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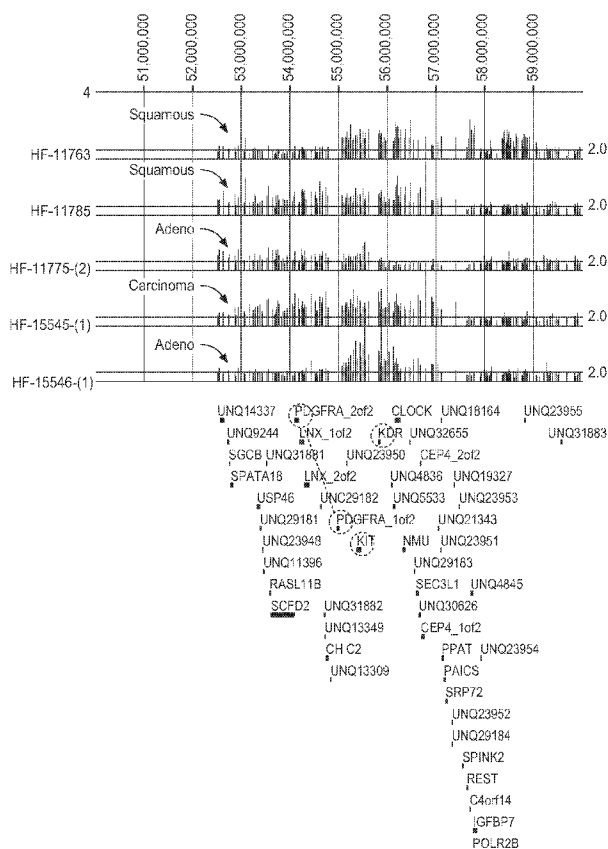
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(57) Abstract: Methods and compositions are provided for the diagnosis and treatment of lung cancers associated with amplification or overexpression of the PRO gene.



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**METHODS AND COMPOSITIONS FOR THE DIAGNOSIS
AND TREATMENT OF CANCER**

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This application claims the benefit of U.S. Provisional Application No. 60/825,369, filed September 12, 2006, the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

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The present invention relates to methods and compositions for the diagnosis and treatment of cancers associated with gene amplification.

BACKGROUND

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Cancer is characterized by an increase in the number of abnormal, or neoplastic, cells derived from a normal tissue that proliferate and, under certain circumstances, invade adjacent tissues and eventually metastasize via the blood or lymphatic system. Alteration of gene expression is intimately related to uncontrolled cell growth and de-differentiation, which are common features of cancer. Certain cancers are characterized by overexpression of certain genes, *e.g.*, oncogenes. A well known mechanism of gene overexpression in cancer cells is gene amplification. Gene amplification is a process in which multiple copies of one or more genes are produced in the chromosome of a cell. In certain instances, the process involves unscheduled replication of the region of the chromosome comprising those genes, followed by recombination of the replicated segments back into the chromosome (Alitalo *et al.*, *Adv. Cancer Res.*, 47:235-281 [1986]). In certain cases, overexpression of a gene is correlated with gene amplification, *i.e.*, is proportional to the number of copies made.

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Amplification and/or overexpression of certain proto-oncogenes, *e.g.*, those that encode growth factors and growth factor receptors, play important roles in the pathogenesis of various human malignancies. In certain instances, amplification and/or overexpression are associated with more malignant forms of cancer and thus may predict clinical outcome (Schwab *et al.*, *Genes Chromosomes Cancer*, 1:181-193 [1990]; Alitalo *et al.*, *supra*). For example, the human *erbB2* gene (also known as *her2* or *c-erbB-2*), which encodes a 185-kd transmembrane glycoprotein receptor (p185^{HER2} or HER2) related to the epidermal growth

