, wherein the PDGF antagonist and VEGF antagonist are formulated separately and in individual dosage amounts.

34. The pharmaceutical pack of claim 31, wherein the PDGF antagonist and VEGF antagonist are formulated together.

35. The pharmaceutical pack of claim 30, wherein the VEGF antagonist is an aptamer.

36. The pharmaceutical pack of claim 35, wherein the aptamer is EYE001.

37. The pharmaceutical pack of claim 30, wherein the VEGF antagonist is an antibody or binding fragment thereof.

38. The pharmaceutical pack of claim 30, wherein the VEGF antagonist is an antisense oligonucleotide.

39. The pharmaceutical pack of claim 30, wherein the PDGF antagonist is an antibody or binding fragment thereof.

40. The pharmaceutical pack of claim 30, wherein the PDGF antagonist is an antisense oligonucleotide.

41. The pharmaceutical composition of claim 20, wherein the pharmaceutically acceptable carrier comprises a microsphere or a hydrogel.

42. The pharmaceutical pack of claim 30, further comprising a delivery vehicle selected from a microsphere and a hydrogel.

43. The method of any of claims 1, 2 or 18, wherein said PDGF antagonist is a pro-drug.

44. The method of any of claims 1, 2 or 18, wherein said VEGF antagonist is a pro-drug.

45. The pharmaceutical composition of claim 20, wherein said PDGF antagonist is a pro-drug.

46. The pharmaceutical composition of claim 20, wherein said VEGF antagonist is a pro-drug.

47. The pharmaceutical pack of claim 30, wherein said PDGF antagonist is a pro-drug.

48. The pharmaceutical pack of claim 30, wherein said VEGF antagonist is a pro-drug.

Figure 1 (A) Sequence of PDGF-B nucleic acid (GenBank Accession No. X02811) (SEQ ID NO: 1)

1 CCCTGCCTGC CTCCCTGCGC ACCCGCAGCC TCCCCCGCTG CCTCCCTAGG GCTCCCCTCC

61 GGCCGCCAGC GCCCATTTTT CATTCCCTAG ATAGAGATAC TTTGCGCGCA CACACATACA

121 TACGCGCGCA AAAAGGAAAA AAAAAAAAAA AAGCCCACCC TCCAGCCTCG CTGCAAAGAG

181 AAAACCGGAG CAGCCGCAGC TCGCAGCTCG CAGCCCGCAG CCCGCAGAGG ACGCCCAGAG

241 CGGCGAGCGG GCGGGCAGAC GGACCGACGG ACTCGCGCCG CGTCCACCTG TCGGCCGGGC

301 CCAGCCGAGC GCGCAGCGGG CACGCCGCGC GCGCGGAGCA GCCGTGCCCG CCGCCCGGGC

361 CCGCCGCCAG GGCGCACACG CTCCCGCCCC CCTACCCGGC CCGGGCGGGA GTTTGCACCT

421 CTCCCTGCCC GGGTGCTCGA GCTGCCGTTG CAAAGCCAAC TTTGGAAAAA GTTTTTTGGG

481 GGAGACTTGG GCCTTGAGGT GCCCAGCTCC GCGCTTTCCG ATTTTGGGGG CCTTTCCAGA

541 AAATGTTGCA AAAAAGCTAA GCCGGCGGGC AGAGGAAAAC GCCTGTAGCC GGCGAGTGAA

601 GACGAACCAT CGACTGCCGT GTTCCTTTTC CTCTTGGAGG TTGGAGTCCC CTGGGCGCCC

661 CCACACGGCT AGACGCCTCG GCTGGTTCGC GACGCAGCCC CCCGGCCGTG GATGCTGCAC

721 TCGGGCTCGG GATCCGCCCA GGTAGCGGCC TCGGACCCAG GTCCTGCGCC CAGGTCCTCC

781 CCTGCCCCCC AGCGACGGAG CCGGGGCCGG GGGCGGCGGC GCCGGGGGCA TGCGGGTGAG

841 CCGCGGCTGC AGAGGCCTGA GCGCCTGATC GCCGCGGACC CGAGCCGAGC CCACCCCCCT

901 CCCCAGCCCC CCACCCTGGC CGCGGGGGCG GCGCGCTCGA TCTACGCGTT CGGGGCCCCG

961 CGGGGCCGGG CCCGGAGTCG GCATGAATCG CTGCTGGGCG CTCTTCCTGT CTCTCTGCTG

1021 CTACCTGCGT CTGGTCAGCG CCGAGGGGGA CCCCATTCCC GAGGAGCTTT ATGAGATGCT

1081 GAGTGACCAC TCGATCCGCT CCTTTGATGA TCTCCAACGC CTGCTGCACG GAGACCCCGG

1141 AGAGGAAGAT GGGGCCGAGT TGGACCTGAA CATGACCCGC TCCCACTCTG GAGGCGAGCT

1201 GGAGAGCTTG GCTCGTGGAA GAAGGAGCCT GGGTTCCCTG ACCATTGCTG AGCCGGCCAT

1261 GATCGCCGAG TGCAAGACGC GCACCGAGGT GTTCGAGATC TCCCGGCGCC TCATAGACCG

1321 CACCAACGCC AACTTCCTGG TGTGGCCGCC CTGTGTGGAG GTGCAGCGCT GCTCCGGCTG

1381 CTGCAACAAC CGCAACGTGC AGTGCCGCCC CACCCAGGTG CAGCTGCGAC CTGTCCAGGT

1441 GAGAAAGATC GAGATTGTGC GGAAGAAGCC AATCTTTAAG AAGGCCACGG TGACGCTGGA

1501 AGACCACCTG GCATGCAAGT GTGAGACAGT GGCAGCTGCA CGGCCTGTGA CCCGAAGCCC

1561 GGGGGGTTCC CAGGAGCAGC GAGCCAAAAC GCCCCAAACT CGGGTGACCA TTCGGACGGT

1621 GCGAGTCCGC CGGCCCCCCA AGGGCAAGCA CCGGAAATTC AAGCACACGC ATGACAAGAC

1681 GGCACTGAAG GAGACCCTTG GAGCCTAGGG GCATCGGCAG GAGAGTGTGT GGGCAGGGTT

1741 ATTTAATATG GTATTTGCTG TATTGCCCCC ATGGGGCCTT GGAGTAGATA ATATTGTTTC

1801 CCTCGTCCGT CTGTCTCGAT GCCTGATTCG GACGGCCAAT GGTGCCTCCC CCACCCCTCC

1861 ACGTGTCCGT CCACCCTTCC ATCAGCGGGT CTCCTCCCAG CGGCCTCCGG CTCTTGCCCA

1921 GCAGCTCAAG AAGAAAAAGA AGGACTGAAC TCCATCGCCA TCTTCTTCCC TTAACTCCAA

1981 GAACTTGGGA TAAGAGTGTG AGAGAGACTG ATGGGGTCGC TCTTTGGGGG AAACGGGTTC

2041 CTTCCCCTGC ACCTGGCCTG GGCCACACCT GAGCGCTGTG GACTGTCCTG AGGAGCCCTG

2101 AGGACCTCTC AGCATAGCCT GCCTGATCCC TGAACCC

Figure 1 (B) Sequence of PDGF-B propeptide (GenBank Accession No. CAA26579) (SEQ ID NO: 2)

1 MNRCWALFLS LCCYLRLVSA EGDPIPEELY EMLSDHSIRS FDDLQRLLHG DPGEEDGAEL

61 DLNMTRSHSG GELESLARGR **RSLGSLTIAE PAMIAECKTR TEVFEISRRL IDRTNANFLV**

121 **WPPCVEVQRC SGCCNNRNVQ CRPTQVQLRP VQVRKIEIVR KKPIFKKATV TLEDHLACKC**

181 **ETVAAARPVT** RSPGGSQEQR AKTPQTRVTI RTVRVRRPPK GKHRKFKHTH DKTALKETLG

241 A

Figure 1 (C) Sequence of PDGF-A nucleic acid (GenBank Accession No. X06374) (SEQ ID NO: 11)

1 TTCTTGGGGC TGATGTCCGC AAATATGCAG AATTACCGGC CGGGTCGCTC CTGAAGCCAG

61 CGCGGGGAGC GAGCGCGGCG GCGGCCAGCA CCGGGAACGC ACCGAGGAAG AAGCCCAGCC

121 CCCGCCCTCC GCCCCTTCCG TCCCCACCCC CTACCCGGCG GCCCAGGAGG CTCCCCGGCT

181 GCGGCGCGCA CTCCCTGTTT CTCCTCCTCC TGGCTGGCGC TGCCTGCCTC TCCGCACTCA

241 CTGCTCGCCG GGCGCCGTCC GCCAGCTCCG TGCTCCCCGC GCCACCCTCC TCCGGGCCGC

301 GCTCCCTAAG GGATGGTACT GAATTTCGCC GCCACAGGAG ACCGGCTGGA GCGCCCGCCC

361 CGCGCCTCGC CTCTCCTCCG AGCAGCCAGC GCCTCGGGAC GCGATGAGGA CCTTGGCTTG

421 CCTGCTGCTC CTCGGCTGCG GATACCTCGC CCATGTTCTG GCCGAGGAAG CCGAGATCCC

481 CCGCGAGGTG ATCGAGAGGC TGGCCCGCAG TCAGATCCAC AGCATCCGGG ACCTCCAGCG

541 ACTCCTGGAG ATAGACTCCG TAGGGAGTGA GGATTCTTTG GACACCAGCC TGAGAGCTCA

601 CGGGGTCCAC GCCACTAAGC ATGTGCCCGA GAAGCGGCCC CTGCCCATTC GGAGGAAGAG

661 AAGCATCGAG GAAGCTGTCC CCGCTGTCTG CAAGACCAGG ACGGTCATTT ACGAGATTCC

721 TCGGAGTCAG GTCGACCCCA CGTCCGCCAA CTTCCTGATC TGGCCCCCGT GCGTGGAGGT

781 GAAACGCTGC ACCGGCTGCT GCAACACGAG CAGTGTCAAG TGCCAGCCCT CCCGCGTCCA

841 CCACCGCAGC GTCAAGGTGG CCAAGGTGGA ATACGTCAGG AAGAAGCCAA AATTAAAAGA

901 AGTCCAGGTG AGGTTAGAGG AGCATTTGGA GTGCGCCTGC GCGACCACAA GCCTGAATCC

961 GGATTATCGG GAAGAGGACA CGGATGTGAG GTGAGGATGA GCCGCAGCCC TTTCCTGGGA

1021 CATGGATGTA CATGGCGTGT TACATTCCTG AACCTACTAT GTACGGTGCT TTATTGCCAG

1081 TGTGCGGTCT TTGTTCTCCT CCGTGAAAAA CTGTGTCCGA GAACACTCGG GAGAACAAAG

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1141 AGACAGTGCA CATTTGTTTA ATGTGACATC AAAGCAAGTA TTGTAGCACT CGGTGAAGCA

1201 GTAAGAAGCT TCCTTGTCAA AAAGAGAGAG AGAGAGAGAG AGAGAGAAAA CAAAACCACA

1261 AATGACAAAA ACAAAACGGA CTCACAAAAA TATCTAAACT CGATGAGATG GAGGGTCGCC

1321 CCGTGGGATG GAAGTGCAGA GGTCTCAGCA GACTGGATTT CTGTCCGGGT GGTCACAGGT

1381 GCTTTTTTGC CGAGGATGCA GAGCCTGCTT TGGGAACGAC TCCAGAGGGG TGCTGGTGGG

1441 CTCTGCAGGG CCCGCAGGAA GCAGGAATGT CTTGGAAACC GCCACGCGAA CTTTAGAAAC

1501 CACACCTCCT CGCTGTAGTA TTTAAGCCCA TACAGAAACC TTCCTGAGAG CCTTAAGTGG

1561 TTTTTTTTTT TGTTTTTGTT TTGTTTTTTT TTTTTTTGTT TTTTTTTTTT TTTTTTTTTT

1621 TTACACCATA AAGTGATTAT TAAGCTTCCT TTTACTCTTT GGCTAGCTTT TTTTTTTTTT

1681 TTTTTTTTTT TTTTTTTTAA TTATCTCTTG GATGACATTT ACACCGATAA CACACAGGCT

1741 GCTGTAACTG TCAGGACAGT GCGACGGTAT TTTTCCTAGC AAGATGCAAA CTAATGAGAT

1801 GTATTAAAAT AAACATGGTA TACCTACCTA TGCATCATTT CCTAAATGTT TCTGGCTTTG

1861 TGTTTCTCCC TTACCCTGCT TTATTTGTTA ATTTAAGCCA TTTTGAAAGA ACTATGCGTC

1921 AACCAATCGT ACGCCGTCCC TGCGGCACCT GCCCCAGAGC CCGTTTGTGG CTGAGTGACA

1981 ACTTGTTCCC CGCAGTGCAC ACCTAGAATG CTGTGTTCCC ACGCGGCACG TGAGATGCAT

2041 TGCCGCTTCT GTCTGTGTTG TTGGTGTGCC CTGGTGCCGT GGTGGCGGTC ACTCCCTCTG

2101 CTGCCAGTGT TTGGACAGAA CCCAAATTCT TTATTTTTGG TAAGATATTG TGCTTTACCT

2161 GTATTAACAG AAATGTGTGT GTGTGGTTTG TTTTTTTGTA AAGGTGAAGT TTGTATGTTT

2221 ACCTAATATT ACCTGTTTTG TATACCTGAG AGCCTGCTAT GTTCTTCTTT TGTTGATCCA

2281 AAATTAAAAA AAAAATACCA CCAAC

Figure 1 (D) <u>**Sequence of PDGF-A polypeptide (GenBank Accession No. CAA29677) (SEQ ID NO: 12)**</u>

```
  1 MRTLACLLLL GCGYLAHVLA EEAEIPREVI ERLARSQIHS IRDLQRLLEI DSVGSEDSLD
 61 TSLRAHGVHA TKHVPEKRPL PIRRKRSIEE AVPAVCKTRT VIYEIPRSQV DPTSANFLIW
121 PPCVEVKRCT GCCNTSSVKC QPSRVHHRSV KVAKVEYVRK KPKLKEVQVR LEEHLECACA
181 TTSLNPDYRE EDTDVR
```

Figure 2 (A) **Sequence of VEGF nucleic acid (GenBank Accession No: NM 003376) (SEQ ID NO: 3)**

