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(54) **Title**: ANTIANGIOGENIC SMALL MOLECULES AND METHODS OF USE

(57) **Abstract**: Methods of inhibiting undesired angiogenesis are provided, which methods include administering to a subject a therapeutically effective amount of at least one of the compounds described herein, or a pharmaceutically acceptable salt thereof.

ANTIANGIOGENIC SMALL MOLECULES AND METHODS OF USE

CROSS REFERENCE TO RELATED APPLICATION

Benefit is claimed to U.S. Provisional Application 61/230,667, filed July 31, 2009, which is incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

The present disclosure relates to antiangiogenic compounds, derivatives thereof, and methods of use of such compounds and derivatives.

BACKGROUND

Angiogenesis is the process of formation of new blood vessels from existing ones. Angiogenesis is a normal and vital process in growth and development, as well as in pathological conditions. Angiogenesis has been intensively studied over the past several decades because of its fundamental importance in tissue development, vascular diseases, and cancer. Under normal physiological conditions, humans or animals undergo angiogenesis only in very specific restricted situations. For example, angiogenesis is normally observed in fetal and embryonal development and formation of the corpus luteum. Post-natal angiogenesis is an important physiological function in the ovary, endometrium, placenta, and in wound healing. Deregulation of angiogenesis plays a major role in many human diseases including diabetic retinopathy, age-related macular degeneration, endometriosis, atherogenesis, arthritis, psoriasis, corneal neovascularization, rheumatoid arthritis, tumorigenesis, and metastasis, among others.

Tumor angiogenesis involves the proliferation of a network of blood vessels that penetrates into cancerous growths, supplying nutrients and oxygen and removing waste products. Angiogenesis is also an element of metastasis of a tumor. Single cancer cells can break away from an established solid tumor, enter the blood vessel, and be carried to a distant site, where they can implant and begin the growth of a secondary tumor. It has even been suggested that the blood vessels in a solid tumor may in fact be mosaic vessels, comprised of both endothelial cells and tumor cells. Such mosaicity allows for substantial shedding of tumor cells into the vasculature.

It has been shown that there is a direct correlation between tumor microvessel density and the incidence of metastasis. Tumor cells themselves can produce factors that stimulate the proliferation of endothelial cells and new capillary growth. Angiogenesis is

important in two stages of tumor metastasis: in vascularization of the tumor, which allows tumor cells to enter the blood stream and to circulate throughout the body; and after the tumor cells have left the primary site and settled into the secondary (metastasis) site, angiogenesis must occur before the new tumor can grow and expand. Therefore, prevention of angiogenesis could lead to the prevention of metastasis of tumors and possibly contain the neoplastic growth at the primary site.

Blockage of angiogenesis is recognized as one of the most promising strategies against cancer (including metastases), retinopathy and endometriosis, among other diseases. A significant increase in the research effort in the angiogenesis field over the past decade has resulted in a substantial increased understanding of the angiogenic process and subsequently the development of new therapeutics to modulate angiogenesis. Because of their extended biological half-life, high diffusibility coefficient and cost effective synthesis non-peptidic antiangiogenic small molecules (SMs) are the main focus of pharmaceutical companies and academic institutions.

Angiogenesis-based anti-tumor therapies typically use natural and synthetic angiogenesis inhibitors such as angiostatin, endostatin and tumstatin. Recently the Food and Drug Administration (FDA) approved an antibody therapy targeting angiogenesis in colorectal cancer. This therapy is based on a monoclonal antibody directed against an isoform of VEGF and is marketed under the trade name Avastin®. The pharmaceutical industry has focused in the development tyrosine kinase inhibitors and tubulin binders as antiangiogenic small molecules. Thus, a need exists for small molecules which exploit other angiogenesis pathways.

SUMMARY OF THE DISCLOSURE

The present disclosure relates to the identification of a new set of antiangiogenic small molecule inhibitors. Cell-based high throughput screenings (HTS) together with chemo-informatic tools were applied to the discovery of antiangiogenic small molecules. Rather than targeting the HTS to a single subcellular molecule, the screen described herein targeted the entire cellular process of angiogenesis. In particular, two cell based assays were employed, which represent the two most important steps in angiogenesis: endothelial cell growth and tube formation.

As a result, a new set of antiangiogenic small molecules (SMs) have been discovered. Structure-activity-relationship (SAR) studies have shown that the majority of the newly identified bioactive SMs are not related to previously recognized antiangiogenic SMs,

based on comparisons to various databases (*e.g.*, FDA marketed compounds; SMs currently in clinical trials compounds; and SMs annotated as antiangiogenic in chemical databases compounds, PubChem, LeadScope, DrugBank, DTP/NCI, etc.).

Based on the identification of this new set of antiangiogenic SMs, disclosed herein
5 are methods for inhibiting angiogenesis (particularly undesired angiogenesis) in a subject that include administering to a subject a therapeutically effective amount of at least one antiangiogenic compound (*e.g.*, antiangiogenic small molecule) from among the compounds referred to herein as Compounds 1-77, or pharmaceutically acceptable salts thereof, examples of which are described in detail below.

10 Also disclosed herein are methods of inhibiting angiogenesis that include administering to a subject a therapeutically effective amount of at least one of the compounds referred to herein as Compounds 1-77, or pharmaceutically acceptable salts thereof, examples of which are described in detail below.

Further disclosed herein are compounds having a structure represented by any one of
15 the formulas shown in TABLE 1 (referred to herein as Compounds 1-77), and pharmaceutically acceptable salts thereof. Pharmaceutical compositions that include the above-described compounds are also disclosed herein.

Thus, disclosed herein are pharmaceutical compositions for treating an angiogenesis-dependent disease, comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-
20 1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically-acceptable salt thereof. In particular examples, the pharmaceutical composition further comprises [4-[(4-
25 arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

Also disclosed herein are pharmaceutical compositions for inhibiting aberrant angiogenesis or inhibiting growth of neoplasitic tissue comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin
30 (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically-acceptable salt thereof. In particular examples, the pharmaceutical

composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

Also disclosed herein are methods of treating an angiogenesis-dependent disease, comprising: administering to a subject having or predisposed to an angiogenesis-dependent disease a therapeutically effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof. In particular embodiments of the methods, the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

Further disclosed herein are methods of inhibiting undesired angiogenesis in a subject, comprising: identifying a subject wherein angiogenesis is not desired, and administering to the subject a therapeutically effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof. In particular examples of the disclosed methods, the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

Also disclosed are methods of inhibiting a neoplasm in a subject, comprising: administering to the subject a therapeutically effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof. In particular examples, the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

Further disclosed are methods of inhibiting angiogenesis in a tissue or a target area in a subject wherein the formation of new blood vessels is not desired, comprising identifying a tissue or target area in a subject wherein the formation of new blood vessels is not desired;

and introducing directly or indirectly into the tissue or target area an effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof, thereby inhibiting angiogenesis in the tissue or target area. In particular examples, the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

The foregoing and other objects, features, and advantages will become more apparent from the following detailed description, which proceeds with reference to the figures.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows a summarized workflow utilized for the identification of the new set of antiangiogenic SMs described herein. Additional details are provided in Example 1.

Figure 2 shows the basic experimental design for the growth and tube formation HTS assays.

Figure 3 shows the results on one of the plates (4143-11) included in the growth HTS using porcine aortic endothelial (PAE) cells. The plot represents fluorescence emission of all 96 wells over 7 days; as expected, fluorescence values increase over time although different wells show different fluorescence values. A composite image of all 96 wells is also shown (at day 4 of growth). Positive controls are shown in the far right column of wells; as expected, these controls show maximum values of fluorescence (in the plot) and high density of cells in the wells. A negative control is shown in the left column of wells; these show low fluorescence values in the plot and low cell density in the wells. Additionally, an example of a compound which blocks growth of PAE is shown in the first row, fourth column from the left, with low fluorescence values and few cells in the well. Furthermore, an example of a compound which does not inhibit the growth of PAE is shown in the seventh row, fourth column. In this case, high fluorescence values are shown in the plot together with a high number of cells in the well.

Figure 4: Following the same protocol, HTS growth experiments were performed for PAE, BEC, A549 and MCF7 cells. These experiments were designed to explore the

specificity of SMs with inhibitory activity in endothelial cells as compared to tumor cells from different anatomical origins.

The image in Figure 4 shows a heatmap which summarizes the results obtained in the HTS experiments. The heatmap was constructed using the function heatmap.2 of the package gplots of the R statistical software. Clustering was performed using Euclidean distance matrix. The X axis shows the 1974 SMs tested and the Y axis represents some of the growth HTS experiments performed. For all experiments, measurements obtained in different days have been included and as expected show a high degree of consistency. Dark cells in the heatmap represent SMs with strongest growth inhibitory activity, and lighter greys are SM with no activity on growth.

Figure 5: In order to study SMs which preferentially inhibit the growth of endothelial cells or tumor cells, average growth activity values for endothelial cells and tumor cells were compared in a bivariate scatterplot. Most of the SMs do not have an effect on growth in any of the cell lines tested and cluster in the center of the scatterplot (indicated within the middle-sized oval). Also, most SMs with growth inhibitory activity show similar potency against tumor cells and endothelial cells and therefore cluster in the lower left quadrant (indicated within the largest oval). Interestingly, a few SMs showed growth inhibitory activity in tumor cells but not in endothelial cells (small oval; see also TABLE 10). Growth activity of these small molecules is shown in the adjacent plot (small molecules are identified by their position in the plate; TABLE 10 correlates plate position to NSC number).

Figure 6: Dose response curves were constructed for all the SMs of interest using PAE cells. Data were fitted to non-linear sigmoid curves using GraphPad Prism (GraphPad Software, Inc., La Jolla, CA). Since the initial screening was performed using a final SM concentration of 1μM, IC50 for most compounds were confirmed to be in the range of 10^{-12} to 10^{-9} M. This confirms that all the SMs discovered in this project are highly potent inhibitors of endothelial cell growth.

Figure 7: In order to explore the cytotoxic potential of the SMs of interest, a novel high throughput cytotoxicity assay was developed, and is further described in U.S. Application No. 12/060,752 (published as US 2009/0088341 on April 2, 2009; incorporated herein by reference in its entirety). In Figure 7, two different hypothetical situations are graphically described: In the lower area of the diagram, fluorescent cells are exposed to a cytotoxic substance, which results in the release of florescence to the cell culture medium. Both the fluorescence in the medium and the remaining fluorescence in the cells can be

quantitated and used to calculate the percentage of cytotoxicity using the formula in the lower area of the figure. The plot shows the expected dose response curve when Triton X is used as a cytotoxic agent on PAE cells.

Figure 8 shows an example of four compounds with growth inhibitory activity, two of which present a strong and moderate cytotoxic activity respectively. Using the cytotoxicity assay illustrated in Figure 7 and described herein, four compounds were identified as cytotoxic (NSC 88903, NSC 310551, NSC 18877, and NSC 321206; see TABLE 10).

Figure 9 shows a screen shot from the an image analysis program named AngioApplication™, which was developed for the HTS format and permitted a morphological quantitative analysis of tube formation (described in detail in U.S. Application No. 12/060,752, which published as US 2009/0088341 on April 2, 2009; incorporated herein by reference in its entirety). This software is able to rapidly assess a variety of metrics in images of tube formation including (but not limited to) tube length, node area, branching points, fractal dimension and lacunarity.

Figure 10 shows how principal component analysis was used to investigate which metrics explained better the variability of the data sets. The results showed that emptiness and branching index were the most appropriate metrics.

Figure 11: Emptiness (C1) and branching index (C2) were plotted in a bivariate scatter plot for every SM tested. The Euclidean distance between the average of the positive controls and every SM was used as metric to define anti-tube formation activity (calculations were done separately for every plate). In essence, compounds which are further away from the positive controls are more likely to be antiangiogenic. This figure illustrates the results from all the SMs in one plate. As expected, most of the compounds (small squares clustered in center of graph) are located closely to the positive controls (large squares clustered near center of graph). In contrast, the negative controls (large squares clustered in lower right corner of graph) are positioned farther away from the positive controls. Representative images of the positive and negative control cells are shown. Tube formation inhibitory compounds are detected as being located at an intermediate distance between the positive controls and the negative controls. A representative image of an active SM is shown. 35 out the 1974 compounds in the library (1.75%) were found to statistically significantly inhibit tube formation (TABLE 10).

Figure 12: IC50 were calculated for all tube formation inhibitors. As expected, most IC50 were in the range of 10^{-9} to 10^{-12} M, making these compounds highly effective

tube formation inhibitors. This figure illustrates an example of the dose response generated with compound NSC119889.

Figure 13 summarizes the results obtained in the growth and tube formation HTS for endothelial cells; information related to specific compounds is summarized in TABLE 10.
5 2.4% (48) of the compounds were growth inhibitors, and 1.75% (35) were tube formation inhibitors. 0.5% (11) of the compounds showed both growth and tube formation inhibitory activity.

Figure 14: The antiangiogenic SMs identified in this project were structurally compared with annotated compounds in available annotated SM databases, such as
10 PubChem, DrugBank, LeadScope and FDA Marketed Drugs among others. Structural classifications were performed with LeadScope software. Only a few of the SMs identified were structurally related to annotated compounds in other databases (numbers in parenthesis in the above figure). This can be explained by the novel drug discovery methodology utilized in this project, which, as expected, results in compounds with novel SARs. None of
15 the antiangiogenic SMs discovered in this project are structurally related to any known antiangiogenic SMs. This supports the novelty of the herein described antiangiogenic SMs and emphasizes that new SARs will result in exploitation of new cellular antiangiogenic pathways.

Figure 15 is a series of graphs showing the inhibitory effects of selected SMs on
20 growth of tumor xenografts. Top panels show the effect of SMs on growth of A549 tumors. Bottom panels show the effect of SMs on growth of SK-ML-1tumors.

Figure 16 is a series of graphs showing the effects of selected SMs on the inhibition of tubulin polymerization.

Figure 17 is a series of volcano plots showing quantitative real time RT-PCR
25 analysis of the effects of selected SMs on expression of genes implicated in angiogenesis

SEQUENCE LISTING

The nucleic and/or amino acid sequences listed in the accompanying sequence listing are shown using standard letter abbreviations for nucleotide bases, and three letter code for
30 amino acids, as defined in 37 C.F.R. 1.822. Only one strand of each nucleic acid sequence is shown, but the complementary strand is understood as included by any reference to the displayed strand. The SEQ ID designations in the accompanying sequence listing are set forth in Table 13. Sequences and information associated with the accession numbers listed

on Table 14 (and available online at ncbi.nlm.nih.gov/guide/) are incorporated by reference herein in their entirety.

The Sequence Listing is submitted as an ASCII text file, Annex C/St.25 text file, created on July 27, 2010, 68.1 KB, which is incorporated by reference herein.

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DETAILED DESCRIPTION OF SEVERAL EMBODIMENTS

I. Abbreviations

bFGF: basic fibroblast growth factor
EC50: The term half maximal effective concentration
10 **FDA:** Food and Drug Administration
GFP: green fluorescent protein
HTS: high throughput screen
PAE: porcine aortic endothelial
RTK: receptor tyrosine kinase
15 **SAR**: structure-activity relationship
SMs: small molecules
RFP: red fluorescent protein
VEGF: vascular endothelial growth factor
YFP: yellow fluorescent protein
20

II. Terms

Unless otherwise noted, technical terms are used according to conventional usage. Definitions of common terms in molecular biology can be found in Benjamin Lewin, Genes V, published by Oxford University Press, 1994 (ISBN 0-19-854287-9); Kendrew *et al.*
25 (eds.), The Encyclopedia of Molecular Biology, published by Blackwell Science Ltd., 1994 (ISBN 0-632-02182-9); and Robert A. Meyers (ed.), Molecular Biology and Biotechnology: a Comprehensive Desk Reference, published by VCH Publishers, Inc., 1995 (ISBN 1-56081-569-8).

Unless otherwise explained, all technical and scientific terms used herein have the
30 same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. The singular terms "a," "an," and "the" include plural referents unless context clearly indicates otherwise. Similarly, the word "or" is intended to include "and" unless the context clearly indicates otherwise. The term "comprises" means "includes." The abbreviation, "*e.g.*" is derived from the Latin *exempli gratia*, and is used herein to indicate a
35 non-limiting example. Thus, the abbreviation "*e.g.*" is synonymous with the term "for example." All chemical compounds include both the (+) and (-) stereoisomers (as well as either the (+) or (-) stereoisomer), and any tautomers thereof. It is further to be understood that all molecular weight or molecular mass values given for compounds are approximate,

and are provided for description. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of this disclosure, suitable methods and materials are described herein. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

5 To facilitate review of the various embodiments of the disclosure, the following explanations of specific terms are provided:

Acid: A compound capable of transferring a hydrogen atom in solution. Acid is inclusive of, but not limited to, a carboxylic acid.

Administer/Administration: To give or apply, for instance to a subject. To 10 "introduce" is understood to be equivalent to "administer." This term includes topical, parenteral, oral, intravenous, intra-muscular, sub-cutaneous, inhalational, nasal, or intra-articular routes of administration, among others. By way of example, a therapeutic compound, such as an antiangiogenic agent, can be administered. Administration can be local or systemic, direct or indirect.

15 Non-limiting examples of local administration include, but are not limited to, topical administration, subcutaneous administration, intramuscular administration, intrathecal administration, intrapericardial administration, intra-ocular administration, topical ophthalmic administration, or administration to the nasal mucosa or lungs by inhalational administration. In addition, local administration includes routes of administration typically 20 used for systemic administration, for example by directing intravascular administration to the arterial supply for a particular organ or tumor. Thus, in particular embodiments, local administration includes intra-arterial administration and intravenous administration when such administration is targeted to the vasculature supplying a particular organ or tumor.

Systemic administration includes any route of administration designed to distribute 25 the administered compound widely throughout the body via the circulatory system. Thus, systemic administration includes, but is not limited to, intra-arterial and intravenous administration. Systemic administration also includes, but is not limited to, topical administration, subcutaneous administration, intramuscular administration, or administration by inhalation, when such administration is directed at absorption and distribution throughout 30 the body by the circulatory system.

Direct administration or introduction involves the direct contact of a compound to a target are, such as by injection. Indirect administration or introduction involves any other method other than direct contact of the compound, for example by oral ingestion.

Alkyl: A branched or straight chain alkyl group containing only carbon and hydrogen. In certain embodiments, alkyl groups may contain one to twelve carbon atoms, particularly one to six carbon atoms. This term is further exemplified by groups such as methyl, ethyl, n-propyl, isobutyl, t-butyl, pentyl, pivalyl, heptyl, adamantyl, and cyclopentyl.
5 Alkyl groups can either be unsubstituted or substituted with one or more substituents, *e.g.*, halogen, alkoxy, cycloalkyl, alkylthio, trifluoromethyl, acyloxy, hydroxy, mercapto, carboxy, aryloxy, aryl, arylalkyl, heteroaryl, amino, alkylamino, dialkylamino, morpholino, piperidino, pyrrolidin-1-yl, piperazin-1-yl, or other functionality.

Amino acid moiety: A moiety that contain one or more primary, secondary or
10 tertiary amino groups and one or more acidic carboxyl groups (-COOH) or a moiety that is a derivative or residue of an amino acid in the sense that the moiety contains one or more amino groups (*e.g.*, $-NH_2$) and one or more ester groups (*i.e.*, -OC(O)-).

Animal: A living multi-cellular vertebrate organism, a category that includes, for example, mammals and birds. The term mammal includes both human and non-human
15 mammals. Similarly, the term "subject" includes both human and veterinary subjects, for example, humans, non-human primates, dogs, cats, horses, pigs, rats, mice, and cows.

Angiogenesis: A biological process leading to the generation of new blood vessels through sprouting and/or growth from pre-existing blood vessels. The process can involve the migration and proliferation of endothelial cells from preexisting vessels. Angiogenesis
20 occurs during pre-natal development, post-natal development, and in the adult. In the adult, angiogenesis occurs during the normal cycle of the female reproductive system, wound healing, and during pathological processes such as cancer (for a review see Battegay, *J. Molec. Med.* 73(7): 333-346, 1995).

Angiogenic activity: The ability of an agent to promote or inhibit angiogenesis.
25 Angiogenic activity can be measured in an angiogenesis assay, for example using the fluorescent cell-lines and assays disclosed herein and/or in U.S. application no. 12/060,752 (published as US 2009/0088341 on April 2, 2009; and incorporated herein by reference in its entirety).

Angiogesis-dependent disease: A disease that is at least partially dependent on the
30 stimulation of aberrant (undesired) angiogenesis for its progression. Aberrant angiogenesis can result from misexpression of angiogenic factors in otherwise normal cells. Aberrant angiogenesis can also be stimulated by tumors producing one or more angiogenic factors.

Angiogenic factor: A molecule that affects angiogenesis, for example by stimulating or inhibiting angiogenesis. Numerous experiments have suggested that tissues

secrete factors that promote angiogenesis under conditions of poor blood supply during normal and pathological angiogenesis processes. The formation of blood vessels is initiated and maintained by a variety of factors secreted either by a cell (such as a tumor cell) or by accessory cells. Many different growth factors and cytokines have been shown to exert chemotactic, mitogenic, modulatory or inhibitory activities on endothelial cells, smooth muscle cells and fibroblasts and can, therefore, be expected to participate in an angiogenic process. For example, factors modulating growth, chemotactic behavior and/or functional activities of vascular endothelial cells include aFGF, bFGF, angiogenin, angiotropin, epithelial growth factor, IL-8, and vascular endothelial growth factor (VEGF) among others.

Because many angiogenic factors are mitogenic and chemotactic for endothelial cells, their biological activities (such as angiogenic activities) can be determined *in vitro* by measuring the induced migration of endothelial cells or the effect of these factors on endothelial cell proliferation using the cell-lines assays and methods disclosed herein. For example, migration assays and other assays, such as tubule formation assays and growth assays can also be used to determine angiogenic activity, for example the angiogenic activity in the presence of a test agent, such as a potential angiogenesis inhibitor.

Aryl: A monovalent unsaturated aromatic carbocyclic group having a single ring (*e.g.*, phenyl) or multiple condensed rings (*e.g.*, naphthyl or anthryl), which can optionally be unsubstituted or substituted with, *e.g.*, halogen, alkyl, alkoxy, mercapto (-SH), alkylthio, trifluoromethyl, acyloxy, hydroxy, mercapto, carboxy, aryloxy, another aryl, arylalkyl, heteroaryl, amino, alkylamino, dialkylamino, morpholino, piperidino, pyrrolidin-1-yl, piperazin-1-yl, or other functionality.

Biological sample: A sample obtained from a plant or animal subject about which information is desired, for example, information about the samples ability to promote cellular growth, tubule formation, and/or cellular migration. As used herein, biological samples include all clinical samples, including, but not limited to, cells, tissues, and bodily fluids, such as: blood; derivatives and fractions of blood, such as serum, and lymphocytes (such as B cells, T cell, and subfractions thereof); extracted galls; biopsied or surgically removed tissue, including tissues that are, for example, unfixed, frozen, fixed in formalin and/or embedded in paraffin; tears; milk; skin scrapes; surface washings; urine; sputum; cerebrospinal fluid; prostate fluid; pus; bone marrow aspirates; middle ear fluids, bronchoalveolar levage, tracheal aspirates, sputum, nasopharyngeal aspirates, oropharyngeal aspirates, or saliva. In particular embodiments, the biological sample is obtained from an animal subject, such as in the form of middle ear fluids, bronchoalveolar levage, tracheal

aspirates, sputum, nasopharyngeal aspirates, oropharyngeal aspirates, or saliva. In particular embodiments, the biological sample is obtained from a subject, such as blood or serum. A **patient sample** is a sample obtained from a subject, such as a mammalian subject, for example a human subject under medical care.

5 **Cellular activity:** An activity of a particular cell-line, such as the ability of the cell to divide, migrate in response to stimulus, or to form three dimensional structures, such as tubules. Cellular activity(s) of a particular cell-line can be assessed using *in vitro* assays, for example the assays disclosed herein.

Cancer: A malignant disease characterized by the abnormal growth and
10 differentiation of cells. "Metastatic disease" refers to cancer cells that have left the original tumor site and migrate to other parts of the body for example via the bloodstream or lymph system.

Examples of hematological tumors include leukemias, including acute leukemias (such as acute lymphocytic leukemia, acute myelocytic leukemia, acute myelogenous
15 leukemia and myeloblastic, promyelocytic, myelomonocytic, monocytic and erythroleukemia), chronic leukemias (such as chronic myelocytic (granulocytic) leukemia, chronic myelogenous leukemia, and chronic lymphocytic leukemia), polycythemia vera, lymphoma, Hodgkin's disease, non-Hodgkin's lymphoma (indolent and high grade forms), multiple myeloma, Waldenstrom's macroglobulinemia, heavy chain disease, myelodysplastic
20 syndrome, hairy cell leukemia, and myelodysplasia.

Examples of solid tumors, such as sarcomas and carcinomas, include fibrosarcoma, myxosarcoma, liposarcoma, chondrosarcoma, osteogenic sarcoma, and other sarcomas, synovioma, mesothelioma, Ewing's tumor, leiomyosarcoma, rhabdomyosarcoma, colon carcinoma, lymphoid malignancy, pancreatic cancer, breast cancer (such as adenocarcinoma),
25 lung cancers, gynecological cancers (such as, cancers of the uterus (*e.g.*, endometrial carcinoma), cervix (*e.g.*, cervical carcinoma, pre-tumor cervical dysplasia), ovaries (*e.g.*, ovarian carcinoma, serous cystadenocarcinoma, mucinous cystadenocarcinoma, endometrioid tumors, celioblastoma, clear cell carcinoma, unclassified carcinoma, granulosa-thecal cell tumors, Sertoli-Leydig cell tumors, dysgerminoma, malignant teratoma), vulva (*e.g.*,
30 squamous cell carcinoma, intraepithelial carcinoma, adenocarcinoma, fibrosarcoma, melanoma), vagina (*e.g.*, clear cell carcinoma, squamous cell carcinoma, botryoid sarcoma), embryonal rhabdomyosarcoma, and fallopian tubules (*e.g.*, carcinoma)), prostate cancer, hepatocellular carcinoma, squamous cell carcinoma, basal cell carcinoma, adenocarcinoma, sweat gland carcinoma, medullary thyroid carcinoma, papillary thyroid carcinoma,

pheochromocytomas sebaceous gland carcinoma, papillary carcinoma, papillary adenocarcinomas, medullary carcinoma, bronchogenic carcinoma, renal cell carcinoma, hepatoma, bile duct carcinoma, choriocarcinoma, Wilms' tumor, cervical cancer, testicular tumor, seminoma, bladder carcinoma, and CNS tumors (such as a glioma, astrocytoma, medulloblastoma, craniopharyogioma, ependymoma, pinealoma, hemangioblastoma, acoustic neuroma, oligodendroglioma, menangioma, melanoma, neuroblastoma and retinoblastoma), and skin cancer (such as melanoma and non-melanoma).

Cell culture: The process by which either prokaryotic or eukaryotic cells are grown under controlled conditions. In practice the term "cell culture" has come to refer to the culturing of cells derived from multicellular eukaryotes, especially animal cells, such as mammalian cells, for example the fluorescent cells disclosed herein. Mammalian cells are grown and maintained at an appropriate temperature and gas mixture (typically, 37°C, 5% CO_2) in a cell incubator. Culture conditions vary widely for each cell type, and variation of conditions for a particular cell type can result in different phenotypes being expressed. Aside from temperature and gas mixture, the most commonly varied factor in culture systems is the growth medium. Recipes for growth media can vary in pH, glucose concentration, growth factors, and the presence of other nutrient components. The growth factors used to supplement media are often derived from animal blood, such as calf serum.

Some cells naturally live without attaching to a surface, such as cells that exist in the bloodstream. Others require a surface, such as most cells derived from solid tissues. Cells grown unattached to a surface are referred to as suspension cultures. Other adherent cultures cells can be grown on tissue culture plastic, which may be coated with extracellular matrix components (for example collagen or fibronectin) to increase its adhesion properties and provide other signals needed for growth. "Co-culture" refers to the culture of more than one cell-line (such as more than one of the disclosed cell-lines) in a single vessel. Co-cultures can be 2-dimensional (2-D) or 3-dimensional (3-D). Examples of both 2-D and 3-D co-cultures are described in U.S. Patent Application No. 12/802,666, filed on June 10, 2010 *published as _______________ on ___________).

Chemotherapeutic agents: Any chemical agent with therapeutic usefulness in the treatment of diseases characterized by abnormal cell growth. Such diseases include tumors, neoplasms, and cancer as well as diseases characterized by hyperplastic growth such as psoriasis. In one embodiment, a chemotherapeutic agent is an angiogenesis inhibitor. Chemotherapeutic agents are described for example in Slapak and Kufe, *Principles of Cancer Therapy*, Chapter 86 in Harrison's Principles of Internal Medicine, 14th edition;

Perry *et al.*, Chemotherapy, Ch. 17 in Abeloff, *Clinical Oncology 2nd ed.*, 2000 Churchill Livingstone, Inc; Baltzer and Berkery. (eds): *Oncology Pocket Guide to Chemotherapy*, 2nd ed. St. Louis, Mosby-Year Book, 1995; Fischer Knobf, and Durivage (eds): *The Cancer Chemotherapy Handbook*, 4th ed. St. Louis, Mosby-Year Book, 1993. Combination
5 chemotherapy is the administration of more than one agent to treat cancer, for example an alkylating agent and an angiogenesis inhibitor.

Contacting: To place in direct physical association, including in solid or in liquid form. Contacting can occur *in vivo,* for example by administering an agent to a subject, or *in vitro* for example with isolated cells or cell-cultures, for example cell-cultures of the
10 disclosed fluorescent cell-lines.

Control: A reference standard. A control can be a known value indicative of basal cellular activity, such as basal migratory potential, doubling time, tubule formation potential and the like, or a control cell-culture, such as a culture including at least one of the disclosed fluorescent cell-lines, not treated with an exogenous agent, such as a test agent, one or more
15 cell-lines (such as the fluorescent cell-lines disclosed herein), angiogenic factor, angiogenic inhibitor, or the like. A difference between a test sample and a control can be an increase or conversely a decrease. The difference can be a qualitative difference or a quantitative difference, for example a statistically significant difference. In some examples, a difference is an increase or decrease, relative to a control, of at least about 10%, such as at least about
20 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 100%, at least about 150%, at least about 200%, at least about 250%, at least about 300%, at least about 350%, at least about 400%, at least about 500%, or greater then 500%.

Cycloalkyl: Includes a moiety that contains at least one cycloalkyl ring structure.
25 There may be one or more ring structures including a bridged cyclic structure or a fused ring structure. The cycloalkyl may be unsubstituted or substituted with one or more substituents, *e.g.*, halogen, alkoxy, alkylthio, trifluoromethyl, acyloxy, hydroxy, mercapto, carboxy, aryloxy, aryl, arylalkyl, heteroaryl, amino, alkylamino, dialkylamino, morpholino, piperidino, pyrrolidin-1-yl, piperazin-1-yl, or other functionality. Illustrative cycloalkyl groups include
30 cyclopropyl, cyclopentyl, cyclohexyl, cyclobutyl, and decahydronaphthyl.

EC50: The term half maximal effective concentration (EC50 or EC_{50}) refers to the concentration of a drug which induces a response halfway between the baseline and maximum. EC50 is commonly used as a measure of drug potency.

Electromagnetic radiation: A series of electromagnetic waves that are propagated by simultaneous periodic variations of electric and magnetic field intensity, and that includes radio waves, infrared, visible light, ultraviolet light, X-rays and gamma rays. In particular examples, electromagnetic radiation is emitted by a laser, which can possess properties of monochromaticity, directionality, coherence, polarization, and intensity. Lasers are capable of emitting light at a particular wavelength (or across a relatively narrow range of wavelengths), for example such that energy from the laser can excite one fluorophore with a specific excitation wavelength but not excite a second fluorophore with a specific excitation wavelength difference and distinct from the excitation wavelength on the first fluorophore.

Emission or emission signal: The light of a particular wavelength generated from a source. In particular examples, an emission signal is emitted from a fluorophore, such as a fluorescent protein, after the fluorophore absorbs light at its excitation wavelength(s).

Excitation or excitation signal: The light of a particular wavelength necessary and/or sufficient to excite an electron transition to a higher energy level. In particular examples, an excitation is the light of a particular wavelength necessary and/or sufficient to excite a fluorophore, such as a fluorescent protein, to a state such that the fluorophore will emit a different (such as a longer) wavelength of light then the wavelength of light from the excitation signal.

Exogenous agent: An exogenous agent is any agent external to a target cell-line that is to be studied, and it includes small molecules, proteins, biological samples (such as patient samples) and other cells or cell-lines, such as fluorescent cell-lines other than the target cell-line, for example a different type of cell that can by identified as different by a distinguishable fluorescent signal.

Expression: With respect to a gene sequence, refers to transcription of the gene and, as appropriate, translation of the resulting mRNA transcript to a protein. Thus, expression of a protein coding sequence, such as the expression of a fluorescent protein, results from transcription and translation of the coding sequence for that protein. **Constitutive expression** refers to the expression of a gene product, such as a protein, for example a fluorescent protein, in a substantial continuous manner, such that the expression is not interrupted. An example of constitutive expression is continuous expression in the absence of an exogenous stimulating agent, such as an agent used to activate a promoter. **Stable expression** refers to expression that is not lost or reduced substantially over time, for example expression that does not diminish through multiple passages of a cell-line, for example a cell-line constitutively expressing a fluorescent protein.

Fluorescent property: A characteristic of a fluorescent molecule, such as a fluorescent protein, for example green fluorescent protein, red fluorescent protein, yellow fluorescent protein, cyan fluorescent protein and the like. Examples of fluorescent properties include the molar extinction coefficient at an appropriate excitation wavelength, the fluorescence quantum efficiency, the shape of the excitation spectrum or emission spectrum (the "fluorescence spectrum," the excitation wavelength maximum and emission wavelength maximum, the ratio of excitation amplitudes at two different wavelengths, the ratio of emission amplitudes at two different wavelengths, the excited state lifetime, or the fluorescence anisotropy. **Quantifying fluorescence** refers to the determination of the amount of fluorescence generated by a fluorophore, for example a fluorescent protein, which can be the quantity of photons emitted by a fluorophore. In some examples, fluorescence is quantified by measuring the intensity of a fluorescence signal at a particular wavelength, for example the wavelength of the emission maxima of a particular fluorophore, such as a fluorescent protein. Fluorescence intensity can also be quantified at a wavelength that is not the emission maxima of a particular fluorophore, for example to avoid emission spectra that overlap and thereby interfere with the emission maxima of a particular fluorophore, such as a particular fluorescent protein. In some examples, a fluorescence signal is emitted by a population of fluorescent proteins, for example fluorescent proteins present in a population of cells containing such fluorescent proteins. Such a signal can be quantified, for example to determine the number, or relative number of cells that emit such a fluorescent signal. **Detecting a pattern of fluorescence** refers to the correlation of a fluorescent signal to a specific location to determine the location where a fluorescence signal, such as a fluorescent signal of a particular wavelength, originates. In some examples, a pattern of fluorescence determines the location and or shape of the cells that emit a fluorescence signal, such as cells containing a fluorescent protein, for example to determine the number of the total area of the tubules, the total number of tubules, number of nodes, number of branch points, the number of tubes per node, or node area formed by such cells using the methods disclosed herein, and disclosed in U.S. application no. 12/060,752 (published as US 2009/0088341 on April 2, 2009; and incorporated herein by reference in its entirety).

Fluorescent protein: A protein capable of emission of a detectable fluorescent signal. Fluorescent proteins can be characterized by the wavelength of their emission spectrum. For example green fluorescent protein (GFP) has a fluorescent emission spectrum in the green part of the visible spectrum. In addition to green-fluorescent proteins, fluorescent proteins are known which fluoresce in other regions of the visible spectrum, for

example blue-fluorescent proteins, cyan-fluorescent proteins, yellow-fluorescent proteins, orange-fluorescent proteins, red-fluorescent proteins, and far-red fluorescent proteins. Examples of fluorescent proteins can be found in the following patent documents: U.S. Patent Nos. 5,804,387; 6,090,919; 6,096,865; 6,054,321; 5,625,048; 5,874,304; 5,777,079;
5 5,968,750; 6,020,192; 6,146,826; 6,969,597; 7,150,979; 7,157,565; and 7,166,444; and published international patent applications WO 07/085923; WO 07/052102, WO 04/058973, WO 04/044203, WO 03/062270; and WO 99/64592. Additional examples of fluorescent proteins are available from Clonetech, Laboratories, Inc. (Mountain View, CA) under the trade name Living Colors®. Nucleic acids encoding such fluorescent proteins can
10 be incorporated into mammalian expression vectors for use in producing the disclosed fluorescent cell-lines.

Growth rate: The expansion of the number of cells of a specified cell-line through cell division as a function of time. In one example the growth rate is the rate at which a cell-line grown in culture doubles.

15 **Halogen**: Refers to fluoro, bromo, chloro and iodo substituents.

High throughput technique: Through this process one can rapidly identify active compounds, antibodies or genes which affect a particular biomolecular pathway, for example pathways in angiogenesis. In certain examples, combining modern robotics, data processing and control software, liquid handling devices, and sensitive detectors, high throughput
20 techniques allows the rapid screening of potential pharmaceutical agents in a short period of time.

Histology: The study of the microscopic anatomy and classification of tissue, including the histology of mammalian cells, such as cells and cell-lines from mammalian tissues. **Histological typing** refers to the categorizing of tissue into histological types, for
25 example by microanatomical origin (such as connective tissue, nerves, muscles, and circulatory cells, among others) or cell-types (such as epithelial cells, stromal cells among others). Cells can be classified as being of **different histological types** by virtue of the staining and/or reaction with antibodies, or by characteristic microanatomical features. Cells of different histological types interact differently with different stains and/or antibodies.
30 Methods for histological typing are well known in the art. Histology can be use to determine if cells are of different types. Thus, in some examples different cell-lines are histologically different cell-lines.

Immortalized cell or cell-line: A cell or cell-line that has acquired the ability to proliferate indefinitely either through random mutation or deliberate modification, such as

artificial expression of the telomerase gene. There are numerous well established immortalized cell-lines representative of particular cell types.

Inhibitor (for example, of angiogenesis): A substance capable of inhibiting [something] to some measurable extent, for example angiogenesis. In disclosed examples, inhibition of angiogenesis is measured in one of the assays disclosed herein.

Mammal: This term includes both human and non-human mammals. Similarly, the term "subject" includes both human and veterinary subjects, for example, humans, non-human primates, mice, rats, dogs, cats, horses, and cows.

Migration potential: The ability of cells, such as the cell-line disclosed herein, to translocate in response to a chemical stimulus, such as a growth factor. Migration potential can be determined with the assays disclosed herein.

Mixed cell population: A population of cells, such as cells in culture, that contains two or more different types of cells, such as histologically different cell-lines. Examples of different types of cells include cells of different embryonic origin (such as cells originating from the ectoderm, endoderm, or mesoderm), cells from different cellular locations (such as cells from epithelium, endothelium, or stroma), cells from different tissues or organs (such as cells from pulmonary myocardial, neural, vascular, skin, bone, or skeletal or smooth muscle tissue).

Neoplasm or tumor: Any new and abnormal growth; particularly a new growth of tissue in which the growth is uncontrolled and progressive. A neoplasm, or tumor, serves no useful function and grows at the expense of the healthy organism.

In general, tumors appear to be caused by abnormal regulation of cell growth. Typically, the growth of cells in the body is strictly controlled; new cells are created to replace older ones or to perform new functions. If the balance of cell growth and death is disturbed, a tumor may form. Abnormalities of the immune system, which usually detects and blocks aberrant growth, also can lead to tumors. Other causes include radiation, genetic abnormalities, certain viruses, sunlight, tobacco, benzene, certain poisonous mushrooms, and aflatoxins.

Tumors are classified as either benign (slow-growing and usually harmless depending on the location), malignant (fast-growing and likely to spread and damage other organs or systems) or intermediate (a mixture of benign and malignant cells). Some tumors are more common in men or women, some are more common amongst children or elderly people, and some vary with diet, environment and genetic risk factors.

Symptoms of neoplasms depend on the type and location of the tumor. For example, lung tumors can cause coughing, shortness of breath, or chest pain, while tumors of the colon can cause weight loss, diarrhea, constipation and blood in the stool. Some tumors produce no symptoms, but symptoms that often accompany tumors include fevers, chills, night sweats, weight loss, loss of appetite, fatigue, and malaise.

Blood vessels supply tumors with nutrients and oxygen. Tumor growth is dependent on the generation of new blood vessels that can maintain the needs of the growing tumor, and many tumors secrete substances (angiogenic factors) that are able to induce proliferation of new blood vessels (angiogenesis). Anti-tumor therapies include the use of angiogenesis inhibitors, which reduce the formation of blood vessels in the tumor, effectively starving the tumor and/or cause the tumor to drown in its own waste.

Neovascularization: The growth of new blood vessels. Neovascularization can be the proliferation of blood vessels in tissue not normally containing them, or the proliferation of blood vessels in an ischemic or otherwise damaged tissue. Neovascularization can be pathological when it is unwanted or mediates a pathological process, for example when it occurs in the retina or cornea.

Passaging cells: Passaging or splitting cells involves transferring a small number of cells into a new vessel. Cells can be cultured for a longer time if they are split regularly, as it avoids the senescence associated with prolonged high cell density. Suspension cultures are easily passaged with a small amount of culture containing a few cells diluted in a larger volume of fresh media. For adherent cultures, cells first need to be detached; which is typically done with a mixture of trypsin-EDTA. A small number of detached cells can then be used to seed a new culture.