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factor receptor EGFR, is overexpressed in about 25% to 30% of human breast cancers (Slamon *et al.*, *Science*, 235:177-182 [1987]; Slamon *et al.*, *Science*, 244:707-712 [1989]). Overexpression of *erbB2* is considered a predictor of a poor prognosis, especially in patients with primary disease that involves axillary lymph nodes (Slamon *et al.*, [1987] and [1989],
5 *supra*; Ravdin and Chamness, *Gene*, 159:19-27 [1995]; and Hynes and Stern, *Biochim. Biophys. Acta*, 1198:165-184 [1994]). Overexpression of *erbB2* has also been linked to sensitivity and/or resistance to certain hormone therapy and chemotherapeutic regimens, including CMF (cyclophosphamide, methotrexate, and fluoruracil) and anthracyclines (Baselga *et al.*, *Oncology*, 11 (3 Suppl 1):43-48 [1997]). However, patients that overexpress
10 *erbB2* show greater response to treatment with taxanes. *Id.*

Overexpression of *erbB2* has provided the basis for targeted breast cancer therapies. A recombinant humanized anti-ErbB2 (anti-HER2) monoclonal antibody (HerceptinTM, Genentech, Inc.) has been successfully used to treat patients with ErbB2-overexpressing metastatic breast cancer. (Baselga *et al.*, *J. Clin. Oncol.*, 14:737-744 [1996]).

15 A continuing need exists for compositions and methods that target amplified genes and the products of those genes in the diagnosis and treatment of cancer.

A continuing need also exists for compositions and methods for the diagnosis and/or treatment of lung cancer. Primary carcinoma of the lung affects over 170,000 people in the United States each year, 86% of whom die within five years of diagnosis. Lung cancer is the
20 leading cause of cancer death in both men and women, accounting for 28% of all cancer deaths. See Minna (2005) "Neoplasms of the Lung," in *Harrison's Principles of Internal Medicine*, 16th ed., Kasper et al., eds. (MacGraw-Hill, USA), Chapter 75.

The invention described herein meets the above-described needs and provides other benefits.

25 SUMMARY

In one aspect, methods and compositions are provided for the diagnosis and treatment of lung cancers associated with amplification and/or overexpression of the PRO gene.

In one aspect, a method of diagnosing the presence of a lung cancer in a mammal is provided, the method comprising detecting whether the PRO gene is amplified in a test lung
30 sample from the mammal relative to a control sample, wherein amplification of the PRO gene indicates the presence of lung cancer in the mammal. In one embodiment, detecting whether

the PRO gene is amplified comprises detecting whether the copy number of the PRO gene is increased by at least 5-fold.

In another aspect, a method of diagnosing the presence of a lung cancer in a mammal is provided, the method comprising detecting expression of the PRO gene in a test lung sample from the mammal, wherein a higher level of PRO gene expression in the test lung sample relative to a control sample indicates the presence of lung cancer in the mammal. In one embodiment, detecting expression of the PRO gene comprises determining the level of mRNA transcription from the PRO gene. In one embodiment, a higher level of PRO expression comprises at least a 5-fold increase in mRNA transcription from the PRO gene in the test lung sample relative to the control sample. In one embodiment, detecting expression of the PRO gene comprises determining the level of PRO. In one embodiment, detecting expression of the PRO gene comprises contacting the test lung sample with an anti-PRO antibody and determining the level of expression of PRO in the test lung sample by detecting binding of the anti-PRO antibody to PRO. In one embodiment, a higher level of PRO expression comprises at least a 5-fold increase in PRO levels.

In another aspect, a method of inhibiting the proliferation of a lung cancer cell is provided, the method comprising exposing the cell to a PRO antagonist. In one embodiment, the PRO antagonist is an anti-PRO antibody. In one embodiment, the anti-PRO antibody binds to the extracellular domain of PRO. In one embodiment, the anti-PRO antibody is an antibody fragment. In one embodiment, the anti-PRO antibody is a chimeric or humanized antibody. In one embodiment, the anti-PRO antibody is a human antibody. In one embodiment, the PRO antagonist is an organic molecule that binds to PRO. In one embodiment, the PRO antagonist is an oligopeptide that binds to PRO. In one embodiment, the PRO antagonist is a soluble form of PRO. In one embodiment, the PRO antagonist is an antisense nucleic acid of 10-30 nucleotides in length that binds to and reduces expression of a nucleic acid encoding PRO.