1 TCGCGGAGGC TTGGGGCAGC CGGGTAGCTC GGAGGTCGTG GCGCTGGGGG CTAGCACCAG
61 CGCTCTGTCG GGAGGCGCAG CGGTTAGGTG GACCGGTCAG CGGACTCACC GGCCAGGGCG
121 CTCGGTGCTG GAATTTGATA TTCATTGATC CGGGTTTTAT CCCTCTTCTT TTTTCTTAAA
181 CATTTTTTTT TAAAACTGTA TTGTTTCTCG TTTTAATTTA TTTTTGCTTG CCATTCCCCA
241 CTTGAATCGG GCCGACGGCT TGGGGAGATT GCTCTACTTC CCCAAATCAC TGTGGATTTT
301 GGAAACCAGC AGAAAGAGGA AAGAGGTAGC AAGAGCTCCA GAGAGAAGTC GAGGAAGAGA
361 GAGACGGGGT CAGAGAGAGC GCGCGGGCGT GCGAGCAGCG AAAGCGACAG GGGCAAAGTG
421 AGTGACCTGC TTTTGGGGGT GACCGCCGGA GCGCGGCGTG AGCCCTCCCC CTTGGGATCC
481 CGCAGCTGAC CAGTCGCGCT GACGGACAGA CAGACAGACA CCGCCCCCAG CCCCAGCTAC
541 CACCTCCTCC CCGGCCGGCG GCGGACAGTG GACGCGGCGG CGAGCCGCGG GCAGGGGCCG
601 GAGCCCGCGC CCGGAGGCGG GGTGGAGGGG GTCGGGGCTC GCGGCGTCGC ACTGAAACTT
661 TTCGTCCAAC TTCTGGGCTG TTCTCGCTTC GGAGGAGCCG TGGTCCGCGC GGGGGAAGCC
721 GAGCCGAGCG GAGCCGCGAG AAGTGCTAGC TCGGGCCGGG AGGAGCCGCA GCCGGAGGAG
781 GGGGAGGAGG AAGAAGAGAA GGAAGAGGAG AGGGGGCCGC AGTGGCGACT CGGCGCTCGG
841 AAGCCGGGCT CATGGACGGG TGAGGCGGCG GTGTGCGCAG ACAGTGCTCC AGCCGCGCGC
901 GCTCCCCAGG CCCTGGCCCG GGCCTCGGGC CGGGGAGGAA GAGTAGCTCG CCGAGGCGCC
961 GAGGAGAGCG GGCCGCCCCA CAGCCCGAGC CGGAGAGGGA GCGCGAGCCG CGCCGGCCCC
1021 GGTCGGGCCT CCGAAACCAT GAACTTTCTG CTGTCTTGGG TGCATTGGAG CCTTGCCTTG
1081 CTGCTCTACC TCCACCATGC CAAGTGGTCC CAGGCTGCAC CCATGGCAGA AGGAGGAGGG
1141 CAGAATCATC ACGAAGTGGT GAAGTTCATG GATGTCTATC AGCGCAGCTA CTGCCATCCA
1201 ATCGAGACCC TGGTGGACAT CTTCCAGGAG TACCCTGATG AGATCGAGTA CATCTTCAAG
1261 CCATCCTGTG TGCCCCTGAT GCGATGCGGG GGCTGCTGCA ATGACGAGGG CCTGGAGTGT
1321 GTGCCCACTG AGGAGTCCAA CATCACCATG CAGATTATGC GGATCAAACC TCACCAAGGC
1381 CAGCACATAG GAGAGATGAG CTTCCTACAG CACAACAAAT GTGAATGCAG ACCAAAGAAA

1441 GATAGAGCAA GACAAGAAAA AAAATCAGTT CGAGGAAAGG GAAAGGGGCA AAAACGAAAG

1501 *CGCAAGAAAT* CCCGGTATAA GTCCTGGAGC GTTCCCTGTG GGCCTTGCTC AGAGCGGAGA

1561 AAGCATTTGT TTGTACAAGA TCCGCAGACG TGTAAATGTT CCTGCAAAAA CACAGACTCG

1621 *CGTTGCAAGG* CGAGGCAGCT *TGAGTTAAAC GAACGTACTT* GCAGATGTGA *CAAGCCGAGG*

1681 CGGTGAGCCG GGCAGGAGGA AGGAGCCTCC CTCAGGGTTT CGG

Figure 2 (B) Sequence of VEGF polypeptide (GenBank Accession No. NP_003367) (SEQ ID NO: 4)