Pharmaceutical agent or drug: A chemical compound or composition capable of inducing a desired therapeutic or prophylactic effect when properly administered to a subject (such as the inhibition of angiogenesis), alone or in combination with another therapeutic agent(s) or pharmaceutically acceptable carriers. Pharmaceutical agents include, but are not limited to, angiogenic factors, for example bFGF, and VEGF, and anti-angiogenic factors, such as inhibitors of bFGF, or VEGF. For example, suitable anti-angiogenic factors include, but are not limited to, SU5416, which is a specific VEGF-R antagonist, SU6668 which blocks the receptors for VEGF, bFGF, and PDGF and Avastin®. See, for example, Liu *et al., Seminars in Oncology* 29 (Suppl 11): 96-103, 2002; Shepherd *et al., Lung Cancer* 34:S81-S89, 2001. The term pharmaceutical agent also can be applied to the bioactive

compounds discussed herein, including specifically the antiangiogenic compounds listed in TABLE 1, and characterized in TABLE 10.

Pharmaceutically acceptable carriers: The pharmaceutically acceptable carriers of use are conventional. *Remington's Pharmaceutical Sciences*, by E.W. Martin, Mack Publishing Co., Easton, PA, 15th Edition, 1975, describes compositions and formulations suitable for pharmaceutical delivery of the compositions disclosed herein.

In general, the nature of the carrier will depend on the particular mode of administration being employed. For instance, parenteral formulations usually comprise injectable fluids that include pharmaceutically and physiologically acceptable fluids such as water, physiological saline, balanced salt solutions, aqueous dextrose, glycerol or the like as a vehicle. For solid compositions (such as powder, pill, tablet, or capsule forms), conventional non-toxic solid carriers can include, for example, pharmaceutical grades of mannitol, lactose, starch, or magnesium stearate. In addition to biologically neutral carriers, pharmaceutical compositions to be administered can contain minor amounts of non-toxic auxiliary substances, such as wetting or emulsifying agents, preservatives, and pH buffering agents and the like, for example sodium acetate or sorbitan monolaurate.

Primary cells: Cells that are cultured directly from a subject. With the exception of some derived from tumors, most primary cell cultures have limited lifespan. After a certain number of population doublings cells undergo the process of senescence and stop dividing, while generally retaining viability.

Signal: A detectable change or impulse in a physical property that provides information. In the context of the disclosed methods, examples include electromagnetic signals, such as light, for example light of a particular quantity or wavelength, for example a wavelength of light emitted from a fluorescent protein.

Small molecule inhibitor (for example, of an inhibitory of angiogenesis): A molecule, typically with a molecular weight less than 1000 Daltons, or in some embodiments, less than about 500 Daltons, wherein the molecule is capable of inhibiting, to some measurable extent, an activity of some target molecule. In particular embodiments, the small molecule inhibitor is an inhibitor of angiogenesis, which activity can be tested, detected, determined, and/or measured using methods known in the art and/or described herein.

Test agent: Any agent that is tested for its effects, for example its effects on a cell. In some embodiments, a test agent is a chemical compound, such as an antiangiogenic agent or even an agent with unknown biological properties.

Therapeutically effective amount/dose: A dose sufficient to have a therapeutic effect, for example to inhibit to some degree advancement, or to cause regression of the disease, or which is capable of relieving symptoms caused by the disease. For example, a therapeutically effective amount of an angiogenesis inhibitor can vary from about 0.1 nM per kilogram (kg) body weight to about 1 μM per kg body weight, such as about 1 nM to about 500 nM per kg body weight, or about 5 nM to about 50 nM per kg body weight. The exact dose of a particular therapeutic/bioactive compound is readily determined by one of skill in the art based on the potency of the compound, the age, weight, sex and physiological condition of the subject, the disease being treated, and so forth.

Treating: Inhibiting the full development of a disease or condition, for example, in a subject who is at risk for a disease such as cancer. "Treatment" refers to a therapeutic intervention that ameliorates a sign or symptom of a disease or pathological condition after it has begun to develop. The term "ameliorating," with reference to a disease or pathological condition, refers to any observable beneficial effect of the treatment. The beneficial effect can be evidenced, for example, by a delayed onset of clinical symptoms of the disease in a susceptible subject, a reduction in severity of some or all clinical symptoms of the disease, a slower progression of the disease, an improvement in the overall health or well-being of the subject, or by other parameters well known in the art that are specific to the particular disease. A "prophylactic" treatment is a treatment administered to a subject who does not exhibit signs of a disease or exhibits only early signs for the purpose of decreasing the risk of developing pathology.

Tubule formation potential: The ability of a cell-line to form a tube-like structure *in vitro*, for example a structure similar to a blood vessel, such as a capillary. Tubule formation potential can be determined by determining the pattern displayed by cells which have been induced to form tubules, for example by determining the pattern of fluorescence from cells expressing fluorescent proteins, such as the cell-lines disclosed herein.

III. Description of Several Embodiments

Described herein is a stringent HTS strategy which, together with advanced bioinformatics mining tools, was used to identify a new set of antiangiogenic small molecules. The strategy included the following:

Two cell-based HTS were designed to identify small molecules that block the main steps of the angiogenic process: growth of endothelial cells and tube formation. In both assays, compounds were tested at a low final concentration (1μM) to avoid false positives.

The following classes of bioactive SMs were identified in these assays: 48 growth inhibitors, 35 tube formation inhibitors. 11 SMs block both growth and tube formation. 3 SMs have been identified as specific inhibitors of tumor growth; these compounds are not antiangiogenic but are antitumoral. See TABLE 10 for a summary of the HTS results.

5 All bioactive compounds were tested for their ability to induce cytotoxicity and apoptosis in endothelial cells. Three out the 77 small molecules were cytotoxic. These cytotoxic SMs were not considered for *in vivo* experiments. Another three SM showed 5-8 fold increase in apoptotic potential, and 11 showed a 2-3 fold increase (see TABLE 10).

Structure similarity analysis has revealed that most of the bioactive SMs (68) are not 10 structurally related to existing FDA marketed antiangiogenic SMs, SMs currently in clinical trials or SMs annotated as angiogenesis modulators in PubChem, DrugBank, LeadScope, etc. Therefore, based on structure-activity relationship (SAR), the compounds identified herein (see TABLE 1) represent a new set of antiangiogenic compounds functionally unrelated to known antiangiogenic SMs. Additional SAR analysis has identified a number of scaffolds 15 which correlate with inhibitory activity of both endothelial cell growth and endothelial cell tube formation (see TABLES 2-9).

Structure-activity-relationship (SAR) studies have shown a potential mechanism of action for some (14) of the SMs of interest. For instance, the structure of some of the growth inhibitors is consistent with topoisomerase II inhibitory activity while some tube formation 20 inhibitors show structures consistent with known tubulin binders. See TABLE 10.

Comparison of the growth inhibitory activity of these compounds in endothelial cells and tumor cells has allowed their classification in several groups including: 1) SMs able to inhibit the growth of both endothelial cells and tumor cells (Compounds 1-73); and 2) SMs which inhibit the growth of tumor cells but not endothelial cells (Compounds 74-77).

25 Thus, described herein are compounds that exhibit inhibition of undesirable angiogenesis, and methods for using these compounds to treat angiogenesis-dependent diseases or neoplasms (*e.g.*, solid tumors). In particular, the presently disclosed method provides for inhibiting unwanted angiogenesis in a human or animal by administering to the human or animal with the undesired angiogenesis a composition comprising an effective 30 amount of at least one of the compounds described herein, such as specifically one or more of Compounds 1 through 77 as shown in TABLE 1. Examples of such methods involve inhibiting angiogenesis by exposing a tissue or cell mass having the undesirable angiogenesis to an angiogenesis inhibiting amount of one or more compounds, or pharmaceutically

acceptable salts or derivatives of such compounds, wherein such compounds are selected from those of Compounds 1 through 77 as shown in TABLE 1.

It will be recognized that although the compounds disclosed herein exhibit antiangiogenic properties, the mechanism for specific action by the compounds are not
5 necessarily limited to antiangiogenic mechanisms. For example, the compounds may also exhibit cytotoxic properties (that may be independent of any antiangiogenic properties) that are useful for treating neoplasms.

Antiangiogenic drugs are among the most promising agents for the clinical management of cancer and other angiogenesis related diseases, such as endometriosis. A
10 multibillion dollar market has developed over the past decade involving innumerable pharmaceutical companies that are in the process of developing or attempting to develop antiangiogenic SMs.

Recent advances in the understanding of the angiogenic process have impelled the development of a new group of antiangiogenic SMs. Most of the antiangiogenic SMs
15 currently being considered in the clinic are tubulin binders or target the tyrosine kinase activity of cell surface receptors involved in the angiogenic process such as the VEGF receptor. Some of these compounds (such as inhibitors of the VEGF pathway) have already shown limited clinical success in the management of angiogenesis-related diseases, mainly cancer.

20 In contrast to the antiangiogenic SMs that were previously identified, the innovative approach to identifying antiangiogenic compounds described herein is not restricted by the subcellular target, rather it targets the main cellular processes involved in angiogenesis. Therefore, this method has permitted the discovery of novel SM that are not related to tyrosine kinase inhibitors, tubulin binders or any other known antiangiogenic SM currently in
25 development. Additionally this highly stringent screening design guarantees the absence of "false positives," which commonly represent a major obstacle in HTS.

Therefore, the newly identified SMs provided herein (*e.g.*, Compounds 1-77) represent new groups of high quality compound leads, defining new antiangiogenic subcellular targets and opening up the possibility of developing drugs based on mechanism
30 of action alternative to the ones currently being considered by academic institutions and private pharmaceutical industry.

In addition, the screen employed herein has provided information about the specificity of the growth inhibitory activity of some of the bioactive SMs. For instance, some molecules have been found which inhibit the growth of tumor cells while having no

substantial effect on endothelial cells. This enables advanced combinatorial drug regimens. For instance, in the treatment of angiogenesis-dependent tumors it may sometimes be important to deliver first drugs that inhibit tumor growth but do not affect endothelial cells (which are the main components of the vasculature), since drugs are delivered through the tumor vasculature and a functional vasculature is needed for drug delivery. Therefore, drugs like those found in this study with the ability to specifically inhibit tumor growth, but not endothelial cell growth (*e.g.*, Compounds 74-77) would be of great value for such treatment. Once the tumor has been significantly reduced, drugs with inhibitory activity in both tumor cells and endothelial cells might be preferred, since both tumor cells and endothelial cells need to be targeted. A number of such drugs have also been found in this study (for instance, Compounds 1-37 and 63-73). Therefore, the SM specificity information obtained in this study will be very useful in the development of anticancer SM therapies.

The bioactive SMs identified herein represent candidates to be applied to the clinical management of a variety of angiogenesis related diseases including (but not limited to) cancer, endometriosis, diabetic retinopathy, age-related macular degeneration, etc.

Thus, disclosed herein are pharmaceuticals composition for treating an angiogenesis-dependent disease, comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically-acceptable salt thereof. In particular examples, the pharmaceutical compositions further comprising [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof. In other examples, the angiogenesis-dependent disease comprises cancer, retinopathy, endometriosis, arthritis, or psoriasis. In further examples, the composition is administered topically, intravenously, orally, parenterally, or as an implant. In still other examples, the pharmaceutical composition further comprises an additional angiogenesis inhibitor.

Also disclosed herein are pharmaceutical compositions for inhibiting aberrant angiogenesis, comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically-acceptable salt thereof. In some examples,

the pharmaceutical compositions further comprise [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof. In some examples, the aberrant angiogenesis is stimulated by a tumor, which can be benign or malignant.

5 Also disclosed herein are pharmaceutical compositions for inhibiting growth of neoplastic tissue, comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; 10 dehydrate (NSC 292596), or a pharmaceutically-acceptable salt thereof. In particular examples, the pharmaceutical compositions further comprise [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

Additonally disclosed are methods of treating an angiogenesis-dependent disease, 15 comprising:administering to a subject having or predisposed to an angiogenesis-dependent disease a therapeutically effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), 20 chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof. In particular examples, the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof. In further examples, the angiogenesis-dependent disease comprises cancer, retinopathy, endometriosis, arthritis, or psoriasis. In some 25 examples, the composition is administered topically, intravenously, orally, parenterally, or as an implant. In still other examples, the methods further comprise administering to the subject an additional angiogenesis inhibitor, such as an inhibitor of bFGF, FGF, or VEGF.

Also disclosed herein are methods of inhibiting undesired angiogenesis in a subject, comprising: identifying a subject wherein angiogenesis is not desired, and administering to 30 the subject a therapeutically effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a

pharmaceutically acceptable salt thereof. In particular examples, the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof. In other examples, the method further comprises administering an additional inhibitor of angiogenesis, such as an inhibitor of bFGF, FGF, or 5 VEGF. In some examples, the undesired angiogenesis comprises tumor angiogenesis, for example wherein the tumor is benign or malignant.

Further disclosed herein are methods of inhibiting a neoplasm in a subject, comprising: administering to the subject a therapeutically effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride 10 (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof. In particular examples, the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 15 48300), or a pharmaceutically-acceptable salt thereof.

Lastly, disclosed herein are methods of inhibiting angiogenesis in a tissue or a target area in a subject wherein the formation of new blood vessels is not desired, comprising identifying a tissue or target area in a subject wherein the formation of new blood vessels is not desired; and

20 introducing directly or indirectly into the tissue or target area an effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; 25 dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof, thereby inhibiting angiogenesis in the tissue or target area. In particular examples, the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof. In some examples, the target area comprises skin, a tumor, a retina, a joint, or endometrial tissue. In other examples, the subject has or is 30 predisposed to developing a tumor, retinopathy, endometriosis, arthritis, or psoriasis.

IV. Bioactive Molecules

A set of diverse chemical compounds (Diversity Set I) was obtained from the NCI/DTP Open Chemical Repository (available on-line at dtp.cancer.gov). Diversity Set I

included 1990 compounds, each of which contains at least five new pharmacophores and five or fewer rotatable bonds as determined by the Chem-X program (Oxford Molecular Group, Oxford, UK). Although Diversity Set I is no longer available as a set, individual compounds can be obtained from the NIC/DTP Open Chemical Repository (though large amounts of NSC 675865, NSC 18877, NSC 176327, NSC 521777, NSC 166687, and NSC 119889 are not available). It will be understood by one of skill in the art that each member of Diversity Set I represents a large family of molecules, information related to which can be accessed through public databases. With the identification herein of the antiangiogenic activity of representative Compounds 1-77, methods of testing each related class of molecules for antiangiogenic activity are now enabled, as is use of any molecules identified through such screening as antiangiogenic agents. Structure similarity analyses, including structure-activity relationship analysis as described below in Section V, will be used to identify additional compounds that could potentially show antiangiogenic activity. Such analysis will enable the screening of compounds that are not associated with the Diversity Set I families, but are available through public databases.

The compounds in Diversity Set I were screened for potential antiangiogenic activity, as provided herein. Table 1 includes 77 compounds from Diversity Set I that were discovered to inhibit (1) endothelial cell growth, (2) tube formation, (3) endothelial cell growth and tube formation, or (4) specific tumor cell growth without concomitant endothelial cell growth inhibition. Specifically, compounds 1-37 are endothelial cell growth inhibitors, compounds 38-62 are tube formation inhibitors, compounds 63-73 are both endothelial cell growth and tube formation inhibitors, and compounds 74-77 are specific tumor cell growth inhibitors. Of the 77 compounds found to be bioactive in the screening assays, compounds 63, 64, 67, 69, and 71 are considered to be of particular interest. Each of these compounds inhibited both endothelial cell growth and tube formation without cytotoxicity (less than 10% cytotoxicity is considered to be a basal level).

TABLE 1: BIOACTIVE SMALL MOLECULES

Compound	Structure	NSC Number/Nomenclature
1	O^-–N^+(=O)– ; O	**NSC 329226** 4-methoxy-2-nitrobenzo[e][1]benzofuran

Compound	Structure	NSC Number/Nomenclature
2		**NSC 15234** (E)-N-(9H-fluoren-2-yl)-3-phenylprop-2-en-1-imine
3		**NSC 15226** N-(9H-fluoren-2-yl)-1-pyridin-2-ylmethanimine
4	Na^	**NSC 24076** diethylaminomethoxymethanedithioic acid; sodium
5	Cl-	**NSC 26081** 3-(dimethylamino)-1-(4-methoxynaphthalen-1-yl)propan-1-one chloride
6		**NSC 133896** 2,3-dinitrofluoren-9-one
7		**NSC 675865** 2-(7-amino-[1,2]thiazolo[4,5-d]pyrimidin-3-yl)-5-(hydroxymethyl)oxolane-3,4-diol

Compound	Structure	NSC Number/Nomenclature
8		**NSC 10460** [4-[(4-aminophenyl)-(4-iminocyclohexa-2,5-dien-1-ylidene)methyl]phenyl]azanium chloride
9		**NSC 207895** 7-(4-methylpiperazin-1-yl)-4-nitro-1-oxido-2,1,3-benzoxadiazol-1-ium
10		**NSC 99445** [5-(4-amino-2-oxopyrimidin-1-yl)-3,4-dihydroxyoxolan-2-yl]methyl dihydrogen phosphate

Compound	Structure	NSC Number/Nomenclature
11	Cl—H	**NSC 88903** 6,6-dimethyl-1-(4-phenylbutyl)-1,3,5-triazine-2,4-diamine hydrochloride
12		**NSC 177407** 5,6-dichloro-2-[3-(trifluoromethyl)phenyl]-1H-imidazo[4,5-b]pyrazine
13		**NSC 123111** (6-Methoxy-1,5-dimethyl-4,7-dioxo-1,1a,2,4,7,8b-hexahydroazireno[2',3':3,4]-pyrrolo[1,2-a]indol-8-yl)methyl carbamate
14		**NSC 329261** 3-(furan-2-ylmethyl)-5-(pyridin-3-ylmethylidene)-2-sulfanylidene-1,3-thiazolidin-4-one (The crossed bond represents a double bond for which the *cis*- or *trans*- structure is unknown or can be either.)
15		**NSC 13316** [2-(4-chlorophenyl)quinolin-4-yl]-piperidin-2-ylmethanol

Compound	Structure	NSC Number/Nomenclature
16		**NSC 5844** N,N'-bis(7-chloroquinolin-4-yl)ethane-1,2-diamine
17		**NSC 5857** 6-tert-butyl-2-[(3-tert-butyl-5-chloro-2-hydroxy-6-methylphenyl)methyl]-4-chloro-3-methylphenol
18		**NSC 656202** [(1R,2R,3E,7S,11E,13S,15S)-2-hydroxy-7-methyl-5-oxo-6-oxabicyclo[11.3.0]hexadeca-3,11-dien-15-yl] 2-(dimethylamino)acetate
19		**NSC 2186** 3,3-bis(4-hydroxy-2-methyl-5-propan-2-ylphenyl)-2-benzofuran-1-one

Compound	Structure	NSC Number/Nomenclature
20		**NSC 97845** (16E)-16-hydroxyimino-13-methyl-3-(2-methylprop-2-enoxy)-6,7,8,9,11,12,14,15-octahydrocyclopenta[a]phenanthren-17-one
21		**NSC 368891** 6,6-dimethyl-1-[3-(phenylsulfanylmethyl)-phenyl]-1,3,5-triazine-2,4-diamine hydrochloride
22		**NSC 126710** 5-(3,4-dichlorophenyl)-6-[(3-methyl-4-nitrophenoxy)methyl]pyrimidine-2,4-diamine
23		**NSC 109836** 6,6-dimethyl-1-[3-[(3-nitrophenyl)methoxy]-phenyl]-1,3,5-triazine-2,4-diamine chloride

Compound	Structure	NSC Number/Nomenclature
24		**NSC 67485** 2-tert-butyl-4-[1-(5-tert-butyl-4-hydroxy-2-methylphenyl)butyl]-5-methylphenol
25		**NSC 47932** 4-chloro-2,6-bis[(5-chloro-2-hydroxyphenyl)methyl]phenol
26		**NSC 176327** 3-(9-methoxy-5,11-dimethylpyrido[4,3-b]carbazol-2-ium-6-yl)propan-1-amine chloride
27		**NSC 48630** 1-[(3S,8R,9S,10R,13S,14S,17R)-3,17-dihydroxy-10,13-dimethyl-1,2,3,4,7,8,9,11,12,14,15,16-dodecahydrocyclopenta[a]phenanthren-17-yl]-3-(dimethylamino)propan-1-one chloride

Compound	Structure	NSC Number/Nomenclature
28		**NSC 71669** 5-[3-(trifluoromethyl)phenyl]-6-[[3-(trifluoromethyl)phenyl]methyl]pyrimidine-2,4-diamine
29		**NSC 150289** 2,3-dibromo-1-(4-nitrophenyl)-3-quinolin-4-ylpropan-1-one
30		**NSC 311153** 5,11-dimethyl-2-(2-piperidin-1-ylethyl)-6H-pyrido[4,3-b]carbazol-2-ium-9-ol acetate
31		**NSC 45238** [(3S,8R,9S,10R,13S,14S,16E)-16-(1-acetyloxy-2,2,2-trifluoroethylidene)-10,13-dimethyl-17-oxo-2,3,4,7,8,9,11,12,14,15-decahydro-1H-cyclopenta[a]phenanthren-3-yl] acetate

Compound	Structure	NSC Number/Nomenclature
32		**NSC 156305** N-[4-(acridin-9-ylamino)phenyl]-methanesulfonamide; methanesulfonic acid
33		**NSC 62914** 2-tert-butyl-6-[[3-[(3-tert-butyl-2-hydroxy-5-methylphenyl)methyl]-2-hydroxy-5-methylphenyl]methyl]-4-methylphenol
34		**NSC 606985** 4-Ethyl-3,14-dioxo-3,4,12,14-tetrahydro-1H-pyrano[3',4':6,7]indolizino[1,2-b]quinolin-4-yl aminoacetate hydrochloride

Compound	Structure	NSC Number/Nomenclature
35		**NSC 254681** (1S,3S)-3-acetyl-11-amino-1-(4-amino-5-hydroxy-6-methyloxan-2-yl)oxy-3,6-dihydroxy-10-methoxy-2,4-dihydro-1H-tetracene-5,12-dione hydrochloride
36		**NSC 268665** 4-amino-1-[6-(hydroxymethyl)-2,2-diphenyl-3a,4,6,6a-tetrahydrofuro[3,4-d][1,3,2]dioxastannol-4-yl]pyrimidin-2-one
37		**NSC 306698** 3-[(2,4-dimethylphenyl)carbamoyl]naphthalen-2-olate; N-(2,4-dimethylphenyl)-3-hydroxynaphthalene-2-carboxamide; nickel(2+)
38		**NSC 4972** 2-tert-butylbenzene-1,4-diol

Compound	Structure	NSC Number/Nomenclature
39		**NSC 19630** (2,5-dioxopyrrol-1-yl)methyl propanoate
40		**NSC 2805** 2-(2,5-dihydroxy-4-methylphenyl)-5-methylbenzene-1,4-diol
41		**NSC 16555** 2-(4-methylphenyl)sulfonyloxyacetic acid
42		**NSC 3535** [(1S,4R,6R)-1,7,7-trimethyl-6-bicyclo[2.2.1]heptanyl] 2-thiocyanatoacetate

Compound	Structure	NSC Number/Nomenclature
43		**NSC 27063** [(E)-(4-methylsulfonylphenyl)methylideneamino]thiourea
44		**NSC 47924** 1-[(4-methoxyanilino)methyl]naphthalen-2-ol
45		**NSC 36738** S-[2-oxo-2-(quinolin-6-ylamino)ethyl] carbamothioate
46		**NSC 108895** 1-(1,3-benzodioxol-5-ylmethyl)pyrrolidine-2-carboxylic acid
47		**NSC 681152** methyl 4-[2-(2,5-dihydroxyphenyl)ethyl]benzoate

Compound	Structure	NSC Number/Nomenclature
48		**NSC 632536** 4-N-phenyl-1-N-(2,2,6,6-tetramethylpiperidin-4-yl)benzene-1,4-diamine
49		**NSC 122351** azidobenzene; 1H-indene; prop-1-en-2-ylbenzene
50		**NSC 268879** (2-aminopurin-9-id-6-yl)sulfanyl-hexylmercury
51		**NSC 48458** 3,8-dibenzyl-5,10-ditert-butyl-2,4,7,9-tetrahydro-[1,3]oxazino[6,5-g][1,3]benzoxazine

Compound	Structure	NSC Number/Nomenclature
52		**NSC 209910** 3,5-di(cyclododecyl)-1,3,5-thiadiazinane-2-thione
53		**NSC 328087** 2-(3,5-dichloro-2-hydroxyphenyl)-3-(2-pyridin-2-ylethyl)-1,2-dihydroquinazolin-4-one
54		**NSC 521777** 17-[(E)-2,6-dihydroxy-6-methyl-3-oxohept-4-en-2-yl]-2,16-dihydroxy-4,4,9,13,14-pentamethyl-8,10,12,15,16,17-hexahydro-7H-cyclopenta[a]phenanthrene-3,11-dione
55		**NSC 310551** copper; [(6-methylpyridin-2-yl)methylidene-amino]-[methylsulfanyl(sulfoniumylidene)-methyl]azanide

Compound	Structure	NSC Number/Nomenclature
56		**NSC 292222** Maytansinol isobutyrate or 4,24-Dioxa-9,22-diazatetracyclo[19.3.1.110,14.03,5]hexacosane, maytansine deriv.
57		**NSC 321237** Mercury, (4-aminophenyl)(6-thioguanosinato-N7,S6)-
58		**NSC 259969** Deoxybouvardin or 24-hydroxy-10-(4-methoxybenzyl)-4,7,9,13,15,29-hexamethyl-22-oxa-3,6,9,12,15,29-hexaazatetracyclo-[14.12.2.2~18,21~.1~23,27~]tritriaconta-18,20,23(31),24,26,32-hexaene-2,5,8,11,14,30-hexone
59		**NSC 259968** Bouvardin or 17,24-dihydroxy-10-(4-methoxybenzyl)-4,7,9,13,15,29-hexamethyl-22-oxa-3,6,9,12,15,29-hexaazatetracyclo-[14.12.2.2~18,21~.1~23,27~]tritriaconta-18,20,23(31),24,26,32-hexaene-2,5,8,11,14,30-hexone

Compound	Structure	NSC Number/Nomenclature
60		**NSC 203328** 3-bromo-4-[(2-bromo-6-tert-butyl-4-cyanophenoxy)-phenylphosphoryl]oxy-5-tert-butylbenzonitrile
61		**NSC 166687** zinc; 8-hydroxy-3,4,4a,5,6,7,8,8a-octahydro-2H-quinolin-1-ide-5-sulfonic acid; 5-sulfo-1,2-dihydroquinolin-8-olate
62		**NSC 119889** 2,3,4,5-tetrabromo-6-(3,6-dihydroxy-9H-xanthen-9-yl)benzoic acid
63		**NSC 676693** 3-(4-methoxyphenyl)thieno[2,3-b]pyrrolizin-8-one

Compound	Structure	NSC Number/Nomenclature
64		**NSC 122657** 1-benzylsulfonyl-2,4-dinitrobenzene
65		**NSC 295642** [benzylsulfanyl(sulfoniumylidene)methyl]-(1-pyridin-2-ylethylideneamino)azanide; chlorocopper
66		**NSC 13480** (2-phenylbenzo[h]quinolin-4-yl)-piperidin-2-ylmethanol
67	Cl^-	**NSC 150117** 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride

Compound	Structure	NSC Number/Nomenclature
68		**NSC 18877** [4-(1-benzothiophene-3-carbonyl)-2-oxido-1,2,5-oxadiazol-2-ium-3-yl]-(1-benzothiophen-3-yl)methanone
69		**NSC 48300** [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid
70		**NSC 321206** bromocopper; (dipyridin-2-ylmethylideneamino)-[methylsulfanyl(sulfoniumylidene)methyl]azanide

Compound	Structure	NSC Number/Nomenclature
71		**NSC 292596** chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dihydrate
72		**NSC 112200** 2,5-dibromo-3,6-dimethylbenzene-1,4-diol; 2,5-dibromo-3,6-dimethylcyclohexa-2,5-diene-1,4-dione
73		**NSC 274547** gold(1+); 1-(2,3,4-triaza-5-azanidacyclopenta-1,3-dien-1-yl)-2,3,4-triaza-5-azanidacyclopenta-1,3-diene; triphenylphosphane

Compound	Structure	NSC Number/Nomenclature
74	Cl—H	**NSC 4265** 1,10-phenanthroline hydrochloride
75		**NSC 130830** 5-[(benzylamino)methyl]quinolin-8-ol
76		**NSC 54044** N'-[1-(1-oxonaphthalen-2-ylidene)ethyl]pyridine-4-carbohydrazide
77		**NSC 327705** 2-chloro-3-phenanthro[9,10-e]-[1,2,4]triazin-3-ylsulfanylnaphthalene-1,4-dione

V. Potentially Active Related Structures

Additional potentially active compounds can be predicted by comparing the structure of any of Compounds 1-77 to the structures of other known compounds (or newly-derived compounds) and determining the similarity through structure-activity relationship (SAR) or quantitative structure-activity relationship (QSAR) analysis. There are several known methods for SAR and QSAR analysis, including Tanimoto's algorithm (Dogra, "Script for

computing Tanimoto coefficient," QSARWorld, available on-line at qsarworld.com/virtual-workshop.php, July 5, 2007) and LeadScope's clustering algorithm (Leadscope Inc., Columbus, OH). SAR and QSAR methods compare molecular structures and determine structural features shared by the molecules.

5 Because Compounds 1-77 (shown in TABLE 1) were derived from a diversity set of small molecules, most of the active compounds are determined not to be structurally related when using Tanimoto's algorithm. However, clustering using LeadScope's algorithm has been used successfully to determine structural similarities between some of the compounds in TABLE 1 and other known compounds. For instance, many compounds in Diversity Set I 10 have family members (which are related by structure) that are not included in Diversity Set I. Such family members and other compounds can be evaluated using LeadScope's algorithm, which searches for (1) large, commonly occurring substructures; (2) substructures that discriminate for a biological response; or (3) substructures that discriminate for membership in a set of compounds (Cross *et al.*, *J. Med. Chem.*, 46:4770-4775, 2003).

15 Two prediction models were built based on bioactive Compounds 1-77: one for compounds that inhibit endothelial cell growth and another for compounds that inhibit tube formation. The models were built using LeadScope software, and were based on logistic regression. To develop a predictive model for small molecules that inhibit growth of endothelial cells, a total of 70 compounds with known growth inhibitory activity and 76 20 compounds with no inhibitory effect were used. The predictive model accurately predicted 70/70 positive compounds and accurately predicted 76/77 negative compounds, producing a concordance of 99.3% with 98.6% sensitivity and 100.0% specificity. Concordance is a measure of the overall model accuracy, *i.e.*, 76/77 = 99.3%. Sensitivity is a measure of how well the model predicts true positives. Sensitivity is calculated using the equation: 25 sensitivity = TP/(TP + FN), where TP is the number of true positives and FN is the number of false negatives. Specificity is a measure of how well the model predicts true negatives. Specificity is calculated using the equation: specificity = TN/(TN + FP), where TN is the number of true negatives and FP is the number of false positives. The concordance for a test set of molecules was 98.0%, with 69 true positives, 1 false positive, 75 true negatives, and 2 30 false negatives. The sensitivity was 97.2% with 98.7% specificity. Each molecule in the training and test sets was tested in an endothelial cell growth assay to assess the accuracy of the prediction.

A predictive model for small molecules that inhibit tube formation was also developed. Concordance for the training set was 100.0%, with 100.0% sensitivity and

specificity. A test set of molecules produced 71.0% concordance, with 12 true positives, 8 false positives, 32 true negatives, and 10 false negatives. The sensitivity was 54.5% with 80.0% specificity. Each molecule in the training and test sets was tested in a tube formation assay to assess the accuracy of the prediction.

5 These predictive models were applied to various databases, including the NCI small molecule database (dtp.nci.nih.gov/), DrugBank (drugbank.ca), LeadScope (leadscope.com), and PubChem (pubchem.ncbi.nlm.nih.gov/). Based on the models, several hundred small molecules have been predicted to inhibit endothelial cell growth and tube formation. For example, several substructures ("scaffolds") were identified in Compounds 1-77 that are

10 predicted to produce endothelial cell growth inhibition or tube formation inhibition.

The scaffolds were identified using LeadScope software. The software calculates a "z-score" for each compound and activity. The z-score compares the mean activity of a subset to its expected value:

$$z = (\bar{x}_1 - \bar{x}_0)\sqrt{\frac{n_1 n_0}{s_0^2 (n_0 - n_1)}}$$

15 (Cross *et al.*, *J. Med. Chem.*, 46:4770-4775, 2003) After performing clustering analysis, each cluster contains a plurality of small molecules having a common scaffold, each molecule having a z-score value. A low z-score value indicates low values for the defined activity, *e.g.*, growth or tube formation. Thus, a small molecule with a low z-score for growth results in less growth than a molecule with a higher z-score. An average z-score

20 value is associated with the cluster, based on the individual z-score values of the small molecules. A cluster with a low z-score value is likely to contain small molecules with individual low z-score values. In the present embodiments, only scaffolds included in clusters with an average z-score of less than -2 were considered. For example, molecules in clusters having an average growth z-score of less than -2 are predicted to be potential growth

25 inhibitors. These identified scaffolds have predictive value for both growth inhibition and/or tube formation inhibition.

Several representative clusters of molecules having scaffolds predicted to inhibit endothelial cell growth are shown below in TABLES 2-6. Additional molecule clusters having scaffolds predicted to inhibit tube formation are shown in TABLES 7-9.

30

TABLE 2: CLUSTER 368

Common Scaffold:

Compound	Structure	NSC Number/Nomenclature
55		**NSC 310551** copper; [(6-methylpyridin-2-yl)methylidene-amino]-[methylsulfanyl(sulfoniumylidene)-methyl]azanide
65		**NSC 295642** [benzylsulfanyl(sulfoniumylidene)methyl]-(1-pyridin-2-ylethylideneamino)azanide; chlorocopper
70		**NSC321206** bromocopper; (dipyridin-2-yl-methylideneamino)-[methylsulfanyl-(sulfoniumylidene)methyl]azanide

TABLE 3: CLUSTER 71

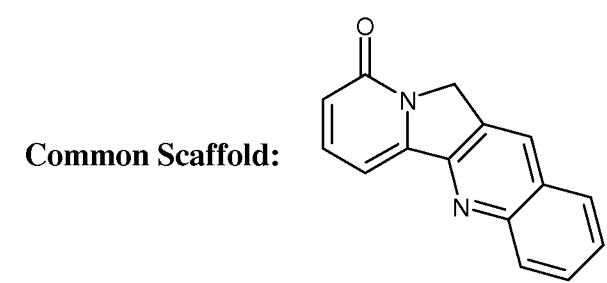
Common Scaffold:

Compound	Structure	NSC Number/Nomenclature
30		**NSC 311153** 5,11-dimethyl-2-(2-piperidin-1-ylethyl)-6H-pyrido[4,3-b]carbazol-2-ium-9-ol acetate
30-A		**NSC 163443** 2-(5,11-dimethylpyrido[4,3-b]carbazol-6-yl)ethyl benzoate
30-B		**NSC 359449** 2-(5,11-dimethyl-6H-pyrido[4,3-b]carbazol-2-ium-2-yl)-N,N-diethylethanamine acetate

30-C		**NSC 311152** 2-(2-diethylaminoethyl)-5,11-dimethyl-6H-pyrido[4,3-b]carbazol-2-ium-9-ol acetate
30-D		**NSC 176327** 3-(9-methoxy-5,11-dimethylpyrido[4,3-b]carbazol-6-yl)propan-1-amine (Same NSC # as 26, but not the chloride salt.)

TABLE 4: CLUSTER 358

Common Scaffold:



Compound	Structure	NSC Number/Nomenclature
34		**NSC 606985** 4-Ethyl-3,14-dioxo-3,4,12,14-tetrahydro-1H-pyrano[3',4':6,7]indolizino[1,2-b]quinolin-4-yl aminoacetate hydrochloride

34-A	Na⁺-----H⁻	**NSC 100880** sodium; hydride; 2-hydroxy-2-[8-(hydroxymethyl)-9-oxo-11H-indolizino[1,2-b]quinolin-7-yl]butanoic acid
34-B	Cl—H	**NSC 609699** Topotecan, Hycamtin, or 10-((dimethylamino)methyl)-4-ethyl-4,9-dihydroxy-1H-pyrano[3',4':6,7]-indolizino[1,2-b]quinoline-3,14(4H,12H)-dione hydrochloride
34-C	Cl—H	**NSC 639174** 2-amino-N-(4-ethyl-4-hydroxy-3,14-dioxo-3,4,12,14-tetrahydro-1H-pyrano[3',4':6,7]indolizino[1,2-b]quinolin-10-yl)acetamide hydrochloride

TABLE 5: CLUSTER 337

Common Scaffold:

Compound	Structure	NSC Number/Nomenclature
17		**NSC 5857** 6-tert-butyl-2-[(3-tert-butyl-5-chloro-2-hydroxy-6-methylphenyl)methyl]-4-chloro-3-methylphenol
25		**NSC 47932** 4-chloro-2,6-bis[(5-chloro-2-hydroxyphenyl)methyl]phenol

5

TABLE 6: CLUSTER 479

Common Scaffold:

Compound	Structure	NSC Number/Nomenclature
64		**NSC 122657** 1-benzylsulfonyl-2,4-dinitrobenzene

64-A		**NSC 228148** 7-benzylsulfonyl-4-nitro-2,1,3-benzoxadiazole

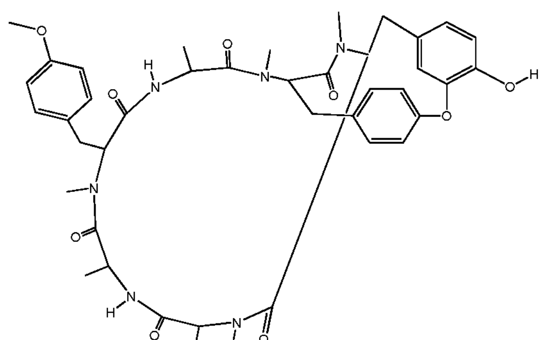
TABLE 7

Common Scaffold:

Compound	Structure	NSC Number/Nomenclature
50		**NSC 268879** (2-aminopurin-9-id-6-yl)sulfanyl-hexylmercury
57		**NSC 321237** Mercury, (4-aminophenyl)(6-thioguanosinato-N7,S6)-

TABLE 8

Common Scaffold:

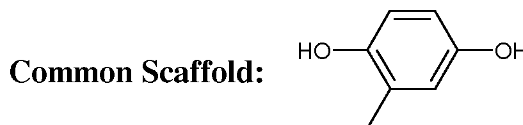


Compound	Structure	NSC Number/Nomenclature
58		**NSC 259969** Deoxybouvardin or 24-hydroxy-10-(4-methoxybenzyl)-4,7,9,13,15,29-hexamethyl-22-oxa-3,6,9,12,15,29-hexaazatetracyclo-[14.12.2.2~18,21~.1~23,27~]tritriaconta-18,20,23(31),24,26,32-hexaene-2,5,8,11,14,30-hexone
59		**NSC 259968** Bouvardin or 17,24-dihydroxy-10-(4-methoxybenzyl)-4,7,9,13,15,29-hexamethyl-22-oxa-3,6,9,12,15,29-hexaazatetracyclo-[14.12.2.2~18,21~.1~23,27~]tritriaconta-18,20,23(31),24,26,32-hexaene-2,5,8,11,14,30-hexone

5

TABLE 9

Common Scaffold:



Compound	Structure	NSC Number/Nomenclature
38		**NSC 4972** 2-tert-butylbenzene-1,4-diol

40		**NSC 2805** 2-(2,5-dihydroxy-4-methylphenyl)-5-methylbenzene-1,4-diol
47		**NSC 681152** methyl 4-[2-(2,5-dihydroxyphenyl)ethyl]benzoate

VI. Bioactivity Tests

Once a new compound has been identified as a potential antiangiogenic compound based on comparison to one of Compounds 1-77, or the compounds additionally listed in any of TABLES 2-9, or any derivative thereof, the identified potential therapeutic compound can be tested for bioactivity. By way of example, any of the methods described herein can be used. The following list provides a description of representative but non-limiting example bioactivity assays. Additional assays will be known to those of ordinary skill; for instance, additional assays are described in U.S. Application No. 12/060,752 (published as US 2009/0088341 on April 2, 2009; incorporated herein by reference in its entirety).

i. Fluorescence-based Growth Assay

A real time growth assay has been applied to mono- or multiple-cell cultures (co-culture). The fluorescence signal emitted by a culture of the disclosed fluorescent cell-lines is proportional to the number of fluorescent cells present in the culture. In other words, the fluorescence signal, for example measured as the intensity of the emission maxima, from a population of fluorescent cells of one type in a culture will double as the number of fluorescent cells of that type in the culture doubles. Conversely, the fluorescence signal, for example measured as the intensity of the emission maxima, from a population of cells of one

type in a culture will be reduced to half if the number of cells of that type in the culture is divided in half. These properties can be used to measure the effect of an exogenous agent, such as one or more additional cell-lines, or a test agent (such as a bioactive SM), on the fluorescent cells in culture. At some point the total fluorescence of a culture may reach signal saturation, such that the signal reaches a plateau as a function of cell number. The effect of an additional cell-line (for example a different cell-line) on a first fluorescent cell-line can be determined (this can be extended to multiple cell-lines and even one or more fluorescent cell-lines, or combinations thereof, for example in a multiplex assay or 3-dimensional co-culture).