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  1 MNFLLSWVHW SLALLLYLHH AKWSQAAPMA EGGGQNHHEV VKFMDVYQRS YCHPIETLVD
 61 IFQEYPDEIE YIFKPSCVPL MRCGGCCNDE GLECVPTEES NITMQIMRIK PHQGQHIGEM
121 SFLQHNKCEC RPKKDRARQE KKSVRGKGKG QKRKRKKSRY KSWSVPCGPC SERRKHLFVQ
181 DPQTCKCSCK NTDSRCKARQ LELNERTCRC DKPRR
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Figure 3 (A) **Sequence of PDGFR-B nucleic acid (GenBank Accession No. NM_002609) (SEQ ID NO: 5)**

```
   1 GGCCCCTCAG CCCTGCTGCC CAGCACGAGC CTGTGCTCGC CCTGCCCAAC GCAGACAGCC
  61 AGACCCAGGG CGGCCCCTCT GGCGGCTCTG CTCCTCCCGA AGGATGCTTG GGGAGTGAGG
 121 CGAAGCTGGG CGCTCCTCTC CCCTACAGCA GCCCCCTTCC TCCATCCCTC TGTTCTCCTG
 181 AGCCTTCAGG AGCCTGCACC AGTCCTGCCT GTCCTTCTAC TCAGCTGTTA CCCACTCTGG
 241 GACCAGCAGT CTTTCTGATA ACTGGGAGAG GGCAGTAAGG AGGACTTCCT GGAGGGGGTG
 301 ACTGTCCAGA GCCTGGAACT GTGCCCACAC CAGAAGCCAT CAGCAGCAAG GACACCATGC
 361 GGCTTCCGGG TGCGATGCCA GCTCTGGCCC TCAAAGGCGA GCTGCTGTTG CTGTCTCTCC
 421 TGTTACTTCT GGAACCACAG ATCTCTCAGG GCCTGGTCGT CACACCCCCG GGGCCAGAGC
 481 TTGTCCTCAA TGTCTCCAGC ACCTTCGTTC TGACCTGCTC GGGTTCAGCT CCGGTGGTGT
 541 GGGAACGGAT GTCCCAGGAG CCCCCACAGG AAATGGCCAA GGCCCAGGAT GGCACCTTCT
 601 CCAGCGTGCT CACACTGACC AACCTCACTG GGCTAGACAC GGGAGAATAC TTTTGCACCC
 661 ACAATGACTC CCGTGGACTG GAGACCGATG AGCGGAAACG GCTCTACATC TTTGTGCCAG
 721 ATCCCACCGT GGGCTTCCTC CCTAATGATG CCGAGGAACT ATTCATCTTT CTCACGGAAA
 781 TAACTGAGAT CACCATTCCA TGCCGAGTAA CAGACCCACA GCTGGTGGTG ACACTGCACG
 841 AGAAGAAAGG GGACGTTGCA CTGCCTGTCC CCTATGATCA CCAACGTGGC TTTTCTGGTA
 901 TCTTTGAGGA CAGAAGCTAC ATCTGCAAAA CCACCATTGG GGACAGGGAG GTGGATTCTG
 961 ATGCCTACTA TGTCTACAGA CTCCAGGTGT CATCCATCAA CGTCTCTGTG AACGCAGTGC
1021 AGACTGTGGT CCGCCAGGGT GAGAACATCA CCCTCATGTG CATTGTGATC GGGAATGAGG
1081 TGGTCAACTT CGAGTGGACA TACCCCCGCA AAGAAAGTGG GCGGCTGGTG GAGCCGGTGA
1141 CTGACTTCCT CTTGGATATG CCTTACCACA TCCGCTCCAT CCTGCACATC CCCAGTGCCG
1201 AGTTAGAAGA CTCGGGGACC TACACCTGCA ATGTGACGGA GAGTGTGAAT GACCATCAGG
1261 ATGAAAAGGC CATCAACATC ACCGTGGTTG AGAGCGGCTA CGTGCGGCTC CTGGGAGAGG
1321 TGGGCACACT ACAATTTGCT GAGCTGCATC GGAGCCGGAC ACTGCAGGTA GTGTTCGAGG
1381 CCTACCCACC GCCCACTGTC CTGTGGTTCA AAGACAACCG CACCCTGGGC GACTCCAGCG
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1441 CTGGCGAAAT CGCCCTGTCC ACGCGCAACG TGTCGGAGAC CCGGTATGTG TCAGAGCTGA

1501 CACTGGTTCG CGTGAAGGTG GCAGAGGCTG GCCACTACAC CATGCGGGCC TTCCATGAGG

1561 ATGCTGAGGT CCAGCTCTCC TTCCAGCTAC AGATCAATGT CCCTGTCCGA GTGCTGGAGC

1621 TAAGTGAGAG CCACCCTGAC AGTGGGGAAC AGACAGTCCG CTGTCGTGGC CGGGGCATGC

1681 CCCAGCCGAA CATCATCTGG TCTGCCTGCA GAGACCTCAA AAGGTGTCCA CGTGAGCTGC

1741 CGCCCACGCT GCTGGGGAAC AGTTCCGAAG AGGAGAGCCA GCTGGAGACT AACGTGACGT

1801 ACTGGGAGGA GGAGCAGGAG TTTGAGGTGG TGAGCACACT GCGTCTGCAG CACGTGGATC

1861 GGCCACTGTC GGTGCGCTGC ACGCTGCGCA ACGCTGTGGG CCAGGACACG CAGGAGGTCA

1921 TCGTGGTGCC ACACTCCTTG CCCTTTAAGG TGGTGGTGAT CTCAGCCATC CTGGCCCTGG

1981 TGGTGCTCAC CATCATCTCC CTTATCATCC TCATCATGCT TTGGCAGAAG AAGCCACGTT

2041 ACGAGATCCG ATGGAAGGTG ATTGAGTCTG TGAGCTCTGA CGGCCATGAG TACATCTACG

2101 TGGACCCCAT GCAGCTGCCC TATGACTCCA CGTGGGAGCT GCCGCGGGAC CAGCTTGTGC

2161 TGGGACGCAC CCTCGGCTCT GGGGCCTTTG GGCAGGTGGT GGAGGCCACG GCTCATGGCC

2221 TGAGCCATTC TCAGGCCACG ATGAAAGTGG CCGTCAAGAT GCTTAAATCC ACAGCCCGCA

2281 GCAGTGAGAA GCAAGCCCTT ATGTCGGAGC TGAAGATCAT GAGTCACCTT GGGCCCCACC

2341 TGAACGTGGT CAACCTGTTG GGGGCCTGCA CCAAAGGAGG ACCCATCTAT ATCATCACTG

2401 AGTACTGCCG CTACGGAGAC CTGGTGGACT ACCTGCACCG CAACAAACAC ACCTTCCTGC

2461 AGCACCACTC CGACAAGCGC CGCCCGCCCA GCGCGGAGCT CTACAGCAAT GCTCTGCCCG

2521 TTGGGCTCCC CCTGCCCAGC CATGTGTCCT TGACCGGGGA GAGCGACGGT GGCTACATGG

2581 ACATGAGCAA GGACGAGTCG GTGGACTATG TGCCCATGCT GGACATGAAA GGAGACGTCA

2641 AATATGCAGA CATCGAGTCC TCCAACTACA TGGCCCCTTA CGATAACTAC GTTCCCTCTG

2701 CCCCTGAGAG GACCTGCCGA GCAACTTTGA TCAACGAGTC TCCAGTGCTA AGCTACATGG

2761 ACCTCGTGGG CTTCAGCTAC CAGGTGGCCA ATGGCATGGA GTTTCTGGCC TCCAAGAACT

2821 GCGTCCACAG AGACCTGGCG GCTAGGAACG TGCTCATCTG TGAAGGCAAG CTGGTCAAGA

2881 TCTGTGACTT TGGCCTGGCT CGAGACATCA TGCGGGACTC GAATTACATC TCCAAAGGCA

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2941 GCACCTTTTT GCCTTTAAAG TGGATGGCTC CGGAGAGCAT CTTCAACAGC CTCTACACCA

3001 CCCTGAGCGA CGTGTGGTCC TTCGGGATCC TGCTCTGGGA GATCTTCACC TTGGGTGGCA

3061 CCCCTTACCC AGAGCTGCCC ATGAACGAGC AGTTCTACAA TGCCATCAAA CGGGGTTACC

3121 GCATGGCCCA GCCTGCCCAT GCCTCCGACG AGATCTATGA GATCATGCAG AAGTGCTGGG

3181 AAGAGAAGTT TGAGATTCGG CCCCCCTTCT CCCAGCTGGT GCTGCTTCTC GAGAGACTGT

3241 TGGGCGAAGG TTACAAAAAG AAGTACCAGC AGGTGGATGA GGAGTTTCTG AGGAGTGACC

3301 ACCCAGCCAT CCTTCGGTCC CAGGCCCGCT TGCCTGGGTT CCATGGCCTC CGATCTCCCC

3361 TGGACACCAG CTCCGTCCTC TATACTGCCG TGCAGCCCAA TGAGGGTGAC AACGACTATA

3421 TCATCCCCCT GCCTGACCCC AAACCCGAGG TTGCTGACGA GGGCCCACTG GAGGGTTCCC

3481 CCAGCCTAGC CAGCTCCACC CTGAATGAAG TCAACACCTC CTCAACCATC TCCTGTGACA

3541 GCCCCCTGGA GCCCCAGGAC GAACCAGAGC CAGAGCCCCA GCTTGAGCTC CAGGTGGAGC

3601 CGGAGCCAGA GCTGGAACAG TTGCCGGATT CGGGGTGCCC TGCGCCTCGG GCGGAAGCAG

3661 AGGATAGCTT CCTGTAGGGG GCTGGCCCCT ACCCTGCCCT GCCTGAAGCT CCCCCCCTGC

3721 CAGCACCCAG CATCTCCTGG CCTGGCCTGA CCGGGCTTCC TGTCAGCCAG GCTGCCCTTA

3781 TCAGCTGTCC CCTTCTGGAA GCTTTCTGCT CCTGACGTGT TGTGCCCCAA ACCCTGGGGC

3841 TGGCTTAGGA GGCAAGAAAA CTGCAGGGGC CGTGACCAGC CCTCTGCCTC CAGGGAGGCC

3901 AACTGACTCT GAGCCAGGGT TCCCCCAGGG AACTCAGTTT TCCCATATGT AAGATGGGAA

3961 AGTTAGGCTT GATGACCCAG AATCTAGGAT TCTCTCCCTG GCTGACAGGT GGGGAGACCG

4021 AATCCCTCCC TGGGAAGATT CTTGGAGTTA CTGAGGTGGT AAATTAACTT TTTTCTGTTC

4081 AGCCAGCTAC CCCTCAAGGA ATCATAGCTC TCTCCTCGCA CTTTTTATCC ACCCAGGAGC

4141 TAGGGAAGAG ACCCTAGCCT CCCTGGCTGC TGGCTGAGCT AGGGCCTAGC CTTGAGCAGT

4201 GTTGCCTCAT CCAGAAGAAA GCCAGTCTCC TCCCTATGAT GCCAGTCCCT GCGTTCCCTG

4261 GCCCGAGCTG GTCTGGGGCC ATTAGGCAGC CTAATTAATG CTGGAGGCTG AGCCAAGTAC

4321 AGGACACCCC CAGCCTGCAG CCCTTGCCCA GGGCACTTGG AGCACACGCA GCCATAGCAA

4381 GTGCCTGTGT CCCTGTCCTT CAGGCCCATC AGTCCTGGGG CTTTTTCTTT ATCACCCTCA

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4441 GTCTTAATCC ATCCACCAGA GTCTAGAAGG CCAGACGGGC CCCGCATCTG TGATGAGAAT

4501 GTAAATGTGC CAGTGTGGAG TGGCCACGTG TGTGTGCCAG TATATGGCCC TGGCTCTGCA

4561 TTGGACCTGC TATGAGGCTT TGGAGGAATC CCTCACCCTC TCTGGGCCTC AGTTTCCCCT

4621 TCAAAAAATG AATAAGTCGG ACTTATTAAC TCTGAGTGCC TTGCCAGCAC TAACATTCTA

4681 GAGTATTCCA GGTGGTTGCA CATTTGTCCA GATGAAGCAA GGCCATATAC CCTAAACTTC

4741 CATCCTGGGG GTCAGCTGGG CTCCTGGGAG ATTCCAGATC ACACATCACA CTCTGGGGAC

4801 TCAGGAACCA TGCCCCTTCC CCAGGCCCCC AGCAAGTCTC AAGAACACAG CTGCACAGGC

4861 CTTGACTTAG AGTGACAGCC GGTGTCCTGG AAAGCCCCAA GCAGCTGCCC CAGGGACATG

4921 GGAAGACCAC GGGACCTCTT TCACTACCCA CGATGACCTC CGGGGGTATC CTGGGCAAAA

4981 GGGACAAAGA GGGCAAATGA GATCACCTCC TGCAGCCCAC CACTCCAGCA CCTGTGCCGA

5041 GGTCTGCGTC GAAGACAGAA TGGACAGTGA GGACAGTTAT GTCTTGTAAA AGACAAGAAG

5101 CTTCAGATGG TACCCCAAGA AGGATGTGAG AGGTGGCCGC TTGGAGTTTG CCCCTCACCC

5161 ACCAGCTGCC CCATCCCTGA GGCAGCGCTC CATGGGGGTA TGGTTTTGTC ACTGCCCAGA

5221 CCTAGCAGTG ACATCTCATT GTCCCCAGCC CAGTGGGCAT TGGAGGTGCC AGGGGAGTCA

5281 GGGTTGTAGC CAAGACGCCC CCGCACGGGG AGGGTTGGGA AGGGGGTGCA GGAAGCTCAA

5341 CCCCTCTGGG CACCAACCCT GCATTGCAGG TTGGCACCTT ACTTCCCTGG GATCCCCAGA

5401 GTTGGTCCAA GGAGGGAGAG TGGGTTCTCA ATACGGTACC AAAGATATAA TCACCTAGGT

5461 TTACAAATAT TTTTAGGACT CACGTTAACT CACATTTATA CAGCAGAAAT GCTATTTTGT

5521 ATGCTGTTAA GTTTTTCTAT CTGTGTACTT TTTTTTAAGG GAAAGATTTT AATATTAAAC

5581 CTGGTGCTTC TCACTCAC

Figure 3 (B) **Sequence of PDGFR-B polypeptide (GenBank Accession No. NP_002600) (SEQ ID NO: 6)**

1 MRLPGAMPAL ALKGELLLLS LLLLLEPQIS QGLVVTPPGP ELVLNVSSTF VLTCSGSAPV
61 VWERMSQEPP QEMAKAQDGT FSSVLTLTNL TGLDTGEYFC THNDSRGLET DERKRLYIFV
121 PDPTVGFLPN DAEELFIFLT EITEITIPCR VTDPQLVVTL HEKKGDVALP VPYDHQRGFS
181 GIFEDRSYIC KTTIGDREVD SDAYYVYRLQ VSSINVSVNA VQTVVRQGEN ITLMCIVIGN
241 EVVNFEWTYP RKESGRLVEP VTDFLLDMPY HIRSILHIPS AELEDSGTYT CNVTESVNDH
301 QDEKAINITV VESGYVRLLG EVGTLQFAEL HRSRTLQVVF EAYPPPTVLW FKDNRTLGDS
361 SAGEIALSTR NVSETRYVSE LTLVRVKVAE AGHYTMRAFH EDAEVQLSFQ LQINVPVRVL
421 ELSESHPDSG EQTVRCRGRG MPQPNIIWSA CRDLKRCPRE LPPTLLGNSS EEESQLETNV
481 TYWEEEQEFE VVSTLRLQHV DRPLSVRCTL RNAVGQDTQE VIVVPHSLPF KVVVISAILA
541 LVVLTIISLI ILIMLWQKKP RYEIRWKVIE SVSSDGHEYI YVDPMQLPYD STWELPRDQL
601 VLGRTLGSGA FGQVVEATAH GLSHSQATMK VAVKMLKSTA RSSEKQALMS ELKIMSHLGP
661 HLNVVNLLGA CTKGGPIYII TEYCRYGDLV DYLHRNKHTF LQHHSDKRRP PSAELYSNAL
721 PVGLPLPSHV SLTGESDGGY MDMSKDESVD YVPMLDMKGD VKYADIESSN YMAPYDNYVP
781 SAPERTCRAT LINESPVLSY MDLVGFSYQV ANGMEFLASK NCVHRDLAAR NVLICEGKLV
841 KICDFGLARD IMRDSNYISK GSTFLPLKWM APESIFNSLY TTLSDVWSFG ILLWEIFTLG
901 GTPYPELPMN EQFYNAIKRG YRMAQPAHAS DEIYEIMQKC WEEKFEIRPP FSQLVLLLER
961 LLGEGYKKKY QQVDEEFLRS DHPAILRSQA RLPGFHGLRS PLDTSSVLYT AVQPNEGDND
1021 YIIPLPDPKP EVADEGPLEG SPSLASSTLN EVNTSSTISC DSPLEPQDEP EPEPQLELQV
1081 EPEPELEQLP DSGCPAPRAE AEDSFL

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Figure 3 (C) Sequence of PDGFR-A nucleic acid (GenBank Accession No. NM_006206) (SEQ ID NO: 13)

1 TTCTCCCCGC CCCCCAGTTG TTGTCGAAGT CTGGGGGTTG GGACTGGACC CCCTGATTGC

61 GTAAGAGCAA AAAGCGAAGG CGCAATCTGG ACACTGGGAG ATTCGGAGCG CAGGGAGTTT

121 GAGAGAAACT TTTATTTTGA AGAGACCAAG GTTGAGGGGG GGCTTATTTC CTGACAGCTA

181 TTTACTTAGA GCAAATGATT AGTTTTAGAA GGATGGACTA TAACATTGAA TCAATTACAA

241 AACGCGGTTT TTGAGCCCAT TACTGTTGGA GCTACAGGGA GAGAAACAGG AGGAGACTGC

301 AAGAGATCAT TTGGGAAGGC CGTGGGCACG CTCTTTACTC CATGTGTGGG ACATTCATTG

361 CGGAATAACA TCGGAGGAGA AGTTTCCCAG AGCTATGGGG ACTTCCCATC CGGCGTTCCT

421 GGTCTTAGGC TGTCTTCTCA CAGGGCTGAG CCTAATCCTC TGCCAGCTTT CATTACCCTC

481 TATCCTTCCA AATGAAAATG AAAAGGTTGT GCAGCTGAAT TCATCCTTTT CTCTGAGATG

541 CTTTGGGGAG AGTGAAGTGA GCTGGCAGTA CCCCATGTCT GAAGAAGAGA GCTCCGATGT

601 GGAAATCAGA AATGAAGAAA ACAACAGCGG CCTTTTTGTG ACGGTCTTGG AAGTGAGCAG

661 TGCCTCGGCG GCCCACACAG GGTTGTACAC TTGCTATTAC AACCACACTC AGACAGAAGA

721 GAATGAGCTT GAAGGCAGGC ACATTTACAT CTATGTGCCA GACCCAGATG TAGCCTTTGT

781 ACCTCTAGGA ATGACGGATT ATTTAGTCAT CGTGGAGGAT GATGATTCTG CCATTATACC

841 TTGTCGCACA ACTGATCCCG AGACTCCTGT AACCTTACAC AACAGTGAGG GGGTGGTACC

901 TGCCTCCTAC GACAGCAGAC AGGGCTTTAA TGGGACCTTC ACTGTAGGGC CCTATATCTG

961 TGAGGCCACC GTCAAAGGAA AGAAGTTCCA GACCATCCCA TTTAATGTTT ATGCTTTAAA

1021 AGCAACATCA GAGCTGGATC TAGAAATGGA AGCTCTTAAA ACCGTGTATA AGTCAGGGGA

1081 AACGATTGTG GTCACCTGTG CTGTTTTTAA CAATGAGGTG GTTGACCTTC AATGGACTTA

1141 CCCTGGAGAA GTGAAAGGCA AAGGCATCAC AATGCTGGAA GAAATCAAAG TCCCATCCAT

1201 CAAATTGGTG TACACTTTGA CGGTCCCCGA GGCCACGGTG AAAGACAGTG GAGATTACGA

1261 ATGTGCTGCC CGCCAGGCTA CCAGGGAGGT CAAAGAAATG AAGAAAGTCA CTATTTCTGT

1321 CCATGAGAAA GGTTTCATTG AAATCAAACC CACCTTCAGC CAGTTGGAAG CTGTCAACCT

1381 GCATGAAGTC AAACATTTTG TTGTAGAGGT GCGGGCCTAC CCACCTCCCA GGATATCCTG

1441 GCTGAAAAAC AATCTGACTC TGATTGAAAA TCTCACTGAG ATCACCACTG ATGTGGAAAA

1501 GATTCAGGAA ATAAGGTATC GAAGCAAATT AAAGCTGATC CGTGCTAAGG AAGAAGACAG

1561 TGGCCATTAT ACTATTGTAG CTCAAAATGA AGATGCTGTG AAGAGCTATA CTTTTGAACT

1621 GTTAACTCAA GTTCCTTCAT CCATTCTGGA CTTGGTCGAT GATCACCATG GCTCAACTGG

1681 GGGACAGACG GTGAGGTGCA CAGCTGAAGG CACGCCGCTT CCTGATATTG AGTGGATGAT

1741 ATGCAAAGAT ATTAAGAAAT GTAATAATGA AACTTCCTGG ACTATTTTGG CCAACAATGT

1801 CTCAAACATC ATCACGGAGA TCCACTCCCG AGACAGGAGT ACCGTGGAGG GCCGTGTGAC

1861 TTTCGCCAAA GTGGAGGAGA CCATCGCCGT GCGATGCCTG GCTAAGAATC TCCTTGGAGC

1921 TGAGAACCGA GAGCTGAAGC TGGTGGCTCC CACCCTGCGT TCTGAACTCA CGGTGGCTGC

1981 TGCAGTCCTG GTGCTGTTGG TGATTGTGAT CATCTCACTT ATTGTCCTGG TTGTCATTTG

2041 GAAACAGAAA CCGAGGTATG AAATTCGCTG GAGGGTCATT GAATCAATCA GCCCGGATGG

2101 ACATGAATAT ATTTATGTGG ACCCGATGCA GCTGCCTTAT GACTCAAGAT GGGAGTTTCC

2161 AAGAGATGGA CTAGTGCTTG GTCGGGTCTT GGGGTCTGGA GCGTTTGGGA AGGTGGTTGA

2221 AGGAACAGCC TATGGATTAA GCCGGTCCCA ACCTGTCATG AAAGTTGCAG TGAAGATGCT

2281 AAAACCCACG GCCAGATCCA GTGAAAAACA AGCTCTCATG TCTGAACTGA AGATAATGAC

2341 TCACCTGGGG CCACATTTGA ACATTGTAAA CTTGCTGGGA GCCTGCACCA AGTCAGGCCC

2401 CATTTACATC ATCACAGAGT ATTGCTTCTA TGGAGATTTG GTCAACTATT TGCATAAGAA

2461 TAGGGATAGC TTCCTGAGCC ACCACCCAGA GAAGCCAAAG AAAGAGCTGG ATATCTTTGG

2521 ATTGAACCCT GCTGATGAAA GCACACGGAG CTATGTTATT TTATCTTTTG AAAACAATGG

2581 TGACTACATG GACATGAAGC AGGCTGATAC TACACAGTAT GTCCCCATGC TAGAAAGGAA

2641 AGAGGTTTCT AAATATTCCG ACATCCAGAG ATCACTCTAT GATCGTCCAG CCTCATATAA

2701 GAAGAAATCT ATGTTAGACT CAGAAGTCAA AAACCTCCTT TCAGATGATA ACTCAGAAGG

2761 CCTTACTTTA TTGGATTTGT TGAGCTTCAC CTATCAAGTT GCCCGAGGAA TGGAGTTTTT

2821 GGCTTCAAAA AATTGTGTCC ACCGTGATCT GGCTGCTCGC AACGTCCTCC TGGCACAAGG

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2881 AAAAATTGTG AAGATCTGTG ACTTTGGCCT GGCCAGAGAC ATCATGCATG ATTCGAACTA

2941 TGTGTCGAAA GGCAGTACCT TTCTGCCCGT GAAGTGGATG GCTCCTGAGA GCATCTTTGA

3001 CAACCTCTAC ACCACACTGA GTGATGTCTG GTCTTATGGC ATTCTGCTCT GGGAGATCTT

3061 TTCCCTTGGT GGCACCCCTT ACCCCGGCAT GATGGTGGAT TCTACTTTCT ACAATAAGAT

3121 CAAGAGTGGG TACCGGATGG CCAAGCCTGA CCACGCTACC AGTGAAGTCT ACGAGATCAT

3181 GGTGAAATGC TGGAACAGTG AGCCGGAGAA GAGACCCTCC TTTTACCACC TGAGTGAGAT

3241 TGTGGAGAAT CTGCTGCCTG GACAATATAA AAAGAGTTAT GAAAAAATTC ACCTGGACTT

3301 CCTGAAGAGT GACCATCCTG CTGTGGCACG CATGCGTGTG GACTCAGACA ATGCATACAT

3361 TGGTGTCACC TACAAAAACG AGGAAGACAA GCTGAAGGAC TGGGAGGGTG GTCTGGATGA

3421 GCAGAGACTG AGCGCTGACA GTGGCTACAT CATTCCTCTG CCTGACATTG ACCCTGTCCC

3481 TGAGGAGGAG GACCTGGGCA AGAGGAACAG ACACAGCTCG CAGACCTCTG AAGAGAGTGC

3541 CATTGAGACG GGTTCCAGCA GTTCCACCTT CATCAAGAGA GAGGACGAGA CCATTGAAGA

3601 CATCGACATG ATGGACGACA TCGGCATAGA CTCTTCAGAC CTGGTGGAAG ACAGCTTCCT

3661 GTAACTGGCG GATTCGAGGG GTTCCTTCCA CTTCTGGGGC CACCTCTGGA TCCCGTTCAG

3721 AAAACCACTT TATTGCAATG CGGAGGTTGA GAGGAGGACT TGGTTGATGT TTAAAGAGAA

3781 GTTCCCAGCC AAGGGCCTCG GGGAGCGTTC TAAATATGAA TGAATGGGAT ATTTTGAAAT

3841 GAACTTTGTC AGTGTTGCCT CTCGCAATGC CTCAGTAGCA TCTCAGTGGT GTGTGAAGTT

3901 TGGAGATAGA TGGATAAGGG AATAATAGGC CACAGAAGGT GAACTTTGTG CTTCAAGGAC

3961 ATTGGTGAGA GTCCAACAGA CACAATTTAT ACTGCGACAG AACTTCAGCA TTGTAATTAT

4021 GTAAATAACT CTAACCAAGG CTGTGTTTAG ATTGTATTAA CTATCTTCTT TGGACTTCTG

4081 AAGAGACCAC TCAATCCATC CATGTACTTC CCTCTTGAAA CCTGATGTCA GCTGCTGTTG

4141 AACTTTTTAA AGAAGTGCAT GAAAAACCAT TTTTGAACCT TAAAAGGTAC TGGTACTATA

4201 GCATTTTGCT ATCTTTTTTA GTGTTAAGAG ATAAAGAATA ATAATTAACC AACCTTGTTT

4261 AATAGATTTG GGTCATTTAG AAGCCTGACA ACTCATTTTC ATATTGTAAT CTATGTTTAT

4321 AATACTACTA CTGTTATCAG TAATGCTAAA TGTGTAATAA TGTAACATGA TTTCCCTCCA

4381 GAGAAAGCAC AATTTAAAAC AATCCTTACT AAGTAGGTGA TGAGTTTGAC AGTTTTTGAC

4441 ATTTATATTA AATAACATGT TTCTCTATAA AGTATGGTAA TAGCTTTAGT GAATTAAATT

4501 TAGTTGAGCA TAGAGAACAA AGTAAAAGTA GTGTTGTCCA GGAAGTCAGA ATTTTTAACT

4561 GTACTGAATA GGTTCCCCAA TCCATCGTAT TAAAAAACAA TTAACTGCCC TCTGAAATAA

4621 TGGGATTAGA AACAAACAAA ACTCTTAAGT CCTAAAAGTT CTCAATGTAG AGGCATAAAC

4681 CTGTGCTGAA CATAACTTCT CATGTATATT ACCCAATGGA AAATATAATG ATCAGCAAAA

4741 AGACTGGATT TGCAGAAGTT TTTTTTTTTT TTCTTCATGC CTGATGAAAG CTTTGGCAAC

4801 CCCAATATAT GTATTTTTTG AATCTATGAA CCTGAAAAGG GTCAGAAGGA TGCCCAGACA

4861 TCAGCCTCCT TCTTTCACCC CTTACCCCAA AGAGAAAGAG TTTGAAACTC GAGACCATAA

4921 AGATATTCTT TAGTGGAGGC TGGATGTGCA TTAGCCTGGA TCCTCAGTTC TCAAATGTGT

4981 GTGGCAGCCA GGATGACTAG ATCCTGGGTT TCCATCCTTG AGATTCTGAA GTATGAAGTC

5041 TGAGGGAAAC CAGAGTCTGT ATTTTTCTAA ACTCCCTGGC TGTTCTGATC GGCCAGTTTT

5101 CGGAAACACT GACTTAGGTT TCAGGAAGTT GCCATGGGAA ACAAATAATT TGAACTTTGG

5161 AACAGGGTTG GAATTCAACC ACGCAGGAAG CCTACTATTT AAATCCTTGG CTTCAGGTTA

5221 GTGACATTTA ATGCCATCTA GCTAGCAATT GCGACCTTAA TTTAACTTTC CAGTCTTAGC

5281 TGAGGCTGAG AAAGCTAAAG TTTGGTTTTG ACAGGTTTTC CAAAAGTAAA GATGCTACTT

5341 CCCACTGTAT GGGGGAGATT GAACTTTCCC CGTCTCCCGT CTTCTGCCTC CCACTCCATA

5401 CCCCGCCAAG GAAAGGCATG TACAAAAATT ATGCAATTCA GTGTTCCAAG TCTCTGTGTA

5461 ACCAGCTCAG TGTTTTGGTG GAAAAAACAT TTTAAGTTTT ACTGATAATT TGAGGTTAGA