The difference between the fluorescence signal (such as the intensity of the fluorescence signal at a particular wavelength, for example the emission maxima of the fluorescence signal) attributable to the fluorescent cell-line of interest grown in co-culture with one or more additional cell-lines relative to a control in some instances will be at least about 10%, meaning that the growth rate of the cell-line of interest is either reduced or increased by at least about 10%, such as at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 100%, at least about 150%, at least about 200%, at least about 250%, at least about 300%, at least about 350%, at least about 400%, at least about 500%, or greater than 500%. The difference may be a statistically significant difference. Thus, the presence of a bioactive SM with or without one or more additional cell-lines can induce a statistically significant difference in the growth rate of a fluorescent cell-line of interest, as compared to the control, such as a value indicative of the basal rate of growth of the fluorescent cell-line, or the fluorescent cell-line of interest grown in the absence of the SM and/or other cells or cell-lines, for example grown in mono-culture. The at least one SM and/or additional cell-line (or additional cell-lines) will in some instances have a negative impact on the first fluorescent cell-line, such that the number of cells of the first fluorescent cell-line is reduced as a function of time relative to a control. In other examples, the at least one SM and/or additional cell-line (or additional cell-lines) will have a positive impact on the first fluorescent cell-line, such that the number of cells of the first fluorescent cell-line present in a cell culture increases as a function of time relative to a control. It is also contemplated that the fluorescent cell-line of interest can be co-cultured with primary cells, such as primary cells obtained from a subject, for example tumor cells, and the effect of the primary cells on the growth rate of the fluorescent cell-line of interest determined. Such co-cultures may be established in 2 or 3 dimensions.

The effect of each fluorescent cell-line on other fluorescent cell-line(s) present in co-culture can be determined, for example in a multiplex assay. For example, using appropriate filters or FACS analysis among other techniques, fluorescent cell-lines expressing different fluorescent proteins, such as red, green, yellow, cyan and the like fluorescent proteins can be discriminated and the fluorescent signal attributable to the different cell-lines determined. Thus, the growth rates of individual fluorescent cell-lines can be determined from a mono-culture and/or a co-culture of two or more fluorescent cell-lines. Such analysis greatly enhances the information that can be obtained about the individual fluorescent cell-lines.

As described herein, in addition to determining the effect of cell-lines on a fluorescent cell-line of interest, the growth assays can be used to determine if an exogenous agent, such as a test agent, for example a chemical agent (for instance a derivative of one of Compounds 1-77, or a structurally related compound), affects the growth of a fluorescent cell-line of interest. This can also be extended to multiple cell-lines (either fluorescent or not grown in co-culture, for example in a multiplex assay). For instance, the growth assay can be used to determine if an exogenous agent, such as a test agent (for example a potential modulator of angiogenesis, such as a potential inhibitor of angiogenesis such as one of Compounds 1-77 or derivatives thereof), growth factor, patient sample, etc. affects the growth rate of a fluorescent cell-line of interest, such as one or more of the fluorescent cell-lines disclosed herein. In addition, the differential effect of the exogenous agent on the different cell-lines can be determined, as can the combinatorial effect of the exogenous agent and the cells on a cell-line of interest.

A fluorescent cell-line of interest can be contacted with an exogenous agent and the impact of the exogenous agent on the growth of the fluorescent cell-line of interest can be determined. For example, a difference between the fluorescence signal of the fluorescent cell-line of interest and a control indicates that the exogenous agent, such as a test agent (for example a potential modulator of angiogenesis, such as a potential inhibitor of angiogenesis), growth factor, patient sample, different cell-line, etc. is a modulator (such as an inhibitor) of angiogenesis. Thus, in several embodiments, one or more of the disclosed fluorescent cell-lines growing in culture are contacted with a test agent (or test agents) to determine if the test agent is a modulator of angiogenesis. Exemplary test agents include compounds that are structurally related to any one of Compounds 1-77 (TABLE 1), structurally related to the scaffolds presented in any one of TABLES 2-9, derivatives or fragments of any of the compounds described herein, and so forth. Following contact with the test agent, the fluorescence of the culture can be measured versus time and/or concentration to determine

the impact of the exogenous agent on the one or more fluorescent cell-lines present in the culture. For example, the fluorescence signal generated by a fluorescent cell-line of interest (such as the intensity of the fluorescence signal at a particular wavelength, for example the emission maxima of the fluorescence signal) can be measured to determine if the fluorescence signal attributable to the fluorescent cell-line of interest (such as the intensity of the fluorescence signal at a particular wavelength, for example the emission maxima of the fluorescence signal) is increasing as a function of concentration of the exogenous agent, time, or both, for example by comparison with a control, such as a value indicative of the basal rate of growth of the fluorescent cell-line of interest or the fluorescent cell-line of interest not contacted with the exogenous agent. In several embodiments, the control is a known value indicative of normal growth of the fluorescent cell-line of interest, for example the doubling time of cellular number. In some embodiments, the control is the fluorescence signal of a culture of cells (typically, but not necessarily, a culture of the fluorescent cell-line of interest) not contacted with the exogenous agent.

In some embodiments, an exogenous agent, such as a test agent, decreases the growth rate of the fluorescent cell-line of interest. A test agent exhibiting such an activity is identified as a potential inhibitor of angiogenesis (that is, having antiangiogenic activity) and would be of use in treating a disease or condition in which normal angiogenesis is increased, for example cancer. In some embodiments, a decrease in the growth rate of the fluorescent cell-line of interest relative to a control is at least about a 30%, at least about a 40%, at least about a 50%, at least about a 60%, at least about a 70%, at least about a 80%, at least about a 90%, at least about a 100%, at least about a 150%, at least about a 200%, at least about a 250%, at least about a 300%, at least about a 350%, at least about a 400%, at least about a 500% decrease. Because the fluorescence signal attributable to a fluorescent cell-line of interest is proportional to the number of cells of the cell-line of interest present, the percentage decrease can be measured as a percentage decrease in the fluorescent signal, for example the fluorescence intensity at a particular wavelength, such as the emission maxima, attributable to the cell-line of interest. In additional embodiments, the decrease is a statistically significant decrease as compared to a control.

ii. Fluorescence-based Tubule Formation Assay

Cultures of fluorescent cell-lines expressing different fluorescent proteins, such as the fluorescent cell-lines disclosed herein and in U.S. Application No. 12/060,752 (published as US 2009/0088341 on April 2, 2009; incorporated herein by reference in its entirety) can be applied to tubule formation assays. Formation of new blood vessels is fundamental to

angiogenesis and is the focus of many drug screening and cell signaling studies. Blood vessel development is a significant event in the development and growth of solid tumors, and is involved in wound healing, retinopathy and macular degeneration. Fluorescent cell-lines, and in particular the disclosed endothelial fluorescent cell-lines, are ideal for use in assays for
5 assessing the degree of blood vessel formation using *in vitro* cell culture assays (see for example Auerbach *et al. Clinical Chemistry* 49:1, 32-40, 2003; Taraboletti and Giavazzi, *EJC* 40, 881-889, 2004). Because no fluorescent/colorimetric staining is needed, the tubule formation assay can be followed over time and can be directly visualized used in existing instrumentation, such as the BD Pathway™ Bioimager (BD Bioscience, San Jose, CA). This
10 allows for the study of the interaction between different cells types, or between a SM(s) of interest and/or one or more cell types, in this angiogenesis *in vitro* assay. In addition, the effects of SMs on tubule formation potential can also be determined for a co-culture of a fluorescent cell-line of interest with primary cells, such as primary cells obtained from a subject, for example tumor cells. Such co-cultures can be established as 2-dimensional or 3-
15 dimensional co-cultures, such as those described in U.S. Patent Application No. 12/802,666.

Tubule formation assays are typically based on the ability of endothelial cells, such as fluorescent endothelial cells (stably-transfected to express a fluorescent protein), to form distinct blood-vessel-like tubules in an extracellular matrix (such as BD Matrigel™ Matrix available from BD Bioscience, BME available from Trevigen, or GELTREX™ available
20 from Invitrogen®, and the like). The cells are visualized by microscopy, such as fluorescence microscopy in the case of fluorescent cells, and the ability of one or more compounds of interest to affect the ability of a fluorescent cell-line of interest to form tubules (also called the tubule formation potential) is determined. The determination of tubule formation can be performed by manual tracing or by automated confocal imaging system, for
25 example using a BD Pathway™ Bioimager in conjunction with AngioApplication™. Using fluorescent cell-lines, tubule formation assays can be performed on live cells, for example to avoid artifacts that may arise from fixation of cells, such as the disruption of tubules. Several parameters can be measured in tubule formation assays, such as the total area of the tubules, the total number of tubules, number of nodes, number of branch points, the number of tubes
30 per node, and/or node area. In some embodiments, the tubule formation potential is determined by a computer implemented method, for example using the program AngioApplication™.

Fluorescent cell-lines can be used to determine the effects of an exogenous agent, such as cell-lines and test agents, on tubule formation. In particular examples, a test agent is

one or more compounds that are structurally related to any one of Compounds 1-77 (TABLE 1), structurally related to the scaffolds presented in any one of TABLES 2-9, derivatives or fragments of any of the compounds described herein, and so forth. In some embodiments, multiple fluorescent cell-lines are grown in co-culture. Thus, the effect of each fluorescent cell-line on the other fluorescent cell-line(s) present can be determined, or the differential effect of an exogenous agent, such as a test agent, or patient sample, on the different cell-lines can be assessed in a multiplex assay. For example using appropriate filters, the fluorescent signal from fluorescent cell-lines expressing different fluorescent proteins, such as red, green, yellow, cyan fluorescent proteins can be discriminated and the fluorescent signal attributable from the different fluorescent cell-lines determined. Thus, the tubule formation potential of individual cell-lines can be determined from a mono-culture or even a co-culture, for example a co-culture of more than one fluorescent cell-line.

When grown in co-culture, a difference between the tubule formation potential of the fluorescent cell-line of interest from a control, such a mono-culture of the fluorescent cell-line of interest indicates that the other cell-line(s) is a modulator of angiogenesis, as evidenced by the difference in tubule formation potential. In some embodiments, the difference between the tubule formation potential, for example as measured by the number of least one of the total area of the tubules, the total number of tubules, number of nodes, number of branch points, the number of tubes per node, or node area formed in the co-culture of the fluorescent cell-line of interest relative to a control is at least about 10%, such as at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 100%, at least about 150%, at least about 200%, at least about 250%, at least about 300%, at least about 350%, at least about 400%, at least about 500%, or greater than 500%. In some embodiments, the difference is a statistically significant difference. Thus, a cell-line can induce a statistically significant difference in the tubule formation potential of a fluorescent cell-line of interest, such as one of the disclosed fluorescent cell-lines. Taking a combinatorial approach the impact of multiple different cell-lines either alone or in combination on the tubule formation potential of the fluorescent cell-line of interest can be determined. In some examples, the presence of one or more additional cell-lines decreases the tubule formation potential of the fluorescent cell-line of interest, for example as measured by the total area of the tubules, the total number of tubules, number of nodes, number of branch points, the number of tubes per node, or node area formed by the fluorescent cell-line of interest. These cell-lines would be identified as negative regulators of angiogenesis.

Utilizing fluorescent cell-lines, tubule formation assays can also be used to screen for a biological effect of a test agent, such as the effect of potential modulators of angiogenesis, for example compounds that are structurally related to any one of Compounds 1-77 (TABLE 1), structurally related to the scaffolds presented in any one of TABLES 2-9, derivatives or fragments of any of the compounds described herein, and so forth. In some embodiments, a fluorescent cell-line of interest (or multiple cell-lines of interest in a multiplex assay) is contacted with an exogenous agent, such as a cell-line or test agent, and the impact of the exogenous agent on tubule formation potential can be determined. Exemplary test agents are provided herein. For example using the difference between the total area of the tubules, the total number of tubules, number of nodes, number of branch points, the number of tubes per node, and/or node area between a fluorescent cell-line of interest and a control are used to determine if an exogenous agent, such as a test agent, impacts the ability of a fluorescent cell-line of interest to form tubules. A difference between the tubule formation potential of a fluorescent cell-line of interest contacted with an exogenous agent and a control (such as a control culture exposed to the exogenous agent) indicates that the exogenous agent is a modulator of angiogenesis. In some embodiments, the difference between the tubule formation potential of the fluorescent cell-line contacted with an exogenous agent relative to a control is at least about 10%, such as at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 100%, at least about 150%, at least about 200%, at least about 250%, at least about 300%, at least about 350%, at least about 400%, at least about 500%, or greater than 500%. In some embodiments, the difference is a statistically significant difference. Thus, an exogenous agent can induce a statistically significant difference in the tubule formation potential of the fluorescent cell-line of interest contacted with the test agent, as compared to the control, such as the fluorescent cell-line of interest not contacted with the exogenous agent.

In one embodiment, the exogenous agent decreases the ability of a fluorescent cell-line of interest to form tubules. A test agent exhibiting such an activity is identified as a potential inhibitor of angiogenesis and would be of use in treating a disease or condition in which normal angiogenesis is increased, for example cancer. Such agents could be used alone, or in combination with other agents (such as, but not limited to a SM, peptide or antibody) known to inhibit angiogenesis by a similar or complementary mechanism (such as at a different step in the angiogenesis pathway). In some embodiments, a decrease in the tubule formation potential of the fluorescent cell-line of interest is at least about a 30%, at

least about a 40%, at least about a 50%, at least about a 60%, at least about a 70%, at least about a 80%, at least about a 90%, at least about a 100%, at least about a 150%, at least about a 200%, at least about a 250%, at least about a 300%, at least about a 350%, at least about a 400%, at least about a 500% decrease as compared to control. In additional
5 embodiments, the decrease is a statistically significant decrease as compared to a control.

iii. Fluorescence-based Migration Assay

Another assay that can be used is a cellular migration assay. These assays assess cellular migration in a controlled environment, such as a differential migration of the cell-line, (or multiple cell-lines in a multiplex assay) as determined by fluorescent signals (such as
10 the intensity of a fluorescent signal of a particular color, or at a particular wavelength, such as the emission maxima of a particular fluorescent protein) in a location that is associated with migration to a particular location.

A cellular migration assay can be used to determine the ability of cells to migrate up or down a chemical gradient. Migration "up" a chemical gradient refers to migration from a
15 region of lower chemical concentration of a chemical to a region of higher chemical concentration (for example migration toward a higher concentration of a chemical attractant or away from a lower concentration of the chemical attractant), while migration "down" a chemical gradient refers to migration from a region of higher chemical concentration to a region of lower chemical concentration (for example migration away from a higher
20 concentration of a chemical repellent toward a lower concentration of the chemical repellent). Such migration is typically referred to as chemotaxis. Cells, such as fluorescent cell-lines, respond to chemical signals in their environment by the stimulation of concerted movement either toward a chemical attractant or away from a chemical repellent. In mammalian cells, such as fluorescent cell-lines, typical chemo-attractants include factors excreted by cells, for
25 example factors found in serum, such as growth factors and the like.

Fluorescent cells (such as those described in U.S. Application No. 12/060,752 (published as US 2009/0088341 on April 2, 2009)) can be used in any cell migration assay format, such as the ChemoTx™ system (NeuroProbe, Rockville, MD), transwell system or any other suitable device or system. In some examples, a cell migration assay is carried out
30 as follows: A culture of a fluorescent cell-line of interest is placed into a first chamber of a cell migration apparatus, and an exogenous agent (such as a chemoattractant) is placed in a second chamber that is adjacent to and in communication with the first chamber of the cell migration apparatus, so that cellular migration from the first chamber to the second chamber can be detected. The chambers may be separated by a membrane or filter that permits

passage of cells from one chamber to the other chamber. The membrane or filter is configured such that the passive diffusion of the cells across the membrane or filter is minimized. In one example, the first chamber is the upper chamber of the apparatus and the second chamber is the lower chamber of the apparatus. In some examples the upper chamber is omitted and the cells are placed directly on a membrane or filter in communication with the lower chamber. The ability of a fluorescent cell-line such as the fluorescent cell-lines used in the assays described herein to be stimulated to migrate can be determined. Typical migration assays have "unknown" sites (with cell suspension above the filter and a solution containing the chemotactic factor below it) and "negative control" sites (with cell suspension above the filter and suspension media, but no chemotactic factor, below). Random migration of unstimulated cells will account for some of the cells that pass through the filter. Migrated cells at the negative control sites show the extent of unstimulated random migration, which can then be differentiated from chemotactic migration, or chemotaxis. Cells that stably express a fluorescent protein, such as the disclosed fluorescent cells can be read in a microplate with a fluorescence microplate reader. Thus, the number of fluorescent cells present in either the upper chamber, lower chamber, or both chambers can be determined, for example as a function of time.

Migration assays can be used to determine if an exogenous agent, such as a test agent, affects or differentially affects the migration of one or more of the fluorescent cell-line of interest. A fluorescent cell-line of interest can be contacted with exogenous agent and the impact of the exogenous agent on the migration of the fluorescent cell-line of interest can be determined. For example, a difference between the number of cells that migrate between a fluorescent cell-line of interest contacted with an exogenous agent and a control indicates that the exogenous agent, such as a test agent, cell-line, growth factor, etc., is a modulator of cellular migration. In other embodiments, differences in migration among different cell-lines in the migration assay provide an indication of differential migration of the different cell-lines in response to the exogenous agent. In some embodiments, the difference between the number of cells that migrate of the fluorescent cell-line contacted with an exogenous agent relative to a control, (for example as measured by the fluorescence intensity of a fluorescent protein stably and constitutively expressed by the cells) is at least about 10%, such as at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 100%, at least about 150%, at least about 200%, at least about 250%, at least about 300%, at least about 350%, at least about 400%, at least about 500%, or greater than 500%. In some embodiments, the

difference is a statistically significant difference. Thus, an exogenous agent can induce a statistically significant difference in the migration of a fluorescent cell-line of interest contacted with the exogenous agent, as compared to the control, such as the fluorescent cell-line of interest not contacted with the exogenous agent or a different cell-line that has been mixed with the cell-line of interest.

In one embodiment, the exogenous agent, such as a test agent, decreases the ability of a fluorescent cell-line of interest to migrate. A test agent with such an activity is identified as a potential inhibitor of angiogenesis and would be of use in treating a disease or condition in which normal angiogenesis is increased, for example cancer. In some embodiments, a decrease in migration of the fluorescent cell-line of interest is at least about a 30%, at least about a 40%, at least about a 50%, at least about a 60%, at least about a 70%, at least about a 80%, at least about a 90%, at least about a 100%, at least about a 150%, at least about a 200%, at least about a 250%, at least about a 300%, at least about a 350%, at least about a 400%, at least about a 500% decrease as compared to control. In additional embodiments, the decrease is a statistically significant decrease as compared to a control.

iv. Fluorescence-based Cell Viability Assay

Another example of an assay is a cell viability assay. Such assays are based on the release of fluorescent protein from the cytoplasm of fluorescent cell-lines that constitutively express fluorescent protein that occurs when the integrity of the cell membrane of the cells is compromised, for example when the cell dies, such as when the cell is exposed to a cytotoxic agent, such as a test agent that is cytotoxic to the cell. Upon exposure to a cytotoxic agent the fluorescent protein is liberated to the culture media and it can be measured, for example using a fluorimeter. The greater the amount of fluorescent protein liberated from the cells present in the culture, the greater the intensity of the fluorescence present in the media. The measured fluorescence in the media corresponds to number of dead cells.

In some embodiments, the cell viability assay is used to determine if an exogenous agent, such as a test agent, is cytotoxic to one or more of the fluorescent cell-lines of interest, such as one or more of the fluorescent cell-lines disclosed herein. A fluorescent cell-line of interest can be contacted with exogenous agent and the impact of the exogenous agent on the death of the fluorescent cell-line of interest can be determined. For example, an increase in the relative florescence present in the media of between a fluorescent cell-line of interest contacted with an exogenous agent and a control indicates that the exogenous agent, such as a test agent, cell-line, growth factor, etc., is cytotoxic to the cell-line of interest. In other embodiments, differential cytotoxicity of an exogenous agent to different cell-lines in the cell

viability assay provides an indication that a specific exogenous agent is preferentially cytotoxic to one cell-line but not other cell-lines present in the culture. Such information is useful for screening agents that are preferentially or differentially cytotoxic to a specific cell-type, for example to the exclusion of other cell types. For example, in a mixed cell population a test agent could be screened to determine if it was cytotoxic (for example differentially cytotoxic) to diseased cells (such as tumor cells) present in the mixed cell population, but not normal cells present in the mixed cell population.

In some embodiments, the difference between the fluorescence of the media of a fluorescent cell-line contacted with an exogenous agent relative to a control, (for example as measured by the fluorescence intensity of a fluorescent protein liberated from the cell-line into the media) is at least about 10%, such as at least about 20%, at least about 30%, at least about 40%, at least about 50%, at least about 60%, at least about 70%, at least about 80%, at least about 90%, at least about 100%, at least about 150%, at least about 200%, at least about 250%, at least about 300%, at least about 350%, at least about 400%, at least about 500%, or greater than 500%. In some embodiments, the difference is a statistically significant difference. Thus, an exogenous agent, such as a test agent, can induce a statistically significant difference in the number of cells that die as a the migration of a fluorescent cell-line of interest contacted with the exogenous agent, as compared to the control, such as the fluorescent cell-line of interest not contacted with the exogenous agent or a different cell-line that has been mixed with the cell-line of interest.

v. Additional Angiogenesis Assays

The following descriptions provide additional examples of angiogenic assays, which may be useful in measurements of the angiogenic (or antiangiogenic) activity of a test compound, such as a compound structurally related to one of Compounds 1-77 (TABLE 1), or a scaffold shown in any of TABLES 2-9, and derivatives thereof. In particular examples, these assays can also be used to measure the antiangiogenic activity of combinations of at least two SMs from Compounds 1-77 or combinations of at least one SM from Compounds 1-77 and an additional known or potential angiogenesis inhibitor. One of ordinary skill in the art will recognize that other angiogenic assays also can be used.

Corneal Pocket Assay: This is the "gold standard" method for following the effect of defined substances to promote neovascularization of the normally avascular cornea. This assay has the advantage that new blood vessels are easily detected and essentially must be newly formed blood vessels in the normally avascular cornea. Agents to be tested for angiogenic or anti-angiogenic activity are immobilized in a slow release form in an inert

hydron pellet of approximately 1-2 μl volume. That pellet is implanted into the corneal epithelium of an anesthetized C57BL mouse (or a rabbit) in a pocket created by micro-dissection. Over a five to seven day period angiogenic factors stimulate the ingrowth of vessels from the adjacent vascularized corneal limbus. A photographic record is created by
5 slit lamp photography. The appearance, density and extent of these vessels are evaluated and scored. In some cases, the time course of the progression is followed in anesthetized animals, prior to sacrifice. Vessels are evaluated for length, density and the radial surface of the limbus from which they emanate (expressed as clock-faced hours).

Intradermal Sponge Angiogenesis Assay: Inert biopolymer sponges impregnated
10 with defined amounts of test reagents are implanted subcutaneously through a transdermal incision, into a pocket created in the subcutaneous tissue. Sponges are then removed following a defined periods ranging from five to fifteen days and the new vessel formation quantitated by a number of biochemical and histomorphometric parameters. Portions of a sponge can be extracted and analyzed by Western blot for endothelial restricted gene product
15 such as VE cadherin, *FLK-1* receptors, and others. Frozen section portions of that same sample are evaluated by immunohistochemistry for similar antigens to confirm that expression levels reflect endothelial cell proteins contained within new vessels that have invaded the sponge. In conjunction with the mouse corneal pocket assay, systemic administration of putative angiogenesis inhibitors by intraperitoneal or intravenous routes
20 permits evaluation and comparison of the local effects of those inhibitors on angiogenic stimuli in different microvascular beds.

Chick Chorioallantoic Membrane (CAM) Assay: Another assay involves the use of chicken chorioallantoic membrane (the CAM assay; see Wilting *et al.*, *Anat. Embryol.* 183: 259, 1991). The CAM assay permits the quantitation of angiogenesis and anti-angiogenesis
25 in the chick embryo chorioallantoic membrane (CAM). Briefly, chicken eggs are windowed on day two or three of incubation and the windows are sealed with tape, wax, glass slides, or PARAFILM® wrapper. On day eight of incubation, the windows are opened, and small sponges or pieces of gelatin are placed on top of the growing CAM.

After implantation, the sponges are treated with at least one stimulator orinhibitor
30 (for example, any of Compounds 1-77) of blood vessel formation. Blood vessels growing vertically into the sponge and at the boundary between sponge and surrounding CAM mesenchyme are counted by a morphometric method on day twelve. Factors that increase the number of blood vessels growing into the sponge are considered angiogenic, whereas factors that inhibit blood vessel growth into the sponge are considered antiangiogenic.

Quantification of the number of new vessels yields a measure of angiogenicity. Thus, this technique facilitates the characterization of agonists or antagonists of angiogenesis. (For more information, see Ribatti *et al., J. Vasc. Res.* 1997, 34:455-463).

Directed in vivo *Angiogenesis Assay (DIVAA)*: Yet another angiogenesis assay is termed a Directed *in vivo* Angiogenesis Assay (DIVAA; Guedez *et al.*, *American Journal of Pathology* 162(5):1431-9, 2003). Silicone tubes (0.15 mm outside diameter, New Age Industries, Southampton, PA) are cut to 1 cm in length, and one end of each tube is closed with liquid silicone and dried for 24 hours, then autoclaved. A dilution of test substances is prepared in matrigel in sterile cold Eppendorf tubes. Tubes are filled with a Hamilton syringe. Nude mice are anesthetized, and a pocket is made in the dorsal skin of each animal. The tubes are then implanted with the open end first and the wounds are sealed.

After nine to eleven days, the tail veins are injected with FITC-dextran to visualize the blood vessels, and the dye is allowed to distribute throughout the vasculature for about 20 minutes. Mice are then euthanized with CO_2 and the skin pockets are removed.

Skin is then dissected, keeping the vessels near the mouth of the tube. The matrigel is then displaced from the tube, incubated at 37 °C in the presence of dispase, then vortexed, centrifuged, and matrigel aliquots are transferred into 96-well plates for fluorescent emission. Fluorescence is read in a fluorimeter.

VII. Pharmaceutical Compositions and Modes of Administration

The compounds described herein (such as Compounds 1-77), and derivatives thereof, are particularly useful for inhibiting or reducing angiogenesis in a subject, such as a subject suffering from a disease or condition accompanied by deregulated angiogenesis. The methods of inhibiting or reducing angiogenesis include administering to a subject a therapeutically effective amount of at least one agent identified as one that inhibits or reduces angiogenesis (*e.g.*, any of Compounds 1-77, as described herein). Thus in some embodiments, the pharmaceutical composition containing a bioactive compound that decreases angiogenesis is administered to a subject, such as a subject with cancer or another disease or condition which would be treated by reducing angiogenesis. In some embodiments, the subject is a human subject. It is also contemplated that the pharmaceutical compositions containing at least one bioactive compound that decreases angiogenesis can be administered with known conventional treatments, for instance treatments for cancer, such as in conjunction with a therapeutically effective amount chemotherapeutic agent.

In particular embodiments, the pharmaceutical composition comprises at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222),
5 chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof. The composition can also comprise any combination of two, three, four, five, or six of these compounds. In other particular embodiments, any of the described compositions further comprise [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable
10 salt thereof. The combinations of the compounds can be determined based in part on the differential effect of each of the SMs in the combination on expression of angiogenesis genes, as described in greater detail in Example 5.

Therapeutic compound(s) can be administered directly to a subject for example a human subject. Administration is by any of the routes normally used for introducing a
15 compound into ultimate contact with the tissue to be treated. The compounds are administered in any suitable manner, optionally with pharmaceutically acceptable carrier(s). Suitable methods of administering therapeutic compounds are available and well known to those of skill in the art, and although more than one route can be used to administer a particular composition, a particular route can often provide a more immediate and more
20 effective reaction than another route.

When the antiangiogenic compound is to be used as a pharmaceutical, it is placed in a form suitable for therapeutic administration. The test agent (antiangiogenic compound) may, for example, be included in a pharmaceutically acceptable carrier such as excipients and additives or auxiliaries, and administered to a subject. Frequently used carriers or auxiliaries
25 include magnesium carbonate, titanium dioxide, lactose, mannitol and other sugars, talc, milk protein, gelatin, starch, vitamins, cellulose and its derivatives, animal and vegetable oils, polyethylene glycols and solvents, such as sterile water, alcohols, glycerol and polyhydric alcohols. Intravenous vehicles include fluid and nutrient replenishers. Preservatives include antimicrobial, anti-oxidants, chelating agents and inert gases. Other pharmaceutically
30 acceptable carriers include aqueous solutions, nontoxic excipients, including salts, preservatives, buffers and the like, as described, for instance, in *Remington's Pharmaceutical Sciences*, 15th ed., Easton: Mack Publishing Co., 1405-1412, 1461-1487, 1975, and *The National Formulary XIV.*, 14th ed., Washington: American Pharmaceutical Association, 1975). The pH and exact concentration of the various components of the pharmaceutical

composition are adjusted according to routine skills in the art. *See Goodman and Gilman The Pharmacological Basis for Therapeutics*, 7th ed.

The pharmaceutical compositions are in general administered topically, intravenously, orally or parenterally or as implants. Suitable solid or liquid pharmaceutical preparation forms are, for example, granules, powders, tablets, coated tablets, (micro)capsules, suppositories, syrups, emulsions, suspensions, creams, aerosols, drops or injectable solution in ampoule form and also preparations with protracted release of active compounds, in whose preparation excipients and additives and/or auxiliaries such as disintegrants, binders, coating agents, swelling agents, lubricants, flavorings, sweeteners or solubilizers are customarily used as described above. The pharmaceutical compositions are suitable for use in a variety of drug delivery systems. For a brief review of methods for drug delivery, see Langer, *Science*, 249:1527-1533, 1990, which is incorporated herein by reference.

For treatment of a patient, depending on activity of the compound, manner of administration, nature and severity of the disorder, age and body weight of the patient, different daily doses are necessary. Under certain circumstances, however, higher or lower daily doses may be appropriate. The administration of the daily dose can be carried out both by single administration in the form of an individual dose unit or else several smaller dose units, and also by multiple administrations of subdivided doses at specific intervals.

A therapeutically effective dose is the quantity of a compound according to the disclosure necessary to prevent, to cure or at least partially ameliorate the symptoms of a disease and its complications. Amounts effective for this use will, of course, depend on the severity of the disease and the weight and general state of the patient. Typically, dosages used *in vitro* may provide useful guidance in the amounts useful for *in situ* administration of the pharmaceutical composition, and animal models may be used to determine effective dosages for treatment of particular disorders. Various considerations are described, *e.g.*, in Gilman *et al.*, eds., *Goodman and Gilman: the Pharmacological Bases of Therapeutics*, 8th ed., Pergamon Press, 1990; and *Remington's Pharmaceutical Sciences*, 17th ed., Mack Publishing Co., Easton, Pa., 1990. Effectiveness of the dosage can be monitored by any method.

The antiangiogenic compounds described herein may be formulated in a variety of ways depending on the location and type of disease to be treated or prevented. Pharmaceutical compositions are thus provided for both local use at or near an affected area and for systemic use (in which the agent is administered in a manner that is widely

disseminated via the cardiovascular system). This disclosure includes within its scope pharmaceutical compositions including at least one antiangiogenic compound, formulated for use in human or veterinary medicine.

Pharmaceutical compositions that include at least one antiangiogenic compound as described herein as an active ingredient, or that include both an antiangiogenic compound and an additional anti-angiogenic agent, may be formulated with an appropriate solid or liquid carrier, depending upon the particular mode of administration chosen. Additional active ingredients include, for example, anti-angiogenic agents, such as inhibitors of bFGF or VEGF.

A suitable administration format may best be determined by a medical practitioner for each subject individually. Various pharmaceutically acceptable carriers and their formulation are described in standard formulation treatises, for example, *Remington's Pharmaceutical Sciences* by E. W. Martin. See also Wang and Hanson, *J. Parenteral Sci. Technol.*, Technical Report No. 10, Supp. 42: 2S, 1988.

The dosage form of the pharmaceutical composition will be determined by the mode of administration chosen. For instance, in addition to injectable fluids, inhalational, topical, ophthalmic, peritoneal, and oral formulations can be employed. Inhalational preparations can include aerosols, particulates, and the like. In general, the goal for particle size for inhalation is about 1μm or less in order that the pharmaceutical reach the alveolar region of the lung for absorption. Oral formulations may be liquid (for example, syrups, solutions, or suspensions), or solid (for example, powders, pills, tablets, or capsules). For solid compositions, conventional non-toxic solid carriers can include pharmaceutical grades of mannitol, lactose, starch, or magnesium stearate. Actual methods of preparing such dosage forms are known, or will be apparent, to those of ordinary skill in the art.

The compositions or pharmaceutical compositions can be administered by any route, including parenteral administration, for example, intravenous, intramuscular, intraperitoneal, intrasternal, or intra-articular injection or infusion, or by sublingual, oral, topical, intra-nasal, ophthalmic, or transmucosal administration, or by pulmonary inhalation. When anti-angiogenic compounds are provided as parenteral compositions, for example, for injection or infusion, they are generally suspended in an aqueous carrier, for example, in an isotonic buffer solution at a pH of about 3.0 to about 8.0, preferably at a pH of about 3.5 to about 7.4, 3.5 to 6.0, or 3.5 to about 5.0. Useful buffers include sodium citrate-citric acid and sodium phosphate-phosphoric acid, and sodium acetate/acetic acid buffers. A form of repository or "depot" slow release preparation may be used so that therapeutically effective amounts of the

preparation are delivered into the bloodstream over many hours or days following transdermal injection or delivery.

Antiangiogenic compounds are also suitably administered by sustained-release systems. Suitable examples of sustained-release formulations include suitable polymeric
5 materials (such as, for example, semi-permeable polymer matrices in the form of shaped articles, for example, films, or mirocapsules), suitable hydrophobic materials (for example as an emulsion in an acceptable oil) or ion exchange resins, and sparingly soluble derivatives (such as, for example, a sparingly soluble salt). Sustained-release antiangiogenic compounds may be administered by intravascular, intravenous, intra-arterial, intramuscular,
10 subcutaneous, intra-pericardial, or intra-coronary injection. Administration can also be oral, rectal, parenteral, intracisternal, intravaginal, intraperitoneal, topical (as by powders, ointments, gels, drops or transdermal patch), buccal, or as an oral or nasal spray.

Preparations for administration can be suitably formulated to give controlled release of antiangiogenic compounds. For example, the pharmaceutical compositions may be in the
15 form of particles comprising a biodegradable polymer and/or a polysaccharide jellifying and/or bioadhesive polymer, an amphiphilic polymer, an agent modifying the interface properties of the particles and a pharmacologically active substance. These compositions exhibit certain biocompatibility features that allow a controlled release of the active substance. See, for example, U.S. Patent No. 5,700,486.

20 In some embodiments, antiangiogenic compounds are delivered by way of a pump (see Sefton, *CRC Crit. Ref. Biomed. Eng.* 14:201, 1987; Buchwald *et al., Surgery* 88:507, 1980; Saudek *et al., N. Engl. J. Med.* 321:574, 1989) or by continuous subcutaneous infusions, for example, using a mini-pump. An intravenous bag solution may also be employed. The key factor in selecting an appropriate dose is the result obtained, as measured
25 by increases or decreases in angiogenesis, or by other criteria for measuring control or prevention of disease, as are deemed appropriate by the practitioner. Other controlled release systems are discussed in the review by Langer (*Science* 249:1527-1533, 1990).

In another aspect of the disclosure, antiangiogenic compounds are delivered by way of an implanted pump, described, for example, in U.S. Patent No. 6,436,091; U.S. Patent No.
30 5,939,380; and U.S. Patent No. 5,993,414. Implantable drug infusion devices are used to provide subjects with a constant and long term dosage or infusion of a drug or any other therapeutic agent. Essentially, such device may be categorized as either active or passive.

Active drug or programmable infusion devices feature a pump or a metering system to deliver the drug into the patient's system. An example of such an active drug infusion

device currently available is the Medtronic SynchroMed™ programmable pump. Such pumps typically include a drug reservoir, a peristaltic pump to pump the drug out from the reservoir, and a catheter port to transport the pumped out drug from the reservoir via the pump to a patient's anatomy. Such devices also typically include a battery to power the
5 pump, as well as an electronic module to control the flow rate of the pump. The Medtronic SynchroMed™ pump further includes an antenna to permit the remote programming of the pump.

Passive drug infusion devices, in contrast, do not feature a pump, but rather rely upon a pressurized drug reservoir to deliver the drug. Thus, such devices tend to be both
10 smaller as well as cheaper as compared to active devices. An example of such a device includes the Medtronic IsoMed™. This device delivers the drug into the patient through the force provided by a pressurized reservoir applied across a flow control unit.

The implanted pump can be completely implanted under the skin of a subject, thereby negating the need for a percutaneous catheter. These implanted pumps can provide
15 the patient with antiangiogenic compounds at a constant or a programmed delivery rate. Constant rate or programmable rate pumps are based on either phase-change or peristaltic technology. When a constant, unchanging delivery rate is required, a constant-rate pump is well suited for long-term implanted drug delivery. If changes to the infusion rate are expected, a programmable pump may be used in place of the constant rate pump system.
20 Osmotic pumps may be much smaller than other constant rate or programmable pumps, because their infusion rate can be very low. An example of such a pump is described listed in U.S. Patent No. 5,728,396.

For oral administration, the pharmaceutical compositions can take the form of, for example, tablets or capsules prepared by conventional means with pharmaceutically
25 acceptable excipients such as binding agents (for example, pregelatinised maize starch, polyvinylpyrrolidone or hydroxypropyl methylcellulose); fillers (for example, lactose, microcrystalline cellulose or calcium hydrogen phosphate); lubricants (for example, magnesium stearate, talc or silica); disintegrants (for example, potato starch or sodium starch glycolate); or wetting agents (for example, sodium lauryl sulphate). The tablets can be
30 coated by methods well known in the art. Liquid preparations for oral administration can take the form of, for example, solutions, syrups or suspensions, or they can be presented as a dry product for constitution with water or other suitable vehicle before use. Such liquid preparations can be prepared by conventional means with pharmaceutically acceptable additives such as suspending agents (for example, sorbitol syrup, cellulose derivatives or

hydrogenated edible fats); emulsifying agents (for example, lecithin or acacia); non-aqueous vehicles (for example, almond oil, oily esters, ethyl alcohol or fractionated vegetable oils); and preservatives (for example, methyl or propyl-p-hydroxybenzoates or sorbic acid). The preparations can also contain buffer salts, flavoring, coloring, and sweetening agents as
5 appropriate.

For administration by inhalation, the compounds for use according to the present disclosure are conveniently delivered in the form of an aerosol spray presentation from pressurized packs or a nebulizer, with the use of a suitable propellant, for example, dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, carbon dioxide
10 or other suitable gas. In the case of a pressurized aerosol, the dosage unit can be determined by providing a valve to deliver a metered amount. Capsules and cartridges for use in an inhaler or insufflator can be formulated containing a powder mix of the compound and a suitable powder base such as lactose or starch.

For topical administration, the compounds for use are, for example, mixed with
15 ethanol, methanol, propylene glycol, or dimethyl sulfoxide, which act as a vehicle to facilitate uniform distribution of the compound to a target area of the subject's body, such as a wound or decubitus ulcer.

Pharmaceutical compositions that comprise an antiangiogenic compound as described herein as an active ingredient will normally be formulated with an appropriate solid
20 or liquid carrier, depending upon the particular mode of administration chosen. The pharmaceutically acceptable carriers and excipients useful in this disclosure are conventional. For instance, parenteral formulations usually comprise injectable fluids that are pharmaceutically and physiologically acceptable fluid vehicles such as water, physiological saline, other balanced salt solutions, aqueous dextrose, glycerol or the like. Excipients that
25 can be included are, for instance, proteins, such as human serum albumin or plasma preparations. If desired, the pharmaceutical composition to be administered may also contain minor amounts of non-toxic auxiliary substances, such as wetting or emulsifying agents, preservatives, and pH buffering agents and the like, for example sodium acetate or sorbitan monolaurate. Actual methods of preparing such dosage forms are known, or will be
30 apparent, to those skilled in the art.

For example, for parenteral administration, antiangiogenic compounds can be formulated generally by mixing them at the desired degree of purity, in a unit dosage injectable form (solution, suspension, or emulsion), with a pharmaceutically acceptable carrier, for instance, one that is non-toxic to recipients at the dosages and concentrations

employed and is compatible with other ingredients of the formulation. A pharmaceutically acceptable carrier is a non-toxic solid, semisolid or liquid filler, diluent, encapsulating material or formulation auxiliary of any type.

Generally, the formulations are prepared by contacting the antiangiogenic compounds each uniformly and intimately with liquid carriers or finely divided solid carriers or both. Then, if necessary, the product is shaped into the desired formulation. Optionally, the carrier is a parenteral carrier, and in some embodiments it is a solution that is isotonic with the blood of the recipient. Examples of such carrier vehicles include water, saline, Ringer's solution, and dextrose solution. Non-aqueous vehicles such as fixed oils and ethyl oleate are also useful herein, as well as liposomes.

The pharmaceutical compositions that comprise an antiangiogenic compound, in some embodiments, will be formulated in unit dosage form, suitable for individual administration of precise dosages. The amount of active compound(s) administered will be dependent on the subject being treated, the severity of the affliction, and the manner of administration, and is best left to the judgment of the prescribing clinician. Within these bounds, the formulation to be administered will contain a quantity of the active component(s) in amounts effective to achieve the desired effect in the subject being treated.

The therapeutically effective amount of antiangiogenic compound will be dependent on the specific compound utilized, the subject being treated, the severity and type of the affliction, and the manner of administration.