5521 TGGGAGGATG AATTGTCACA TCTATCCACA CTGTCAAACA GGTTGGTGTG GGTTCATTGG

5581 CATTCTTTGC AATACTGCTT AATTGCTGAT ACCATATGAA TGAAACATGG GCTGTGATTA

5641 CTGCAATCAC TGTGCTATCG GCAGATGATG CTTTGGAAGA TGCAGAAGCA ATAATAAAGT

5701 ACTTGACTAC CTACTGGTGT AATCTCAATG CAAGCCCCAA CTTTCTTATC CAACTTTTTC

5761 ATAGTAAGTG CGAAGACTGA GCCAGATTGG CCAATTAAAA ACGAAAACCT GACTAGGTTC

5821 TGTAGAGCCA ATTAGACTTG AAATACGTTT GTGTTTCTAG AATCACAGCT CAAGCATTCT

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5881 GTTTATCGCT CACTCTCCCT TGTACAGCCT TATTTTGTTG GTGCTTTGCA TTTTGATATT

5941 GCTGTGAGCC TTGCATGACA TCATGAGGCC GGATGAAACT TCTCAGTCCA GCAGTTTCCA

6001 GTCCTAACAA ATGCTCCCAC CTGAATTTGT ATATGACTGC ATTTGTGGGT GTGTGTGTGT

6061 TTTCAGCAAA TTCCAGATTT GTTTCCTTTT GGCCTCCTGC AAAGTCTCCA GAAGAAAATT

6121 TGCCAATCTT TCCTACTTTC TATTTTTATG ATGACAATCA AAGCCGGCCT GAGAAACACT

6181 ATTTGTGACT TTTTAAACGA TTAGTGATGT CCTTAAAATG TGGTCTGCCA ATCTGTACAA

6241 AATGGTCCTA TTTTTGTGAA GAGGGACATA AGATAAAATG ATGTTATACA TCAATATGTA

6301 TATATGTATT TCTATATAGA CTTGGAGAAT ACTGCCAAAA CATTTATGAC AAGCTGTATC

6361 ACTGCCTTCG TTTATATTTT TTTAACTGTG ATAATCCCCA CAGGCACATT AACTGTTGCA

6421 CTTTTGAATG TCCAAAATTT ATATTTTAGA AATAATAAAA AGAAAGATAC TTACATGTTC

6481 CCAAAACAAT GGTGTGGTGA ATGTGTGAGA AAAACTAACT TGATAGGGTC TACCAATACA

6541 AAATGTATTA CGAATGCCCC TGTTCATGTT TTTGTTTTAA AACGTGTAAA TGAAGATCTT

6601 TATATTTCAA TAAATGATAT ATAATTTAAA GTT

Figure 3 (D) Sequence of human PDGFR-A polypeptide

(GenBank Accession No. NP_006197) (SEQ ID NO: 14)

1 *MGTSHPAFLV LGCLLTGLSL ILCQLSLPSI* LPNENEKVVQ LNSSFSLRCF GESEVSWQYP

61 MSEEESSDVE IRNEENNSGL FVTVLEVSSA SAAHTGLYTC YYNHTQTEEN ELEGRHIYIY

121 VPDPDVAFVP LGMTDYLVIV *EDDDSAIIPC RTTDPETPVT LHNSEGVVPA* SYDSRQGFNG

181 TFTVGPYICE ATVKGKKFQT IPFNVYALKA TSELDLEMEA LKTVYKSGET IVVTCAVFNN

241 EVVDLQWTYP GEVKGKGITM LEEIKVPSIK LVYTLTVPEA TVKDSGDYEC AARQATREVK

301 EMKKVTISVH EKGFIEIKPT FSQLEAVNLH EVKHFVVEVR AYPPPRISWL KNNLTLIENL

361 TEITTDVEKI QEIRYRSKLK LIRAKEEDSG HYTIVAQNED AVKSYTFELL TQVPSSILDL

421 VDDHHGSTGG QTVRCTAEGT PLPDIEWMIC KDIKKCNNET SWTILANNVS NIITEIHSRD

481 RSTVEGRVTF AKVEETIAVR CLAKNLLGAE NRELKLVAPT LRSELTVAAA VLVLLVIVII

541 SLIVLVVIWK QKPRYEIRWR VIESISPDGH EYIYVDPMQL PYDSRWEFPR DGLVLGRVLG

601 SGAFGKVVEG TAYGLSRSQP VMKVAVKMLK PTARSSEKQA LMSELKIMTH LGPHLNIVNL

661 LGACTKSGPI YIITEYCFYG DLVNYLHKNR DSFLSHHPEK PKKELDIFGL NPADESTRSY

721 VILSFENNGD YMDMKQADTT QYVPMLERKE VSKYSDIQRS LYDRPASYKK KSMLDSEVKN

781 LLSDDNSEGL TLLDLLSFTY QVARGMEFLA SKNCVHRDLA ARNVLLAQGK IVKICDFGLA

841 RDIMHDSNYV SKGSTFLPVK WMAPESIFDN LYTTLSDVWS YGILLWEIFS LGGTPYPGMM

901 VDSTFYNKIK SGYRMAKPDH ATSEVYEIMV KCWNSEPEKR PSFYHLSEIV ENLLPGQYKK

961 SYEKIHLDFL KSDHPAVARM RVDSDNAYIG VTYKNEEDKL KDWEGGLDEQ RLSADSGYII

1021 PLPDIDPVPE EEDLGKRNRH SSQTSEESAI ETGSSSSTFI KREDETIEDI DMMDDIGIDS

1081 SDLVEDSFL

Figure 4 (A) Sequence of VEGFR-1 (Flt-1) nucleic acid

(GenBank Accession No. AF063657) (SEQ ID NO: 7)

1 ATGGTCAGCT ACTGGGACAC CGGGGTCCTG CTGTGCGCGC TGCTCAGCTG TCTGCTTCTC

61 ACAGGATCTA GTTCAGGTTC AAAATTAAAA GATCCTGAAC TGAGTTTAAA AGGCACCCAG

121 CACATCATGC AAGCAGGCCA GACACTGCAT CTCCAATGCA GGGGGGAAGC AGCCCATAAA

181 TGGTCTTTGC CTGAAATGGT GAGTAAGGAA AGCGAAAGGC TGAGCATAAC TAAATCTGCC

241 TGTGGAAGAA ATGGCAAACA ATTCTGCAGT ACTTTAACCT TGAACACAGC TCAAGCAAAC

301 CACACTGGCT TCTACAGCTG CAAATATCTA GCTGTACCTA CTTCAAAGAA GAAGGAAACA

361 GAATCTGCAA TCTATATATT TATTAGTGAT ACAGGTAGAC CTTTCGTAGA GATGTACAGT

421 GAAATCCCCG AAATTATACA CATGACTGAA GGAAGGGAGC TCGTCATTCC CTGCCGGGTT

481 ACGTCACCTA ACATCACTGT TACTTTAAAA AAGTTTCCAC TTGACACTTT GATCCCTGAT

541 GGAAAACGCA TAATCTGGGA CAGTAGAAAG GGCTTCATCA TATCAAATGC AACGTACAAA

601 GAAATAGGGC TTCTGACCTG TGAAGCAACA GTCAATGGGC ATTTGTATAA GACAAACTAT

661 CTCACACATC GACAAACCAA TACAATCATA GATGTCCAAA TAAGCACACC ACGCCCAGTC

721 AAATTACTTA GAGGCCATAC TCTTGTCCTC AATTGTACTG CTACCACTCC CTTGAACACG

781 AGAGTTCAAA TGACCTGGAG TTACCCTGAT GAAAAAAATA AGAGAGCTTC CGTAAGGCGA

841 CGAATTGACC AAAGCAATTC CCATGCCAAC ATATTCTACA GTGTTCTTAC TATTGACAAA

901 ATGCAGAACA AAGACAAAGG ACTTTATACT TGTCGTGTAA GGAGTGGACC ATCATTCAAA

961 TCTGTTAACA CCTCAGTGCA TATATATGAT AAAGCATTCA TCACTGTGAA ACATCGAAAA

1021 CAGCAGGTGC TTGAAACCGT AGCTGGCAAG CGGTCTTACC GGCTCTCTAT GAAAGTGAAG

1081 GCATTTCCCT CGCCGGAAGT TGTATGGTTA AAAGATGGGT TACCTGCGAC TGAGAAATCT

1141 GCTCGCTATT TGACTCGTGG CTACTCGTTA ATTATCAAGG ACGTAACTGA AGAGGATGCA

1201 GGGAATTATA CAATCTTGCT GAGCATAAAA CAGTCAAATG TGTTTAAAAA CCTCACTGCC

1261 ACTCTAATTG TCAATGTGAA ACCCCAGATT TACGAAAAGG CCGTGTCATC GTTTCCAGAC

1321 CCGGCTCTCT ACCCACTGGG CAGCAGACAA ATCCTGACTT GTACCGCATA TGGTATCCCT

1381 CAACCTACAA TCAAGTGGTT CTGGCACCCC TGTAACCATA ATCATTCCGA AGCAAGGTGT

1441 GACTTTTGTT CCAATAATGA AGAGTCCTTT ATCCTGGATG CTGACAGCAA CATGGGAAAC

1501 AGAATTGAGA GCATCACTCA GCGCATGGCA ATAATAGAAG GAAAGAATAA GATGGCTAGC

1561 ACCTTGGTTG TGGCTGACTC TAGAATTTCT GGAATCTACA TTTGCATAGC TTCCAATAAA

1621 GTTGGGACTG TGGGAAGAAA CATAAGCTTT TATATCACAG ATGTGCCAAA TGGGTTTCAT

1681 GTTAACTTGG AAAAAATGCC GACGGAAGGA GAGGACCTGA AACTGTCTTG CACAGTTAAC

1741 AAGTTCTTAT ACAGAGACGT TACTTGGATT TTACTGCGGA CAGTTAATAA CAGAACAATG

1801 CACTACAGTA TTAGCAAGCA AAAAATGGCC ATCACTAAGG AGCACTCCAT CACTCTTAAT

1861 CTTACCATCA TGAATGTTTC CCTGCAAGAT TCAGGCACCT ATGCCTGCAG AGCCAGGAAT

1921 GTATACACAG GGGAAGAAAT CCTCCAGAAG AAAGAAATTA CAATCAGAGA TCAGGAAGCA

1981 CCATACCTCC TGCGAAACCT CAGTGATCAC ACAGTGGCCA TCAGCAGTTC CACCACTTTA

2041 GACTGTCATG CTAATGGTGT CCCCGAGCCT CAGATCACTT GGTTTAAAAA CAACCACAAA

2101 ATACAACAAG AGCCTGGAAT TATTTTAGGA CCAGGAAGCA GCACGCTGTT TATTGAAAGA

2161 GTCACAGAAG AGGATGAAGG TGTCTATCAC TGCAAAGCCA CCAACCAGAA GGGCTCTGTG

2221 GAAAGTTCAG CATACCTCAC TGTTCAAGGA ACCTCGGACA AGTCTAATCT GGAGCTGATC

2281 ACTCTAACAT GCACCTGTGT GGCTGCGACT CTCTTCTGGC TCCTATTAAC CCTCTTTATC

2341 CGAAAAATGA AAAGGTCTTC TTCTGAAATA AAGACTGACT ACCTATCAAT TATAATGGAC

2401 CCAGATGAAG TTCCTTTGGA TGAGCAGTGT GAGCGGCTCC CTTATGATGC CAGCAAGTGG

2461 GAGTTTGCCC GGGAGAGACT TAAACTGGGC AAATCACTTG GAAGAGGGGC TTTTGGAAAA

2521 GTGGTTCAAG CATCAGCATT TGGCATTAAG AAATCACCTA CGTGCCGGAC TGTGGCTGTG

2581 AAAATGCTGA AAGAGGGGGC CACGGCCAGC GAGTACAAAG CTCTGATGAC TGAGCTAAAA

2641 ATCTTGACCC ACATTGGCCA CCATCTGAAC GTGGTTAACC TGCTGGGAGC CTGCACCAAG

2701 CAAGGAGGGC CTCTGATGGT GATTGTTGAA TACTGCAAAT ATGGAAATCT CTCCAACTAC

2761 CTCAAGAGCA AACGTGACTT ATTTTTTCTC AACAAGGATG CAGCACTACA CATGGAGCCT

2821 AAGAAAGAAA AAATGGAGCC AGGCCTGGAA CAAGGCAAGA AACCAAGACT AGATAGCGTC

2881 ACCAGCAGCG AAAGCTTTGC GAGCTCCGGC TTTCAGGAAG ATAAAAGTCT GAGTGATGTT
2941 GAGGAAGAGG AGGATTCTGA CGGTTTCTAC AAGGAGCCCA TCACTATGGA AGATCTGATT
3001 TCTTACAGTT TTCAAGTGGC CAGAGGCATG GAGTTCCTGT CTTCCAGAAA GTGCATTCAT
3061 CGGGACCTGG CAGCGAGAAA CATTCTTTTA TCTGAGAACA ACGTGGTGAA GATTTGTGAT
3121 TTTGGCCTTG CCCGGGATAT TTATAAGAAC CCCGATTATG TGAGAAAAGG AGATACTCGA
3181 CTTCCTCTGA AATGGATGGC TCCTGAATCT ATCTTTGACA AAATCTACAG CACCAAGAGC
3241 GACGTGTGGT CTTACGGAGT ATTGCTGTGG GAAATCTTCT CCTTAGGTGG GTCTCCATAC
3301 CCAGGAGTAC AAATGGATGA GGACTTTTGC AGTCGCCTGA GGGAAGGCAT GAGGATGAGA
3361 GCTCCTGAGT ACTCTACTCC TGAAATCTAT CAGATCATGC TGGACTGCTG GCACAGAGAC
3421 CCAAAAGAAA GGCCAAGATT TGCAGAACTT GTGGAAAAAC TAGGTGATTT GCTTCAAGCA
3481 AATGTACAAC AGGATGGTAA AGACTACATC CCAATCAATG CCATACTGAC AGGAAATAGT
3541 GGGTTTACAT ACTCAACTCC TGCCTTCTCT GAGGACTTCT TCAAGGAAAG TATTTCAGCT
3601 CCGAAGTTTA ATTCAGGAAG CTCTGATGAT GTCAGATATG TAAATGCTTT CAAGTTCATG
3661 AGCCTGGAAA GAATCAAAAC CTTTGAAGAA CTTTTACCGA ATGCCACCTC CATGTTTGAT
3721 GACTACCAGG GCGACAGCAG CACTCTGTTG GCCTCTCCCA TGCTGAAGCG CTTCACCTGG
3781 ACTGACAGCA AACCCAAGGC CTCGCTCAAG ATTGACTTGA GAGTAACCAG TAAAAGTAAG
3841 GAGTCGGGGC TGTCTGATGT CAGCAGGCCC AGTTTCTGCC ATTCCAGCTG TGGGCACGTC
3901 AGCGAAGGCA AGCGCAGGTT CACCTACGAC CACGCTGAGC TGGAAAGGAA AATCGCGTGC
3961 TGCTCCCCGC CCCCAGACTA CAACTCGGTG GTCCTGTACT CCACCCCACC CATCTAG

Figure 4 (B) **Sequence of VEGFR-1 (Flt-1) polypeptide (GenBank Accession No.) (SEQ ID NO: 8)**

1 MVSYWDTGVL LCALLSCLLL TGSSSGSKLK DPELSLKGTQ HIMQAGQTLH LQCRGEAAHK

61 WSLPEMVSKE SERLSITKSA CGRNGKQFCS TLTLNTAQAN HTGFYSCKYL AVPTSKKKET

121 ESAIYIFISD TGRPFVEMYS EIPEIIHMTE GRELVIPCRV TSPNITVTLK KFPLDTLIPD

181 GKRIIWDSRK GFIISNATYK EIGLLTCEAT VNGHLYKTNY LTHRQTNTII DVQISTPRPV

241 KLLRGHTLVL NCTATTPLNT RVQMTWSYPD EKNKRASVRR RIDQSNSHAN IFYSVLTIDK

301 MQNKDKGLYT CRVRSGPSFK SVNTSVHIYD KAFITVKHRK QQVLETVAGK RSYRLSMKVK

361 AFPSPEVVWL KDGLPATEKS ARYLTRGYSL IIKDVTEEDA GNYTILLSIK QSNVFKNLTA

421 TLIVNVKPQI YEKAVSSFPD PALYPLGSRQ ILTCTAYGIP QPTIKWFWHP CNHNHSEARC

481 DFCSNNEESF ILDADSNMGN RIESITQRMA IIEGKNKMAS TLVVADSRIS GIYICIASNK

541 VGTVGRNISF YITDVPNGFH VNLEKMPTEG EDLKLSCTVN KFLYRDVTWI LLRTVNNRTM

601 HYSISKQKMA ITKEHSITLN LTIMNVSLQD SGTYACRARN VYTGEEILQK KEITIRDQEA

661 PYLLRNLSDH TVAISSSTTL DCHANGVPEP QITWFKNNHK IQQEPGIILG PGSSTLFIER

721 VTEEDEGVYH CKATNQKGSV ESSAYLTVQG TSDKSNLELI TLTCTCVAAT LFWLLLTLFI

781 RKMKRSSSEI KTDYLSIIMD PDEVPLDEQC ERLPYDASKW EFARERLKLG KSLGRGAFGK

841 VVQASAFGIK KSPTCRTVAV KMLKEGATAS EYKALMTELK ILTHIGHHLN VVNLLGACTK

901 QGGPLMVIVE YCKYGNLSNY LKSKRDLFFL NKDAALHMEP KKEKMEPGLE QGKKPRLDSV

961 TSSESFASSG FQEDKSLSDV EEEEDSDGFY KEPITMEDLI SYSFQVARGM EFLSSRKCIH

1021 RDLAARNILL SENNVVKICD FGLARDIYKN PDYVRKGDTR LPLKWMAPES IFDKIYSTKS

1081 DVWSYGVLLW EIFSLGGSPY PGVQMDEDFC SRLREGMRMR APEYSTPEIY QIMLDCWHRD

1141 PKERPRFAEL VEKLGDLLQA NVQQDGKDYI PINAILTGNS GFTYSTPAFS EDFFKESISA

1201 PKFNSGSSDD VRYVNAFKFM SLERIKTFEE LLPNATSMFD DYQGDSSTLL ASPMLKRFTW

1261 TDSKPKASLK IDLRVTSKSK ESGLSDVSRP SFCHSSCGHV SEGKRRFTYD HAELERKIAC

1321 CSPPPDYNSV VLYSTPPI

Figure 4 (C) Sequence of VEGFR-2 (KDR/Flk-1) nucleic acid (GenBank Accession No. AF035121) (SEQ ID NO: 9)

1 ACTGAGTCCC GGGACCCCGG GAGAGCGGTC AGTGTGTGGT CGCTGCGTTT CCTCTGCCTG
61 CGCCGGGCAT CACTTGCGCG CCGCAGAAAG TCCGTCTGGC AGCCTGGATA TCCTCTCCTA
121 CCGGCACCCG CAGACGCCCC TGCAGCCGCC GGTCGGCGCC CGGGCTCCCT AGCCCTGTGC
181 GCTCAACTGT CCTGCGCTGC GGGGTGCCGC GAGTTCCACC TCCGCGCCTC CTTCTCTAGA
241 CAGGCGCTGG GAGAAAGAAC CGGCTCCCGA GTTCTGGGCA TTTCGCCCGG CTCGAGGTGC
301 AGGATGCAGA GCAAGGTGCT GCTGGCCGTC GCCCTGTGGC TCTGCGTGGA GACCCGGGCC
361 GCCTCTGTGG GTTTGCCTAG TGTTTCTCTT GATCTGCCCA GGCTCAGCAT ACAAAAAGAC
421 ATACTTACAA TTAAGGCTAA TACAACTCTT CAAATTACTT GCAGGGGACA GAGGGACTTG
481 GACTGGCTTT GGCCCAATAA TCAGAGTGGC AGTGAGCAAA GGGTGGAGGT GACTGAGTGC
541 AGCGATGGCC TCTTCTGTAA GACACTCACA ATTCCAAAAG TGATCGGAAA TGACACTGGA
601 GCCTACAAGT GCTTCTACCG GGAAACTGAC TTGGCCTCGG TCATTTATGT CTATGTTCAA
661 GATTACAGAT CTCCATTTAT TGCTTCTGTT AGTGACCAAC ATGGAGTCGT GTACATTACT
721 GAGAACAAAA ACAAAACTGT GGTGATTCCA TGTCTCGGGT CCATTTCAAA TCTCAACGTG
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901 TGTGAAGCAA AAATTAATGA TGAAAGTTAC CAGTCTATTA TGTACATAGT TGTCGTTGTA
961 GGGTATAGGA TTTATGATGT GGTTCTGAGT CCGTCTCATG GAATTGAACT ATCTGTTGGA
1021 GAAAAGCTTG TCTTAAATTG TACAGCAAGA ACTGAACTAA ATGTGGGGAT TGACTTCAAC
1081 TGGGAATACC CTTCTTCGAA GCATCAGCAT AAGAAACTTG TAAACCGAGA CCTAAAAACC
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1201 AGTGACCAAG GATTGTACAC CTGTGCAGCA TCCAGTGGGC TGATGACCAA GAAGAACAGC
1261 ACATTTGTCA GGGTCCATGA AAAACCTTTT GTTGCTTTTG GAAGTGGCAT GGAATCTCTG
1321 GTGGAAGCCA CGGTGGGGGA GCGTGTCAGA ATCCCTGCGA AGTACCTTGG TTACCCACCC

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1381 CCAGAAATAA AATGGTATAA AAATGGAATA CCCCTTGAGT CCAATCACAC AATTAAAGCG

1441 GGGCATGTAC TGACGATTAT GGAAGTGAGT GAAAGAGACA CAGGAAATTA CACTGTCATC

1501 CTTACCAATC CCATTTCAAA GGAGAAGCAG AGCCATGTGG TCTCTCTGGT TGTGTATGTC

1561 CCACCCCAGA TTGGTGAGAA ATCTCTAATC TCTCCTGTGG ATTCCTACCA GTACGGCACC

1621 ACTCAAACGC TGACATGTAC GGTCTATGCC ATTCCTCCCC CGCATCACAT CCACTGGTAT

1681 TGGCAGTTGG AGGAAGAGTG CGCCAACGAG CCCAGCCAAG CTGTCTCAGT GACAAACCCA

1741 TACCCTTGTG AAGAATGGAG AAGTGTGGAG GACTTCCAGG GAGGAAATAA AATTGAAGTT

1801 AATAAAAATC AATTTGCTCT AATTGAAGGA AAAAACAAAA CTGTAAGTAC CCTTGTTATC

1861 CAAGCGGCAA ATGTGTCAGC TTTGTACAAA TGTGAAGCGG TCAACAAAGT CGGGAGAGGA

1921 GAGAGGGTGA TCTCCTTCCA CGTGACCAGG GGTCCTGAAA TTACTTTGCA ACCTGACATG

1981 CAGCCCACTG AGCAGGAGAG CGTGTCTTTG TGGTGCACTG CAGACAGATC TACGTTTGAG

2041 AACCTCACAT GGTACAAGCT TGGCCCACAG CCTCTGCCAA TCCATGTGGG AGAGTTGCCC

2101 ACACCTGTTT GCAAGAACTT GGATACTCTT TGGAAATTGA ATGCCACCAT GTTCTCTAAT

2161 AGCACAAATG ACATTTTGAT CATGGAGCTT AAGAATGCAT CCTTGCAGGA CCAAGGAGAC

2221 TATGTCTGCC TTGCTCAAGA CAGGAAGACC AAGAAAAGAC ATTGCGTGGT CAGGCAGCTC

2281 ACAGTCCTAG AGCGTGTGGC ACCCACGATC ACAGGAAACC TGGAGAATCA GACGACAAGT

2341 ATTGGGGAAA GCATCGAAGT CTCATGCACG GCATCTGGGA ATCCCCCTCC ACAGATCATG

2401 TGGTTTAAAG ATAATGAGAC CCTTGTAGAA GACTCAGGCA TTGTATTGAA GGATGGGAAC

2461 CGGAACCTCA CTATCCGCAG AGTGAGGAAG GAGGACGAAG GCCTCTACAC CTGCCAGGCA

2521 TGCAGTGTTC TTGGCTGTGC AAAAGTGGAG GCATTTTTCA TAATAGAAGG TGCCCAGGAA

2581 AAGACGAACT TGGAAATCAT TATTCTAGTA GGCACGGCGG TGATTGCCAT GTTCTTCTGG

2641 CTACTTCTTG TCATCATCCT ACGGACCGTT AAGCGGGCCA ATGGAGGGGA ACTGAAGACA

2701 GGCTACTTGT CCATCGTCAT GGATCCAGAT GAACTCCCAT TGGATGAACA TTGTGAACGA

2761 CTGCCTTATG ATGCCAGCAA ATGGGAATTC CCCAGAGACC GGCTGAAGCT AGGTAAGCCT

2821 CTTGGCCGTG GTGCCTTTGG CCAAGTGATT GAAGCAGATG CCTTTGGAAT TGACAAGACA

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2881 GCAACTTGCA GGACAGTAGC AGTCAAAATG TTGAAAGAAG GAGCAACACA CAGTGAGCAT

2941 CGAGCTCTCA TGTCTGAACT CAAGATCCTC ATTCATATTG GTCACCATCT CAATGTGGTC

3001 AACCTTCTAG GTGCCTGTAC CAAGCCAGGA GGGCCACTCA TGGTGATTGT GGAATTCTGC

3061 AAATTTGGAA ACCTGTCCAC TTACCTGAGG AGCAAGAGAA ATGAATTTGT CCCCTACAAG

3121 ACCAAAGGGG CACGATTCCG TCAAGGGAAA GACTACGTTG GAGCAATCCC TGTGGATCTG

3181 AAACGGCGCT TGGACAGCAT CACCAGTAGC CAGAGCTCAG CCAGCTCTGG ATTTGTGGAG

3241 GAGAAGTCCC TCAGTGATGT AGAAGAAGAG GAAGCTCCTG AAGATCTGTA TAAGGACTTC

3301 CTGACCTTGG AGCATCTCAT CTGTTACAGC TTCCAAGTGG CTAAGGGCAT GGAGTTCTTG

3361 GCATCGCGAA AGTGTATCCA CAGGGACCTG GCGGCACGAA ATATCCTCTT ATCGGAGAAG

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3961 ATCAGTCAGT ATCTGCAGAA CAGTAAGCGA AAGAGCCGGC CTGTGAGTGT AAAAACATTT

4021 GAAGATATCC CGTTAGAAGA ACCAGAAGTA AAAGTAATCC CAGATGACAA CCAGACGGAC

4081 AGTGGTATGG TTCTTGCCTC AGAAGAGCTG AAAACTTTGG AAGACAGAAC CAAATTATCT

4141 CCATCTTTTG GTGGAATGGT GCCCAGCAAA AGCAGGGAGT CTGTGGCATC TGAAGGCTCA

4201 AACCAGACAA GCGGCTACCA GTCCGGATAT CACTCCGATG ACACAGACAC CACCGTGTAC

4261 TCCAGTGAGG AAGCAGAACT TTTAAAGCTG ATAGAGATTG GAGTGCAAAC CGGTAGCACA

4321 GCCCAGATTC TCCAGCCTGA CTCGGGGACC ACACTGAGCT CTCCTCCTGT TTAAAAGGAA

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4381 GCATCCACAC CCCAACTCCC GGACATCACA TGAGAGGTCT GCTCAGATTT TGAAGTGTTG
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4681 CCCCATCCTC AAAGAAGTAG CAGTACCTGG GGAGCTGACA CTTCTGTAAA ACTAGAAGAT
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4801 TATCCAAGAG GCTTTGTTTA GGACGTGGGT CCCAAGCCAA GCCTTAAGTG TGGAATTCGG
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5101 CCCCAGGAAG AAAATGATGC AGCTCTGGCT CCTTGTCTCC CAGGCTGATC CTTTATTCAG
5161 AATACCACAA AGAAAGGACA TTCAGCTCAA GGCTCCCTGC CGTGTTGAAG AGTTCTGACT
5221 GCACAAACCA GCTTCTGGTT TCTTCTGGAA TGAATACCCT CATATCTGTC CTGATGTGAT
5281 ATGTCTGAGA CTGAATGCGG GAGGTTCAAT GTGAAGCTGT GTGTGGTGTC AAAGTTTCAG
5341 GAAGGATTTT ACCCTTTTGT TCTTCCCCCT GTCCCCAACC CACTCTCACC CCGCAACCCA
5401 TCAGTATTTT AGTTATTTGG CCTCTACTCC AGTAAACCTG ATTGGGTTTG TTCACTCTCT
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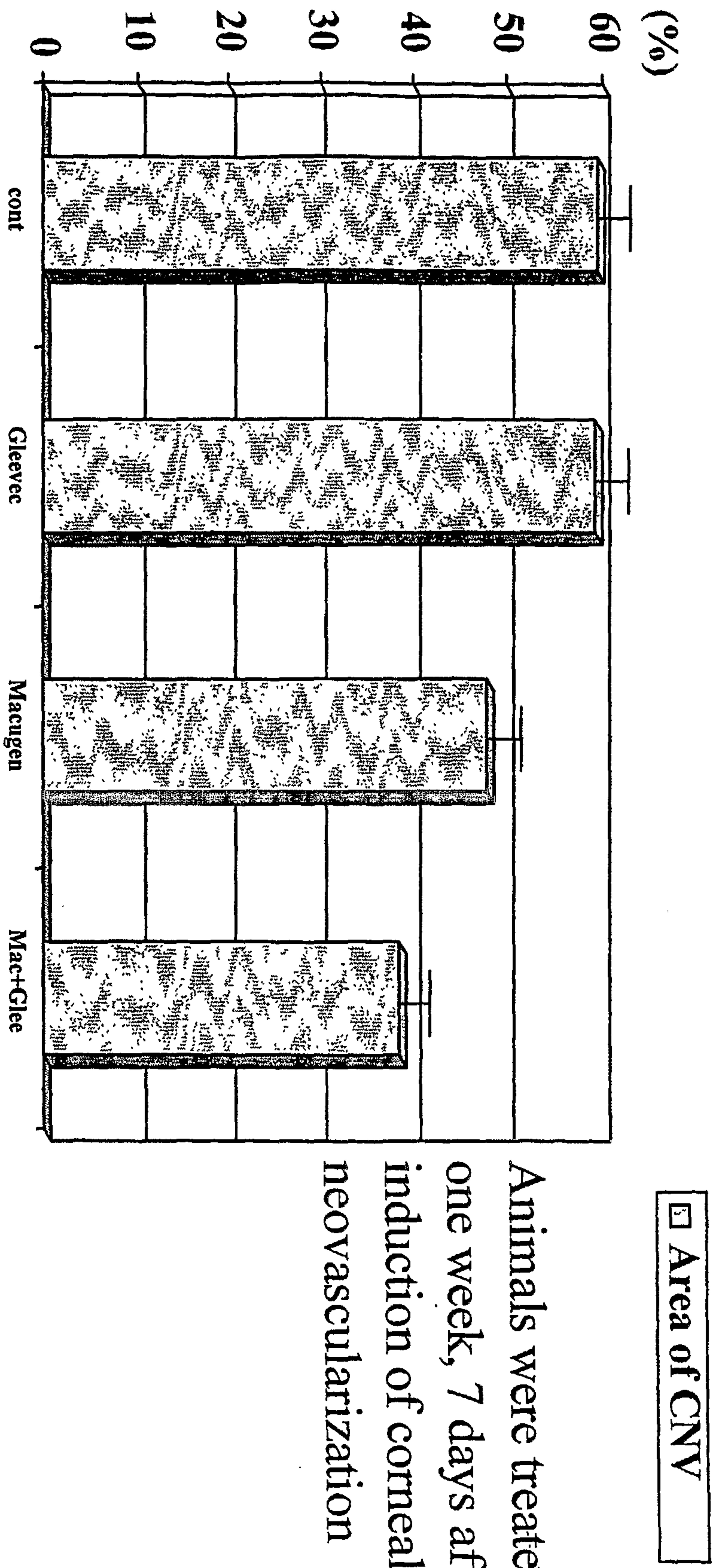
5581 TTTTTCAAAA AAGAAAATGT GTTTTTTGTT TGGTACCATA GTGTGAAATG CTGGGAACAA
5641 TGACTATAAG ACATGCTATG GCACATATAT TTATAGTCTG TTTATGTAGA AACAAATGTA
5701 ATATATTAAA GCCTTATATA TAATGAACTT TGTACTATTC ACATTTTGTA TCAGTATTAT
5761 GTAGCATAAC AAAGGTCATA ATGCTTTCAG CAATTGATGT CATTTTATTA AAGAACATTG
5821 AAAAACTTGA

Figure 4 (D) **Sequence of VEGFR-2 (KDR/Flk-1) polypeptide (GenBank Accession No. AAB88005) (SEQ ID NO: 10)**