VII. Therapeutic Uses

Methods are disclosed herein for inhibiting angiogenesis in a subject (or in an area in a subject) who has or is at risk for developing, for instance, a tumor (whether malignant or benign), retinopathy, psoriasis, endometriosis, arthritis, or any other disease for which it would be beneficial to inhibit angiogenesis. The methods include introducing a therapeutically effective amount of an antiangiogenic compound (*e.g.*, one of Compounds 1-77) to the area (or systemically), thereby inhibiting angiogenesis in the subject.

In one embodiment, the angiogenesis inhibitory compound is administered locally. For subjects with a tumor, administration may be, for example, by intra-arterial injection to the tumor's arterial supply, or by direct injection into the tumor. Other routes of administration will be determined by the tumor location. Ovarian tumors are, for example, treated by intraperitoneal washing with the inhibitor. A brain tumor is, for example, treated by intra-arterial or intrathecal injection, by intranasal administration, by direct injection of

affected brain areas, or by intravenous or intra-arterial injection following osmotic disruption of the blood brain barrier (see, for example, U.S. Patent No. 5,124,146). Lung cancer is treated, for example, by direct injection of the tumor, by inhalation, or infusion into the lobar circulation of an affected lobe of the lung. Efficacy of the treatment is determined, for example, by monitoring tumor burden, or is indicated, for example, by a lessening of symptoms, such as pain.

For subjects with retinopathy, administration is, for example, by intra-ocular injection (for example, into the posterior chamber of the eye), or by topical ophthalmic administration. Alternatively, the agent may be administered intravascularly, for example into the vascular supply for the retinal artery. Efficacy of the treatment is determined, for example, by an improvement in vision, by a stabilization of vision, by a lack of new blood vessel formation in the retina, or by failure of the disease to progress.

For subjects with psoriasis, administration is, for example, by subcutaneous or intravenous injection, or by topical application. Efficacy of the treatment is determined, for example, by an abatement of psoriasis symptoms. For subjects with arthritis, administration is, for example, by intra-articular injection. Efficacy of the treatment is monitored, for example, by detecting an improvement in mobility, or a lessening of joint pain. For subjects with endometriosis, administration is, for example, by direct injection of the endometrial growths, or by intraperitoneal washing with the antiangiogenic compound. Efficacy of the treatment is shown, for example, by an improvement in mobility, or a lessening of pelvic pain.

Administration of the angiogenesis inhibitor may begin whenever a subject has developed, or is at risk for developing a tumor, retinopathy, psoriasis, or endometriosis, or when symptoms of inappropriate neovascularization are present.

Also disclosed are methods for treating undesirable angiogenesis and angiogenesis dependent or associated diseases, in a subject. The method includes administering one or more of the presently described compounds, or a combination of one or more of the compounds and one or more other pharmaceutical agents, to the subject in a pharmaceutically compatible carrier. The administration is made in an amount effective to inhibit the development or progression of angiogenesis and diseases associated with the same. Although the treatment can be used prophylactically in any patient in a demographic group at significant risk for such diseases, subjects can also be selected using more specific criteria, such as a definitive diagnosis of the condition.

The vehicle in which the drug is delivered can include pharmaceutically acceptable compositions of the drugs, using methods well known to those with skill in the art. Any of the common carriers, such as sterile saline or glucose solution, can be utilized with the drugs disclosed herein. Routes of administration include but are not limited to oral and parenteral routes, such as intravenous (iv), intraperitoneal (ip), rectal, topical, ophthalmic, nasal, and transdermal.

The drug may be administered in a suitable manner now known or later developed, *e.g.*, orally or intravenously, in any conventional medium. For example, intravenous injection may be by an aqueous saline medium. The medium may also contain conventional pharmaceutical adjunct materials such as, for example, pharmaceutically acceptable salts to adjust the osmotic pressure, lipid carriers such as cyclodextrins, proteins such as serum albumin, hydrophilic agents such as methyl cellulose, detergents, buffers, preservatives and the like. A more complete explanation of parenteral pharmaceutical carriers can be found in *Remington: The Science and Practice of Pharmacy* (19th Edition, 1995) in chapter 95.

Examples of other pharmaceutical compositions can be prepared with conventional pharmaceutically acceptable carriers, adjuvants and counterions as would be known to those of skill in the art. The compositions are preferably in the form of a unit dose in solid, semi-solid and liquid dosage forms such as tablets, pills, powders, liquid solutions or suspensions.

The compounds illustrated herein are ideally administered as soon as possible after unwanted angiogenesis is detected. For example, once unwanted angiogenesis has been confirmed or the presence of a tumor has been identified, a therapeutically effective amount of the drug is administered. The compound(s) can be administered in a single dose, or in multiple doses, for example daily, weekly, every two weeks, or monthly during a course of treatment.

Therapeutically effective doses of the presently described compounds can be determined by one of skill in the art, with a goal of achieving a desired level of antiangiogenesis as illustrated in the foregoing examples. In one embodiment, an antiangiogenic effective amount is an amount sufficient to achieve a statistically significant inhibition of angiogenesis compared to a control. Angiogenesis can be readily assessed using an assay, *e.g.*, any of the assays described herein. Alternatively, angiogenesis can be determined in another assay or by direct or indirect signs of angiogenesis in a patient.

The relative toxicities of the compounds make it possible to administer in various dosage ranges. An example of such a dosage range is from about 0.5 to about 50 mg/kg body weight orally in single or divided doses. Another example of a dosage range is from

about 1.0 to about 25 mg/kg body weight orally in single or divided doses. For oral administration, the compositions are, for example, provided in the form of a tablet containing from about 25 to about 500 mg of the active ingredient, particularly 100 mg of the active ingredient for the symptomatic adjustment of the dosage to the subject being treated.

5 The specific dose level and frequency of dosage for any particular subject may be varied and will depend upon a variety of factors, including the activity of the specific compound, the extent of existing angiogenic activity, the age, body weight, general health, sex, diet, mode and time of administration, rate of excretion, drug combination, and severity of the condition of the host undergoing therapy.

10 The pharmaceutical compositions containing at least one of the antiangiogenic SMs described herein can be used in the treatment of a variety of diseases mediated by angiogenesis. Examples of such angiogenesis-dependent diseases include all types of cancer, ocular neovascular disease, tumor formation and metastasis in tumors such as myeloma, rhabdomyosarcomas, retinoblastoma, Ewing sarcoma, neuroblastoma, osteosarcoma, colon,
15 prostate, head and neck, breast, bladder, liver, pancreatic, lung, CNS, and blood-born tumors such as leukemia, also diseases such as hemangioma, ulcerative colitis, Crohn's disease, diabetic retinopathy, macular degeneration, sickle cell anemia, sarcoid, syphilis, pseudoxanthoma elasticum, Paget's disease, vein occlusion, artery occlusion, carotid obstructive disease, chronic uveitis/vitritis, mycobacterial infections, Lyme's disease,
20 systemic lupus erythematosis, retinopathy of prematurity, Eale's disease, Bechet's disease, infections causing a retinitis or choroiditis, presumed ocular histoplasmosis, Best's disease, myopia, optic pits, Stargart's disease, pars planitis, chronic retinal detachment, hyperviscosity syndromes, toxoplasmosis, trauma and post-laser complications. Other diseases include, but are not limited to, diseases associated with rubeosis (neovasculariation of the angle) and
25 diseases caused by the abnormal proliferation of fibrovascular or fibrous tissue including all forms of proliferative vitreoretinopathy.

Also disclosed herein are combinations of one or more of the presently described compounds with one or more of various other angiogenesis inhibitor compounds. For example, the presently described compounds may be administered in combination with
30 effective doses of other antiangiogenic agents. The term "administration in combination" refers to both concurrent and sequential (in either order) administration of the active agents. Non-limiting examples of antiangiogenic agents that can be used in combination with the compounds indentified herein are TNP-470, carbonic anhydrase inhibitors, endostatin, angiostatin, 2-methoxyestradiol, IMiD (Immune-modulating inhibitor drug) CC5013, matrix

metalloproteinase inhibitors, and COL-3, as well as bFGF or VEGF inhibitor, such as SU5416, which is a specific VEGF-R antagonist, and SU6668 which blocks the receptors for VEGF, bFGF, and PDGF (see, for example, Liu *et al., Seminars in Oncology* 29 (Suppl 11): 96-103, 2002; Shepherd *et al., Lung Cancer* 34:S81-S89, 2001). In addition, the presently described compounds may be used in combination with other forms of cancer therapy (*e.g.*, chemotherapy, radiation therapy, hormonal therapy) or other therapies known for use with angiogenesis-related disorders and diseases.

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EXAMPLES

Example 1: Antiangiogenic small molecule signatures

This example describes the identification and initial characterization of antiangiogenic small molecules using cell-based HTS methodology.

The present disclosure relates to the discovery of a new set of antiangiogenic small molecules. The antiangiogenic small molecules were identified through a combination of cell-based high throughput screening (HTS) together with chemo-informatic tools. This approach differs from the one taken by previous studies and pharmaceutical companies, in that the HTS is not targeted to a single subcellular molecule but instead targets a whole

cellular process. In particular, two cell based assays have been developed which represent the two most important steps in angiogenesis: endothelial cell growth and tube formation.

Using the cell-based HTS screen, a new set of antiangiogenic small molecules have been discovered. Structure-activity-relationship (SAR) studies have shown that most of these new bioactive SMs are not related to known antiangiogenic SMs (FDA marketed; SMs currently in clinical trials; SMs annotated as antiangiogenic in chemical databases such as LeadScope, DrugBank, PubChem, etc.).

Overview of High Throughput Screen

The small molecule library screened was the NCI Diversity Set I (available on-line at dtp.nci.nih.gov/branches/dscb/diversity_explanation.html). The library was obtained from DTP/NCI (available on-line at dtp.nci.nih.gov/). This library contains 1974 small molecules (SMs) which are representative members of the same number of structural families each containing a variable number of members. The SMs included in the NCI Diversity Set I were selected to summarize the structural diversity found in a library of approximately 72,000 SMs. The library was obtained in 96-well plates and plate-to-plate DMSO dilutions were prepared at a stock concentration of 200μM.

Two different cell-based HTS assays were developed which mimic the two main steps of the angiogenesis process: (1) a growth assay and (2) a tube formation assay (see below for more detail on assay protocols). The primary goal of the two HTSs was to find SMs which block either growth or tube formation of endothelial cells. These two assays comprised the *primary screening* which defined a first group of "bioactive compounds" which were then evaluated with *secondary screening*. See Figure 1.

The secondary screening included two steps: (1) a cytotoxicity assay (described below) which was designed to discriminate cytotoxic compounds and (2) calculation of IC50 for every of the compounds identified in the primary screening. This secondary screening was also designed to eliminate putative false positives found in the primary screening and to evaluate the potency of the bioactive compounds. See Figure 1.

The set of biologically active compounds obtained after the secondary screening was then used in a number of chemoinformatic studies as well as in *in vitro* studies in order to partially characterize their mechanism of action as well as compare them with existing antiangiogenic small molecules currently approved by the FDA, or in development by pharmaceutical companies.

Based on the compiled results of the HTS and other *in vitro* assays, a small set of compounds was chosen for *in vivo* studies. These studies included primarily xenograft

experiments (*See* Example 2) and were designed to confirm the antiangiogenic activity of the compounds of interest, as well as test innovative anti-tumor/anti-angiogenic drug-combination regimens.

5 *Experimental Design for HTS*

Figure 2 illustrates the basic experimental design for all HTS assays; the same scheme was applied to both growth and tube formation assays. All assays were performed in clear bottom black 96-well plates. The plates were always arranged to include a column for negative controls (column 1), a column for positive controls (column 12), and 10 columns for
10 evaluation of 80 compounds. In order to increase stringency and avoid false positives in the HTS assays, all compounds were tested at a low final concentration of 1μM.

Both HTS assays (growth and tube formation) were based on the use of fluorescent reporter cell lines, essentially as described in U.S. Application No. 12/060,752 (published as US 2009/0088341 on April 2, 2009; incorporated herein by reference in its entirety). In
15 summary, the cell lines porcine aortic endothelial cell (PAE), BEC (a human microvascular endothelial cell line), HMEC-1 (human microvascular endothelial cell line), A549 (human adenocarcinoma from the lung) and MCF7 (breast cancer cell line), among others, were stably transfected with different fluorescent proteins (green fluorescent protein –GFP-, yellow fluorescent protein –YFP-, red fluorescent protein –RFP-, and blue fluorescent
20 protein –BFP-). Details on the production of these cell lines are described in U.S. Application No. 12/060,752, which published as US 2009/0088341 on April 2, 2009.

Growth HTS: Previously, we demonstrated that there is a linear correlation between the fluorescence emission of the reporter cell lines and their number in culture. In summary, 1,000 cells/well were seeded in the 96-well plates described above. Cells in
25 columns 2-12 were seeded in 10% FBS and cells in column 1 (negative control) were seeded in 0% FBS. Small molecules (80 per plate) were added in columns 2-11 at a final concentration of 1μM (both positive and negative controls were exposed to the same percentage of DMSO in wells containing test compounds). The fluorescence emitted by every well was measured spectrophotometrically (Infinite M200, TECAN®, Mannedorf,
30 Switzerland) every 24 hours for 5-7 days. The assay quality was evaluated y calculating the Z' score (Zhang *et al.*, *J. Biomol. Screen* 4(2):67-73, 1999) for every plate (only plates with Z'>0.5 were considered).

Tube Formation HTS: In summary, 20,000 cells/well were seeded on top of 50 μl of pre-gelled GELTREX® gel matrix (Invitrogen, Carlsbad, CA). All cells were seeded in

10% FBS. Cells in column 1 (negative control) were exposed to 25 µM of suramine (an antiangiogenic factor known to be an inhibitor of endothelial tube formation). Small molecules (80 per plate) were added to columns 2-11 at a final concentration of 1µM (both positive and negative controls were exposed to the same percentage of DMSO in wells
5 containing test compounds). Plates were incubated for 5-7 hours and automatically imaged with the help of an epifluorescence microscope (Axiovert® 200M, Zeiss) equipped with a motorized stage and AxioVision® (Zeiss) software. Images were analyzed with the AngioApplication™ software (see below).

Hit detection: Data obtained from both the growth and tube formation HTSs were
10 processed with the HTS Corrector software (Makarenkov *et al.*, *Bioinformatics* 23(11):1408-0409, 2007). Data were normalized using "well correction" (Makarenkov *et al.*, *Bioinformatics* 23(13):1648-1657, 2007) and hit identification was achieved using clustering by "sum of the average squared inside-cluster distances" (Gagarin *et al.*, *J. Biomol. Screen* 11(8):903-914, 2006). For hit detection, a stringent threshold (sigma 3.5) was applied to
15 avoid false positives.

Results of HTS Growth Assay

Figure 3 shows the results on one the plates (4143-11) included in the growth HTS using PAE cells. The plot represents fluorescence emission of all 96 wells over 7 days. As
20 expected, fluorescence values increase over time although different wells show different fluorescence values. A composite image of all 96 wells is also shown (at day 4 of growth). Positive controls are shown in the far right column of wells; as expected, these controls show maximum values of fluorescence (in the plot) and high density of cells in the wells. A negative control is shown in the left column of wells; these show low fluorescence values in
25 the plot and low cell density in the wells. Additionally, an example of a compound which blocks growth of PAE is shown in the first row, fourth column from the left, with low fluorescence values and few cells in the well. Furthermore, an example of a compound which does not inhibit the growth of PAE is shown in the seventh row, fourth column. In this case, high fluorescence values are shown in the plot together with a high number of cells
30 in the well.

Growth HTS Summary

Following the same protocol, HTS growth experiments were performed for PAE, BEC, A549 and MCF7 cells. These experiments were designed to explore the specificity of

SMs with inhibitory activity in endothelial cells as compared to tumor cells from different anatomical origins.

Figure 4 shows a heatmap that summarizes obtained results. The heatmap was constructed using the function heatmap.2 of the package gplots of the R statistical software. Clustering was performed using Euclidean distance matrix. The X axis shows the 1974 SM tested and the Y axis represents some of the growth HTS experiments performed. For all experiments measurements obtained in different days have been included and as expected show a high degree of consistency. Dark blue cells in the heatmap represent SM with strongest growth inhibitory activity and green and yellow SM with no activity on growth.

As expected, a small percentage of the SMs in the library had an inhibitory effect on the different cell lines. Interestingly, the majority of SMs shown to block growth of endothelial cells also inhibited the growth of tumor cells. Statistical analysis of these data identified 48 SMs which consistently inhibited the growth of endothelial cells (see TABLE 10).

Comparison of Growth Inhibitory Activity in Endothelial Cells vs. Tumor Cells

In the heatmap shown in Figure 4, it is difficult to distinguish the SMs which preferentially inhibit the growth of endothelial cells or tumor cells. In order to study this possibility, average growth activity values for endothelial cells and tumor cells were compared in a bivariate scatterplot. Most of the SMs do not have an effect in growth in any of the cell lines tested and cluster in the center of the scatterplot (indicated within the middle-sized oval at the center of the plot). Also, most SMs with growth inhibitory activity affected with similar potency to tumor cells and endothelial cells and cluster in the lower left quadrant (indicated within the largest oval). Interestingly, a few SMs showed growth inhibitory activity in tumor cells but not in endothelial cells (small oval; see also TABLE 10). Growth activity of these small molecules is shown in the adjacent plot (small molecules are identified by their position in the plate; TABLE 10 correlates plate position to NSC number). No SMs were found with specific inhibitory activity for endothelial cells.

Specificity in the growth inhibitory activity of SMs is an important feature in the context of combinatorial drug therapy. In the treatment of angiogenesis-dependent tumors it is likely important to first deliver drugs that inhibit tumor growth but do not affect endothelial cells in order to not damage the vasculature which serves as drug delivery conduit to effectively reach the tumor. Therefore, drugs like the ones found in this study with the ability of specifically inhibit tumor growth but not endothelial cell growth would be of great value. Once the tumor has been significantly reduced, drugs with inhibitory activity in both

tumor cells and endothelial cells would be preferred since both tumor cells and endothelial cells need to be targeted. A number of such drugs have also been found in this study (see TABLE 10).

Half Maximal Inhibitory Concentration (IC50) in PAE

5 Dose response curves were constructed for all the SM of interest using PAE cells. Data were fitted to non-linear sigmoid curves using GraphPad Prism (GraphPad software, Inc.). This assay was designed as a multipurpose experiment aimed to: (1) confirm bioactivity of SMs of interest, (2) confirm dose response of the growth inhibitory activity, and (3) calculate the half maximal inhibitory concentration (IC50). Since the initial 10 screening was performed using a final SM concentration of 1μM, IC50 form most compounds were confirmed to be in the range of 10^{-12} to 10^{-9} M (Figure 6). This confirms that all the SMs discovered in this project show high growth inhibitory potency in endothelial cells (see TABLE 10).

Cytotoxicity Assay

15 Evaluation of the results obtained in the HTS growth assay does not provide information on whether the identified bioactive compounds inhibit growth through cell toxicity. Cytotoxicity is a common problem associated with non-peptidic small molecule drugs. In order to explore the cytotoxic potential of the SMs of interest, a novel high throughput cytotoxicity assay was previously developed (U.S. Application No. 12/060,752; 20 published as US 2009/0088341 on April 2, 2009). The assay is based on the fact that cytotoxicity involves damage to the cell membrane which results in release of cytoplasmic content to the cell milieu. Since the reporter fluorescent cells used herein constitutively synthesize fluorescent proteins which are present in the cytoplasm, liberation of fluorescence to the medium can be used as an assessment of cytotoxicity.

25 Figure 7 shows two different hypothetical outcomes of the cytotoxicity assay. In the lower area of the diagram, fluorescent cells are exposed to a cytotoxic substance, which results in the liberation of floresence to the cell culture medium. Both the fluorescence in the medium and the remaining fluorescence in the cells can be quantitated and used to determine percentage of cytotoxicity using the formula in the lower are of the figure. The 30 plot shows the expected dose response curve when Triton X is used as cytotoxic agent on PAE cells.

Figure 8 shows an example of four compounds with growth inhibitory activity from which two present a strong and moderate cytotoxic activity respectively. Using this cytotoxicity assay four compounds were identified as cytotoxic (see TABLE 10). Although

these cytotoxic compounds may be of clinical interest, they were excluded from consideration for subsequent *in vivo* experiments.

Tube Formation

A HTS tube formation assay was also used for evaluation of antiangiogenic compounds. After being seeded, the endothelial cells are homogeneously distributed on the matrigel. Over time, cells migrate and interact with other endothelial cells to form tube-like structures which mimic the vasculature *in vivo*. Tube formation recapitulates several key steps of the angiogenic process: endothelial cell activation, cell migration, matrix degradation, cell polarization, cell to cell interaction and tube formation (among others).

Data Analysis using AngioApplication™

The major obstacle that was encountered in adapting the tube formation assay to a HTS format was performing a morphological quantitative analysis of the tube formation. For that purpose, an image analysis program named AngioApplication™ was developed (described in detail in U.S. Application No. 12/060,752; published as US 2009/0088341 on April 2, 2009). This software (Figure 9) is able to rapidly assess a variety of metrics in images of tube formation including (but not limited to) tube length, node area, branching points, fractal dimension and lacunarity.

In order to understand which one of those metrics better explained the variability of the HTS tube formation assay data, a principal component analysis (PCA) was run. The PCA showed that branching index (the number of branches which converge in each node) and lacunarity (the average area of the empty spaces left by the tubes in the images) explain 53.8% and 45.0% respectively of the variability of the data (components C1 and C2 in the plots below) (see Figure 10), making them the most appropriate metrics to measure tube formation.

Both emptiness (C1) and branching index (C2) were plotted in a bivariate scatter plot for every SM tested. The Euclidean distance between the average of the positive controls and every SM was used as metric to define anti-tube formation activity (calculations were done separately for every plate). In essence, compounds which are further away from the positive controls are more likely to be antiangiogenic. Figure 11 illustrates the results from all the SMs in one test plates. As expected, most of the compounds (small squares clustered in center of graph) are located closely to the positive controls (large squares clustered near center of graph); this cluster is due to the fact that most small molecules do not have an effect on tube formation and therefore show similar branching index and emptiness values. In contrast, the negative controls (large squares clustered in lower right corner of graph) are

positioned farther away from the positive controls. Representative images of the positive and negative controls are shown. Tube formation inhibitory compounds are detected as being located at an intermediate distance between the positive controls and the negative controls. A representative image of an active SM is shown (Figure 11).

5 35 out the 1974 compounds in the library (1.75%) were found to statistically significantly inhibit tube formation (see TABLE 10).

Dose Response of NSC 119889 in Tube Formation Assay

IC50 were calculated for all tube formation inhibitor SMs. As expected, most IC50 were in the range of 10^{-9} to 10^{-12} M, making these compounds highly effective tube formation 10 inhibitors. Figure 12 shows an example of the dose response generated with compound NSC119889.

Results of Screen and Analysis

Figure 13 summarizes the results obtained in the growth and tube formation HTS for endothelial cells (for information on specific compounds, see TABLE 10). 2.4% (48) of the 15 compounds were growth inhibitors and 1.75% (35) were tube formation inhibitors. Interestingly, 0.5% (11) of the compounds showed both growth and tube formation inhibitory activity. These SMs are especially interesting from the perspective of network pharmacology. It has been suggested that exquisitely selective compounds, compared with multitarget drugs, may exhibit lower than desired clinical efficacy (Hopkins, *Nat. Chem.* 20 *Biol.* 4(11):682-690, 2008). However, it is challenging to design multitarget drugs while maintaining their drug-like properties. Here we have identified 11 SMs which show both growth and tube formation inhibitory activity (see TABLE 10).

Structure-Based Analysis

The structures of the antiangiogenic SMs identified herein were compared with 25 annotated compounds in available annotated SM databases such as PubChem, DrugBank, LeadScope and FDA Marketed Drugs among others. Structural classifications were performed with LeadScope software. Only a few of our SMs were structurally related to annotated compounds in other databases (numbers in parenthesis in Figure 14). This can be explained by the novel drug discovery methodology utilized in this project, which, as 30 expected, results in novel SARs discoveries. Particularly interesting is the fact that none of the antiangiogenic SMs discovered herein are structurally related to any of the known antiangiogenic SMs. This supports the novelty of these newly-discovered antiangiogenic SMs and emphasizes that new SARs will result in exploitation of new cellular antiangiogenic pathways.

One of the areas for future work in this project is the identification of specific mechanisms of action for the newly-discovered antiangiogenic SMs. Some progress has already been achieved by applying Tanimoto's similarity algorithm (40-80% similarity) to compare the SMs described herein with SMs with known mechanism of action (Fligner *et al., Technomet*, 110-19, 2002. The structure of 12 compounds was found to be compatible with a potential mechanism of action (noted in parenthesis in "Mechnism of Action" in TABLE 10).

TABLE 10: BIOACTIVE SMALL MOLECULES

Compound	Location in Plate	NSC Numbers	Bioactivity	Cytotoxicity (%)	Growth IC50 (M) in PAE	Apoptosis PAE (RFU)	Mechanism of Action
1	4125_G10	329226	1	7.564570142	3.719E-10	2.63432836	
2	4127_D3	15234	1	7.734030998	1.106E-10	0.70335821	
3	4127_E3	15226	1	9.013157895	>1.00E-06	0.81599813	
4	4127_E6	24076	1	7.346874506	>1.00E-06	0.6823694	
5	4127_E11	26081	1	7.103315772	>1.00E-06	0.67490672	
6	4130_D6	133896	1	6.968579807	5.77E-10	0.68983209	
7	4131_C11	675865	1	7.322550338	1.118E-11	1.63945896	
8	4131_E10	10460	1	8.512827087	>1.00E-06	0.85797575	
9	4132_D9	207895	1	7.69900465	2.297E-10	0.98763993	Tubulin Binder (80)
10	4133_H4	99445	1	6.79005243	>1.00E-06	1.05550373	DNA synthesis inhibitor (80)
11	4133_H10	88903	1	18.69722406	2.366E-11	0.90298507	
12	4134_A8	177407	1	6.734835623	3.016E-10	1.66487873	
13	4135_D8	123111	1	7.062612517	1.65E-11	0.96338619	Alkylating agent (40)
14	4136_F10	329261	1	6.510813456	1.885E-09	0.93913246	
15	4137_C5	13316	1	7.93334652	6.552E-10	0.93516791	
16	4137_G3	5844	1	6.779904279	>1.00E-06	0.90578358	
17	4138_C3	5857	1	7.344979376	3.979E-10	2.10704291	
18	4138_E2	656202	1	7.599327541	4.635E-10	1.5886194	
19	4138_G2	2186	1	6.564555483	9.626E-10	1.34001866	
20	4138_H7	97845	1	8.180294654	4.684E-09	0.94986007	Tubulin binder (80)
21	4139_H6	368891	1	6.565516968	2.291E-11	0.96805037	
22	4140_A3	126710	1	6.745211776	1.535E-12	1.22807836	
23	4140_C2	109836	1	7.015392379	1.207E-09	0.82649254	
24	4140_D11	67485	1	8.537374177	>1.00E-06	1.37546642	
25	4140_E9	47932	1	9.566749391	2.267E-10	1.43283582	Antifungal (60)
26	4141_F2	176327	1	8.243912666	8.379E-11	2.6798041	
27	4141_F6	48630	1	7.89544627	>1.00E-06	0.95895522	
28	4141_G8	71669	1	8.645721955	7.412E-11	1.34025187	
29	4142_E8	150289	1	9.782711919	>1.00E-06	0.97504664	
30	4143_A4	311153	1	8.808756865	9.265E-10	0.63899254	
31	4143_A9	45238	1	7.617204067	0.0005062	1.23763993	
32	4143_C6	156305	1	6.821926473	>1.00E-06	1.34981343	Topoisomerase II inhibitor (40)

Compound	Location in Plate	NSC Numbers	Bioactivity	Cytotoxicity (%)	Growth IC50 (M) in PAE	Apoptosis PAE (RFU)	Mechanism of Action
33	4143_C9	62914	1	7.444298641	2.801E-10	2.06296642	
34	4143_C10	606985	1	10.19900361	9.919E-12	2.93703358	Topoisomerase II inhibitor (80)
35	4144_G7	254681	1	7.976999744	2.41E-11	3.30060634	Topoisomerase II inhibitor (60)
36	4145_D4	268665	1	7.657827234	2.453E-10	0.97737873	DNA synthesis inhibitor (60)
37	4145_G5	306698	1	7.923868435	>1.00E-06	2.03708022	
38	4121_A6	4972	2	6.742820667		0.70335821	
39	4121_A8	19630	2	8.537524348		0.73997201	
40	4123_H10	2805	2	7.23286013		0.6770056	
41	4124_E8	16555	2	7.591147773		0.8048041	
42	4125_B6	3535	2	6.993009343		0.84584888	
43	4127_G11	27063	2	6.439058017		1.13456157	
44	4128_D5	47924	2	6.449536192		0.89412313	
45	4129_D8	36738	2	6.610206089		0.87290112	
46	4130_H10	108895	2	7.361554387		0.86054104	
47	4131_H11	681152	2	6.856025461		0.59864739	
48	4136_E6	632536	2	7.00534393		0.80806903	
49	4140_G4	122351	2	6.968172168		1.23507463	
50	4142_D8	268879	2	13.72791324		3.10284515	DNA synthesis inhibitor (40)
51	4142_H2	48458	2	8.564443963		1.66954291	
52	4143_E3	209910	2	9.581766236		1.22504664	
53	4143_E10	328087	2	8.762714287		1.21245336	
54	4144_D9	521777	2	9.262232258		8.04127799	
55	4144_D11	310551	2	28.17915266		0.92863806	
56	4144_E2	292222	2	7.520592126		3.41907649	Tubulin Binder (60)
57	4144_G11	321237	2	7.377240696		1.14552239	DNA synthesis inhibitor (40)
58	4144_H2	259969	2	11.1918293		5.61497201	
59	4144_H5	259968	2	9.793991594		6.21501866	
60	4145_C4	203328	2	6.947818406		1.26096082	
61	4145_E6	166687	2	7.901324787		1.84071828	
62	4145_H6	119889	2	13.63421931		1.26888993	
63	4132_F3	676693	3	7.48119818	1.546E-11	1.44776119	****
64	4135_D7	122657	3	7.092535262	2.79E-10	0.78941231	****
65	4138_B4	295642	3	13.74937928	1.085E-11	2.22714552	
66	4139_B8	13480	3	13.10907474	4.117E-10	1.04967351	
67	4139_B11	150117	3	7.776786651	9.16E-11	0.67537313	****
68	4139_C8	18877	3	19.12681814	1.404E-10	1.3542444	
69	4141_B4	48300	3	8.261734079	3.837E-10	1.1354944	****
70	4142_A2	321206	3	38.52519823	6.112E-12	1.02122201	
71	4142_B6	292596	3	9.501696674	7.577E-11	2.30573694	****
72	4144_G4	112200	3	13.88370945	1.386E-10	1.36847015	
73	4145_D5	274547	3	15.66300644	3.579E-10	0.90625	
74	4123_B6	4265	4				
75	4130_G5	130830	4				
76	4133_D11	54044	4				
77	4143_A5	327705	4				

Bioactivity 1 Endothelial Cell Growth Inhibitor

2 Tube Formation Inhibitor
3 Growth Inhibitor + Tube Formation Inhibitor
4 Specific Tumor Cell Growth Inhibitor

**** Compounds with both growth and tube formation inhibitory activities and no significant cytotoxicity.

Example 2: *In vivo* inhibition of angiogenesis in xenograft tumors

This example shows the *in vivo* inhibition of angiogenesis in tumor xenografts by administration of selected small molecules described herein.

Methods

For generation of mouse xenografts, female athymic nude mice were injected with $5x10^6$ A549 or SK-ML-1 cells (100 µl/mouse) in the left hindquarters. The resulting tumors were measured three times a week and body weight was measured twice a week. 14 days following tumor cell injection, mice with tumor burdens greater than $100mm^3$ or less than $50mm^3$ were eliminated from the study. The remaining mice were randomized into groups (10 animals per group) and treated three times a week (Mon/Wed/Fri) for four weeks with 100 µl of 10 µM sterile drug solutions (stored at 4°C) that were administered via IP injection. Tumors were measured three times per week (Mon/Wed/Fri) for four additional weeks and mice weighed twice weekly (Tues/Thu) for an additional four weeks. On week six or when tumors exceeded 2 cm, the mice were euthanized. A full necropsy was performed and any abnormal tissues were snap frozen (-80°C). Tumors were excised and bisected into four parts. Two parts were fixed in 2% formalin overnight at 4°C, rinsed in cold PBS and prepared for paraffin embedding. The other two parts were snap frozen on dry ice or liquid nitrogen and stored at -80°C.

Results

7 of the 77 SMs described above were chosen for *in vivo* xenograft experiments. SMs were selected based on the type of inhibition (tube formation –NSC 19630, NSC 292222, NSC 259969; or tube formation + growth –NSC 122657, NSC 150117, NSC 48300, NSC 292596), percentage of inhibition, low cytotoxicity levels and availability. For the tumor xenografts, two different human cancer models were chosen. A549 is a lung carcinoma which induces almost exclusively peritumoral vasculature in subcutaneous tumors. In contrast, SK-ML-1 is a leiomyosarcoma which induces high levels of intratumoral angiogenesis. Every experiment included a negative PBS control as well as the known antiangiogenic drug AVASTIN® as a positive control. AVASTIN® was previously shown to significantly inhibit the growth of both A549 as well as SK-ML-1.

As shown in Figure 15, all the small molecules inhibited tumor growth to varying degrees. In general, and as expected, the small molecules more strongly inhibited the growth of the angiogenic tumor SK-ML-1 (bottom panels) in comparison to the less angiogenic tumor A549 (top panels). Of the SMs tested, the strongest inhibitors of tumor growth were NSC 48300, NSC 150117 and NSC 259969, all of which showed potencies similar to AVASTIN® in the SK-ML-1 model.

Example 3: Tubulin binding potential of antiangiogenic small molecules.

Many known antiangiogenic drugs bind to tubulin and interfere with its polymerization. Likewise, it has also been shown that molecules which interfere with tubulin polymerization are potentially antiangiogenic. In contrast, the above-described SAR analysis predicted that none of the seven small molecules shown in Example 2 to be antiangiogenic in xenograft assays would inhibit tubulin polymerization. This example confirms this prediction.

The tubulin binding activity of the small molecules studied *in vivo* was characterized using a fluorescence-based, tubulin polymerization assay from Cytoskeleton (Denver, CO; Cat. # BK011P), according to the manufacturer's instructions. As predicted by the SAR analysis, none of the small molecules studied interfered with tubulin polymerization (Figure 16).

Example 4: Effect of SMs on Receptor Tyrosine Kinase activity

Most of the currently FDA approved antiangiogenic therapies (such as AVASTIN® or sunitinib) target receptor tyrosine kinase (RTK) activity. It has recently been proposed by independent groups (Pàez-Ribes *et al.*, *Cancer Cell*, 15: 220-231, 2009; Ebos *et al.*, *Cancer Cell*, 15: 232-239, 2009) that RTK inhibitors have deleterious collateral effects, including stimulation of metastasis and alternative angiogenesis pathways other than those inhibited by the drugs. This example shows the characterization of the RTK inhibitory activity of a subset of the small molecules described herein.

To characterize the RTK inhibitory activity of the antiangiogenic SMs described herein, 36 compounds were chosen and screened using Invitrogen's SelectScreen® kinase activity profiling service (described on-line at tools.invitrogen.com/content.cfm?pageid =10413#selection). VEGFR1 and FGFR2 RTK inhibitory activities were studied. The results of the screen are detailed in Table 11. The % inhibition (and mean % inhibition) of RTK activity from two independent trials is shown Of the seven SMs tested *in vivo* in

Example 2, only NSC19630 and NSC48300 showed RTK inhibitory activity, and only for for the VEGFR2 receptor. Overall, a small minority of the SMs tested had any substantial kinase inhibitory activity. This observation supports a mechanism of antiangiogenic action other than RTK inhibition for most of the SMs described herein.

5

TABLE 11: KINASE INHIBITION

SMs that inhibited kinase activity 40% or more are indicated in bold.
SMs also characterized for *in vivo* activity are italicized.

Comp. NSC#	Kinase Activity Tested	% Inhibition	% Inhibition	Mean % Inhibition
4972	FGFR1	3	-7	-2
4972	KDR(VEGFR2)	2	11	7
19630	*FGFR1*	*2*	*-2*	*0*
19630	***KDR(VEGFR2)***	***90***	***91***	***90***
2805	FGFR1	1	10	6
2805	**KDR(VEGFR2)**	**42**	**52**	**47**
16555	FGFR1	3	3	3
16555	KDR(VEGFR2)	11	11	11
3535	FGFR1	-1	-3	-2
3535	KDR(VEGFR2)	10	5	8
27063	FGFR1	-3	-2	-3
27063	KDR(VEGFR2)	12	11	11
47924	FGFR1	1	3	2
47924	KDR(VEGFR2)	21	18	19
36738	FGFR1	-1	4	1
36738	KDR(VEGFR2)	16	17	16
108895	FGFR1	4	4	4
108895	KDR(VEGFR2)	5	6	6
681152	FGFR1	4	3	3
681152	KDR(VEGFR2)	10	8	9
676693	FGFR1	4	3	3
676693	KDR(VEGFR2)	1	8	5
122657	*FGFR1*	*-3*	*-3*	*-3*
122657	*KDR(VEGFR2)*	*14*	*14*	*14*
632536	FGFR1	1	7	4
632536	KDR(VEGFR2)	15	16	16
295642	FGFR1	2	9	6
295642	KDR(VEGFR2)	19	17	18
150117	*FGFR1*	*2*	*7*	*5*
150117	*KDR(VEGFR2)*	*28*	*24*	*26*
13480	FGFR1	5	10	8
13480	KDR(VEGFR2)	4	2	3
18877	FGFR1	-3	0	-2
18877	KDR(VEGFR2)	10	4	7
122351	FGFR1	-1	4	1
122351	KDR(VEGFR2)	4	4	4
48300	*FGFR1*	*8*	*10*	*9*
48300	***KDR(VEGFR2)***	***76***	***78***	***77***
321206	FGFR1	5	5	5

Comp. NSC#	Kinase Activity Tested	% Inhibition	% Inhibition	Mean % Inhibition
321206	**KDR(VEGFR2)**	**52**	**45**	**49**
292596	*FGFR1*	*4*	*4*	*4*
292596	*KDR(VEGFR2)*	*9*	*18*	*14*
268879	FGFR1	3	-2	1
268879	KDR(VEGFR2)	40	38	39
48458	FGFR1	5	8	6
48458	KDR(VEGFR2)	13	9	11
328087	FGFR1	3	5	4
328087	KDR(VEGFR2)	9	9	9
209910	FGFR1	2	5	4
209910	KDR(VEGFR2)	9	10	10
310551	FGFR1	-5	-1	-3
310551	KDR(VEGFR2)	21	18	20
521777	FGFR1	1	0	1
521777	KDR(VEGFR2)	10	8	9
292222	*FGFR1*	*2*	*5*	*3*
292222	*KDR(VEGFR2)*	*8*	*7*	*7*
321237	FGFR1	7	5	6
321237	**KDR(VEGFR2)**	**105**	**104**	**105**
112200	FGFR1	9	5	7
112200	**KDR(VEGFR2)**	**100**	**99**	**99**
259969	*FGFR1*	*3*	*3*	*3*
259969	*KDR(VEGFR2)*	*0*	*9*	*5*
259968	FGFR1	5	2	3
259968	KDR(VEGFR2)	8	9	8
203328	FGFR1	4	4	4
203328	KDR(VEGFR2)	9	7	8
274547	FGFR1	4	7	6
274547	KDR(VEGFR2)	14	12	13
166687	FGFR1	21	22	22
166687	KDR(VEGFR2)	9	6	8
119889	**FGFR1**	**96**	**95**	**96**
119889	**KDR(VEGFR2)**	**103**	**104**	**103**

Example 5: Effect of antiangiogenic SMs on gene expression during endothelial tube formation

This example shows the effect of anti-angiogenic small molecules described herein on the expression of genes in the angiogenesis pathway.

Methods

For gene expression studies, three independent experiments were run for each SM tested. 90.000 cells/well (6 wells/treatment) of dermal microvascular endothelial cells (Lonza, Walkersville, MD) were seeded on polymerized GELTREX™ gel matrix (Invitrogen, Carlsbad, CA) in 24 well plates. Wells were immediately treated with the same volume of 1μM SM or PBS. After 24 hours incubation at 37°C and 5% CO_2, cells were

extracted using Cell Recovery Solution (BD Biosciences, San Jose, CA, Cat. # 354253). Total RNA was extracted with the RNeasy Mini Kit (Qiagen, Valencia, CA, Cat. # 74104), and retrotranscribed using SUPERSCRIPT® First-Strand reverse transcriptase (Invitrogen, Carlsbad, CA, Cat. # 11904-018). The real time PCR reactions were performed in an
5 Opticon 2 cycler (MJ Research, Waltham, MA). Amplification was performed in a final volume of 25 μl, containing 2 μl cDNA (1:10 dilution from the reversed transcribed reaction) and 2 μl of primer mixture (10 μM each of forward and reverse primers). Samples were amplified as follows: after initial denaturation at 95 C for 2 minutes, reactions were run for 46 cycles at 95 °C for 30 seconds, 60 °C for 30 seconds, and 72 °C for 45 seconds.
10 Fluorescence was measured in every cycle and a melting curve was run after the PCR by increasing temperature from 50 to 96 °C (in 0.5 °C increments). A defined single peak was obtained for all amplicons, thus confirming the specificity of the amplification.

Results

15 To better understand the mechanism of action of the seven small molecules used in the *in vivo* studies presented in Example 2, the effect of these molecules on the expression of angiogenesis genes in primary endothelial cells during tube formation was studied. The genes that were montitored were selected based on their relevance to the angiogenesis process. The genes assayed and primers used in the real-time PCR are presented in Tables
20 12 and 13. All experiments were done in triplicate. The results are shown in the volcano plots of Figure 17. Log2 fold-change is presented in the X-axis and log10 P value in the Y-axis. These results are also summarized below in Table 14.