```
   1 MQSKVLLAVA LWLCVETRAA SVGLPSVSLD LPRLSIQKDI LTIKANTTLQ ITCRGQRDLD
  61 WLWPNNQSGS EQRVEVTECS DGLFCKTLTI PKVIGNDTGA YKCFYRETDL ASVIYVYVQD
 121 YRSPFIASVS DQHGVVYITE NKNKTVVIPC LGSISNLNVS LCARYPEKRF VPDGNRISWD
 181 SKKGFTIPSY MISYAGMVFC EAKINDESYQ SIMYIVVVVG YRIYDVVLSP SHGIELSVGE
 241 KLVLNCTART ELNVGIDFNW EYPSSKHQHK KLVNRDLKTQ SGSEMKKFLS TLTIDGVTRS
 301 DQGLYTCAAS SGLMTKKNST FVRVHEKPFV AFGSGMESLV EATVGERVRI PAKYLGYPPP
 361 EIKWYKNGIP LESNHTIKAG HVLTIMEVSE RDTGNYTVIL TNPISKEKQS HVVSLVVYVP
 421 PQIGEKSLIS PVDSYQYGTT QTLTCTVYAI PPPHHIHWYW QLEEECANEP SQAVSVTNPY
 481 PCEEWRSVED FQGGNKIEVN KNQFALIEGK NKTVSTLVIQ AANVSALYKC EAVNKVGRGE
 541 RVISFHVTRG PEITLQPDMQ PTEQESVSLW CTADRSTFEN LTWYKLGPQP LPIHVGELPT
 601 PVCKNLDTLW KLNATMFSNS TNDILIMELK NASLQDQGDY VCLAQDRKTK KRHCVVRQLT
 661 VLERVAPTIT GNLENQTTSI GESIEVSCTA SGNPPPQIMW FKDNETLVED SGIVLKDGNR
 721 NLTIRRVRKE DEGLYTCQAC SVLGCAKVEA FFIIEGAQEK TNLEIIILVG TAVIAMFFWL
 781 LLVIILRTVK RANGGELKTG YLSIVMDPDE LPLDEHCERL PYDASKWEFP RDRLKLGKPL
 841 GRGAFGQVIE ADAFGIDKTA TCRTVAVKML KEGATHSEHR ALMSELKILI HIGHHLNVVN
 901 LLGACTKPGG PLMVIVEFCK FGNLSTYLRS KRNEFVPYKT KGARFRQGKD YVGAIPVDLK
 961 RRLDSITSSQ SSASSGFVEE KSLSDVEEEE APEDLYKDFL TLEHLICYSF QVAKGMEFLA
1021 SRKCIHRDLA ARNILLSEKN VVKICDFGLA RDIYKDPDYV RKGDARLPLK WMAPETIFDR
1081 VYTIQSDVWS FGVLLWEIFS LGASPYPGVK IDEEFCRRLK EGTRMRAPDY TTPEMYQTML
1141 DCWHGEPSQR PTFSELVEHL GNLLQANAQQ DGKDYIVLPI SETLSMEEDS GLSLPTSPVS
1201 CMEEEEVCDP KFHYDNTAGI SQYLQNSKRK SRPVSVKTFE DIPLEEPEVK VIPDDNQTDS
1261 GMVLASEELK TLEDRTKLSP SFGGMVPSKS RESVASEGSN QTSGYQSGYH SDDTDTTVYS
1321 SEEAELLKLI EIGVQTGSTA QILQPDSGTT LSSPPV
```

FIGURE 5

Effect of blocking PDGFRβ and VEGF signaling on corneal neovascularization



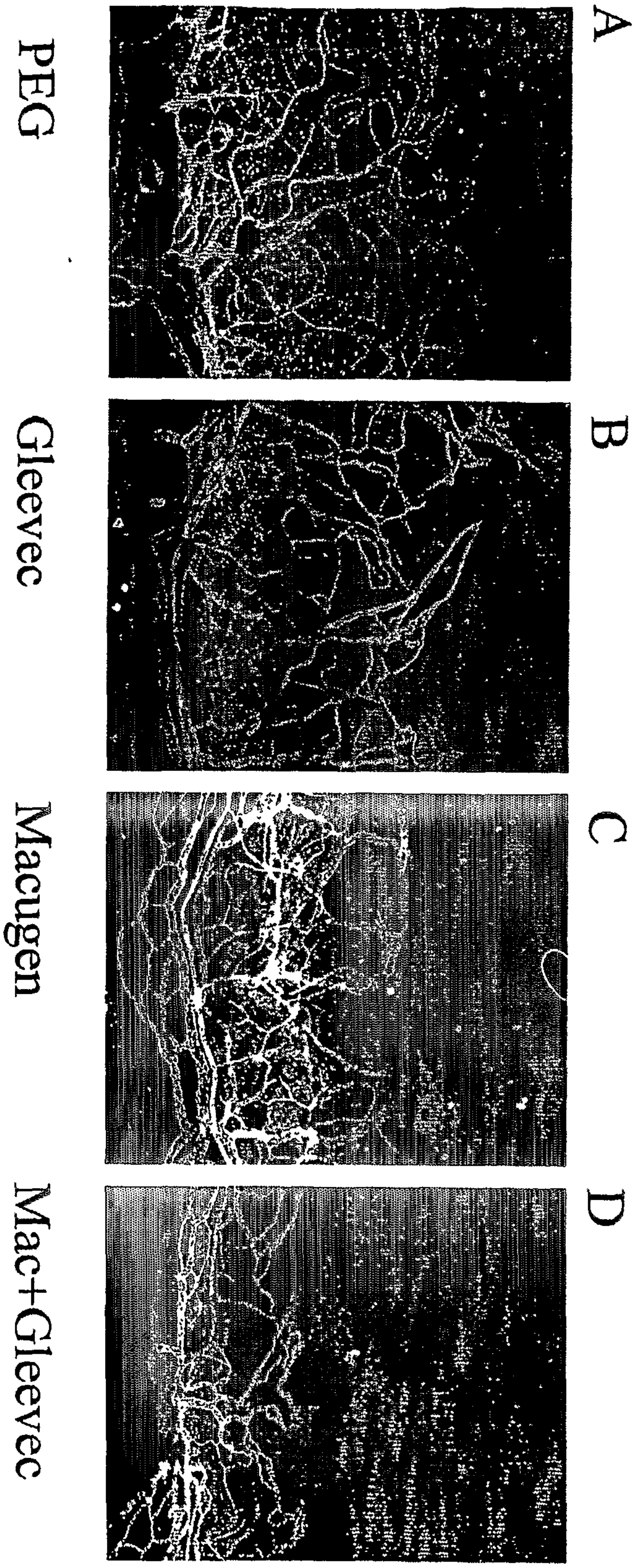


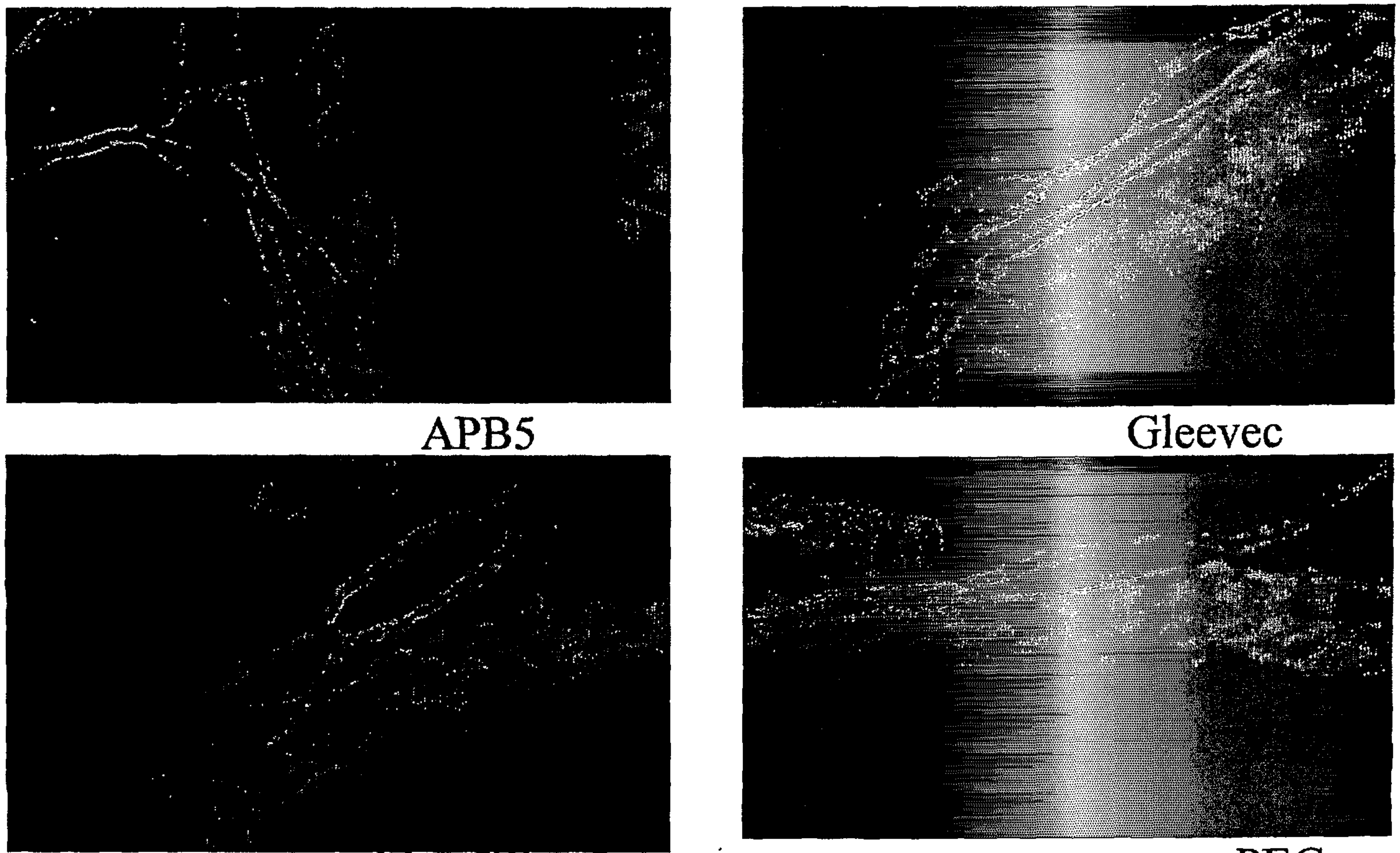
FIGURE 6

FIGURE 7

Effect of PDGFRβ and VEGF signaling inhibitors on normal vasculature