TABLE 12 – GENES IN REAL TIME PCR ARRAYS

Gene Symbol	GenBank Accession	NCBI Protein Accession	Coding DNA Length
AKT1	NM_005163	NP_005154	1443
ANGPT1	NM_001146	NP_001137	1497
ANGPT2	AF187858	AAF76526	1335
ANGPTL3	NM_014495	NP_055310	1383
ANGPTL4	NM_016109	NP_057193	1221
ANPEP	NM_001150	NP_001141	2904
BAI1	NM_001702	NP_001693	4755
CCL11	NM_002986	NP_002977	294
CCL2	NM_002982	NP_002973	300
CDH5	NM_001795	NP_001786	2355
COL18A1	NM_030582	NP_085059	4551
COL4A3	NM_000091	NP_000082	5013
dll4	NM_019074	NP_061947	2058

Gene Symbol	GenBank Accession	NCBI Protein Accession	Coding DNA Length
CXCL10	NM_001565	NP_001556	297
CXCL3	NM_002090	NP_002081	321
CXCL5	NM_002994	NP_002985	345
CXCL6	NM_002993	NP_002984	345
CXCL9	NM_002416	NP_002407	378
TYMP	NM_001953	NP_001944	1449
S1PR1	NM_001400	NP_001391	1149
EFNA1	NM_182685	NP_872626	552
EFNA3	NM_004952	NP_004943	717
EFNB2	NM_004093	NP_004084	1002
EGF	NM_001963	NP_001954	3624
ENG	NM_000118	NP_000109	1878
EPHB4	NM_004444	NP_004435	2964
EREG	NM_001432	NP_001423	510
FGF1	NM_000800	NP_000791	468
FGF2	NM_002006	NP_001997	633
FGFR3	NM_000142	NP_000133	2421
FIGF	NM_004469	NP_004460	1065
FLT1	NM_002019	NP_002010	4017
HAND2	NM_021973	NP_068808	654
HGF	NM_000601	NP_000592	2187
HIF1A	NM_001530	NP_001521	2481
HPSE	NM_006665	NP_006656	1632
ID1	NM_002165	NP_002156	468
ID3	NM_002167	NP_002158	360
IFNA1	NM_024013	NP_076918	570
IFNB1	NM_002176	NP_002167	564
IFNG	NM_000619	NP_000610	501
IGF1	NM_000618	NP_000609	462
IL1B	NM_000576	NP_000567	810
IL6	NM_000600	NP_000591	639
IL8	NM_000584	NP_000575	300
ITGAV	NM_002210	NP_002201	3147
ITGB3	NM_000212	NP_000203	2367
JAG1	NM_000214	NP_000205	3657
KDR	NM_002253	NP_002244	4071
LAMA5	NM_005560	NP_005551	11088
LECT1	NM_007015	NP_008946	1005
LEP	NM_000230	NP_000221	504
MDK	NM_002391	NP_002382	432
MMP2	NM_004530	NP_004521	1983
MMP9	NM_004994	NP_004985	2124
Notch4	NM_004557	NP_004548	6009
NRP1	NM_003873	NP_003864	2772
NRP2	NM_003872	NP_003863	2781
PDGFA	NM_002607	NP_002598	636
PECAM1	NM_000442	NP_000433	2217
PGF	NM_002632	NP_002623	513

Gene Symbol	GenBank Accession	NCBI Protein Accession	Coding DNA Length
PLAU	NM_002658	NP_002649	1296
PLG	NM_000301	NP_000292	2433
PLXDC1	NM_020405	NP_065138	1503
PROK2	NM_021935	NP_068754	327
PTGS1	NM_000962	NP_000953	1800
SERPINF1	NM_002615	NP_002606	1257
SPHK1	NM_021972	NP_068807	1197
STAB1	NM_015136	NP_055951	7713
TEK	NM_000459	NP_000450	3375
TGFA	NM_003236	NP_003227	483
TGFB1	NM_000660	NP_000651	1176
TGFB2	NM_003238	NP_003229	1245
TGFBR1	NM_004612	NP_004603	1512
THBS1	NM_003246	NP_003237	3513
THBS2	NM_003247	NP_003238	3519
TIMP1	NM_003254	NP_003245	624
TIMP2	NM_003255	NP_003246	663
TIMP3	NM_000362	NP_000353	636
TNF	NM_000594	NP_000585	702
TNFAIP2	NM_006291	NP_006282	1965
VEGFA	NM_003376	NP_003367	648
VEGFC	NM_005429	NP_005420	1260
CD248	NM_020404	NP_065137	2274
GPR124	AB040964	BAA96055	3621
PLXDC1	NM_020405	NP_065138	1503
ANTXR1	NM_032208	NP_115584	1695
RASD2	NM_014310	NP_055125	801
ARHGEF17	NM_014786	NP_055601	6192
TNS3	AL833845	CAD38705	2714
DKK3	NM_015881	NP_056965	1053
MMP11	NM_005940	NP_005931	1467
NID1	BC045606	AAH45606	3345
THY1	NM_006288	NP_006279	486
CST4	NM_001899	NP_001890	426
MRC2	NM_006039	NP_006030	4440
TNS1	AK001785	BAA91910	1197
BMP1	AF318323	AAL55830	933
COMT	NM_000754	NP_000745	816
PTPRCAP	NM_005608	NP_005599	621
57722	AB046848	BAB13454	2943
EXTL3	NM_001440	NP_001431	2760
vWF	NM_000552	NP_000543	8442
PNMT	NM_002686	NP_002677	849
58488	BC005112	AAH05112	582
ltbp4	AK074499	BAC11024	1911
23001	AK055806	BAB71020	2169
4247	NM_002408	NP_002399	1344
Sdc4	NM_002999	NP_002990	597

Gene Symbol	GenBank Accession	NCBI Protein Accession	Coding DNA Length
Ralb	NM_002881	NP_002872	621
DGKG	NM_001346	NP_001337	2376
TRA2B	AK098191	BAC05256	759
CLIC1	NM_001288	NP_001279	726
90780	NM_138300	NP_612157	1221
5569	NM_181839	NP_862822	231
151516	NM_152792	NP_690005	1032
CALD1	AF247820	AAF69498	1446
DUT	AF018432	AAB71393	759
copa	BC038447	AAH38447	3702
PDCD2	NM_144781	NP_659005	687
151516	NM_152792	NP_690005	1032
VGLL4	D50911	BAA09470	891
APOE	NM_000041	NP_000032	954
8131	NM_012075	NP_036207	1710
10988	AK091730	BAC03733	1368
9569	NM_005685	NP_005676	2835
Acvrl1	NM_000020	NP_000011	1512
Adcy4	NM_139247	NP_640340	3234
Calcrl	NM_005795	NP_005786	1386
Caskin2	NM_020753	NP_065804	3609
Ccbp2	NM_001296	NP_001287	1155
Cldn5	BC019290	AAH19290	801
01839	NM_001945	NP_001936	627
Egfl7	NM_016215	NP_057299	822
Ehd4	NM_139265	NP_644670	1626
Entpd1	AJ133134	CAB41887	921
Epas1	BC015869	AAH15869	306
Erg	NM_004449	NP_004440	1389
ESAM1	NM_138961	NP_620411	1173
Fgd5	BX640820	CAE45896	3387
Gpr116	AL050295	CAB43394	1855
Hspa12b	NM_052970	NP_443202	2061
Icam1	NM_000201	NP_000192	1599
Icam2	NM_000873	NP_000864	828
Kifc1	BC000712	AAH00712	2180
Lats2	NM_014572	NP_055387	3267
Lrrk1	AB058693	BAB47419	4112
Mmrn2	NM_024756	NP_079032	2850
Myo1b	AJ001381	CAA04712	1310
PALD	AB033100	BAA86588	2586
NM_023516	BC015770	AAH15770	1446
55332	BC018435	AAH18435	717
CTTNBP2NL	NM_018704	NP_061174	1920
CENTD3	NM_022481	NP_071926	4635
C1orf54	NM_024579	NP_078855	396
134265	AK074185	BAB85011	2381
Npr3	NM_000908	NP_000899	1623

Gene Symbol	GenBank Accession	NCBI Protein Accession	Coding DNA Length
Pltp	NM_182676	NP_872617	1326
Ptprb	BC051329	AAH51329	2316
Ptprm	NM_002845	NP_002836	4359
GRRP1	BC025658	AAH25658	816
stard9	AB037721	BAA92538	5464
Ramp2	NM_005854	NP_005845	528
Rasip1	BC042111	AAH42111	1567
Robo4	AK074163	BAB84989	2109
Sdpr	NM_004657	NP_004648	1278
Slc43a3	AF118070	AAF22014	318
Slc9a3r2	U82108	AAB53042	981
Slco2a1	BC041140	AAH41140	2035
B2M	NM_004048	NP_004039	360
HPRT1	NM_000194	NP_000185	657
RPL13A	NM_012423	NP_036555	612
GAPDH	NM_002046	NP_002037	1008
ACTB	NM_001101	NP_001092	1128

TABLE 13 – REAL TIME PCR PRIMERS

Gene	PrimerBank ID	Forward Primer	Reverse Primer
AKT1	4885061a1	GCACAAACGAGGGGAGTACAT (SEQ ID NO: 1)	CCTCACGTTGGTCCACATC (SEQ ID NO: 2)
ANGPT1	20532340a1	CTCGCTGCCATTCTGACTCAC (SEQ ID NO: 3)	GACAGTTGCCATCGTGTTCTG (SEQ ID NO: 4)
ANGPT2	8570647a1	TCTTGGCCGCAGCCTATAAC (SEQ ID NO: 5)	TGCTGGACCTGATATTGCTTCT (SEQ ID NO: 6)
ANGPTL3	7656888a1	CTTCAATGAAACGTGGGAGAACT (SEQ ID NO: 7)	GCCAGTAATCGCAACTAGATGT (SEQ ID NO: 8)
ANGPTL4	21536396a1	TCCTGGGACGAGATGAATGTC (SEQ ID NO: 9)	CTGAGCCTTGAGTTGTGTCTG (SEQ ID NO: 10)
ANPEP	4502095a1	GCACAATCATCGCACTGTCAG (SEQ ID NO: 11)	CGCTTTACTTTGGTCCAAGGT (SEQ ID NO: 12)
BAI1	4502355a1	GCGGCGCTACACTCTCTAC (SEQ ID NO: 13)	AGCACCTCGTCGAAGCTCT (SEQ ID NO: 14)
CCL11	4506827a1	ATACCCCTTCAGCGACTAGAG (SEQ ID NO: 15)	GCTTTGGAGTTGGAGATTTTTGG (SEQ ID NO: 16)
CCL2	4506841a1	CAGCCAGATGCAATCAATGCC (SEQ ID NO: 17)	TGGAATCCTGAACCCACTTCT (SEQ ID NO: 18)
CDH5	4502727a1	GATCAAGTCAAGCGTGAGTCG (SEQ ID NO: 19)	AGCCTCTCAATGGCGAACAC (SEQ ID NO: 20)
COL18A1	13385620a1	GCTGAACCTGAACTGGCTTTG (SEQ ID NO: 21)	GACACCGGCAATGTTCTCCTC (SEQ ID NO: 22)
COL4A3	10835113a1	CAGCTCTGATGCCAATGAACA (SEQ ID NO: 23)	TTGCACGTTCCTCTTCCATGA (SEQ ID NO: 24)
dll4	9506545a1	TCCAACTGCCCTTCAATTTCAC (SEQ ID NO: 25)	CTGGATGGCGATCTTGCTGA (SEQ ID NO: 26)
CXCL10	4504701a1	GTGGCATTCAAGGAGTACCTC (SEQ ID NO: 27)	GCCTTCGATTCTGGATTCAGACA (SEQ ID NO: 28)

Gene	PrimerBank ID	Forward Primer	Reverse Primer
CXCL3	4504157a1	CGCCCAAACCGAAGTCATAG (SEQ ID NO: 29)	GCTCCCCTTGTTCAGTATCTTTT (SEQ ID NO: 30)
CXCL5	4506849a1	GAGAGCTGCGTTGCGTTTG (SEQ ID NO: 31)	TTTCCTTGTTTCCACCGTCCA (SEQ ID NO: 32)
CXCL6	4506851a1	AGAGCTGCGTTGCACTTGTT (SEQ ID NO: 33)	GCAGTTTACCAATCGTTTTGGGG (SEQ ID NO: 34)
CXCL9	4505187a1	CCAGTAGTGAGAAAGGGTCGC (SEQ ID NO: 35)	TGGGGCAAATTGTTTAAGGTCTT (SEQ ID NO: 36)
TYMP	4503445a1	AGCTGGAGTCTATTCCTGGATT (SEQ ID NO: 37)	GGCTGCATATAGGATTCCGTC (SEQ ID NO: 38)
S1PR1	13027636a1	CTTGCTGACCATTTGGAAAACC (SEQ ID NO: 39)	CTGTGTAGGCTACTCCTGCC (SEQ ID NO: 40)
EFNA1	33359680a1	CGGAGAAGCTGTCTGAGAAGT (SEQ ID NO: 41)	CTGAGGACTGTGAGAGATGTAGT (SEQ ID NO: 42)
EFNA3	4826708a1	TCTCTGGGCTACGAGTTCCAC (SEQ ID NO: 43)	ACGTTGATCTTCACATTGGGG (SEQ ID NO: 44)
EFNB2	4758250a1	ACTGCTGGGGTGTTTTGATGG (SEQ ID NO: 45)	TGTGGGTATAGTACCAGTCCTTG (SEQ ID NO: 46)
EGF	4503491a1	AAGGTACTCTCGCAGGAAATGG (SEQ ID NO: 47)	ACATACTCTCTCTTGCCTTGACC (SEQ ID NO: 48)
ENG	4557555a1	AGCCCCACAAGTCTTGCAG (SEQ ID NO: 49)	GCTAGTGGTATATGTCACCTCGC (SEQ ID NO: 50)
EPHB4	32528301a1	CGGCAGCCTCACTACTCAG (SEQ ID NO: 51)	TCCCATTTTGATGGCCCGAAG (SEQ ID NO: 52)
EREG	4557567a1	CTGCCTGGGTTTCCATCTTCT (SEQ ID NO: 53)	GCCATTCATGTCAGAGCTACACT (SEQ ID NO: 54)
FGF1	4503697a1	ACACCGACGGGCTTTTATACG (SEQ ID NO: 55)	CCCATTCTTCTTGAGGCCAAC (SEQ ID NO: 56)
FGF2	15451898a1	AGAAGAGCGACCCTCACATCA (SEQ ID NO: 57)	ACTGCCCAGTTCGTTTCAGTG (SEQ ID NO: 58)
FGFR3	4503711a1	TCCTTGCACAACGTCACCTTT (SEQ ID NO: 59)	GCAGAGTGATGAGAAAACCCAA (SEQ ID NO: 60)
FIGF	4758378a1	ACAGAGAGTGGGTAGTGGTGA (SEQ ID NO: 61)	GTTCCTCCAAACTAGAAGCAGC (SEQ ID NO: 62)
FLT1	4503749a1	CTGTCATGCTAATGGTGTCCC (SEQ ID NO: 63)	TGCTGCTTCCTGGTCCTAAAATA (SEQ ID NO: 64)
HAND2	12545384a1	ATGAGTCTGGTAGGTGGTTTTCC (SEQ ID NO: 65)	CATACTCGGGGCTGTAGGACA (SEQ ID NO: 66)
HGF	33859835a1	TACAGGGGCACTGTCAATACC (SEQ ID NO: 67)	GGATACTGAGAATCCCAACGC (SEQ ID NO: 68)
HIF1A	4504385a1	GGCGCGAACGACAAGAAAAAG (SEQ ID NO: 69)	CCTTATCAAGATGCGAACTCACA (SEQ ID NO: 70)
HPSE	5729873a1	TCCTGCGTACCTGAGGTTTG (SEQ ID NO: 71)	CAACCGTAACTTCTCCTCCAC (SEQ ID NO: 72)
ID1	31317299a1	ACGAGCAGCAGGTAAACGTG (SEQ ID NO: 73)	GAAGGTCCCTGATGTAGTCGAT (SEQ ID NO: 74)
ID3	32171182a1	AGTCCCGAGAGGCACTCAG (SEQ ID NO: 75)	GCTCCTTTTGTCGTTGGAGATG (SEQ ID NO: 76)
IFNA1	13128950a1	GCCTCGCCCTTTGCTTTACT (SEQ ID NO: 77)	CTGTGGGTCTCAGGGAGATCA (SEQ ID NO: 78)
IFNB1	4504603a1	ATGACCAACAAGTGTCTCCTCC (SEQ ID NO: 79)	GCTCATGGAAAGAGCTGTAGTG (SEQ ID NO: 80)

Gene	PrimerBank ID	Forward Primer	Reverse Primer
IFNG	10835171a1	CTCTTGGCTGTTACTGCCAGG (SEQ ID NO: 81)	CTCCACACTCTTTTGGATGCT (SEQ ID NO: 82)
IGF1	11024682a1	ATGCTCTTCAGTTCGTGTGTG (SEQ ID NO: 83)	GCACTCCCTCTACTTGCGTTC (SEQ ID NO: 84)
IL1B	10835145a1	CTCGCCAGTGAAATGATGGCT (SEQ ID NO: 85)	GTCGGAGATTCGTAGCTGGAT (SEQ ID NO: 86)
IL6	10834984a1	AAATTCGGTACATCCTCGACGG (SEQ ID NO: 87)	GGAAGGTTCAGGTTGTTTTCTGC (SEQ ID NO: 88)
IL8	10834978a1	TTTTGCCAAGGAGTGCTAAAGA (SEQ ID NO: 89)	AACCCTCTGCACCCAGTTTTC (SEQ ID NO: 90)
ITGAV	4504763a1	TCGGGACTCCTGCTACCTC (SEQ ID NO: 91)	CACGAGAAGAAACATCCGGGA (SEQ ID NO: 92)
ITGB3	4557677a1	AGGATGACTGTGTCGTCAGAT (SEQ ID NO: 93)	GGTAGACGTGGCCTCTTTATACA (SEQ ID NO: 94)
JAG1	4557679a1	TCGGGTCAGTTCGAGTTGGA (SEQ ID NO: 95)	AGGCACACTTTGAAGTATGTGTC (SEQ ID NO: 96)
KDR	11321597a1	GGCCCAATAATCAGAGTGGCA (SEQ ID NO: 97)	TGTCATTTCCGATCACTTTTGGA (SEQ ID NO: 98)
LAMA5	21264602a1	CCCACCGAGGACCTTTACTG (SEQ ID NO: 99)	GGTGTGCCTTGTTGCTGTT (SEQ ID NO: 100)
LECT1	5901932a1	GGTGGGACCTGATGACGTG (SEQ ID NO: 101)	AGCTCCCGAAATGAGGACCA (SEQ ID NO: 102)
LEP	4557715a1	GAACCCTGTGCGGATTCTTGT (SEQ ID NO: 103)	TCCATCTTGGATAAGGTCAGGAT (SEQ ID NO: 104)
MDK	4505135a1	CGCGGTCGCCAAAAAGAAAG (SEQ ID NO: 105)	CAGTCGGCTCCAAACTCCT (SEQ ID NO: 106)
MMP2	11342666a1	CCGTCGCCCATCATCAAGTT (SEQ ID NO: 107)	CTGTCTGGGGCAGTCCAAAG (SEQ ID NO: 108)
MMP9	4826836a1	TGGCAGAGATGCGTGGAGA (SEQ ID NO: 109)	GGCAAGTCTTCCGAGTAGTTTT (SEQ ID NO: 110)
Notch4	27894370a1	GGGTGAGACGTGCCAGTTTC (SEQ ID NO: 111)	CTGGGTGTCAATGGAGAGGGA (SEQ ID NO: 112)
NRP1	4505457a1	TGGGGCTCTCACAAGACCTT (SEQ ID NO: 113)	AGCTTGGGAATAGATGAAGTTGC (SEQ ID NO: 114)
NRP2	4505459a1	GAAGGGAACATGCACTATGACA (SEQ ID NO: 115)	AGCGTTTTTACCGTGGGCTT (SEQ ID NO: 116)
PDGFA	15208658a1	CCAGCGACTCCTGGAGATAGA (SEQ ID NO: 117)	CTTCTCGGGCACATGCTTAGT (SEQ ID NO: 118)
PECAM1	21314617a1	AACAGTGTTGACATGAAGAGCC (SEQ ID NO: 119)	TGTAAAACAGCACGTCATCCTT (SEQ ID NO: 120)
PGF	20149543a1	TGCTGCGGCGATGAGAATC (SEQ ID NO: 121)	GTCTCCTCCTTTCCGGCTT (SEQ ID NO: 122)
PLAU	4505863a1	GTGAGCGACTCCAAAGGCA (SEQ ID NO: 123)	GCAGTTGCACCAGTGAATGTT (SEQ ID NO: 124)
PLG	4505881a1	CAGGGGGCTTCACTGTTCAG (SEQ ID NO: 125)	GCCATTATCACACATTGTTGCTC (SEQ ID NO: 126)
PLXDC1	15011862a1	CCTGGGCATGTGTCAGAGC (SEQ ID NO: 127)	GGTGTTGGAGAGTATTGTGTGG (SEQ ID NO: 128)
PROK2	17530787a1	GTGACAAGGACTCCCAATGTG (SEQ ID NO: 129)	TCTTGACCCAGATACTGACAGC (SEQ ID NO: 130)
PTGS1	18104967a1	CTCCCAGGAGTACAGCTACGA (SEQ ID NO: 131)	CCAGCAATCTGGCGAGAGA (SEQ ID NO: 132)

Gene	PrimerBank ID	Forward Primer	Reverse Primer
SERPINF1	34098938a1	GCCCTGGTGCTACTCCTCT (SEQ ID NO: 133)	CAGCTTGTTCACGGGGACTTT (SEQ ID NO: 134)
SPHK1	21361088a1	AGGCTGAAATCTCCTTCACGC (SEQ ID NO: 135)	GTCTCCAGACATGACCACCAG (SEQ ID NO: 136)
STAB1	12225240a1	ACATCTGCTCGAACCCAAACA (SEQ ID NO: 137)	GACAGCGACATCTGGCAACA (SEQ ID NO: 138)
TEK	4557869a1	TGCCACCCTGGTTTTTACGG (SEQ ID NO: 139)	TTGGAAGCGATCACACATCTC (SEQ ID NO: 140)
TGFA	4507461a1	GGCCCTGGCTGTCCTTATC (SEQ ID NO: 141)	AGCAAGCGGTTCTTCCCTTC (SEQ ID NO: 142)
TGFB1	10863873a1	GGCCAGATCCTGTCCAAGC (SEQ ID NO: 143)	GTGGGTTTCCACCATTAGCAC (SEQ ID NO: 144)
TGFB2	4507463a1	CTGCATCTGGTCACGGTCG (SEQ ID NO: 145)	CCTCGGGCTCAGGATAGTCT (SEQ ID NO: 146)
TGFBR1	4759226a1	ACGGCGTTACAGTGTTTCTG (SEQ ID NO: 147)	GCACATACAAACGGCCTATCT (SEQ ID NO: 148)
THBS1	4507485a1	TGCCTGATGACAAGTTCCAAG (SEQ ID NO: 149)	CCAGAGTGGTCTTTCCGCTC (SEQ ID NO: 150)
THBS2	4507487a1	ACAAAGACACGACCTTCGACC (SEQ ID NO: 151)	GACTTGCCGTCCTGCTTGA (SEQ ID NO: 152)
TIMP1	4507509a1	CTTCTGCAATTCCGACCTCGT (SEQ ID NO: 153)	CCCTAAGGCTTGGAACCCTTT (SEQ ID NO: 154)
TIMP2	4507511a1	AAGCGGTCAGTGAGAAGGAAG (SEQ ID NO: 155)	TCCTCTTGATAGGGTTGCCATA (SEQ ID NO: 156)
TIMP3	4507513a1	CAACTCCGACATCGTGATCCG (SEQ ID NO: 157)	GAAGCCTCGGTACATCTTCATC (SEQ ID NO: 158)
TNF	25952111a1	ATGAGCACTGAAAGCATGATCC (SEQ ID NO: 159)	GAGGGCTGATTAGAGAGAGGTC (SEQ ID NO: 160)
TNFAIP2	26051240a1	TCCCCGAGAGCGTCTTTCT (SEQ ID NO: 161)	ATGTCATTGGGGTAGAGGTTCT (SEQ ID NO: 162)
VEGFA	30172564a1	CAACATCACCATGCAGATTATGC (SEQ ID NO: 163)	GCTTTCGTTTTTGCCCCTTTC (SEQ ID NO: 164)
VEGFC	4885653a1	CACGGCTTATGCAAGCAAAGA (SEQ ID NO: 165)	TCCTTTCCTTAGCTGACACTTGT (SEQ ID NO: 166)
CD248	9966885a1	TGCGAACACGAATGTGTGGA (SEQ ID NO: 167)	CAATCTGGCACTCATCTGTGTC (SEQ ID NO: 168)
GPR124	20521932a1	TGAGCAATAACAAGATCACGGG (SEQ ID NO: 169)	TCGGAGGTGAGACAGCCAA (SEQ ID NO: 170)
PLXDC1	15011862a1	CCTGGGCATGTGTCAGAGC (SEQ ID NO: 171)	GGTGTTGGAGAGTATTGTGTGG (SEQ ID NO: 172)
ANTXR1	14149904a1	CGGTAGACGCCTCTTATTATGGT (SEQ ID NO: 173)	CCTTTTCCAACTTAGCACCTTCT (SEQ ID NO: 174)
RASD2	22027486a1	CAGTGTGCCCGCCAAAAAC (SEQ ID NO: 175)	TGGGTGTGTACTGGTCCTCAA (SEQ ID NO: 176)
ARHGEF17	21361458a1	CGACTCTGAATCCCCAGGAAC (SEQ ID NO: 177)	CCTGCGGTTGGGAGAAGATA (SEQ ID NO: 178)
TNS3	21739317a1	GGCATTACCCCGTGAACAGT (SEQ ID NO: 179)	CACCCCGATGTCTCTGTGAT (SEQ ID NO: 180)
DKK3	27735014a1	TGGGGTCACTGCACCAAAAT (SEQ ID NO: 181)	GAAGGTCGGCTTGCACACATA (SEQ ID NO: 182)
MMP11	5174581a1	GAGGCCCTAAAGGTATGGAGC (SEQ ID NO: 183)	CCCTTCTCGGTGAGTCTTGG (SEQ ID NO: 184)

Gene	PrimerBank ID	Forward Primer	Reverse Primer
NID1	28374139a1	CACATTGAGCCCTACACGGAG (SEQ ID NO: 185)	GCTGAGAGCATAGCGCAAGAT (SEQ ID NO: 186)
THY1	19923362a1	TCGCTCTCCTGCTAACAGTCT (SEQ ID NO: 187)	CTCGTACTGGATGGGTGAACT (SEQ ID NO: 188)
CST4	4503109a1	CCTCTGTGTACCCTGCTACTC (SEQ ID NO: 189)	CTTCGGTGGCCTTGTTGTACT (SEQ ID NO: 190)
MRC2	5174485a1	CCGAAACCGGCTATTCAACCT (SEQ ID NO: 191)	CAGCGAAGATTCAGTGCTTCC (SEQ ID NO: 192)
TNS1	13624033a1	TAGATGGGAGCCTGTATGCTAAG (SEQ ID NO: 193)	GTAGGACGTGTGGCATTAACA (SEQ ID NO: 194)
BMP1	18027738a1	CTCTCTCGTTTCAGAAAAGAGGC (SEQ ID NO: 195)	TTCCTGAGTAACAAGGGGTCC (SEQ ID NO: 196)
COMT	4502969a1	TACTGCGAGCAGAAGGAGTG (SEQ ID NO: 197)	CCAGCGAAATCCACCATCC (SEQ ID NO: 198)
PTPRCAP	5032005a1	AGCTGGGGTCCACAGACAA (SEQ ID NO: 199)	GACGCCTCTCCACATTGCT (SEQ ID NO: 200)
57722	10047333a1	GCGAGCAGATCATCGGCTT (SEQ ID NO: 201)	TGCAAACTGGTATTCCACATTGT (SEQ ID NO: 202)
EXTL3	4503617a1	CGCTCATCGCCCACTATTACC (SEQ ID NO: 203)	TGTTCAGCTCTTGGCGCTT (SEQ ID NO: 204)
vWF	4507907a1	AGCCTTGTGAAACTGAAGCAT (SEQ ID NO: 205)	GGCCATCCCAGTCCATCTG (SEQ ID NO: 206)
PNMT	4505921a1	GCAGACCGTAGCCCCAATG (SEQ ID NO: 207)	GCGTAGTTGTTGCGGAGGTA (SEQ ID NO: 208)
58488	13477277a1	CGGTGCCTCCAAGTGACTG (SEQ ID NO: 209)	AGGCTGAACTCCTGTGACCTT (SEQ ID NO: 210)
ltbp4	22759983a1	TATGCTGGTTCCCTGGCTGA (SEQ ID NO: 211)	GGCCTCATCACACTCGTTG (SEQ ID NO: 212)
23001	16550629a1	TCTTGCGGTGGAACAGAATAAG (SEQ ID NO: 213)	GCATAGCCCCAAGCAAAAGTT (SEQ ID NO: 214)
4247	4505163a1	GTGCATAACCGGCCCGAATA (SEQ ID NO: 215)	AACCGGACAGAAATTCACCCC (SEQ ID NO: 216)
Sdc4	4506861a1	GCTCTTCGTAGGCGGAGTC (SEQ ID NO: 217)	CCTCATCGTCTGGTAGGGCT (SEQ ID NO: 218)
ralb	4506405a1	GCCAACAAGAGTAAGGGCCAG (SEQ ID NO: 219)	CGTCATACATGAACTGAAGCGTC (SEQ ID NO: 220)
DGKG	4503315a1	GGTGAAGAACGGTGGGTCTC (SEQ ID NO: 221)	AATCGGCTCATGTGGGTCATA (SEQ ID NO: 222)
TRA2B	21758154a1	CCCCTGCAAAGTCTCGCTC (SEQ ID NO: 223)	AATCTCGACTGTAAGACCTGCTA (SEQ ID NO: 224)
CLIC1	14251209a1	ACAACCGCAGGTCGAATTGTT (SEQ ID NO: 225)	GTGACTCCCTTGAGCCACA (SEQ ID NO: 226)
90780	23510333a1	CCAGAAAAGAAGCGAAGGAAGT (SEQ ID NO: 227)	TCCGAAGTCATCTTCAAAAGGG (SEQ ID NO: 228)
5569	32483386a1	GCCTTGAAATTAGCAGGTCTTGA (SEQ ID NO: 229)	CTGTAGAACTTCGTTGTGCATCT (SEQ ID NO: 230)
151516	22758146a1	TTCGAGAGGCCCCGTTTTC (SEQ ID NO: 231)	ATTGGCCCCATCAAAAGGTTC (SEQ ID NO: 232)
CALD1	13186201a1	TTTGAGCGTCGCAGAGAACTT (SEQ ID NO: 233)	TGTCCCAAGGATTCTTCCTCC (SEQ ID NO: 234)
DUT	2443580a1	CGCCATTTCACCCAGTAAGC (SEQ ID NO: 235)	AGCCACTCTTCCATAACACCC (SEQ ID NO: 236)

Gene	PrimerBank ID	Forward Primer	Reverse Primer
copa	23512328a1	TCAGCTTTCACCCCAAAAGAC (SEQ ID NO: 237)	CACATCCGATAGTCCCATAACTG (SEQ ID NO: 238)
PDCD2	21735594a1	CCGGCCTGCGAGTTTTTAG (SEQ ID NO: 239)	GGGGGAGGATTCTCAGAAGGT (SEQ ID NO: 240)
151516	22758146a1	TTCGAGAGGCCCCGTTTTC (SEQ ID NO: 241)	ATTGGCCCCATCAAAAGGTTC (SEQ ID NO: 242)
VGLL4	6633997a1	AATATCGGCATTCTGTGCTACG (SEQ ID NO: 243)	GCAGGGTCTGTATTCTGGGT (SEQ ID NO: 244)
APOE	4557325a1	GTTGCTGGTCACATTCCTGG (SEQ ID NO: 245)	GGTAATCCCAAAAGCGACCCA (SEQ ID NO: 246)
8131	6912302a1	CAGCCCCATCAGCGTGATT (SEQ ID NO: 247)	GCGGCTTACTTGTCTGGGAC (SEQ ID NO: 248)
10988	21750170a1	AGACCCTCCCTCAGTTCCAAT (SEQ ID NO: 249)	GGGTATTCGCATTCTTGTCCTT (SEQ ID NO: 250)
9569	15011924a1	CTGCTCTTCAACACACGATACG (SEQ ID NO: 251)	CCCTCTCTTGACTATCCACGAT (SEQ ID NO: 252)
Acvrl1	4557243a1	CCAACCTCCTTCGGAGCAG (SEQ ID NO: 253)	CTGTGGTGCAGTCACTGTCC (SEQ ID NO: 254)
Adcy4	24497587a1	AGCTGACCTCAGACCCGAG (SEQ ID NO: 255)	CATACGCCGTGAAGATGACGA (SEQ ID NO: 256)
Calcrl	5031621a1	AAGACCCCATTCAACAAGCAG (SEQ ID NO: 257)	CCAGTTTCCATCTTGGTCACAG (SEQ ID NO: 258)
Caskin2	24638431a1	CTGATCCTCGCCGTCAAGAAT (SEQ ID NO: 259)	GTTCACGTTGAGCCTCTTTGT (SEQ ID NO: 260)
Ccbp2	13929467a1	CTGAGGATGCCGATTCTGAGA (SEQ ID NO: 261)	TAACGGAGCAAGACCATGAGA (SEQ ID NO: 262)
Cldn5	17939486a1	CTCTGCTGGTTCGCCAACAT (SEQ ID NO: 263)	CAGCTCGTACTTCTGCGACA (SEQ ID NO: 264)
01839	4503413a1	CCCTCCCACTGTATCCACG (SEQ ID NO: 265)	AGTGACTCTCAAAAGGTCCAGA (SEQ ID NO: 266)
Egfl7	7705889a1	CAGCACCTACCGAACCATCTA (SEQ ID NO: 267)	CCCTCCTAGCACTGCATTCAT (SEQ ID NO: 268)
Ehd4	21264315a1	CTGCTCTTTGACGCTCACAAG (SEQ ID NO: 269)	GTCGGCCTTATTCAGCACG (SEQ ID NO: 270)
Entpd1	4741547a1	CAACTATCTGCTGGGCAAATTCA (SEQ ID NO: 271)	GGCAGGTCTGGATTGAGTTATAC (SEQ ID NO: 272)
Epas1	16198412a1	TTTCACACGGCACATTTGGAC (SEQ ID NO: 273)	GTGGACGGGGTCACTATACC (SEQ ID NO: 274)
Erg	4758300a1	CCAGCAGCTCATATCAAGGAAG (SEQ ID NO: 275)	GTTCCGTAGGCACACTCAAAC (SEQ ID NO: 276)
ESAM1	20452464a1	CCCCTGGTGACCAACTTGC (SEQ ID NO: 277)	TGGGATGAAGACACCTCCCC (SEQ ID NO: 278)
Fgd5	34365081a1	AGCCCCTATGAGTTCTTCCCA (SEQ ID NO: 279)	GTGCCTGCTCTGATTCTAAACC (SEQ ID NO: 280)
Gpr116	4886491a1	TGCACTGAACTGGAATTACGAG (SEQ ID NO: 281)	CAGCCGTAGGACTTTTTGTGG (SEQ ID NO: 282)
Hspa12b	31317303a1	CACCCTCGCAGTCTCCAAAA (SEQ ID NO: 283)	GAAAGCATAGCCACTAGACGTG (SEQ ID NO: 284)
Icam1	4557878a1	TCTGTGTCCCCCTCAAAAGTC (SEQ ID NO: 285)	GGGGTCTCTATGCCCAACAA (SEQ ID NO: 286)
Icam2	4504557a1	CGGATGAGAAGGTATTCGAGGT (SEQ ID NO: 287)	CACCCACTTCAGGCTGGTTAC (SEQ ID NO: 288)

Gene	PrimerBank ID	Forward Primer	Reverse Primer
Kifc1	33875771a1	GAGCCGTGCGAGTTCTCTAC (SEQ ID NO: 289)	GGCCTTAATCAGAGGTCTCTTCA (SEQ ID NO: 290)
Lats2	18959200a1	ACTTTTCCTGCCACGACTTATTC (SEQ ID NO: 291)	ATCCAGGGAAGTGTCACTGTT (SEQ ID NO: 292)
Lrrk1	14017797a1	GCCCGACAACGACATCAAG (SEQ ID NO: 293)	GCCAAATAGGGTCGAGGAAGTA (SEQ ID NO: 294)
Mmrn2	13376091a1	GGACCCCGTTGGACGTAAC (SEQ ID NO: 295)	CTTGACCTGGTACACTGGCTT (SEQ ID NO: 296)
Myo1b	2764617a1	TGGCCTCATTGGAAAGGACC (SEQ ID NO: 297)	CCAGGCGTTGCTTCCTCAG (SEQ ID NO: 298)
PALD	20521820a1	GGCTGCTGGCAGACTATGG (SEQ ID NO: 299)	TGGACTTGGCCTTGCTGTTAT (SEQ ID NO: 300)
NM_023516	16041779a1	GCTGACCCTGCTTGGCTTAT (SEQ ID NO: 301)	CCCTCGCCATACCGATGTATTA (SEQ ID NO: 302)
55332	22450862a1	TGCTTCCTGAGGGGAATGG (SEQ ID NO: 303)	ATCGTGGCTGCACCAAGAAA (SEQ ID NO: 304)
CTTNBP2NL	24308179a1	AGCCTGAACTCCTGACACTAT (SEQ ID NO: 305)	TGCTTTTCGCCATCATTTTTCTC (SEQ ID NO: 306)
CENTD3	21264337a1	GTATGCAGACACGTTCCGAC (SEQ ID NO: 307)	CAGGCGTAGAATGCGTTTCC (SEQ ID NO: 308)
C1orf54	13375758a1	ACAGTCACCCCCAGTTATGAT (SEQ ID NO: 309)	ATCTGGACTAGGTTCCGTTGT (SEQ ID NO: 310)
134265	18676718a1	TGTGGGTGACAACTGTTCTACC (SEQ ID NO: 311)	AGAAGCCAATGATACGGGTGAT (SEQ ID NO: 312)
Npr3	4505441a1	TGCTCACTTTCTCCCCGTG (SEQ ID NO: 313)	GGGCAGTAACACCAGCACC (SEQ ID NO: 314)
Pltp	33356541a1	TCACAGAGCTGCAACTGACAT (SEQ ID NO: 315)	AGGCATTGGTGATTTGAAGCA (SEQ ID NO: 316)
Ptprb	30410925a1	CATGGTGATTCTTACCTGCTTGA (SEQ ID NO: 317)	CCCACGACCACTTTCTCATTTT (SEQ ID NO: 318)
Ptprm	18860904a1	TCCAGCAAGAGTAATTCTCCTCC (SEQ ID NO: 319)	GTACGTGTTGGGTCTCCAGATA (SEQ ID NO: 320)
GRRP1	19343581a1	TCAAGACGCACCAGGTGATAG (SEQ ID NO: 321)	CGGTAGAAGATGAGGGAATCAGG (SEQ ID NO: 322)
stard9	7242955a1	CTCATGCTTATTCCTCCCATTCC (SEQ ID NO: 323)	AGGGTGGGTGGATAGTATGTG (SEQ ID NO: 324)
Ramp2	5032021a1	CTGGGCGCTGTCCTGAATC (SEQ ID NO: 325)	CAATCTCGCAGGGTGCTATAAG (SEQ ID NO: 326)
Rasip1	27469793a1	TCTGGTGAACGGAAGGAGG (SEQ ID NO: 327)	CGAAGAAGACTTGACAGAGGC (SEQ ID NO: 328)
Robo4	18676674a1	GTGGGTGAGCAGTTTACTCTG (SEQ ID NO: 329)	GCCAGGGGTTTCCCATCTTTC (SEQ ID NO: 330)
Sdpr	4759082a1	CATCCGGGACAACTCACAGG (SEQ ID NO: 331)	CTCCAAACTGATCTGTCGCTG (SEQ ID NO: 332)
Slc43a3	6650786a1	TCAGCCCCGAGGATGGTTT (SEQ ID NO: 333)	AAGGCTAAGTGCAAGGAGACA (SEQ ID NO: 334)
Slc9a3r2	2047328a1	GCTCCGAAGCTGGCAAGAA (SEQ ID NO: 335)	GGGACTTGTCACTATGCAGGTT (SEQ ID NO: 336)
Slco2a1	26996627a1	GGGCAGCGACACCTCTACTA (SEQ ID NO: 337)	TGGAAATGAGACCCGATGAAGAA (SEQ ID NO: 338)
B2M	4757826a1	GGCTATCCAGCGTACTCCAAA (SEQ ID NO: 339)	CGGCAGGCATACTCATCTTTTT (SEQ ID NO: 340)

Gene	PrimerBank ID	Forward Primer	Reverse Primer
HPRT1	4504483a1	CCTGGCGTCGTGATTAGTGAT (SEQ ID NO: 341)	AGACGTTCAGTCCTGTCCATAA (SEQ ID NO: 342)
RPL13A	6912634a1	CGAGGTTGGCTGGAAGTACC (SEQ ID NO: 343)	CTTCTCGGCCTGTTTCCGTAG (SEQ ID NO: 344)
GAPDH	7669492a1	ATGGGGAAGGTGAAGGTCG (SEQ ID NO: 345)	GGGGTCATTGATGGCAACAATA (SEQ ID NO: 346)
ACTB	4501885a1	CATGTACGTTGCTATCCAGGC (SEQ ID NO: 347)	CTCCTTAATGTCACGCACGAT (SEQ ID NO: 348)

TABLE 14 - EFFECTS OF ANTIANGIOGENIC SMs ON ANGIOGENEIS GENE EXPRESSION

Log2 fold-change of gene expression. Fold-changes with P≤0.001 are underlined.

NSC:	19630	122567	150117	259969	292222	292596
AKT1	0.1	-1.6	1.6	-1.4	0.7	-0.8
ANGPT1	-0.5	<u>1.6</u>	1.7	1.4	0.9	2.2
ANGPT2	-1.8	-0.9	-1.2	0.9	-1.3	0.8
ANGPTL3	-5.0	-1.7	1.8	3.6	0.6	1.0
ANGPTL4	-0.2	-0.4	<u>-4.0</u>	1.5	1.3	-3.2
ANPEP	-0.4	-1.2	-1.7	0.2	-0.6	0.8
BAL1	-0.9	0.2	0.8	0.4	0.2	1.7
CCL11	-0.3	0.6	0.7	0.0	0.2	2.1
CCL2	<u>2.3</u>	<u>2.5</u>	0.9	<u>3.6</u>	0.9	2.4
CDH5	-0.2	-1.9	-1.6	-1.6	-0.1	-0.2
COL18A1	0.4	1.6	0.8	1.9	1.2	2.3
COL4A3	0.1	<u>1.9</u>	2.4	3.2	2.0	1.9
DLL4	<u>-4.5</u>	<u>-8.7</u>	5.5	<u>-4.1</u>	<u>-2.2</u>	<u>-6.6</u>
CXCL10	4.7	3.7	-1.7	2.8	0.8	2.5
CXCL3	<u>12.1</u>	4.0	0.8	<u>11.6</u>	<u>5.0</u>	-3.8
CXCL5	4.8	4.3	-3.5	<u>10.2</u>	3.4	5.6
CXCL6	-0.5	1.1	1.2	1.0	0.4	2.2
CXCL9	-1.0	1.6	1.2	0.5	0.4	1.5
TYMP	0.3	-0.3	-1.1	0.1	-0.1	-5.5
S1PR1	-2.6	-0.7	-1.9	-0.3	-0.3	0.2
EFNA1	3.7	-0.3	0.4	<u>7.8</u>	0.9	3.1
EFNA3	-0.4	-0.4	-1.8	0.3	0.1	0.5
EFNB2	<u>-1.9</u>	<u>-4.0</u>	0.4	<u>-6.6</u>	<u>-2.2</u>	<u>-3.4</u>
EGF	-1.0	-0.3	-2.3	0.2	2.8	2.2
ENG	0.1	-1.7	-0.1	-0.7	-0.9	-0.3
EPHB4	-0.8	-0.5	-1.2	0.3	-0.5	0.9
EREG	7.6	<u>1.9</u>	-2.4	9.3	5.0	<u>9.6</u>
FGF1	-3.0	<u>1.9</u>	-3.8	5.7	-1.4	4.8
FGF2	1.7	-0.7	0.0	<u>2.5</u>	-0.6	2.5
FGFR3	-0.2	1.2	1.0	1.2	0.8	2.2

NSC:	19630	122567	150117	259969	292222	292596
FIGF	-3.2	-0.1	2.4	0.2	0.1	1.7
FLT1	-2.1	-4.4	-0.5	-0.7	-0.2	-1.9
HAND2	-0.5	0.4	1.5	1.4	1.0	1.7
HGF	-0.3	1.3	1.5	1.5	1.3	2.2
HIF1A	-1.7	-3.1	-1.8	0.7	-0.7	-2.1
HPSE	0.6	-8.3	-0.2	2.6	1.6	-0.3
ID1	1.0	-0.2	0.3	1.5	0.0	4.0
ID3	0.4	-0.3	0.5	2.5	-0.2	1.0
IFNA1	0.4	1.1	1.9	1.1	0.8	2.2
IFNB1	-0.4	1.2	2.1	1.6	1.1	2.6
IFNG	4.7	8.3	-1.9	6.0	3.1	6.5
IGF1	3.6	-0.1	-0.2	-2.6	6.0	0.6
IL1B	0.2	-0.1	9.5	1.3	4.3	-4.1
B2M	0.0	0.1	2.8	1.2	-0.4	-2.0
HPRT1	0.8	0.0	-0.4	0.6	0.3	-0.5
RPL13A	-0.2	0.7	-0.8	1.2	0.7	1.9
GADPH	0.1	-0.7	-1.3	-1.0	-0.1	0.3
ACTB	0.1	-1.0	-0.9	-2.5	-0.8	0.0
IL6	3.5	14.4	2.2	9.4	3.0	3.7
IL8	3.0	7.4	6.0	11.3	13.9	5.1
ITGAV	-0.3	-2.7	-1.8	-0.9	1.2	-0.9
ITGB3	-0.9	-1.4	-1.4	-2.9	2.5	-1.8
JAG1	-1.2	0.6	0.3	1.7	1.6	0.5
KDR	-2.7	-2.3	-2.1	-0.5	-1.2	-1.8
LAMAS5	-0.8	-1.1	-2.2	-0.8	-0.4	-0.3
LECT1	-0.4	0.3	-0.2	-8.0	1.4	1.4
LEP	-4.5	0.2	-0.2	0.8	-0.6	2.6
MDK	-1.1	-0.9	-1.5	-1.0	0.8	-1.5
MMP2	0.5	0.3	-0.6	-0.1	2.8	1.1
MMP9	0.3	0.9	-0.3	4.3	3.3	1.8
Notch4	-1.8	-1.1	-0.7	-0.3	-0.4	-0.6
NRP1	-0.5	-3.0	-2.0	-2.6	0.8	-2.3
NRP2	-2.2	-4.3	-3.2	-3.5	1.0	-3.2
PDGFA	-0.7	-1.7	-0.9	1.1	1.6	4.0
PECAM1	-2.6	-2.7	-2.5	-3.0	-0.7	-1.8
PGF	-2.4	-4.9	-1.6	-7.2	0.6	-1.7
PLAU	0.1	-0.1	0.0	3.8	2.7	-0.2
PLG	-2.7	-1.5	-3.9	-1.0	-0.7	-0.4
PLXDC1	-4.0	0.7	-3.2	2.3	-0.1	0.3
PROK2	-1.3	1.3	0.7	2.2	1.9	2.0
PTGS1	-2.4	0.8	0.3	2.9	2.0	1.1
SERPINF1	-0.8	0.2	1.5	6.5	2.3	0.7

NSC:	19630	122567	150117	259969	292222	292596
SPHK1	-0.5	0.9	1.2	3.2	2.0	1.8
STAB1	-1.0	-1.7	-0.9	0.5	0.2	-0.5
TEK	-0.4	0.3	0.7	1.6	2.0	1.3
TGFA	1.1	2.0	5.3	8.7	-3.4	8.9
TGFB1	-1.3	-1.2	-1.3	0.3	1.1	-0.8
TGFB2	-0.5	1.2	1.6	1.3	1.9	2.1
TGFBR1	-0.1	1.2	1.2	1.1	1.8	1.4
THBS1	0.5	0.1	-0.6	-0.1	1.1	-0.1
THBS2	-0.6	1.2	0.9	2.6	1.9	1.1
TIMP1	-0.8	-1.4	-0.7	2.5	1.6	1.4
TIMP2	-0.9	-1.4	-0.8	0.0	1.1	0.4
TIMP3	0.7	-4.3	-2.7	-0.6	-0.4	-1.2
TNF	-0.6	-0.2	2.4	9.3	1.0	6.1
TNFAIP2	0.2	-1.0	-0.6	4.6	0.6	-0.2
TNFAIP2	-0.4	-1.1	2.7	4.7	0.2	-0.1
VEGFA	4.2	4.9	-0.3	5.7	3.2	0.4
VEGFC	0.1	1.8	2.0	1.9	2.7	1.6
ROBO4	0.1	0.0	-0.2	-4.1	1.1	-1.2
EphB1	0.0	0.8	0.7	0.6	0.9	0.4
B2M	-0.1	-0.2	-1.2	1.5	1.3	-1.6
HPRT1	0.9	0.0	0.6	-0.5	1.4	0.1
RPL13A	0.3	1.2	0.1	0.7	1.7	1.5
GADPH	-0.3	-0.8	-0.1	0.0	1.4	0.8
ACTB	-0.3	-1.0	-0.6	-2.2	-6.3	-0.4
CD248	1.3	1.2	-0.4	0.6	1.3	0.2
GPCR124	-1.7	-3.7	-2.9	-4.6	-1.9	-6.7
PLXDC1	-5.7	-1.7	-0.6	-2.4	0.3	0.2
ANTXR1	-0.3	-3.5	-4.2	-1.4	-0.2	-2.1
RASD2	0.9	0.5	-0.1	0.5	0.3	-0.5
ARHGEF17	0.2	-5.0	-2.0	-0.8	-0.9	-1.6
TNS3	-1.8	2.0	0.6	-8.0	0.5	1.3
DKK3	-1.5	-1.9	-3.3	-2.7	-1.1	-0.4
MMP11	0.8	1.3	-0.2	0.1	0.1	-0.3
NID1	-2.6	-6.3	-5.2	-3.6	-2.5	-3.6
THY1	-11.3	-9.4	-12.7	-3.0	-8.0	-5.8
CST4	0.8	1.3	-0.1	0.4	0.8	0.3
MRC2	1.6	0.7	-0.7	-0.6	0.6	-0.5
TNS1	0.6	0.0	-0.9	-0.3	-0.3	-0.5
BMP1	0.5	0.9	-0.4	-0.6	0.4	-0.4
COMT	-0.7	-1.5	-1.0	-1.7	-0.2	-0.7
PTPRCAP	0.4	0.0	0.2	0.9	0.1	-0.5
57722	0.2	0.1	-0.9	-0.1	0.0	-0.2

NSC:	19630	122567	150117	259969	292222	292596
EXTL3	1.0	0.3	0.0	0.4	0.8	-0.5
Vwf	-1.8	-3.5	-3.7	-5.4	-3.3	-2.6
PNMT	0.7	1.1	-0.4	-0.1	0.1	-0.7
58488	1.2	1.5	0.3	0.4	1.0	0.2
itbp4	-0.8	-1.9	-2.5	-1.7	0.1	-1.5
23001	0.4	-0.5	-1.0	0.3	-0.8	0.1
4247	1.0	0.3	-0.1	0.2	0.5	-0.3
Sdc4	2.2	0.4	0.2	4.0	0.7	1.4
ralb	0.1	0.3	-0.7	0.7	-0.4	-0.5
DGKG	5.4	2.0	3.4	6.1	2.9	1.8
TRA2B	1.5	-1.6	-0.2	0.6	-0.6	0.9
CLIC1	-0.1	0.9	0.0	1.8	6.6	0.6
90780	-1.2	-1.9	-1.4	-2.4	0.1	-0.8
5569	-3.0	0.8	-0.1	4.6	1.5	0.1
151516	1.2	1.1	0.0	0.5	0.7	0.3
CALD1	1.7	2.3	1.1	-0.6	0.6	1.6
DUT	-0.8	-1.8	-0.2	-1.9	-0.4	-1.2
copa	0.4	0.1	0.0	-2.1	0.2	-0.5
PDCD2	0.5	-0.4	-0.9	-1.7	0.2	-1.1
151516	0.9	1.3	0.0	0.5	0.7	0.3
VGLL4	-1.3	-3.5	-3.5	1.3	-0.8	-2.8
APOE	3.3	0.8	-1.0	0.8	-2.2	5.1
8131	0.6	0.1	-0.5	-0.2	0.1	0.3
10988	2.5	1.2	0.8	0.3	1.0	0.9
9569	-2.3	-2.2	-4.2	-1.7	0.2	-2.0
B2M	-1.4	-0.2	-0.7	0.5	0.0	-0.4
HPRT1	0.2	-0.6	1.1	0.8	0.2	0.4
RPL13A	1.0	0.9	0.6	0.0	0.3	1.1
GADPH	0.1	-0.7	-0.5	-1.7	-0.1	-0.3
ACTB	-0.9	-0.5	-0.5	-2.2	-0.9	-0.9
Acvrl1	-0.6	-1.3	-1.2	-1.9	0.0	-1.6
Adcy4	0.0	-0.4	-0.5	-0.6	-0.4	4.3
Calcrl	-4.3	-4.0	-5.4	-2.9	-1.1	-4.3
Caskin2	-2.8	-2.3	-2.7	-2.3	-6.7	-2.3
Ccbp2	-0.1	1.4	0.4	5.6	0.4	0.0
Cldn5	0.6	0.0	0.1	0.4	-0.1	-0.6
1839	-1.2	1.0	0.9	-4.2	-0.1	-0.3
Egfl7	-3.8	-2.6	-3.3	-2.3	-1.2	-3.3
Ehd4	-1.1	-0.8	-0.6	-0.7	-1.4	-1.0
Entpd1	-4.9	-0.3	-8.9	-5.6	-5.5	-8.3
Epas1	1.8	0.9	0.4	1.5	-1.7	0.3
Erg	-1.6	2.4	-3.2	-3.9	3.7	-6.4

NSC:	19630	122567	150117	259969	292222	292596
ESAM1	-3.3	-2.9	-2.6	-1.6	-1.1	-2.0
Fgd5	-1.6	-1.5	-1.2	-0.8	-0.8	-1.0
Grp116	-1.9	-2.3	-3.1	-5.5	-4.4	-3.1
Hspa12b	-4.6	-3.4	-3.5	-10.2	-2.2	-3.3
Icam1	0.1	0.0	0.6	2.8	0.5	0.5
Icam2	0.4	0.1	0.0	7.5	0.1	-0.4
Kifc1	3.4	1.1	-0.1	-4.8	0.5	1.6
Lasts2	-0.1	4.8	0.3	1.5	0.1	0.4
Lrrk1	-2.9	-0.5	-1.8	0.3	-0.1	-1.5
Mmm2	-2.4	-3.5	-3.4	-7.5	-1.0	-2.4
Myo1b	-2.3	-2.9	-2.7	-3.0	-1.5	-2.0
PALD	-1.1	-0.5	-1.7	-1.3	1.8	-1.9
NM_023516	0.5	0.2	0.6	0.9	0.4	0.2
55332	-1.1	-1.0	-1.7	0.1	2.4	-8.6
CTTNBP2NL	-2.3	-0.9	-2.3	-1.0	0.2	-3.4
CENTD3	0.6	1.1	-0.2	-1.0	-0.5	0.1
C1orf54	-4.8	-3.4	-1.3	-6.1	-0.1	-2.2
134265	-1.6	-0.2	-1.0	-0.6	-1.3	-1.6
Npr3	8.3	1.5	0.5	2.7	0.9	0.7
Pltp	0.9	1.5	0.9	1.4	0.4	0.5
Ptprb	-1.6	0.5	-2.6	-0.1	0.3	-1.9
Ptprm	-1.2	-0.4	-1.4	1.7	-0.1	-0.8
GRRP1	0.0	-0.3	0.0	0.6	0.1	0.2
stard9	-0.7	0.5	0.1	0.0	0.8	-0.9
RAMP2	-4.8	-5.8	-4.4	-5.9	-0.6	-5.0
Rasip1	3.1	-1.2	-1.7	-1.1	-0.3	-0.5
Robo4	0.3	1.2	-0.3	0.3	0.0	0.2
Sdpr	-0.1	1.6	0.0	0.9	-4.9	0.8
Slc43a3	-0.8	1.8	0.0	0.2	1.0	0.6
Slc9a3r2	-0.5	-1.9	-2.6	-0.8	-2.4	-4.4
Slco2a1	-2.5	-0.6	-2.9	-2.4	-5.3	-1.0
B2M	-0.9	0.3	-0.8	0.8	0.6	-0.8
HPRT1	2.0	-0.2	0.4	0.5	0.4	0.1
RPL13A	0.4	1.3	0.2	0.0	1.2	0.6
GADPH	-1.6	-2.0	-0.5	-2.1	-0.2	0.4
ACTB	-1.6	-0.1	-0.2	0.4	-0.6	-0.1

Clustering analysis of gene expression data

It is well known that tumors become resistant to antiangiogenic therapy (Bergers and Hanahan, *Nature Reviews: Cancer*, 8:592-603, 2008). Tumor angiogenesis involves
5 multiple pathways. Current antiangiogenic drugs (such as AVASTIN®) successfully inhibit

one pathway and are followed by activation of alterative pathways which resume the angiogenesis process within the tumor. A multitargeted strategy that inhibits multiple angiogenesis pathways is expected to more successfully avoid drug resistance.

To that end, clustering analysis was performed with the gene expression data to identify drugs which inhibit angiogenesis, and by extension tumor growth, by targeting different sets of genes and therefore different angiogenesis pathways.

Combinations of drugs which effect distant gene sets in the clustering analysis could potentially target different angiogenesis pathways and therefore be more efficient antiangiogenic regimens. Several potential drug combinations emerge from this clustering analysis, such as NSC259969 + NSC150117.

In view of the many possible embodiments to which the principles of our invention may be applied, it should be recognized that the illustrated embodiments are only examples and should not be taken as a limitation on the scope of the invention. Rather, the scope of the invention is defined by the following claims. We therefore claim as our invention all that comes within the scope and spirit of these claims.

CLAIMS

1. A pharmaceutical composition for treating an angiogenesis-dependent disease, comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically-acceptable salt thereof.

2. The pharmaceutical composition of claim 1, further comprising [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

3. The pharmaceutical composition of claim 1 of claim 2, wherein the angiogenesis-dependent disease comprises cancer, retinopathy, endometriosis, arthritis, or psoriasis.

4. The pharmaceutical composition of any one of claims 1-3, wherein the composition is administered topically, intravenously, orally, parenterally, or as an implant.

5. The pharmaceutical composition of any one of claims 1-4, further comprising an additional angiogenesis inhibitor.

6. A pharmaceutical composition for inhibiting aberrant angiogenesis, comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically-acceptable salt thereof.

7. The pharmaceutical composition of claim 6, further comprising [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

8. The pharmaceutical composition of claim 6 or claim 7, wherein the aberrant angiogenesis is stimulated by a tumor.

9. The pharmaceutical composition of claim 8, wherein the tumor is benign or malignant.

10. A pharmaceutical composition for inhibiting growth of neoplastic tissue, comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate

(NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically-acceptable salt thereof.

11. The pharmaceutical composition of claim 10, further comprising [4-[(4-
5 arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

12. A method of treating an angiogenesis-dependent disease, comprising:

administering to a subject having or predisposed to an angiogenesis-dependent disease a therapeutically effective amount of a composition comprising at least one of 2-
10 benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof.

15 13. The method of claim 12, wherein the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

14. The method of claim 12 or claim 13, wherein the angiogenesis-dependent disease comprises cancer, retinopathy, endometriosis, arthritis, or psoriasis.

20 15. The method of any one of claims 12-14, wherein the composition is administered topically, intravenously, orally, parenterally, or as an implant.

16. The method of any one of claims 12-15, further comprising administering to the subject an additional angiogenesis inhibitor.

17 The method of claim 16, wherein the additional angiogenesis inhibitor is an
25 inhibitor of bFGF, FGF, or VEGF.

18. A method of inhibiting undesired angiogenesis in a subject, comprising:

identifying a subject wherein angiogenesis is not desired, and

administering to the subject a therapeutically effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride
30 (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof.

19. The method of claim 18, wherein the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

20. The method of claim 18 or claim 19, further comprising administering an additional inhibitor of angiogenesis.

21. The method of claim 20, wherein the additional inhibitor of angiogenesis is an inhibitor of bFGF, FGF, or VEGF.

22. The method of any one of claims 18-21, wherein the undesired angiogenesis comprises tumor angiogenesis.

23. The method of claim 22, wherein the tumor is benign or malignant.

24. A method of inhibiting a neoplasm in a subject, comprising:

administering to the subject a therapeutically effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof.

25. The method of claim 24, wherein the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

26. A method of inhibiting angiogenesis in a tissue or a target area in a subject wherein the formation of new blood vessels is not desired, comprising

identifying a tissue or target area in a subject wherein the formation of new blood vessels is not desired; and

introducing directly or indirectly into the tissue or target area an effective amount of a composition comprising at least one of 2-benzylidene-3-(cyclohexylamino)-3H-inden-1-one chloride (NSC 150117), deoxybouvardin (NSC 259969), (2,5-dioxopyrrol-1-yl)methyl propanoate (NSC 19630), 1-benzylsulfonyl-2,4-dinitrobenzene (NSC 122657), maytansinol isobutyrate (NSC 292222), chloroplatinum(1+); 2-(4-methylpiperidin-1-yl)ethanethiolate; dehydrate (NSC 292596), or a pharmaceutically acceptable salt thereof, thereby inhibiting angiogenesis in the tissue or target area.

27. The method of claim 26, wherein the composition further comprises [4-[(4-arsonophenyl)methyl]phenyl]arsonic acid (NSC 48300), or a pharmaceutically-acceptable salt thereof.

28. The method of claim 26 or 27, wherein the target area comprises skin, a tumor, a retina, a joint, or endometrial tissue.

29. The method of any one of claims 26-28, wherein the subject has or is predisposed to developing a tumor, retinopathy, endometriosis, arthritis, or psoriasis.

5

FIG. 1

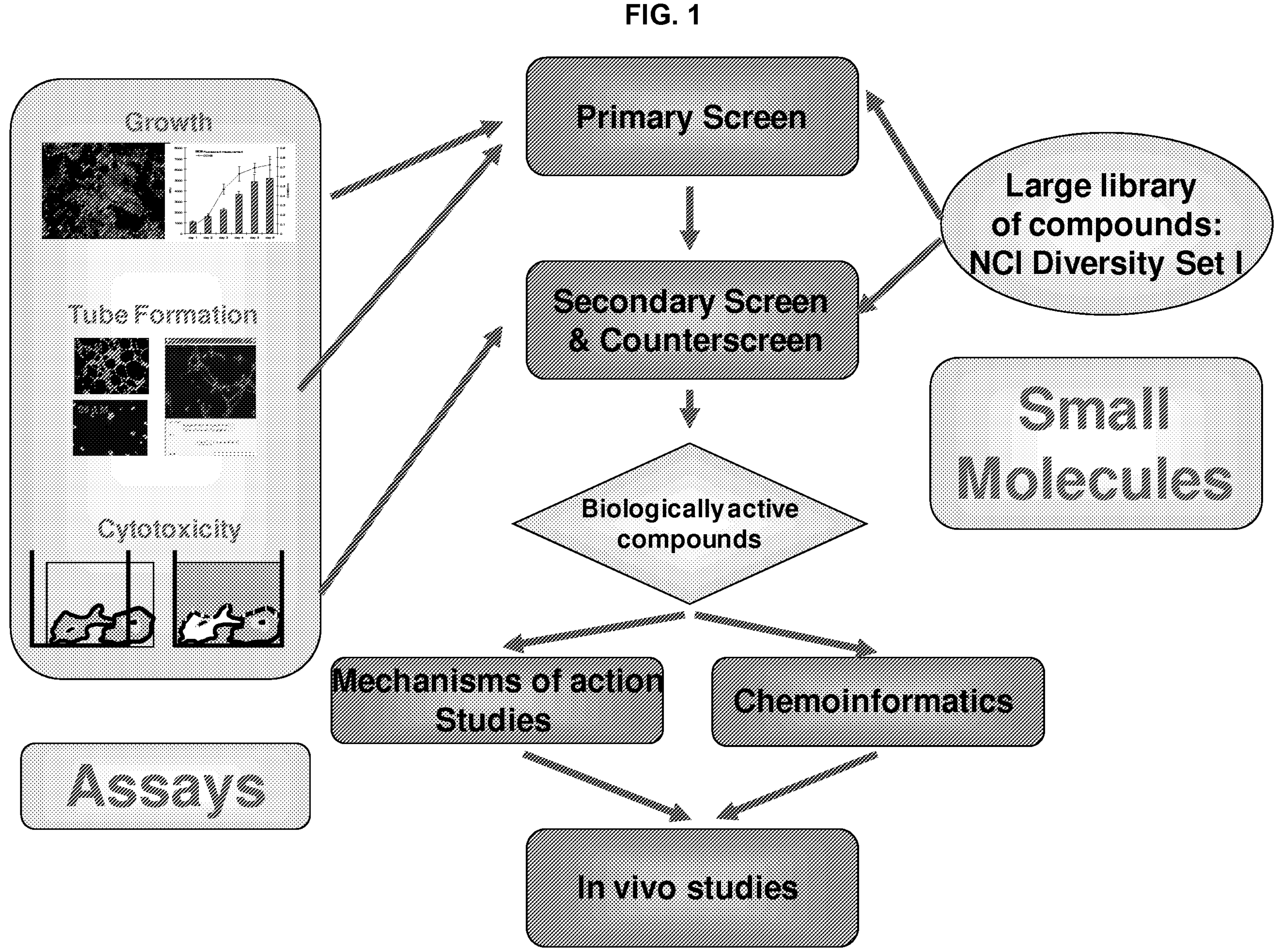
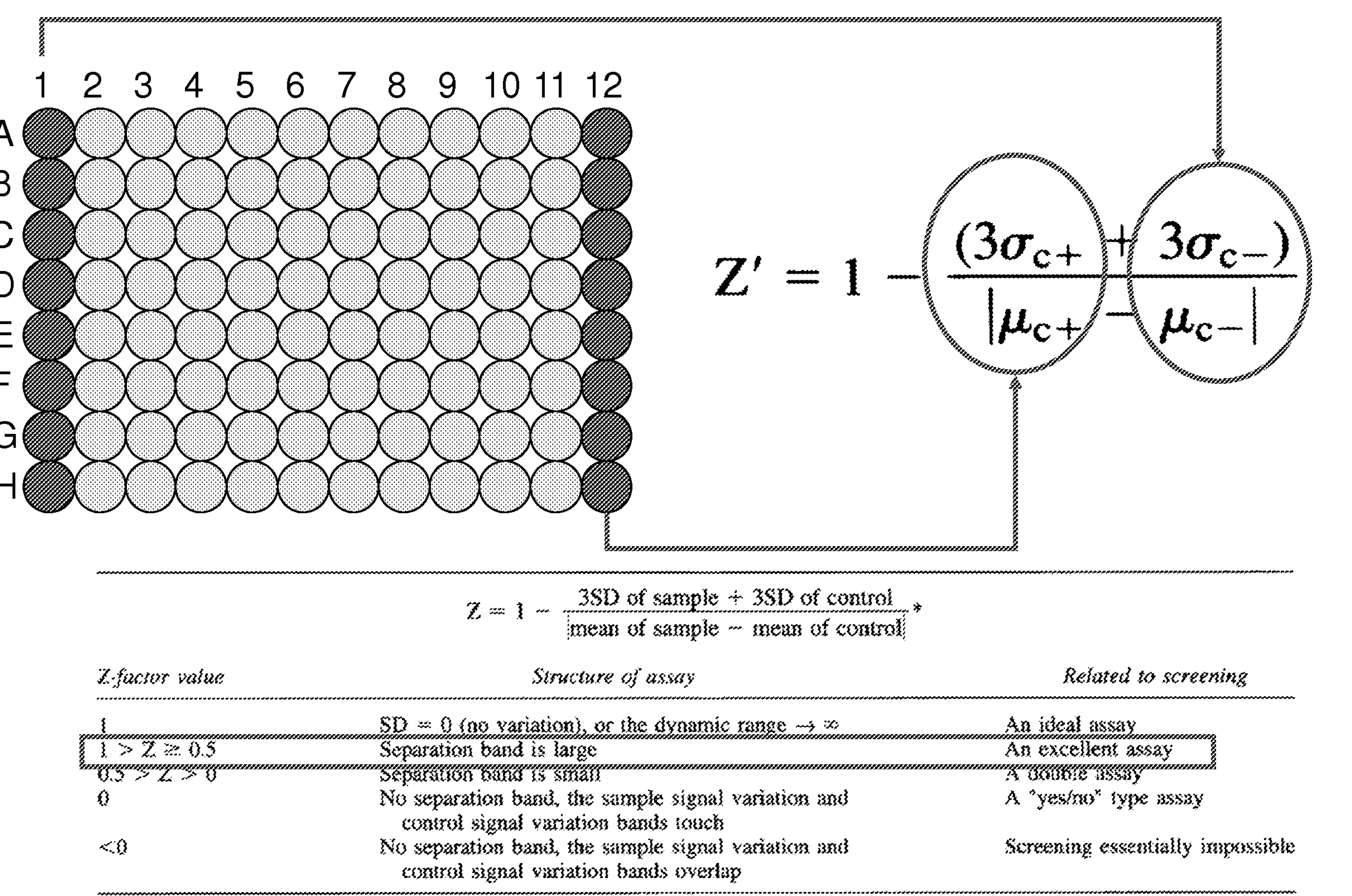


FIG. 2



$$Z = 1 - \frac{3SD\ of\ sample + 3SD\ of\ control}{|mean\ of\ sample - mean\ of\ control|}$$*

Z-factor value	Structure of assay	Related to screening
1	SD = 0 (no variation), or the dynamic range → ∞	An ideal assay
1 > Z ≥ 0.5	Separation band is large	An excellent assay
0.5 > Z > 0	Separation band is small	A double assay
0	No separation band, the sample signal variation and control signal variation bands touch	A "yes/no" type assay
<0	No separation band, the sample signal variation and control signal variation bands overlap	Screening essentially impossible

FIG. 3

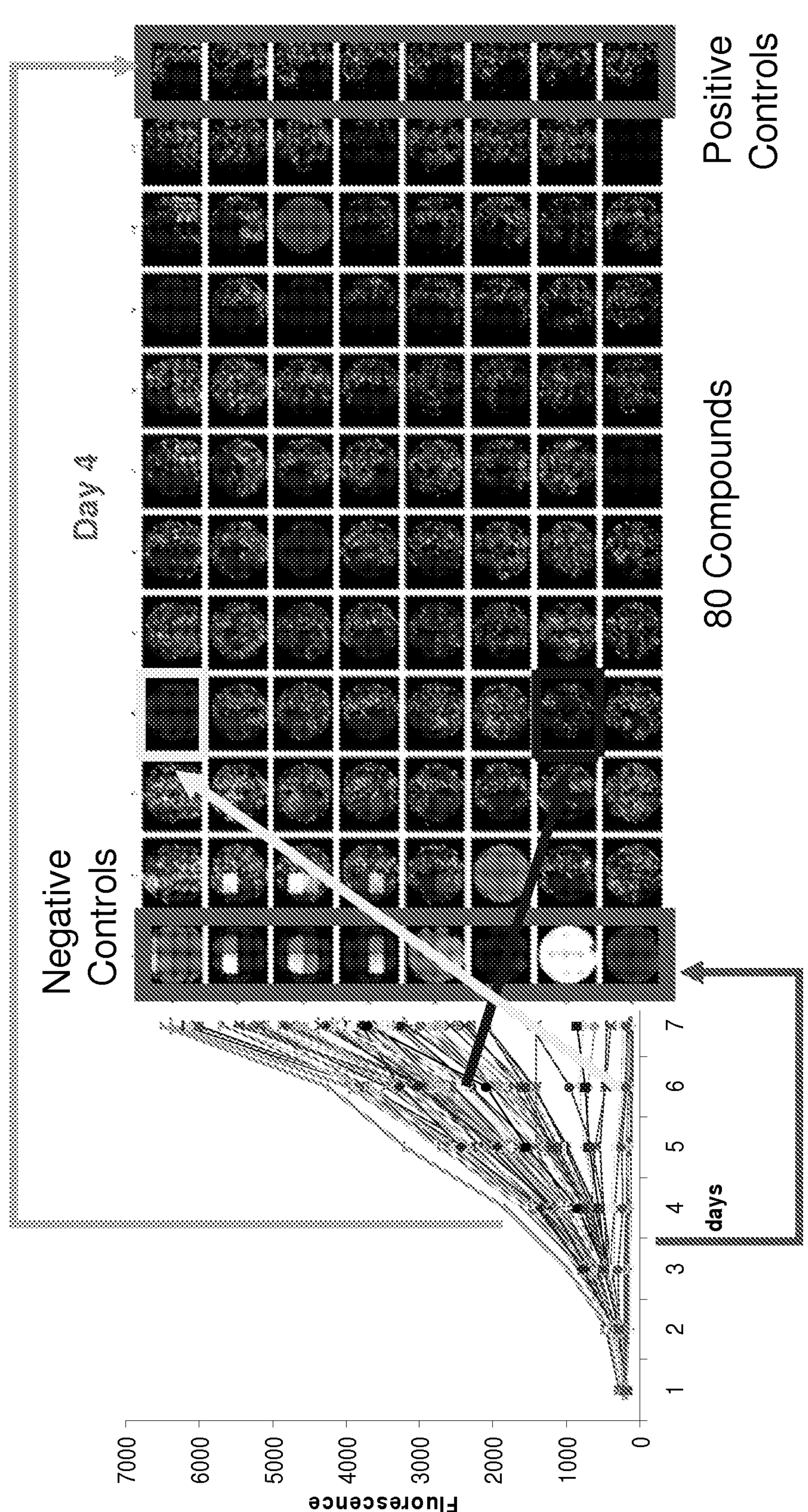


FIG. 4

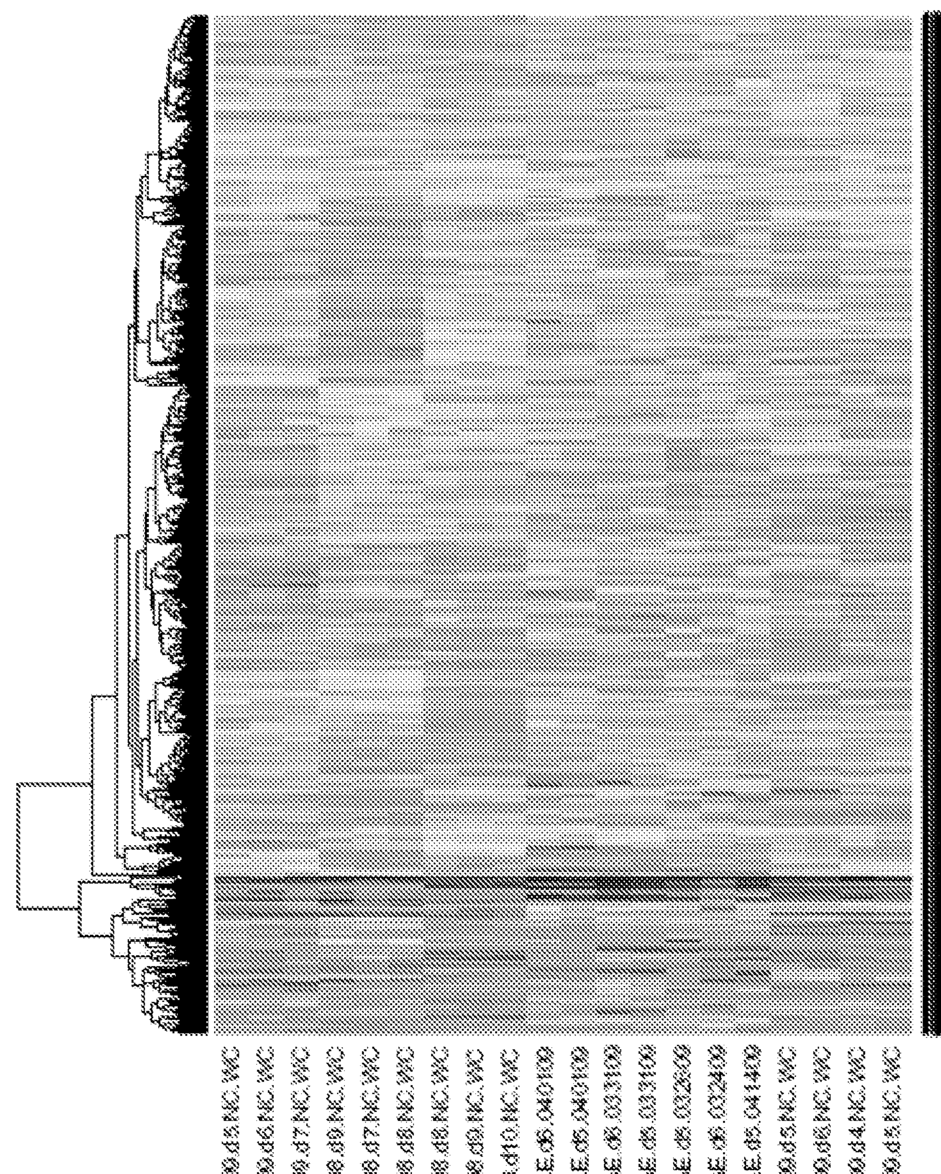


FIG. 5

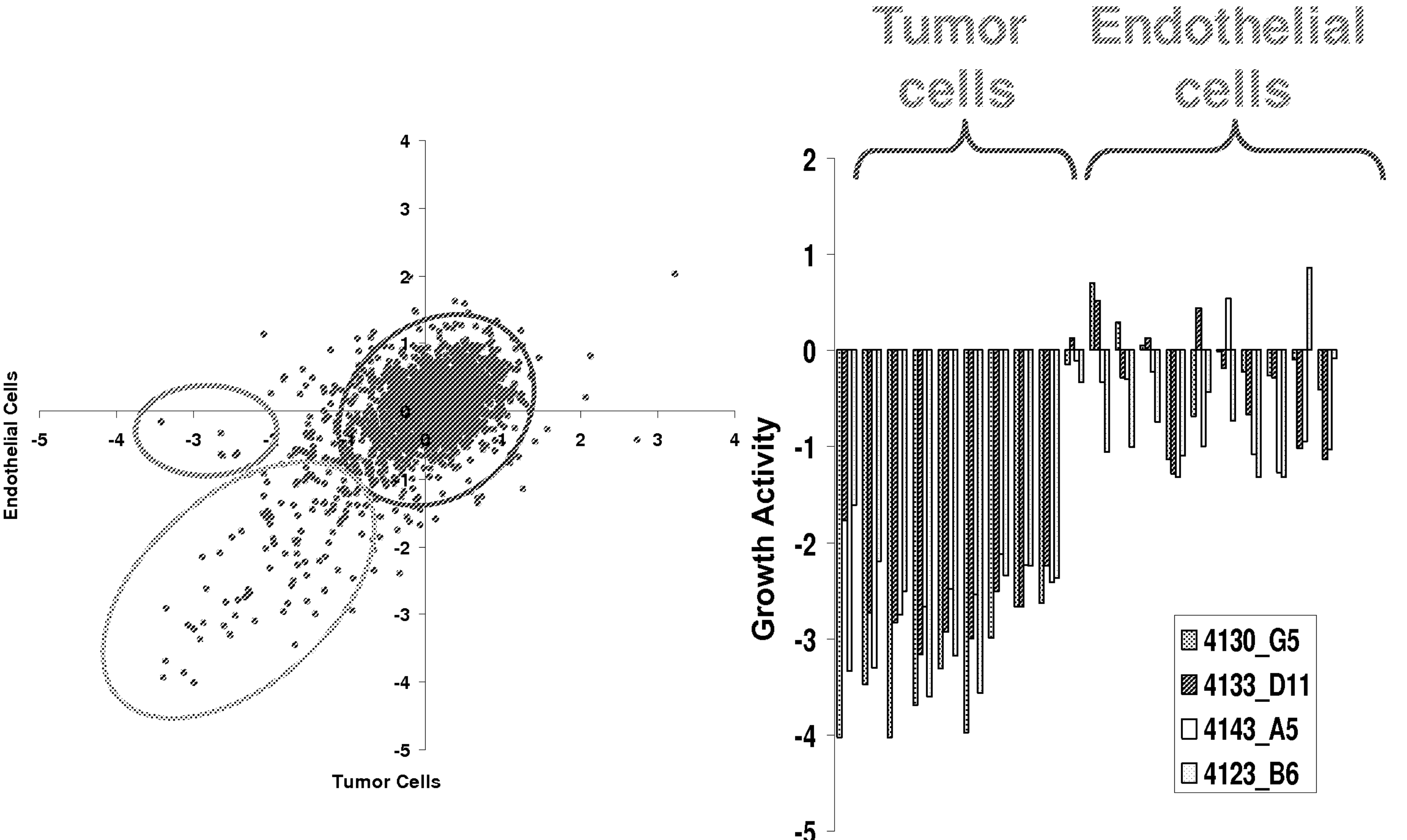


FIG. 6

Half maximal inhibitory concentration (IC50) in PAE

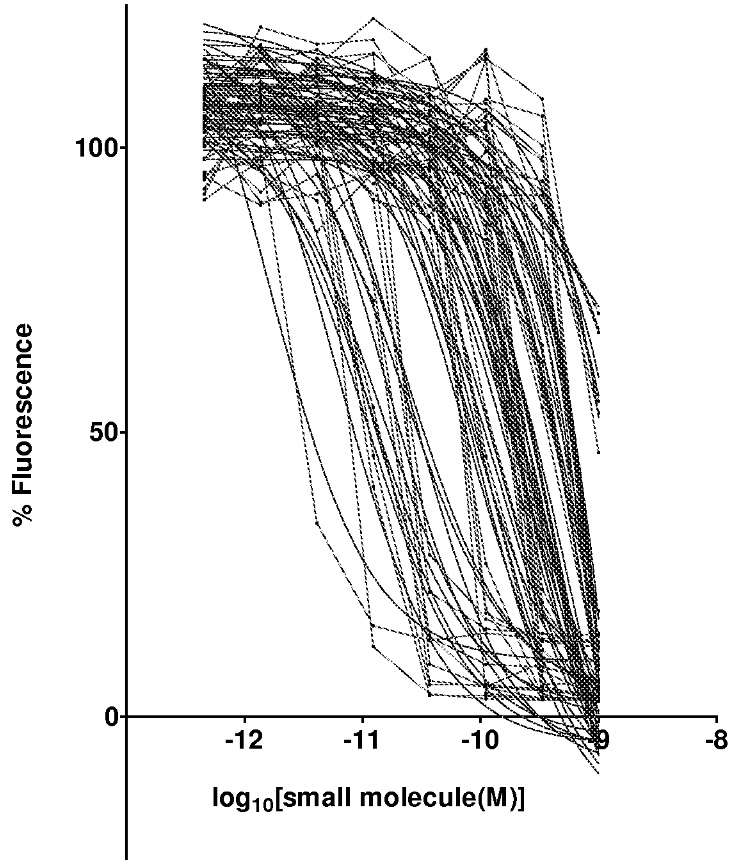


FIG. 7

New Cytotoxicity Assay

$$\% \text{ Cytotoxicity} = \frac{\text{Fluorescence}_{\text{medium}}}{\text{Fluorescence}_{\text{total}}} * 100$$