The vasculature of control eyes was unaffected by administration of Gleevec, APB5, PEG or Macugen suggesting that blocking either PDGFRβ or VEGF signaling or both targets new and not established blood vessels.

A B



APB5 Gleevec

C D

Mac+Gleevec PEG

FIGURE 8

Area of Choroidal Neovascularization following treatment with APB5 antibody and Macugen

All treatment was for one week, starting on day 7 after laser-burned

25mg/kg of Macugen and 5mg/kg of APB5 were injected twice a day by IP

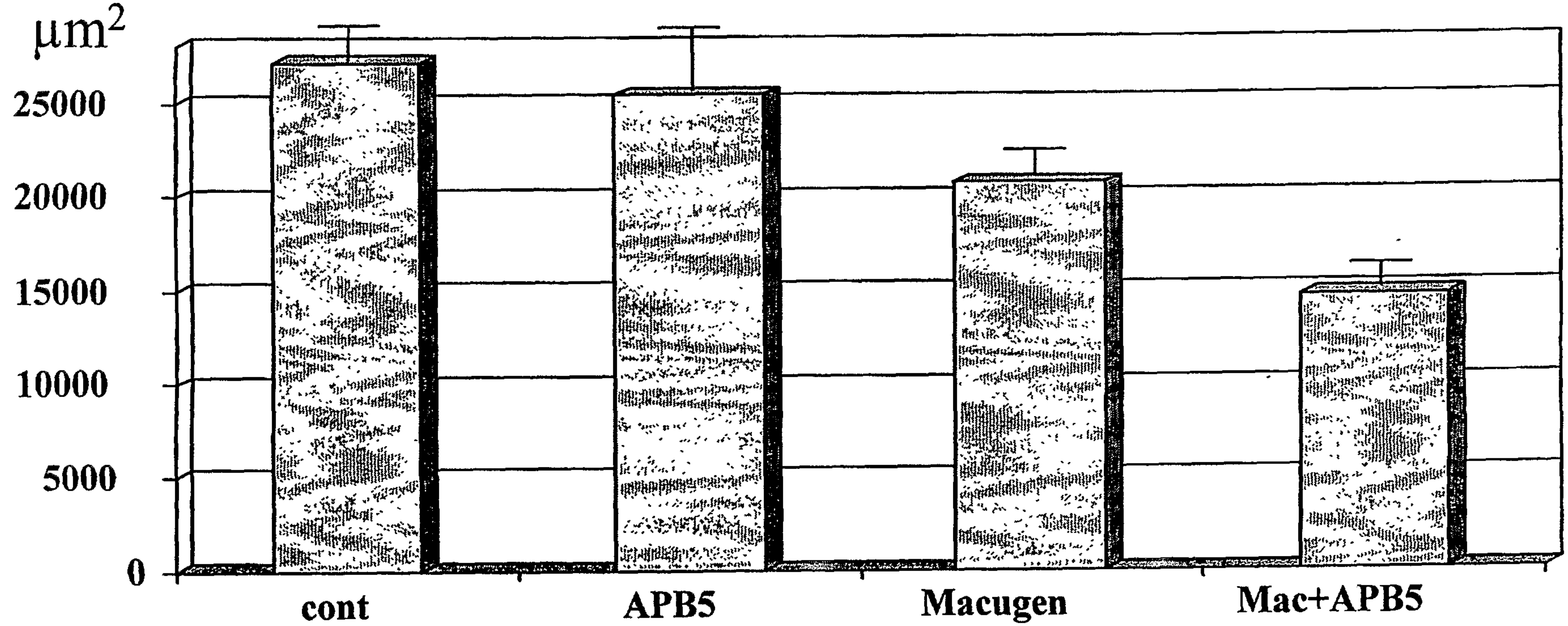


FIGURE 9

Area of Choroidal Neovascularization following treatment with Gleevec and Macugen

All treatment was for one week, starting on day 7 after laser-burned

25mg/kg of Macugen were injected twice a day by IP

50mg/kg of Gleevec were administered by gavage twice a day

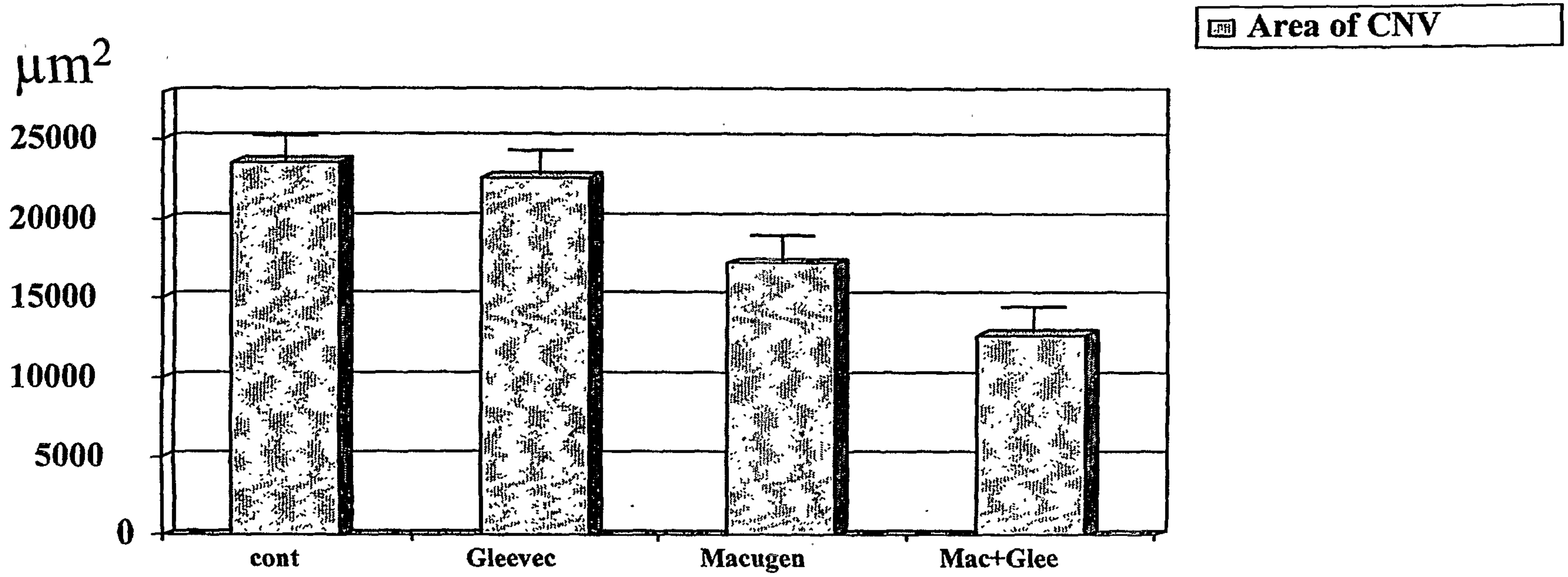
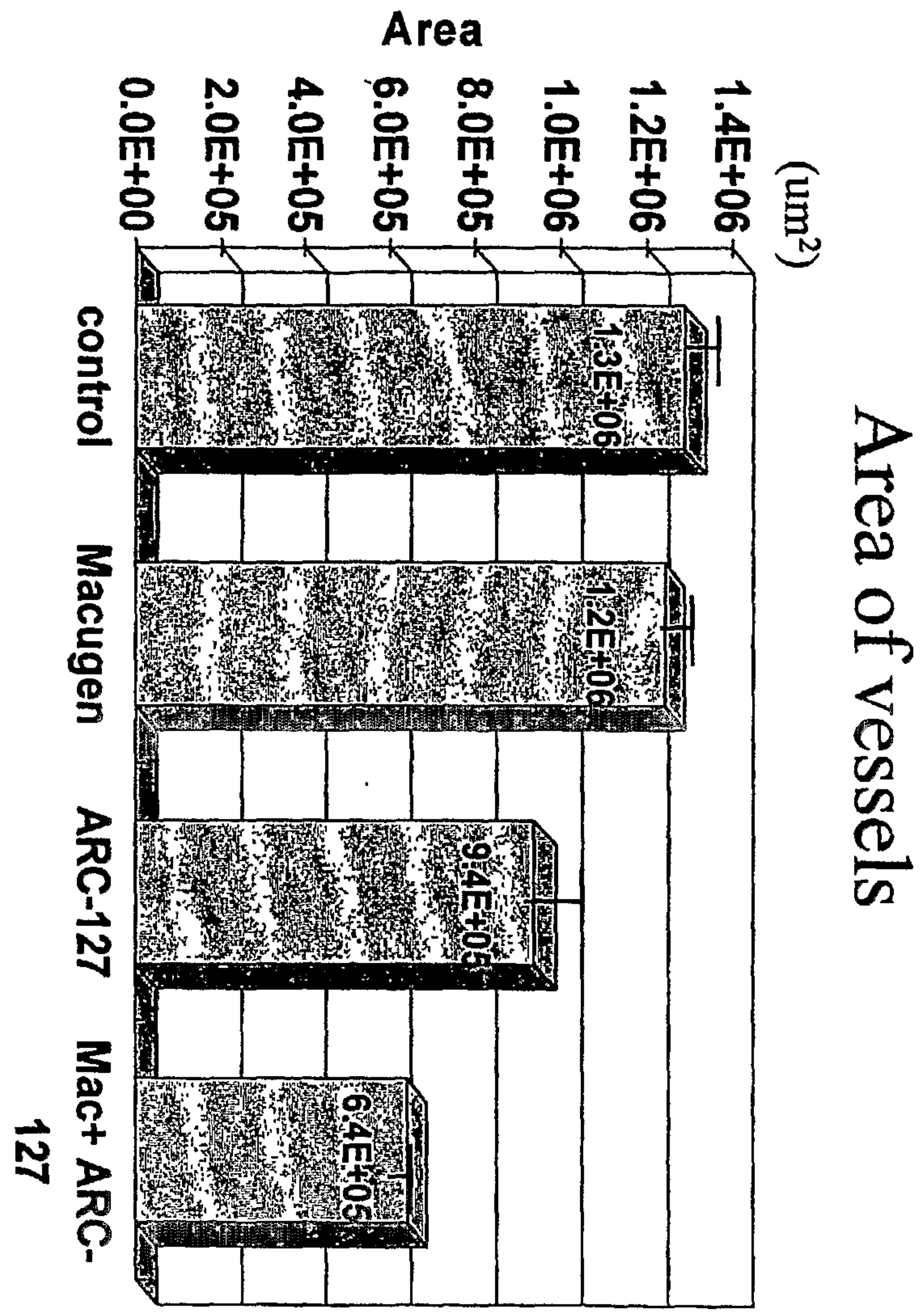


FIGURE 10


Area of vessels
Area
(um²)
1.4E+06
1.2E+06
1.0E+06
8.0E+05
6.0E+05
4.0E+05
2.0E+05
0.0E+00
1.3E+06
1.2E+06
9.4E+05
6.4E+05
control
Macugen
ARC-127
Mac+ ARC-127

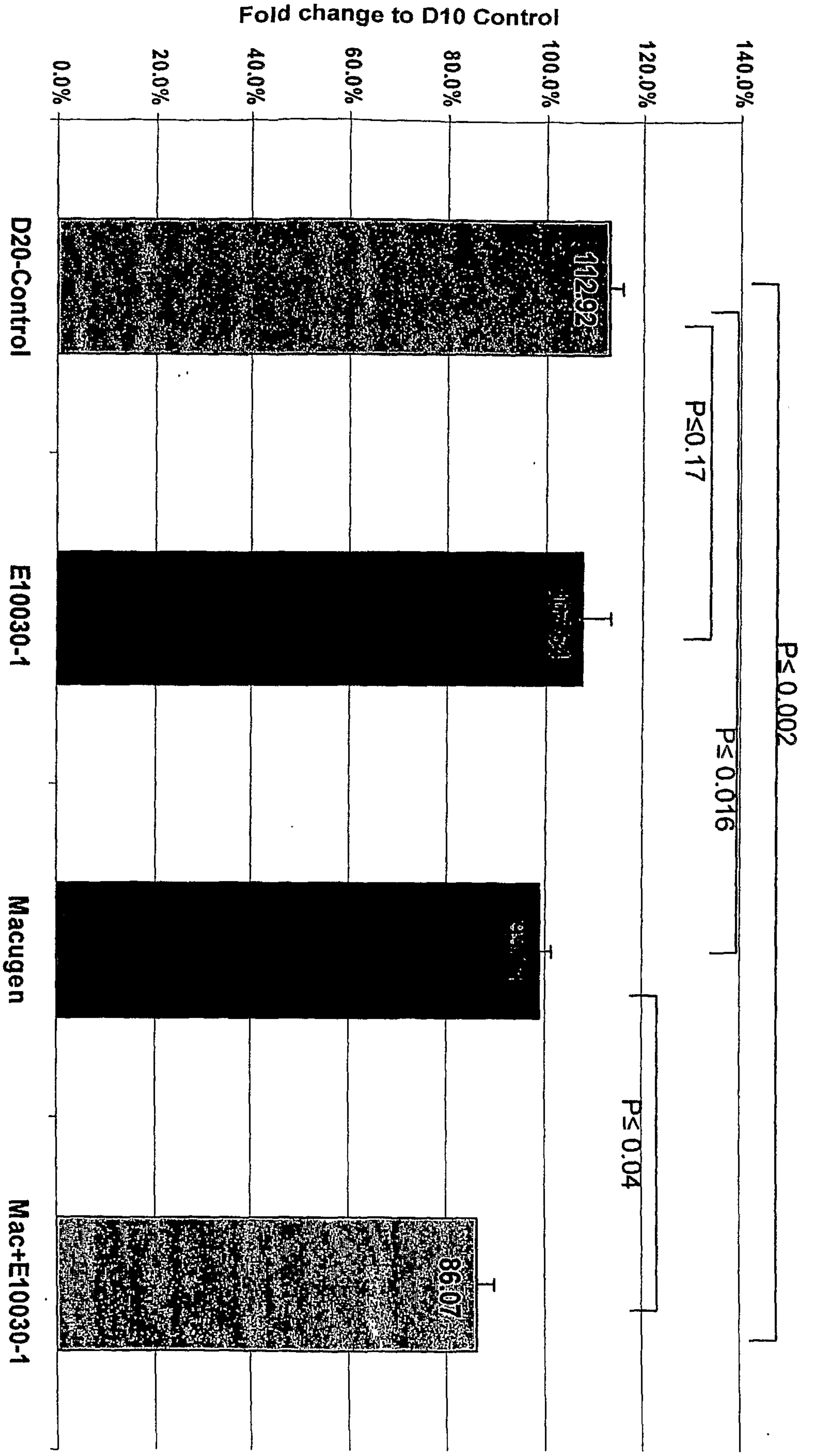
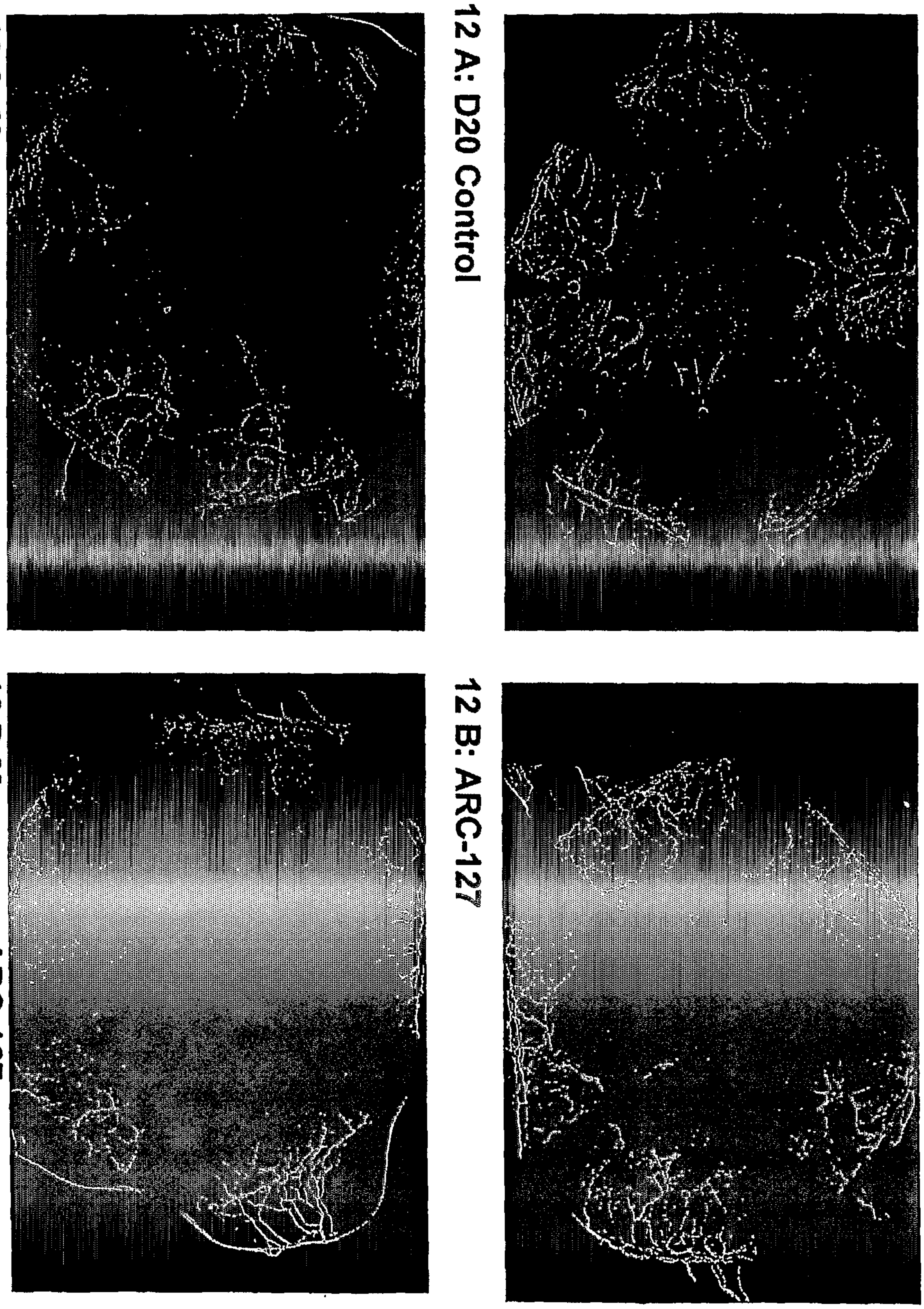

Fold change to D10 Control
0.0%
20.0%
40.0%
60.0%
80.0%
100.0%
120.0%
140.0%
112.92
86.07
D20-Control
E10030-1
Macugen
Mac+E10030-1
P≤0.17
P≤0.016
P≤0.002
P≤0.04

FIGURE 11

FIGURE 12



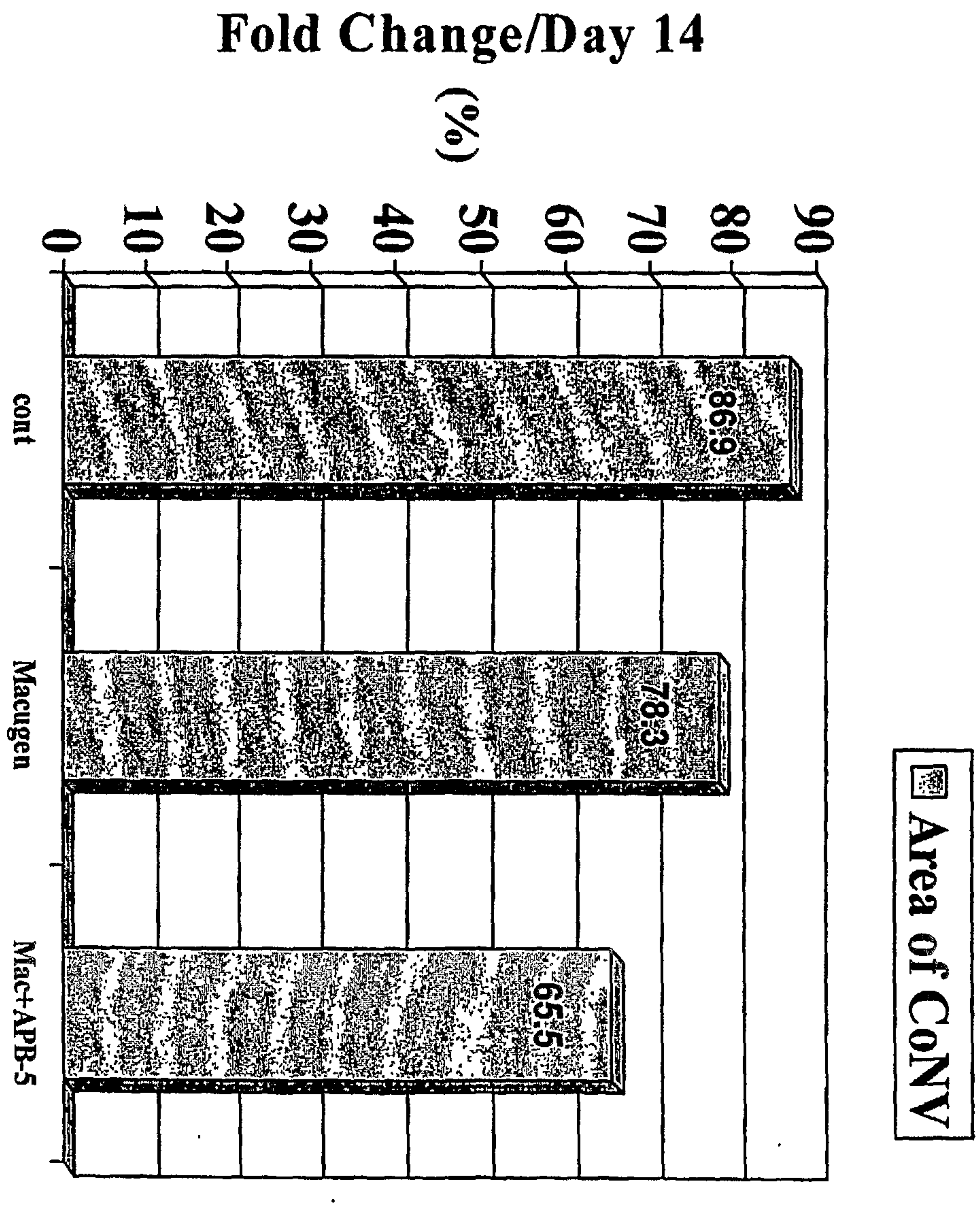
12 A: D20 Control

12 B: ARC-127

12 C: Macugen

12 D:Macugen + ARC-127

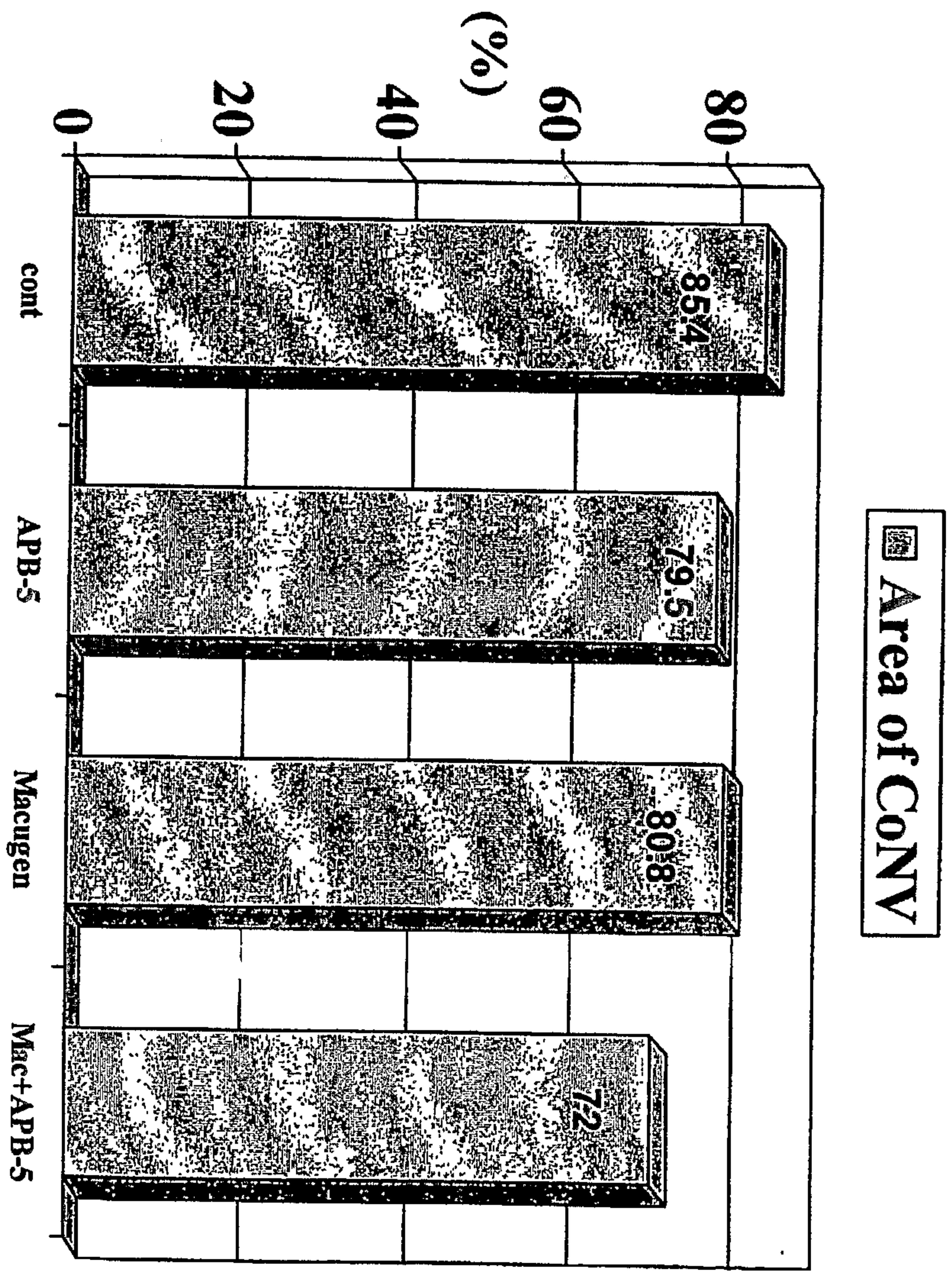
FIGURE 13


Fold Change/Day 14
(%)
0
10
20
30
40
50
60
70
80
90
cont
Macugen
Mac+APB-5
86.9
78.3
65.5
Area of CoNV

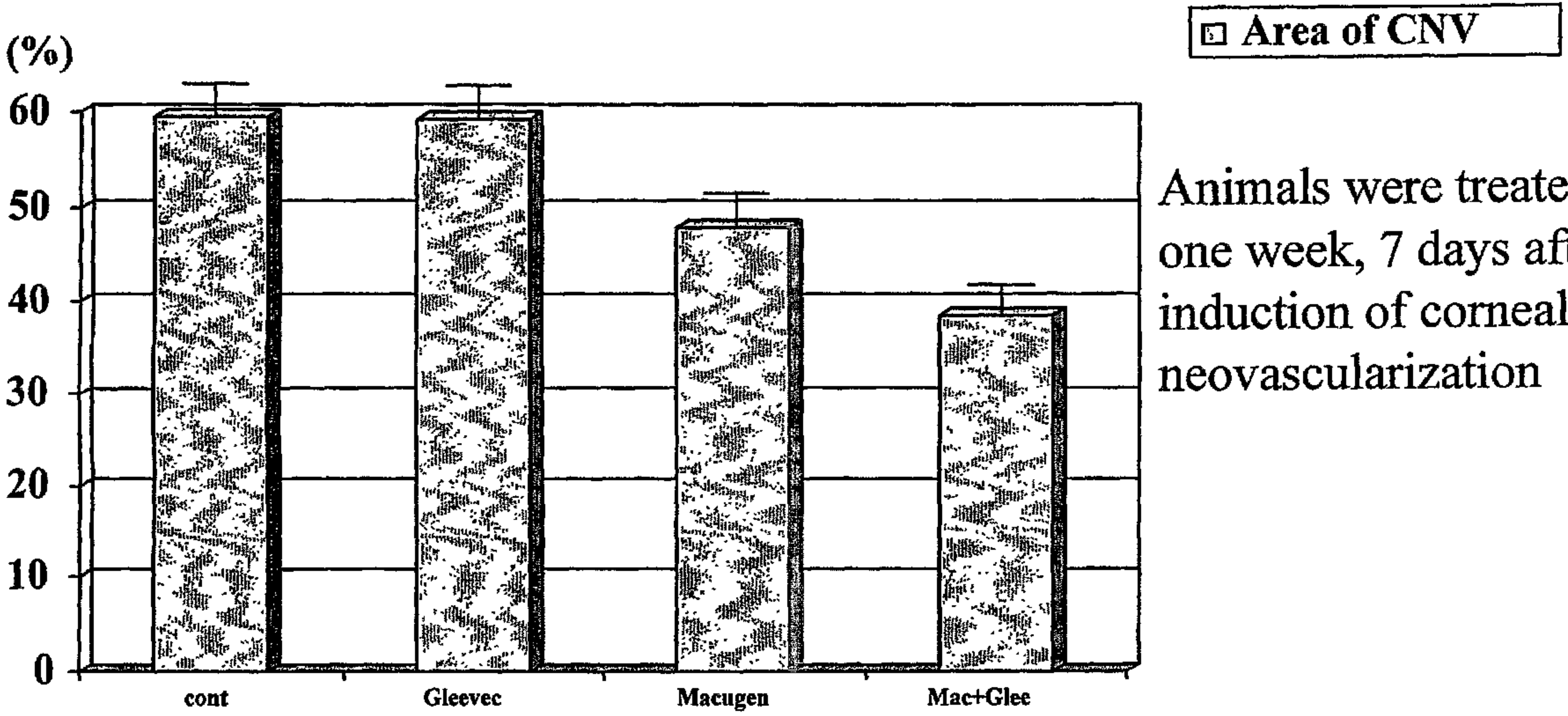
39/39

FIGURE 14

Fold Change/Day 14



Effect of blocking PDGFRβ and VEGF signaling on corneal neovascularization



Animals were treated fo one week, 7 days after induction of corneal neovascularization