FIG. 8

Hits in 4143-11

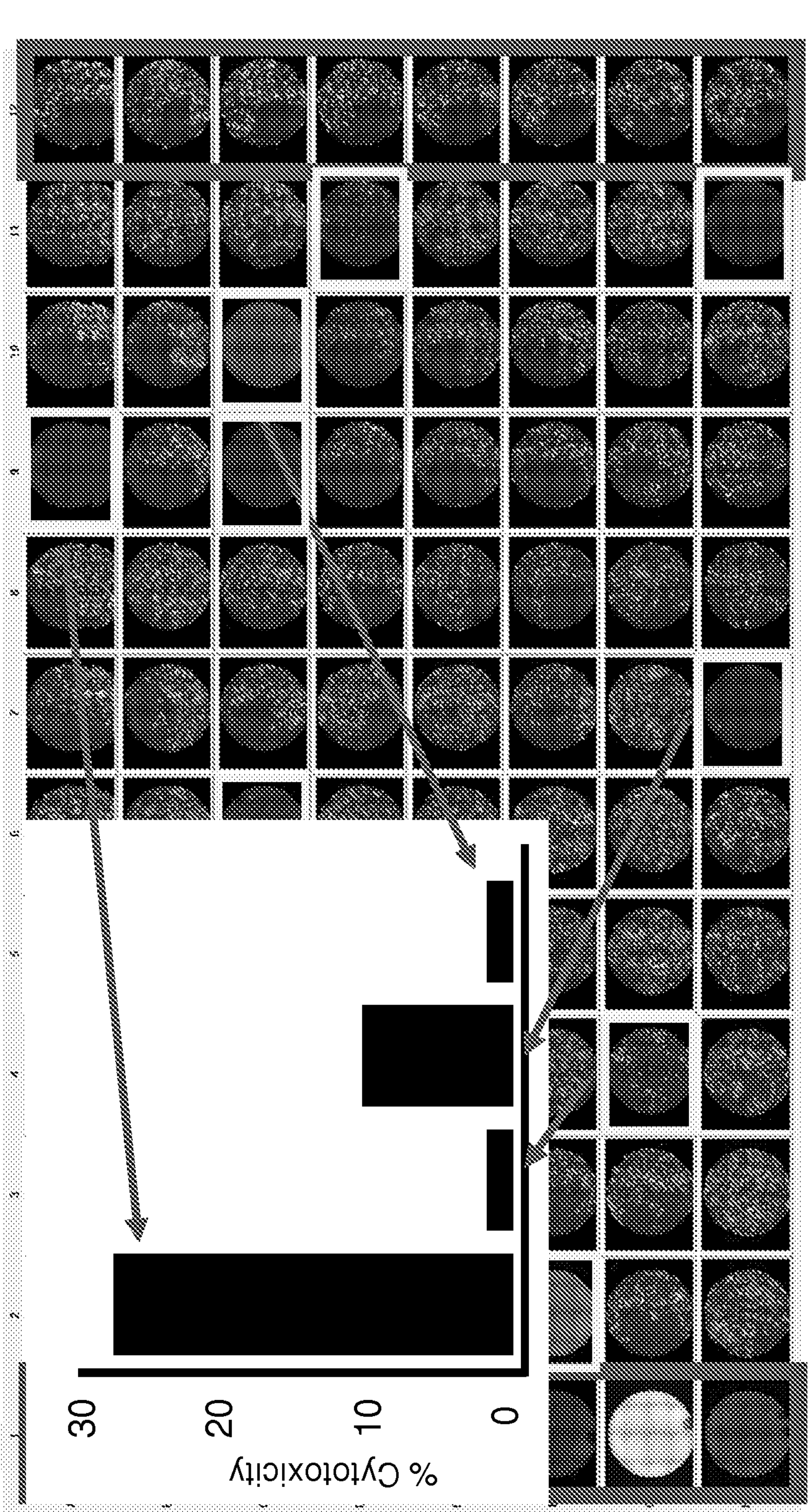


FIG. 9

AngioApplication

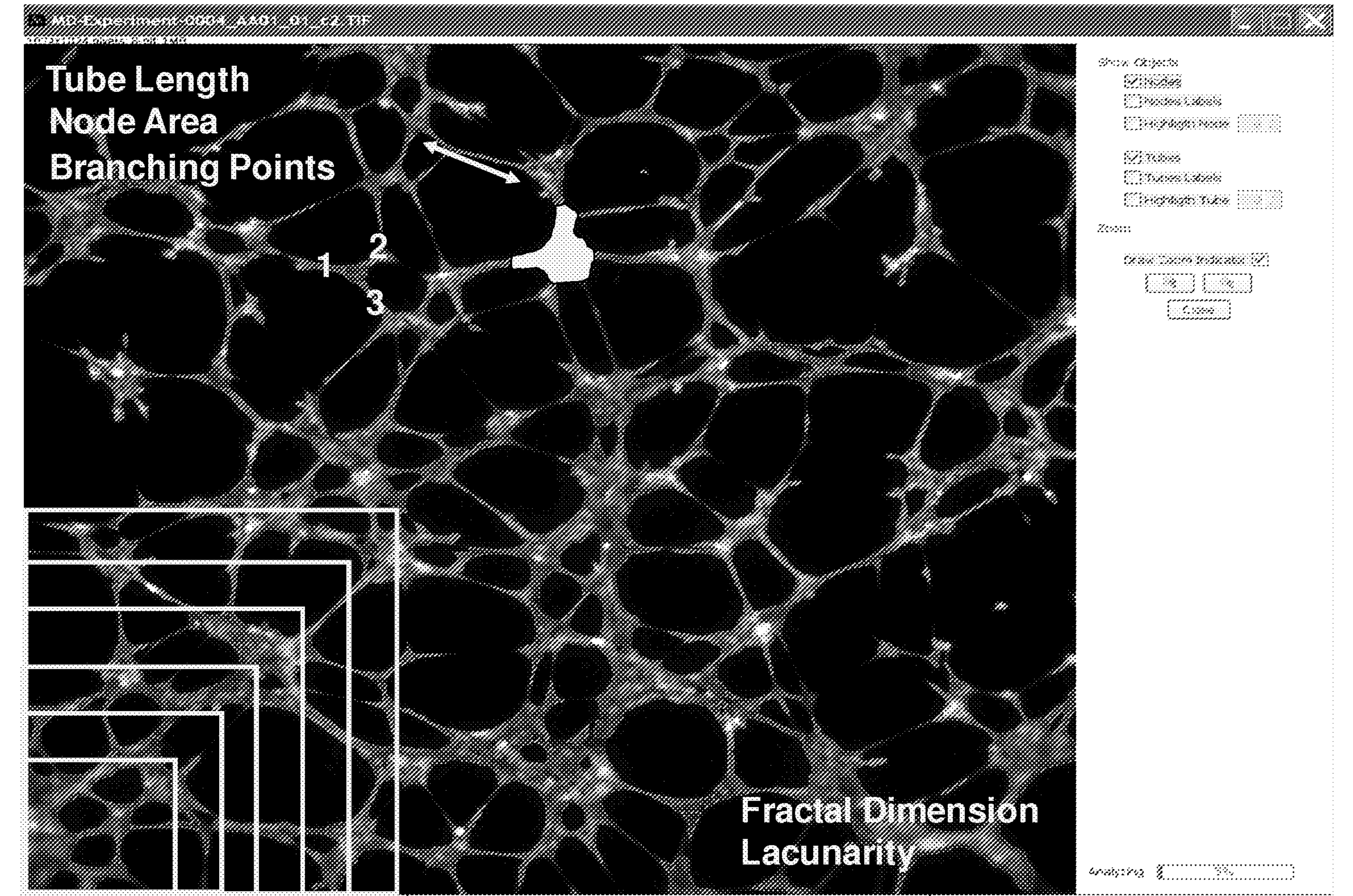


FIG. 10

Data Reduction and Hit Definition

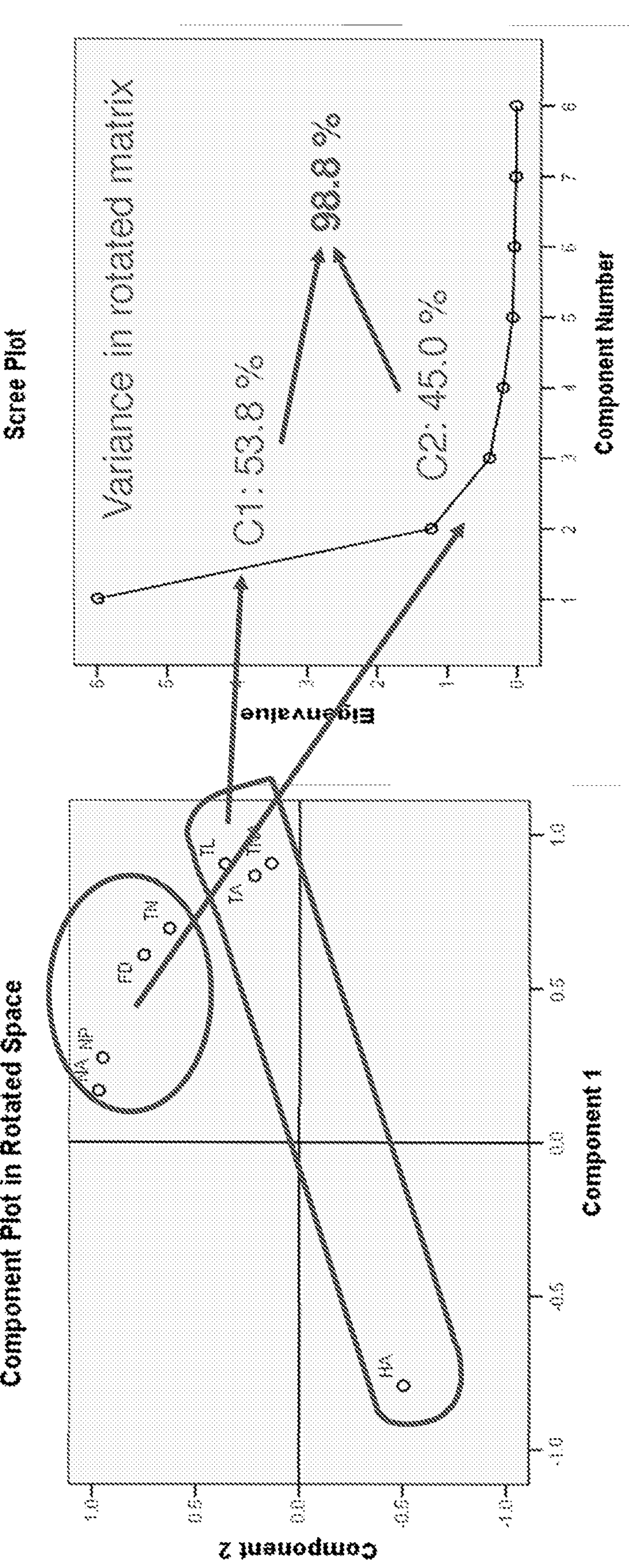


FIG. 11

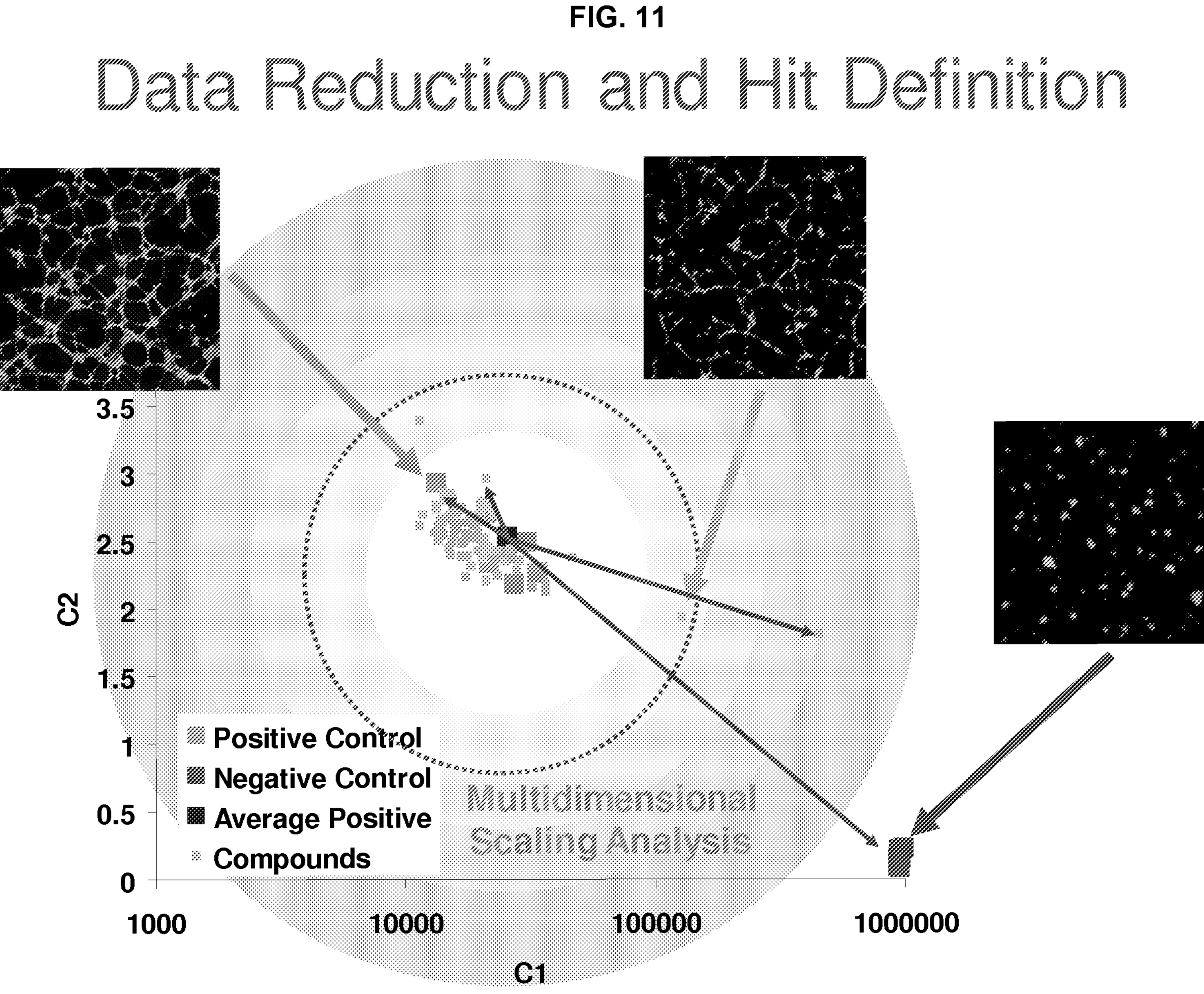


FIG. 12

Dose response of NSC119889 in tube formation assays

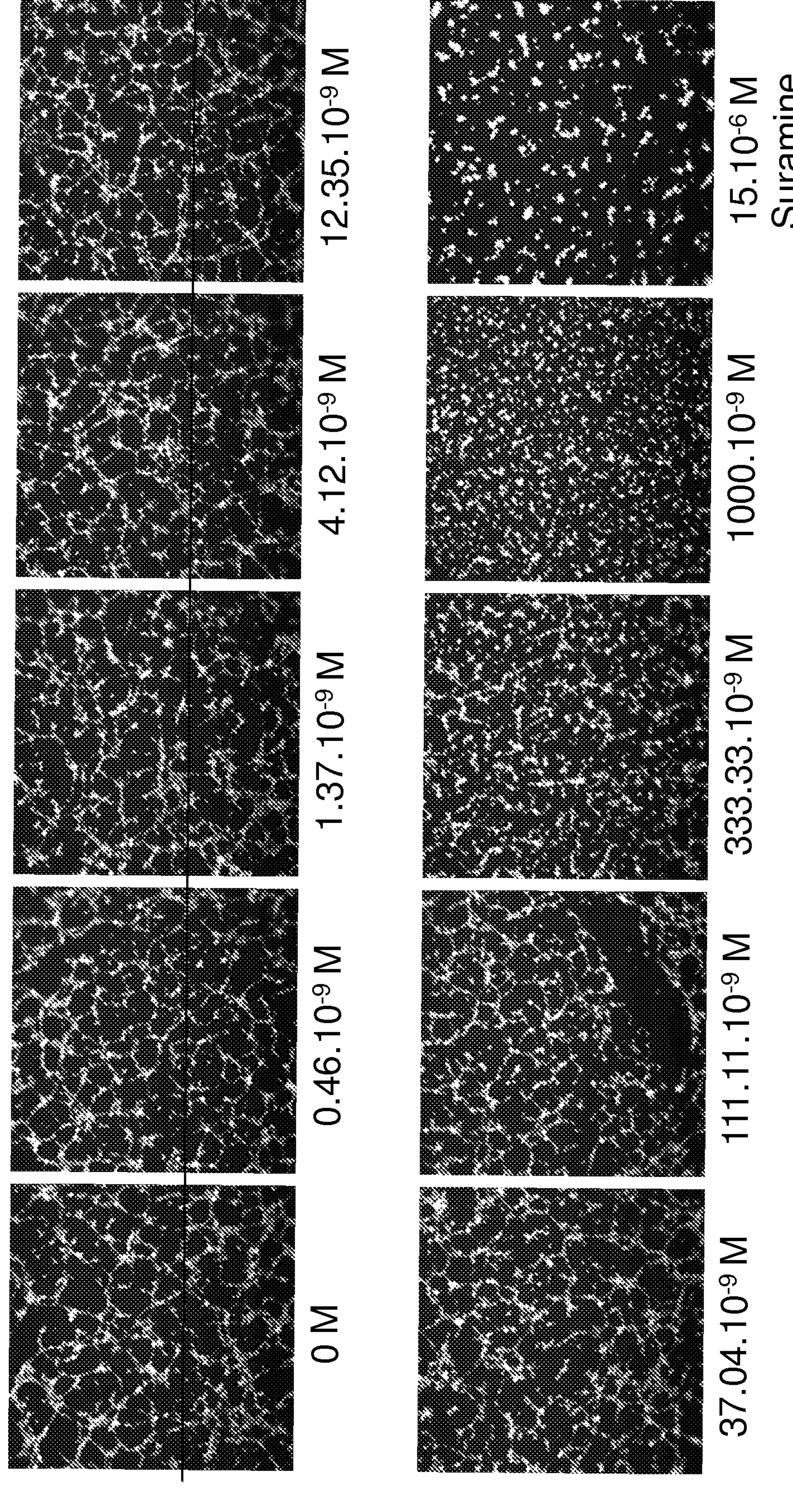


FIG. 13

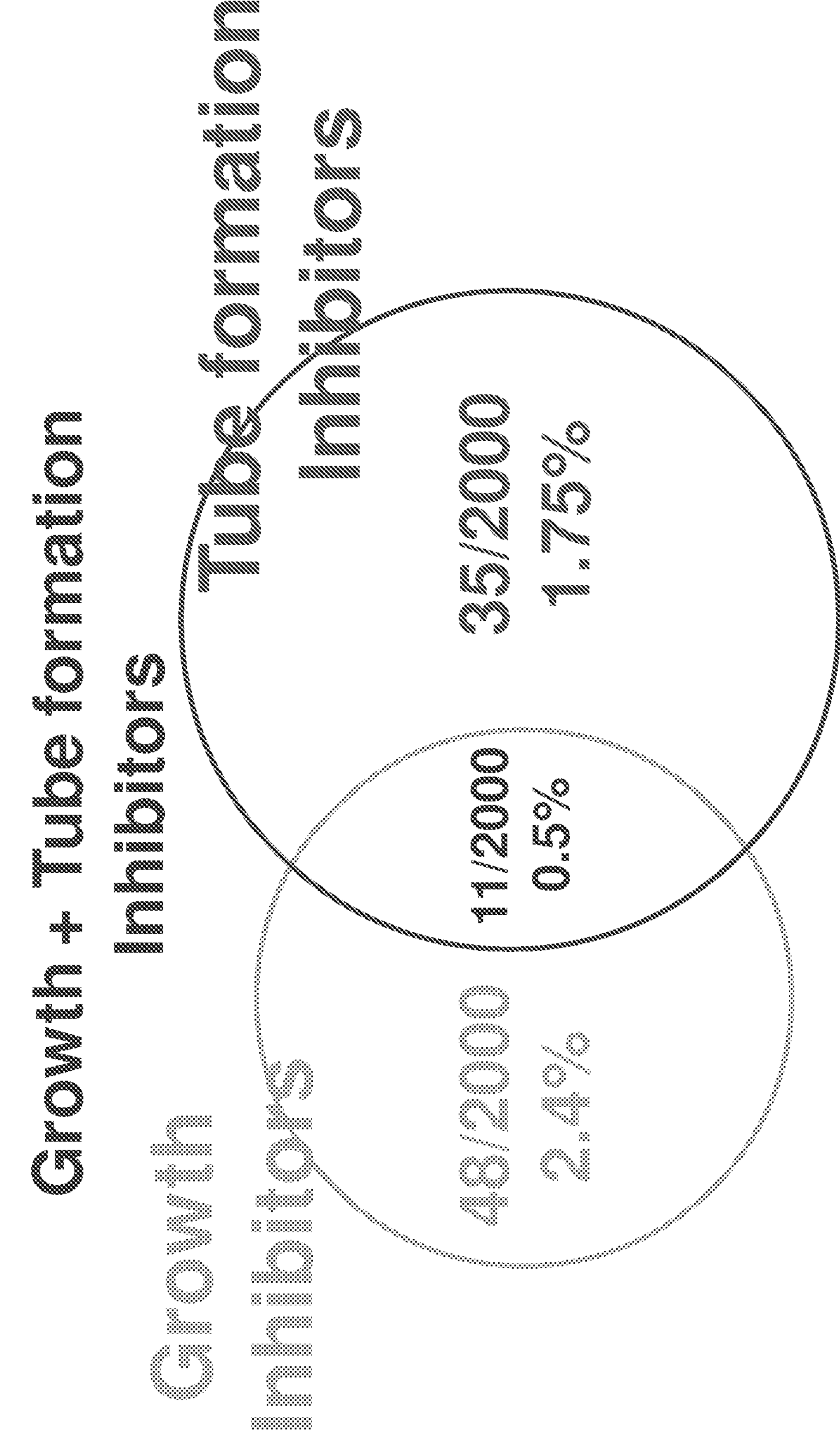


FIG. 14

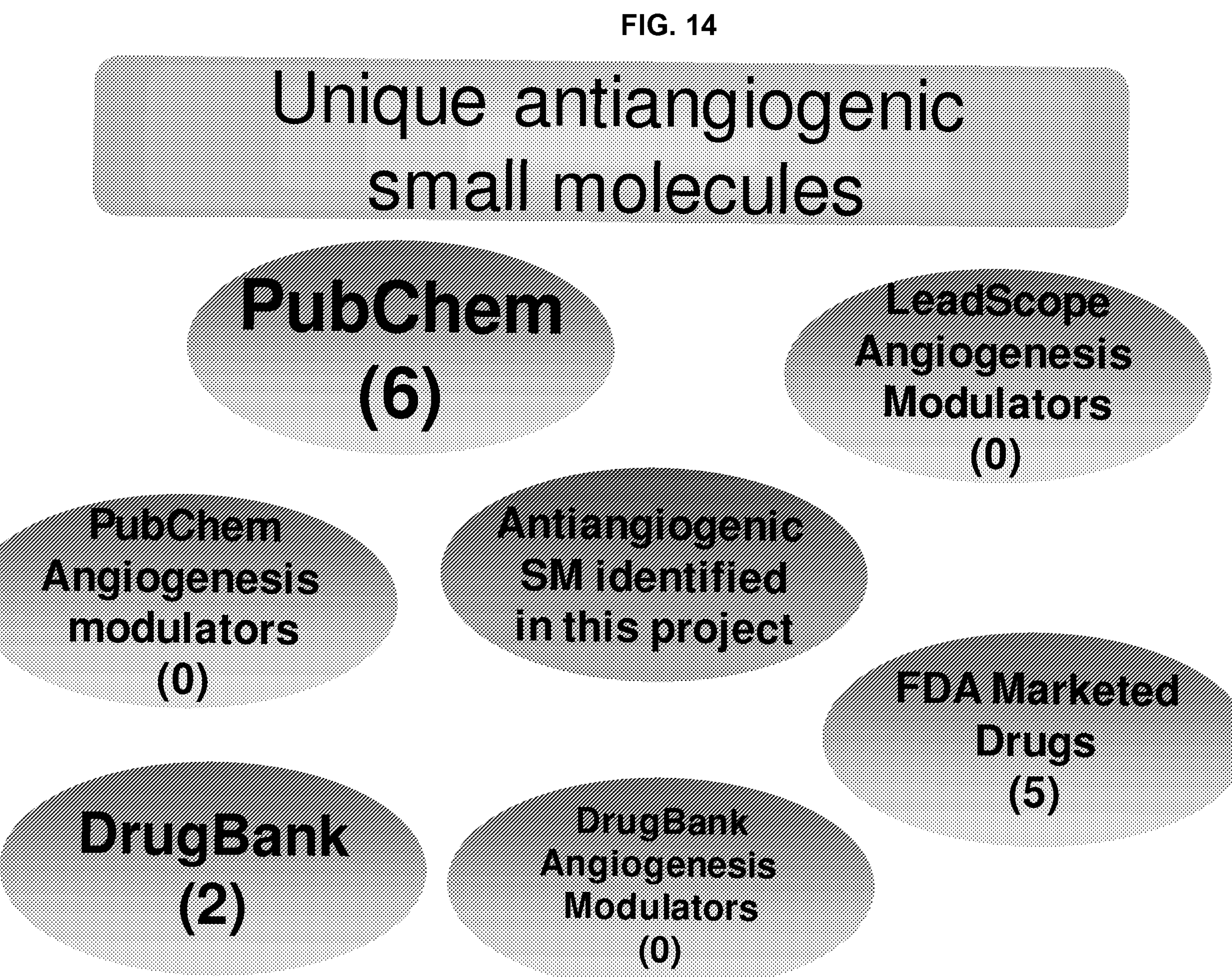
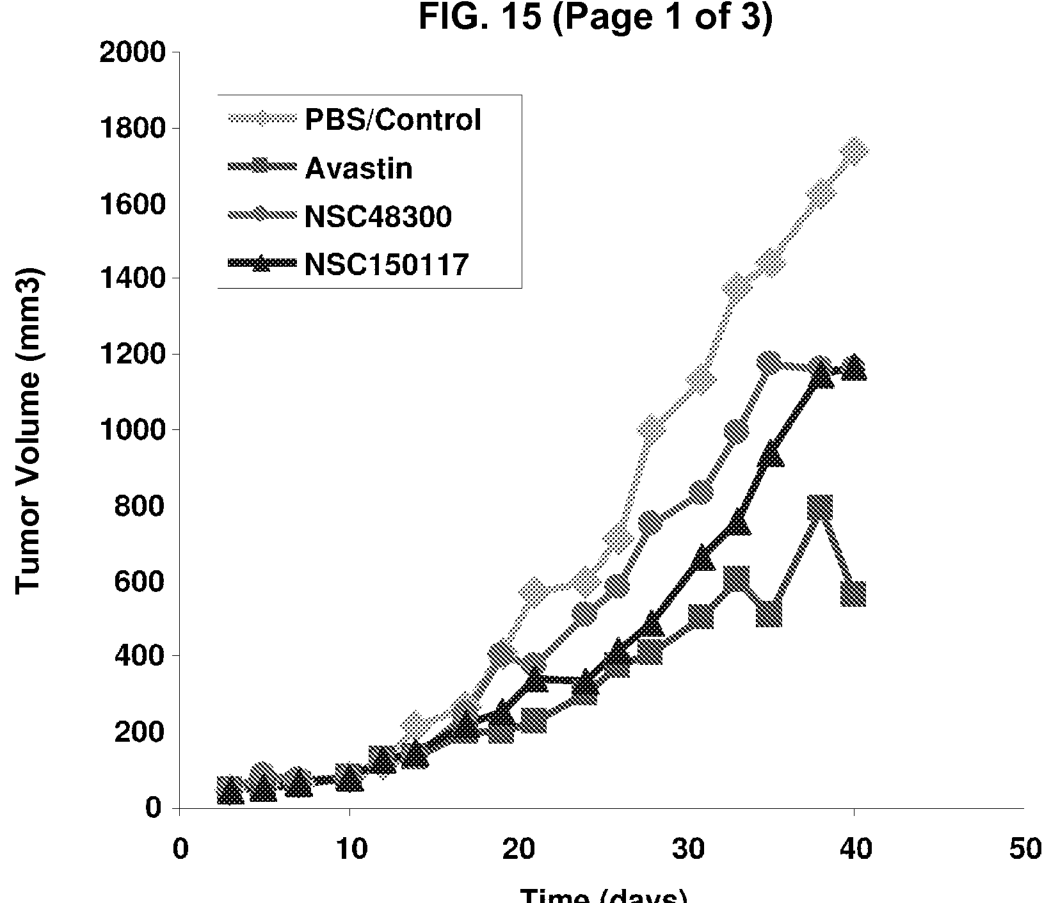


FIG. 15 (Page 1 of 3)



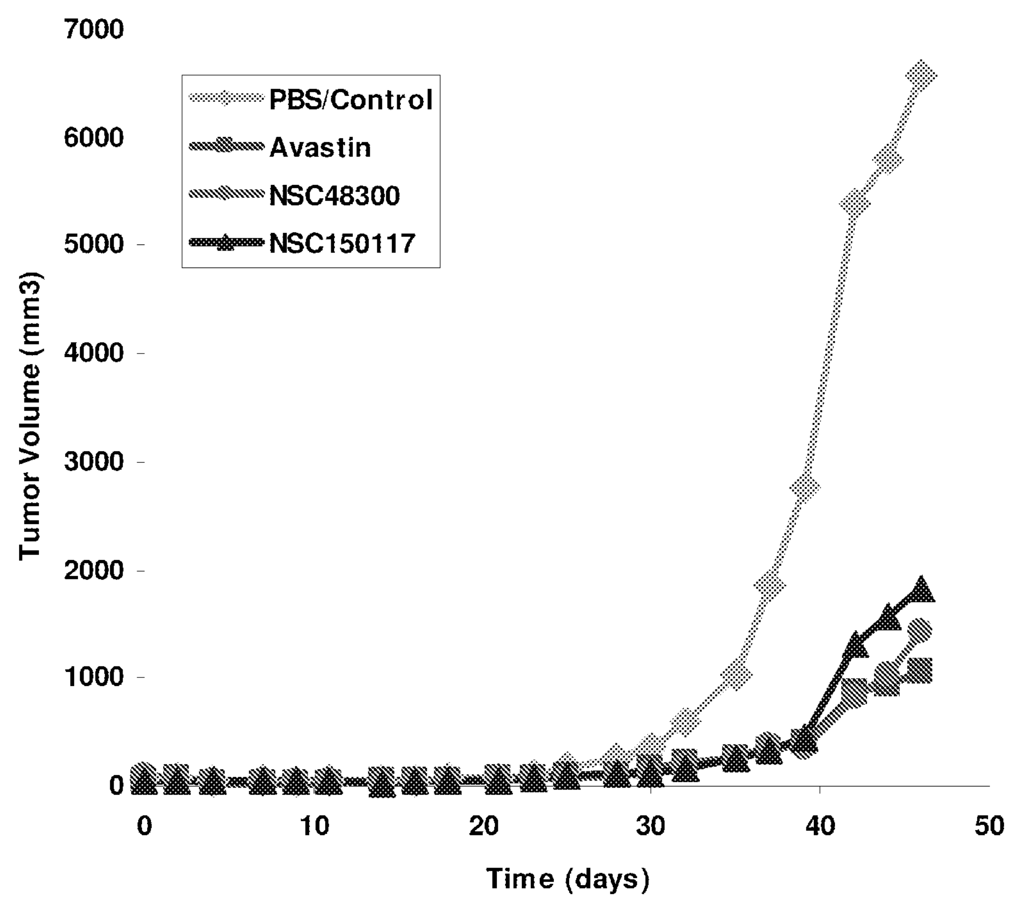
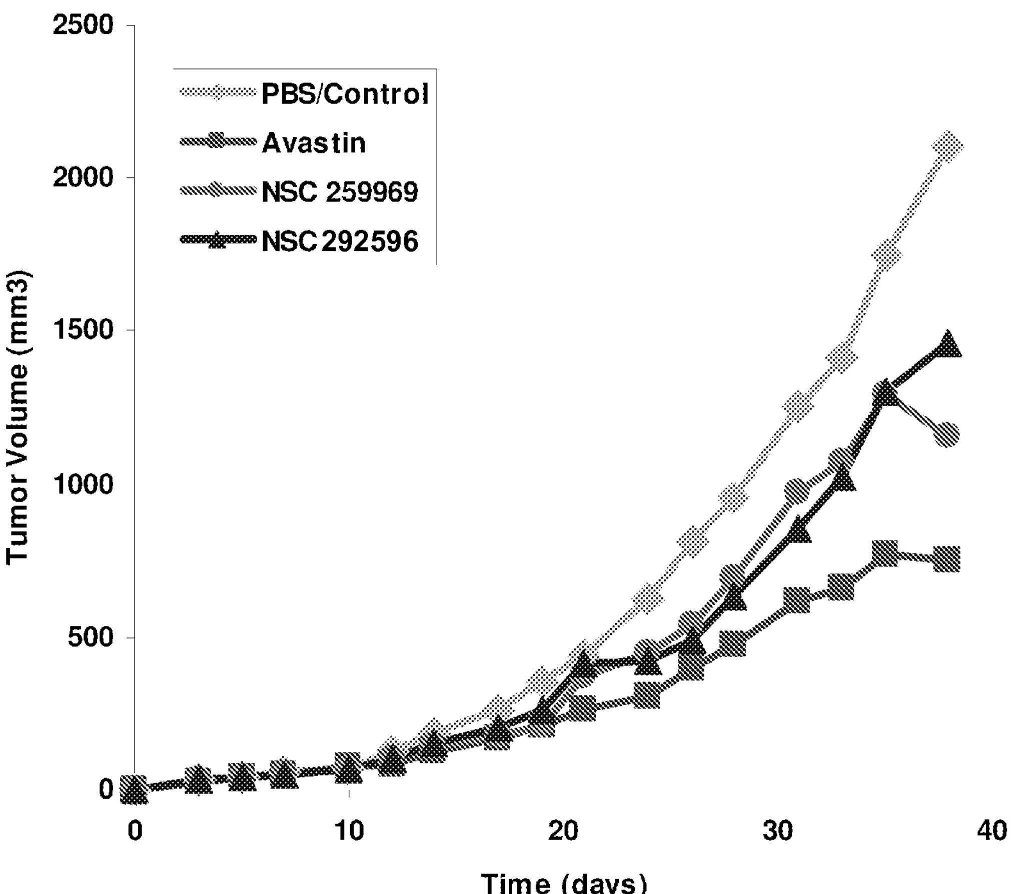


FIG. 15 (Page 2 of 3)



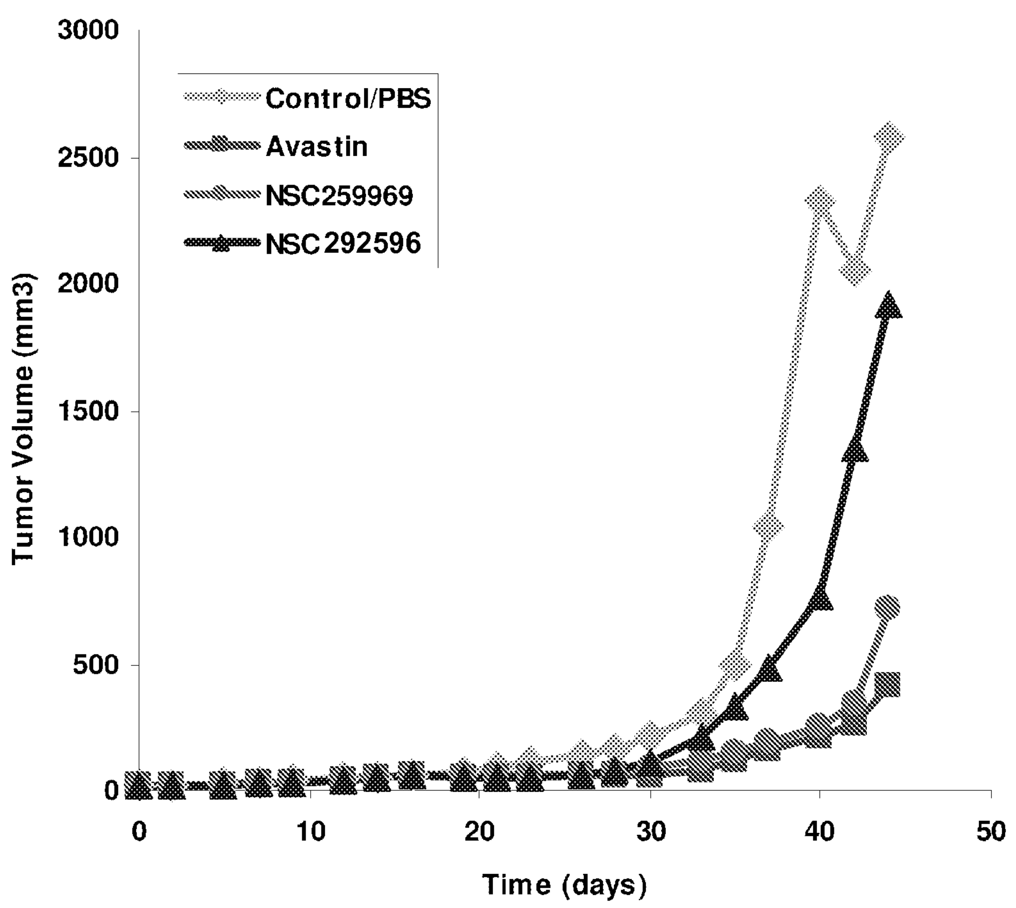
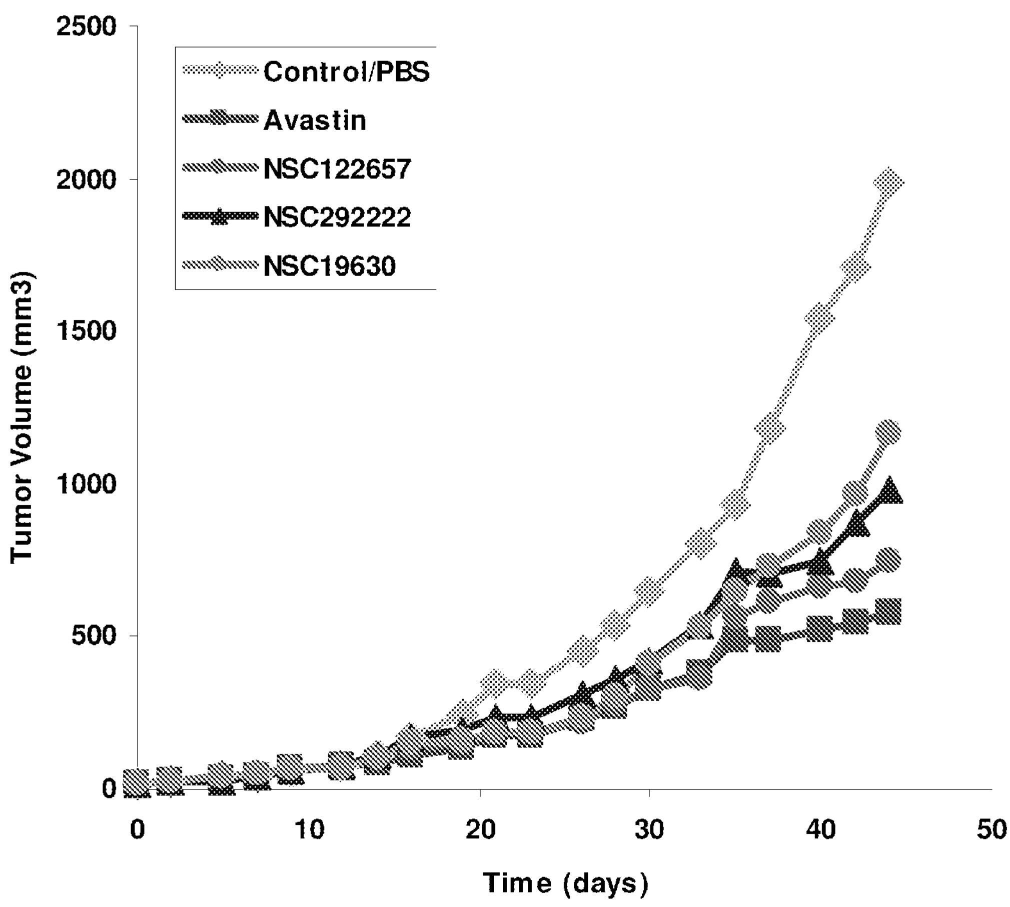


FIG. 15 (Page 3 of 3)



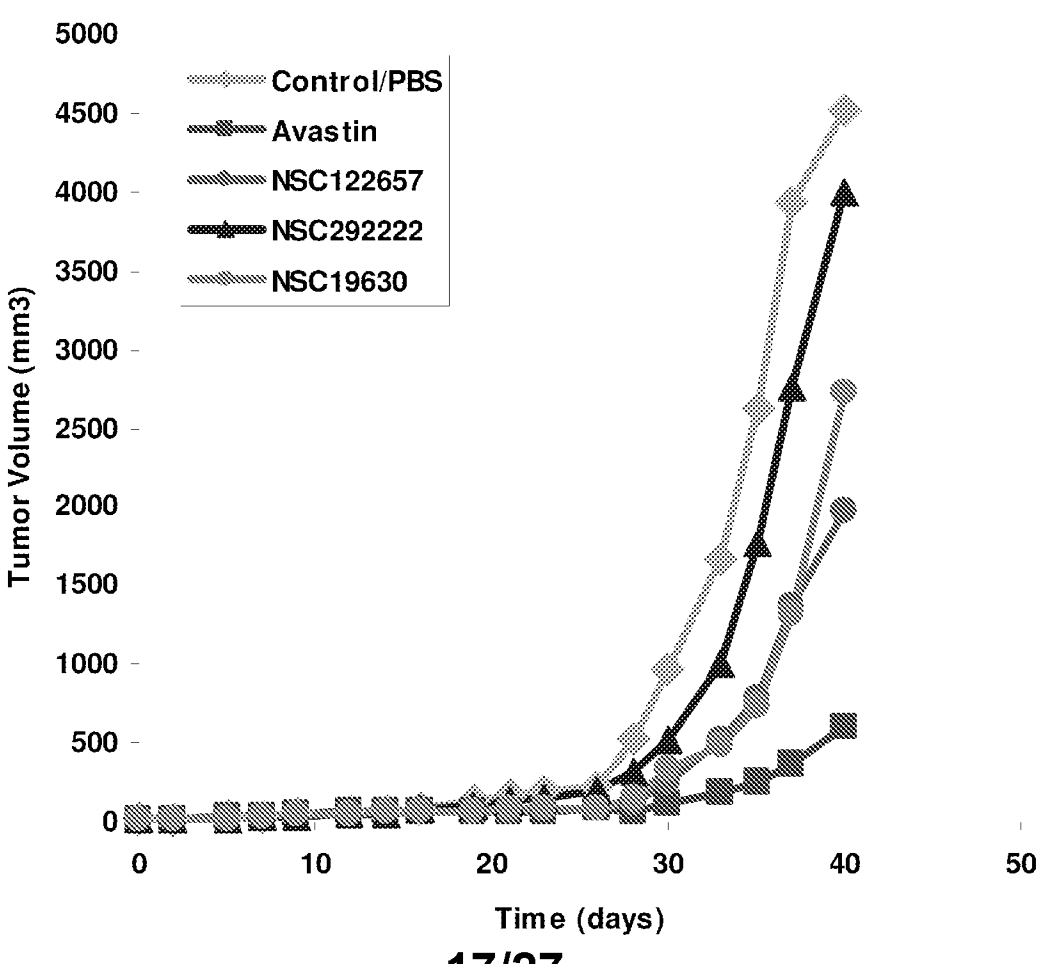
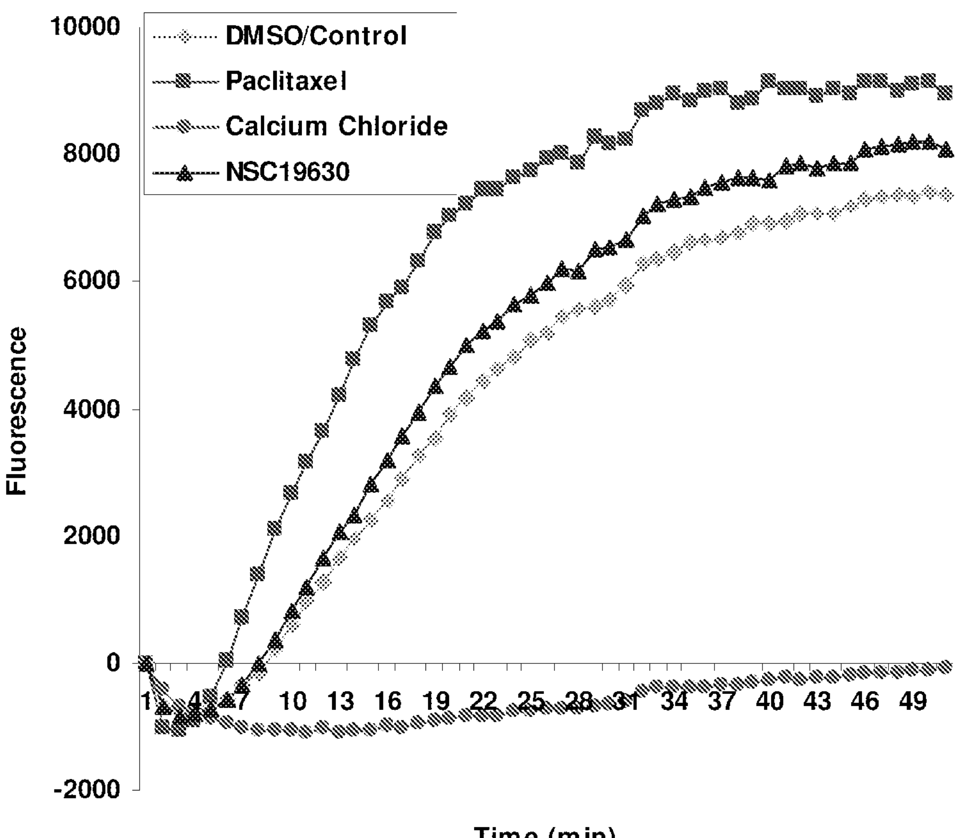


FIG. 16 (Page 1 of 4)



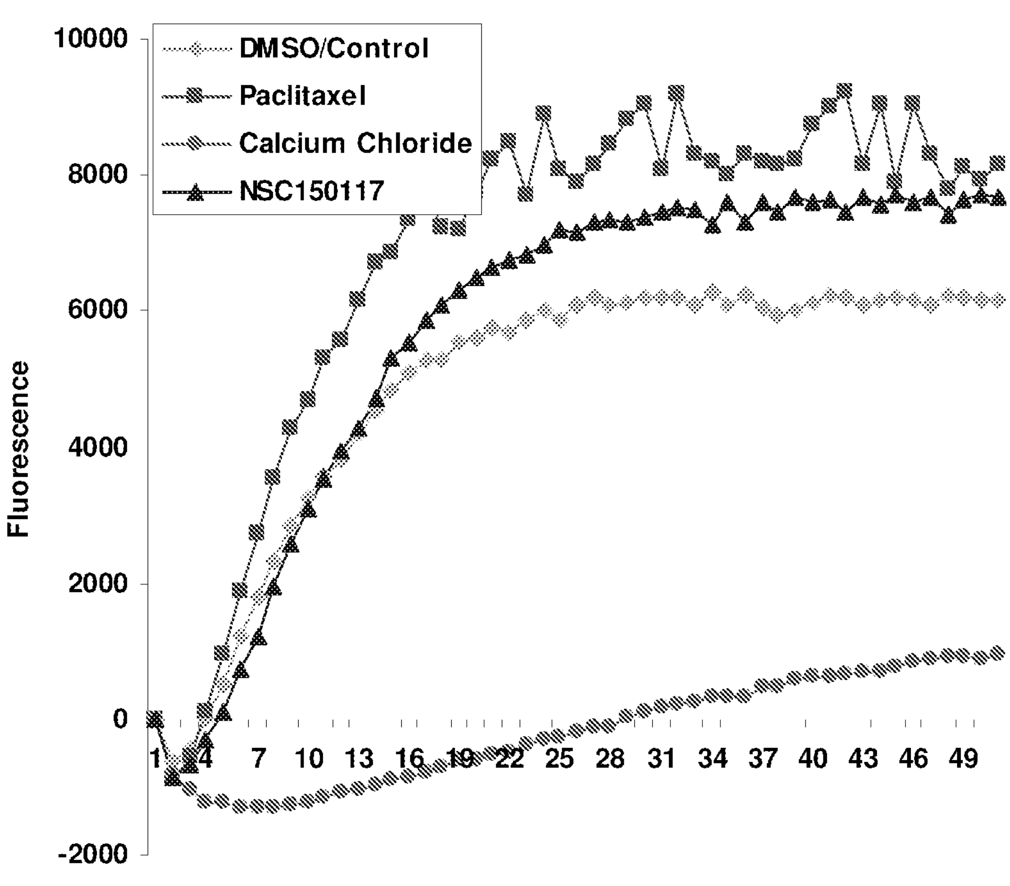
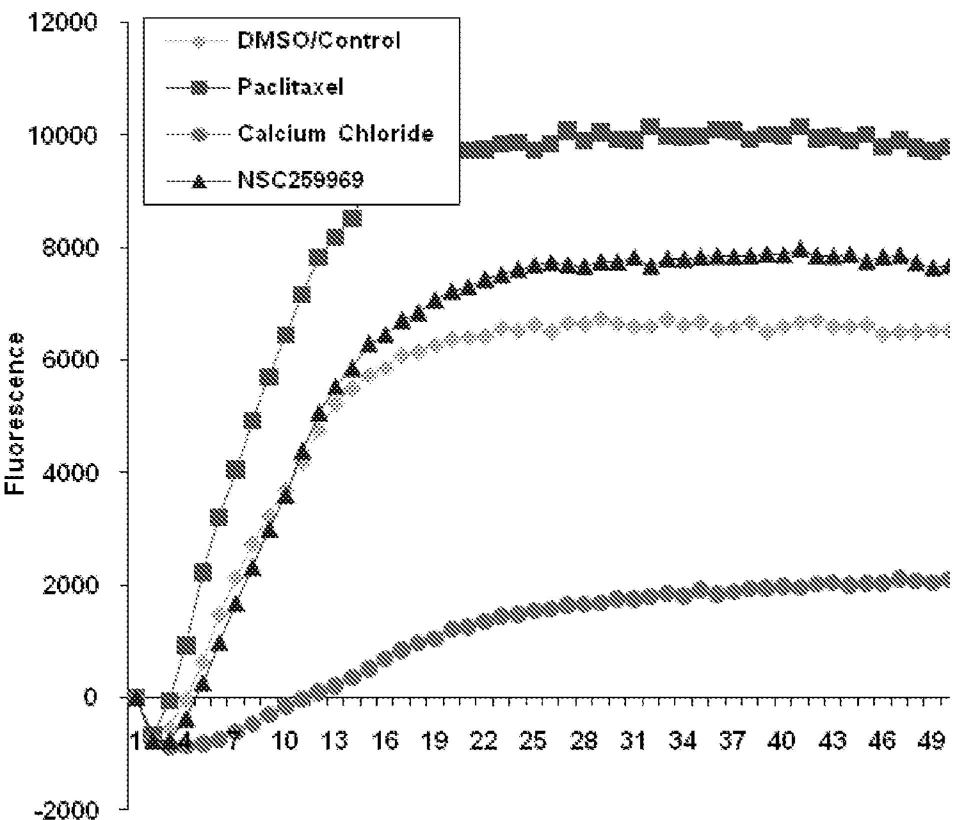


FIG. 16 (Page 2 of 4)



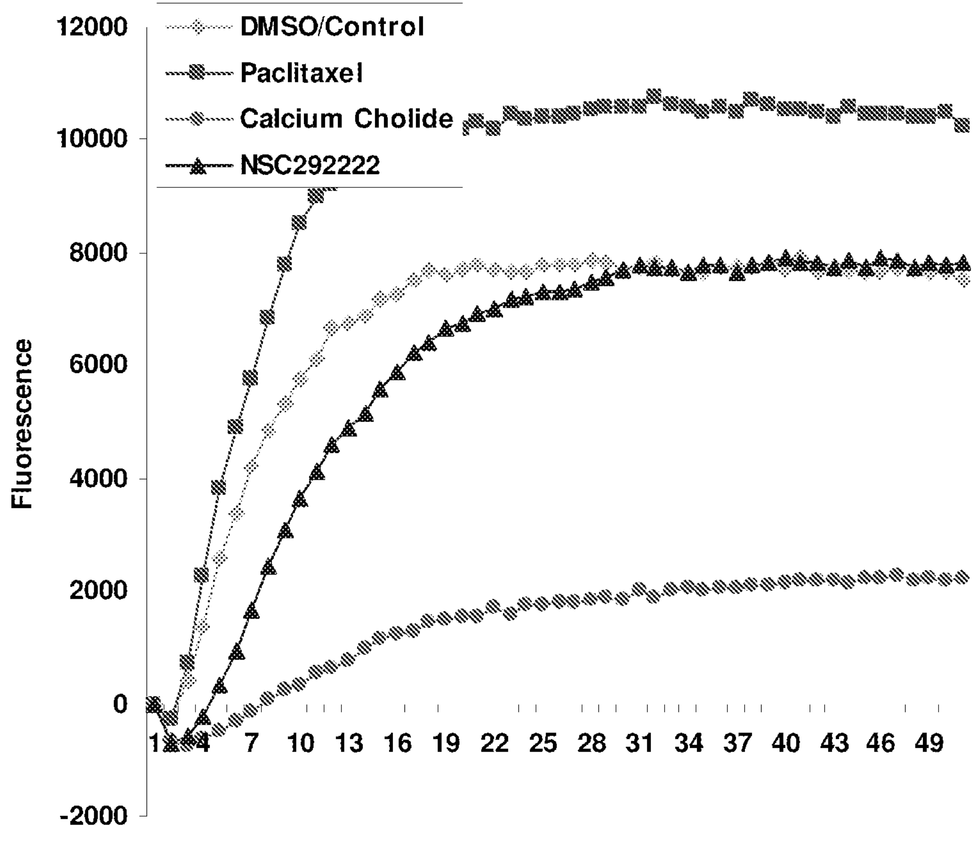
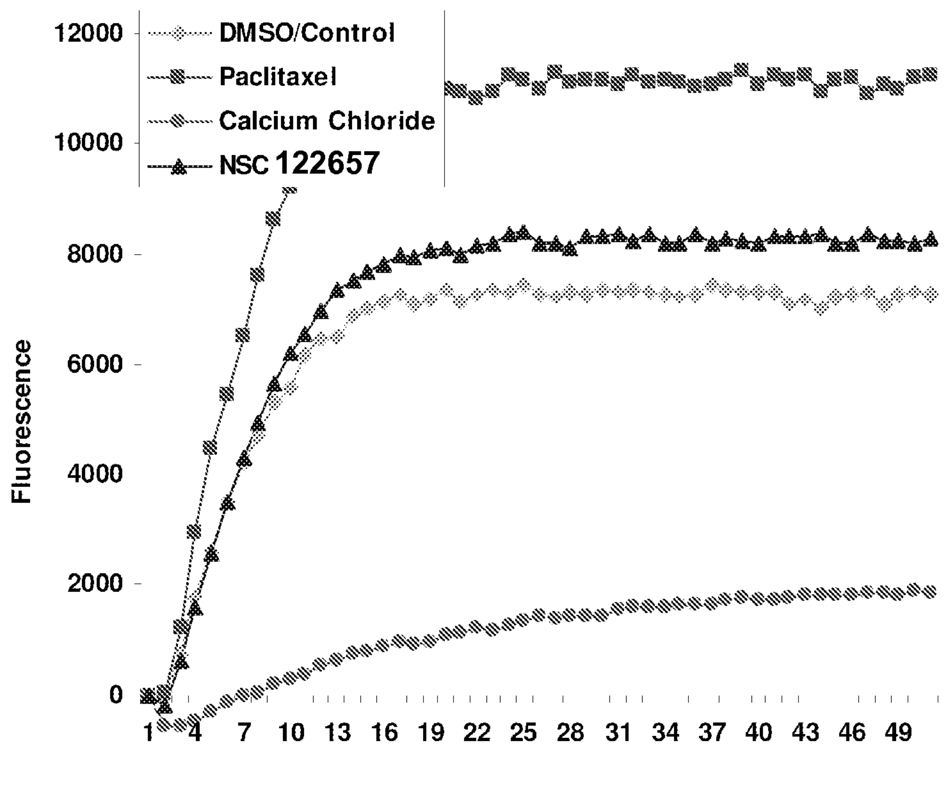


FIG. 16 (Page 3 of 4)



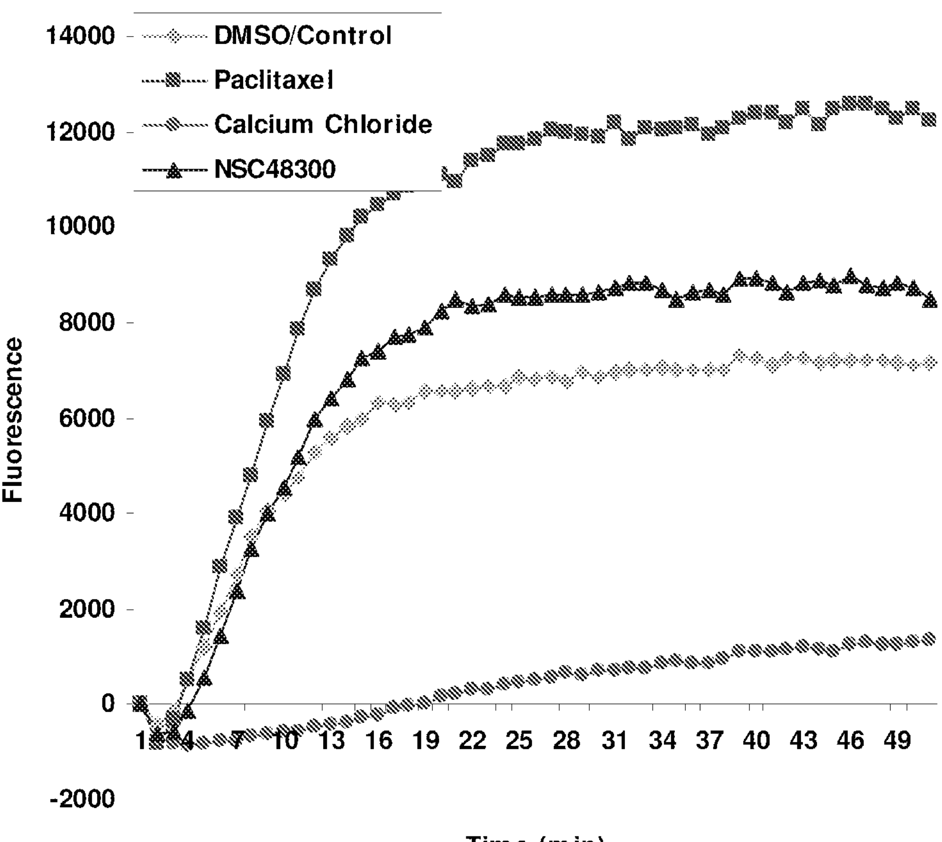


FIG. 16 (Page 4 of 4)

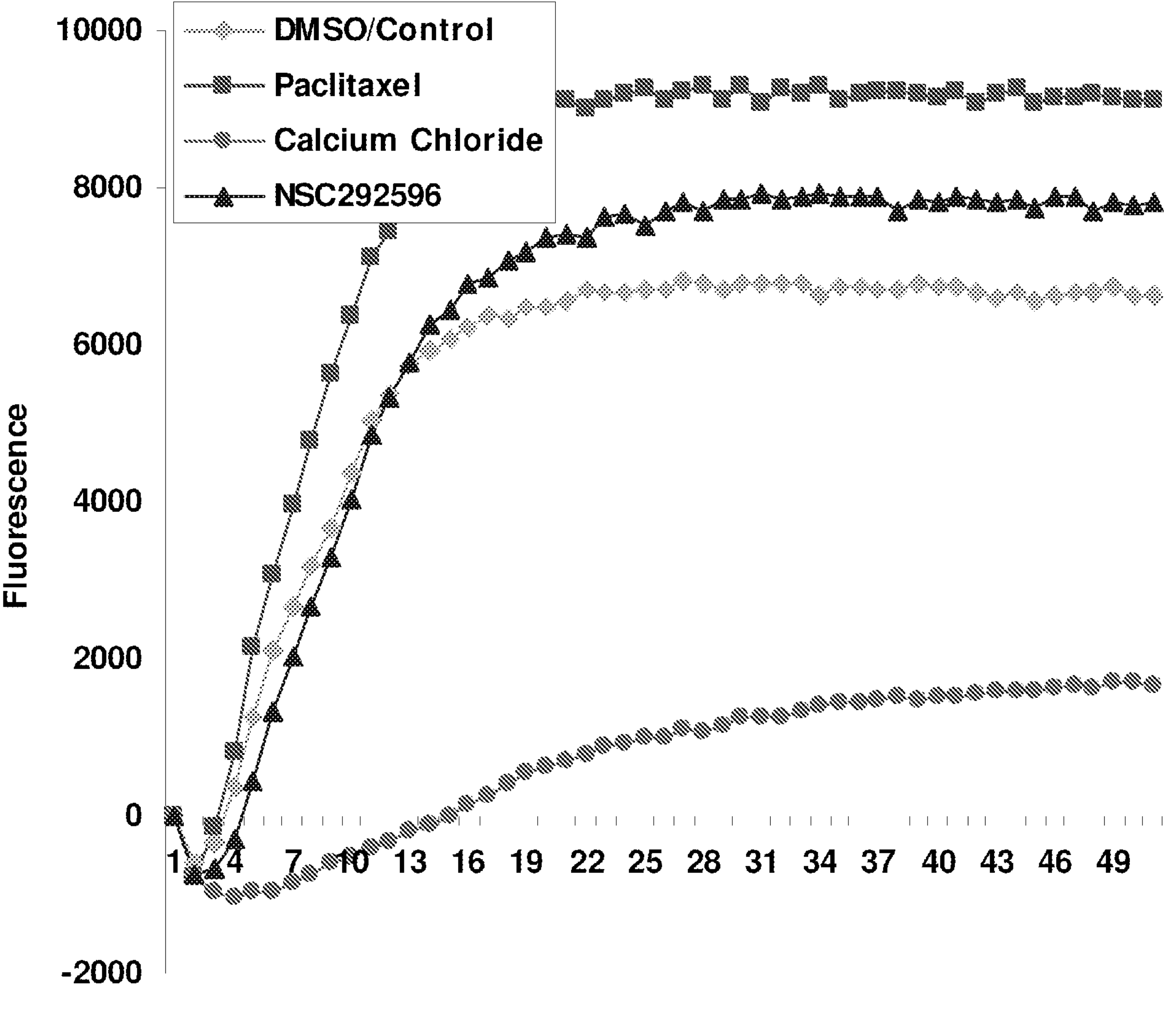


FIG. 17 (Page 1 of 6)

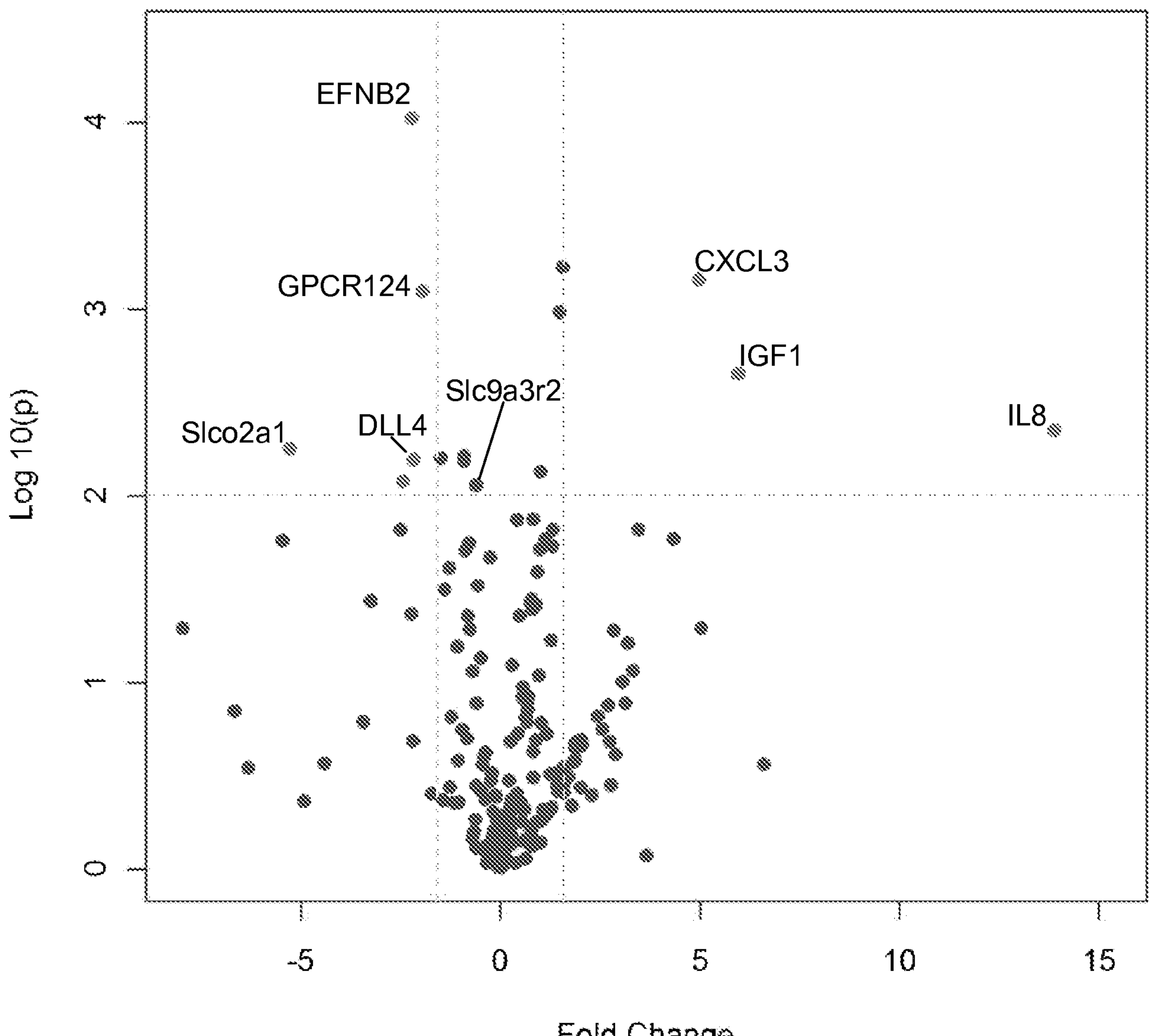


FIG. 17 (Page 2 of 6)

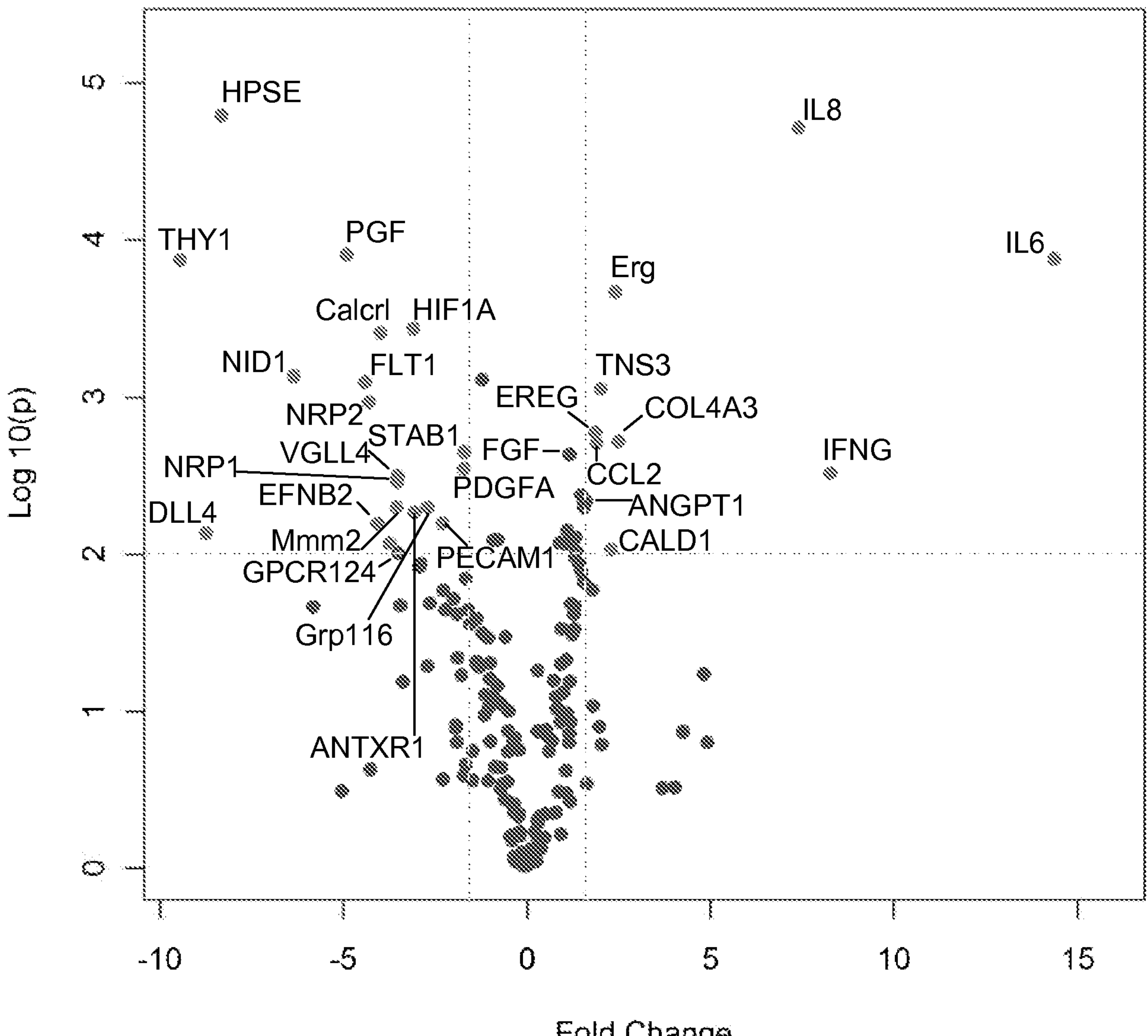


FIG. 17 (Page 3 of 6)

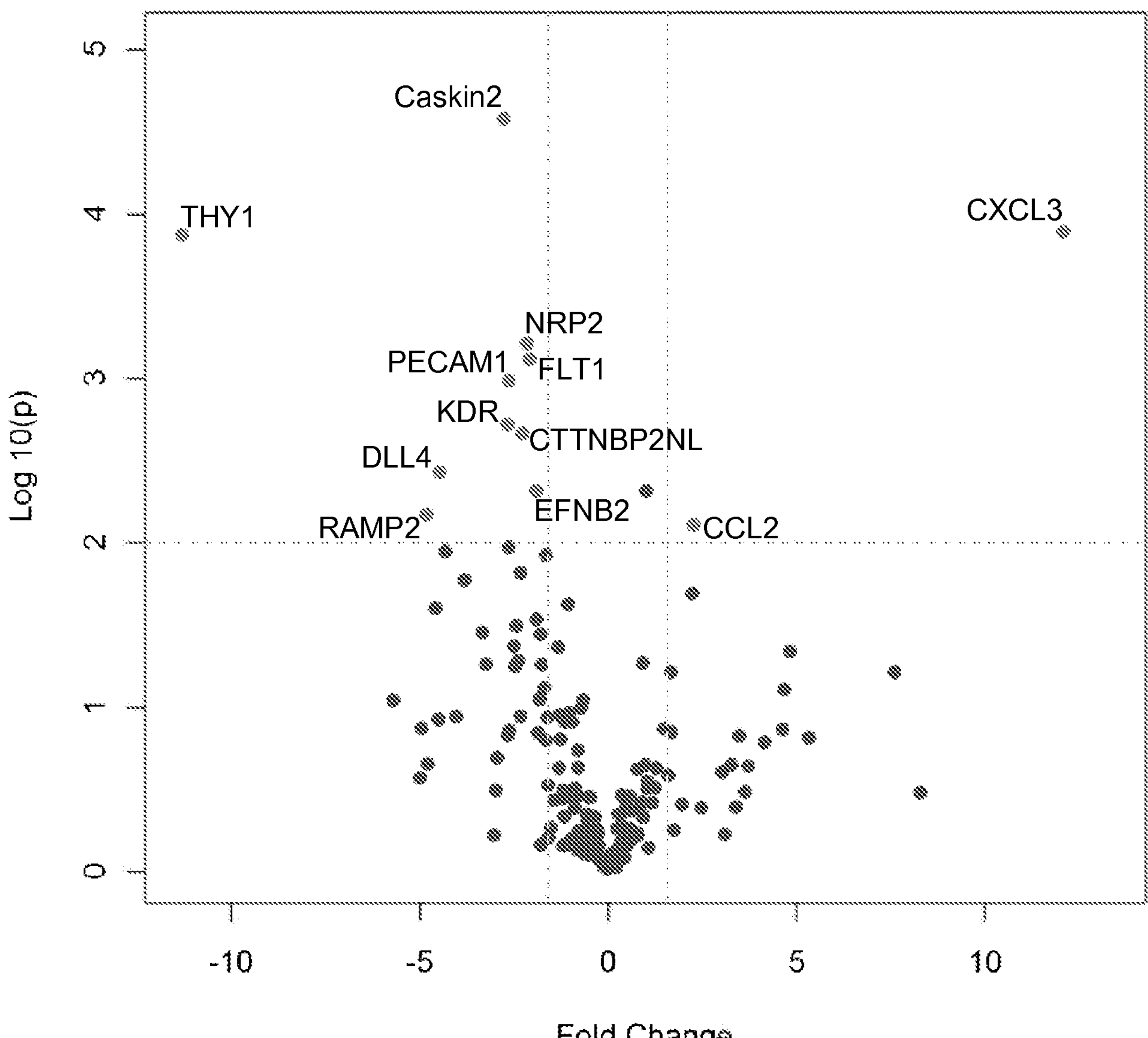


FIG. 17 (Page 4 of 6)

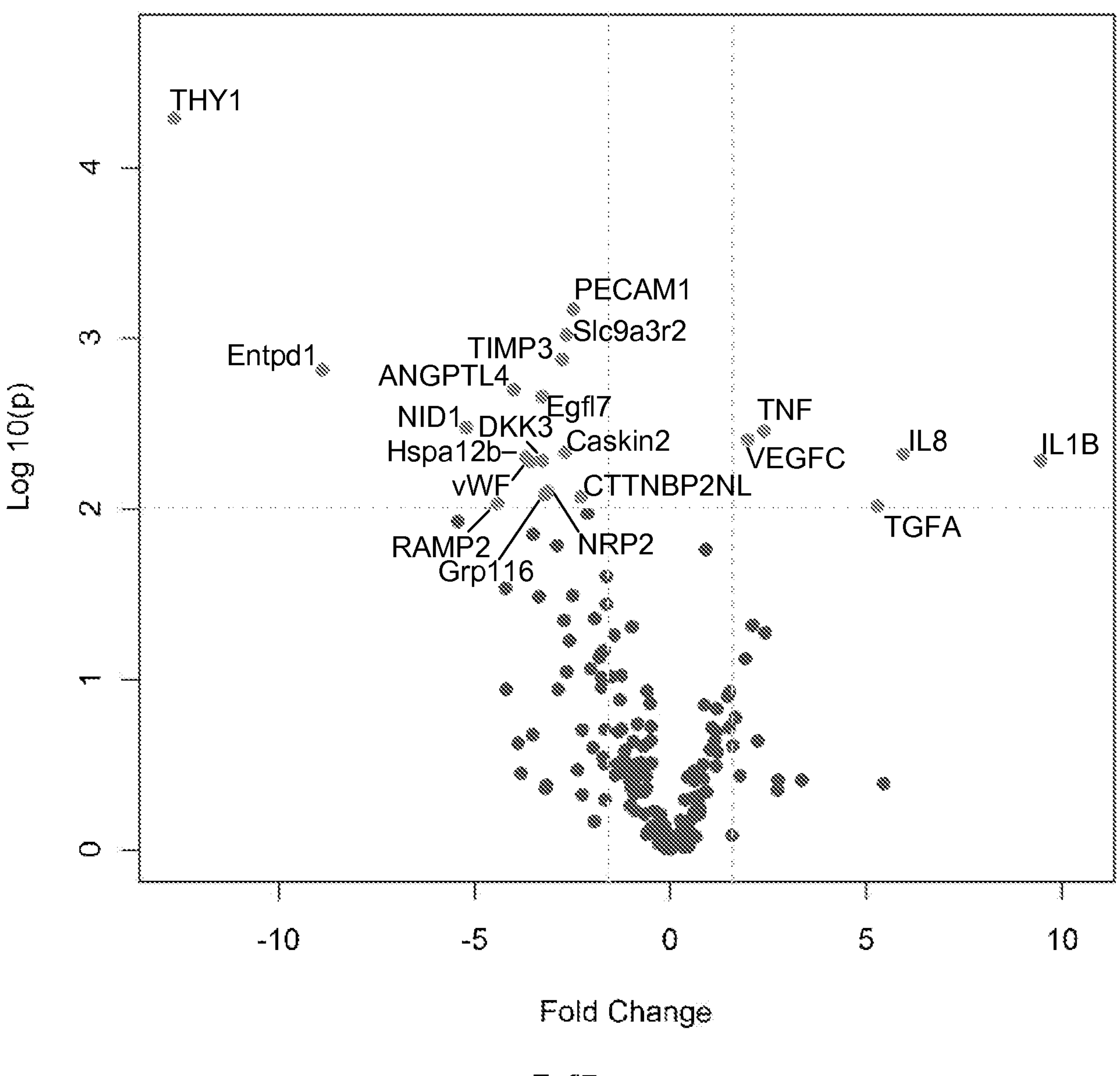


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FIG. 17 (Page 5 of 6)

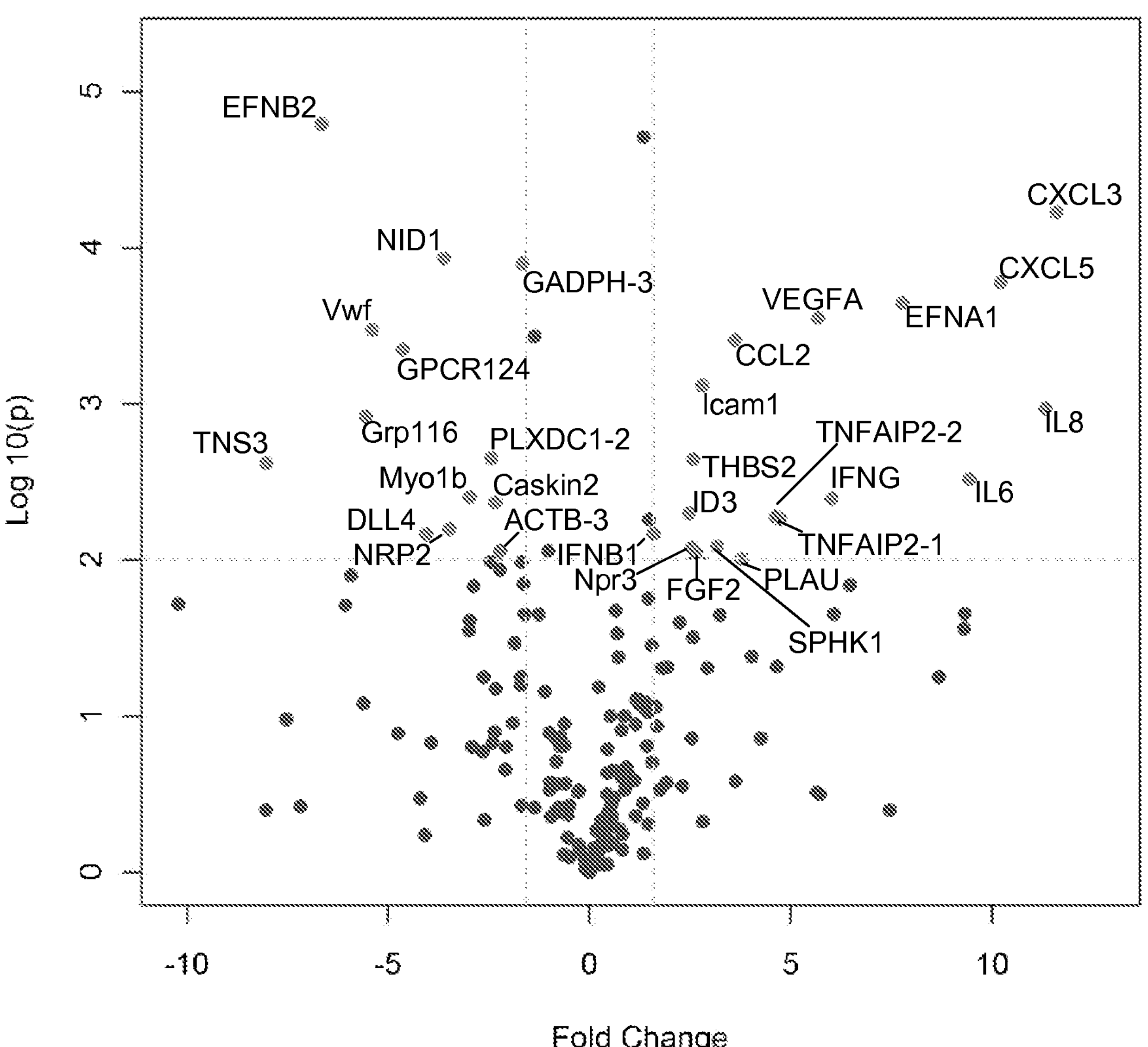

FIG. 17 (Page 6 of 6)