In another aspect, a method of inhibiting the proliferation of a lung cancer cell is provided, the method comprising exposing the cell to (a) a cytotoxic anti-PRO antibody or (b) an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent. In one embodiment, the method comprises exposing the cell to a cytotoxic anti-PRO antibody. In one embodiment, the method comprises exposing the cell to an immunoconjugate comprising

an anti-PRO antibody and a cytotoxic agent. In one embodiment, the cytotoxic agent is a maytansinoid or an auristatin.

In another aspect, a method of treating a lung cancer associated with amplification or overexpression of the PRO gene is provided, the method comprising administering to an individual having the lung cancer an effective amount of a pharmaceutical formulation comprising an antagonist of PRO. In one embodiment, the PRO antagonist is an anti-PRO antibody. In one embodiment, the anti-PRO antibody binds to the extracellular domain of PRO. In one embodiment, the anti-PRO antibody is an antibody fragment. In one embodiment, the anti-PRO antibody is a chimeric or humanized antibody. In one embodiment, the anti-PRO antibody is a human antibody. In one embodiment, the PRO antagonist is an organic molecule that binds to PRO. In one embodiment, the PRO antagonist is an oligopeptide that binds to PRO. In one embodiment, the PRO antagonist is a soluble form of PRO. In one embodiment, the PRO antagonist is an antisense nucleic acid of 10-30 nucleotides in length that binds to and reduces expression of a nucleic acid encoding PRO.

In another aspect, a method of treating a lung cancer associated with amplification or overexpression of the PRO gene is provided, the method comprising administering to an individual having the lung cancer an effective amount of a pharmaceutical formulation comprising (a) a cytotoxic anti-PRO antibody or (b) an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent. In one embodiment, the method comprises administering to an individual having the lung cancer an effective amount of a pharmaceutical formulation comprising a cytotoxic anti-PRO antibody. In one embodiment, the method comprises administering to an individual having the lung cancer an effective amount of a pharmaceutical formulation comprising an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent. In one embodiment, the cytotoxic agent is a maytansinoid or an auristatin.

In another aspect, a method for determining whether an individual having a lung cancer will respond to a therapeutic that targets PRO or the PRO gene is provided, the method comprising determining whether the PRO gene is amplified in the lung cancer, wherein amplification of the PRO gene indicates that the individual will respond to the therapeutic. In one embodiment, the therapeutic is selected from (a) a PRO antagonist, (b) a cytotoxic anti-PRO antibody, or (c) an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows the analysis of DNA copy number for chromosome 4 in five lung tumor samples.

Figure 2 shows the analysis of DNA copy number for a region of chromosome 4 from about nucleotide 50,000,000 to 60,000,000 in the five lung tumor samples depicted in Figure 1. Figure 2 also shows the locations of open reading frames that occur within the depicted region of chromosome 4.

DETAILED DESCRIPTION OF EMBODIMENTS

Methods and compositions for the diagnosis and treatment of cancers associated with gene amplification are provided. In certain embodiments, the invention provides methods and compositions for the treatment of lung cancer associated with amplification and/or overexpression of the PRO gene.

I. DEFINITIONS

The phrases "gene amplification" and "gene duplication" (and variants such as "amplification of a gene" or "duplication of a gene") are used interchangeably and refer to a process by which multiple copies of a gene or gene fragment are formed in a particular cell or cell line. The duplicated region (a stretch of amplified DNA) is often referred to as an "amplicon." Usually, the amount of the messenger RNA (mRNA) produced, *i.e.*, the level of gene expression, also increases in proportion to the number of copies made of the particular gene.

The term "PDGFRA," as used herein, refers to any native platelet derived growth factor receptor alpha from any vertebrate source, including mammals such as primates (e.g. humans and monkeys) and rodents (e.g., mice and rats), unless otherwise indicated. The term encompasses "full-length," unprocessed PDGFRA as well as any form of PDGFRA that results from processing in the cell. The term also encompasses naturally occurring variants of PDGFRA, e.g., splice variants, allelic variants, and other isoforms. The term also encompasses fragments or variants of a native PDGFRA that maintain at least one biological activity of PDGFRA.

The term "KIT," as used herein, refers to any native c-Kit from any vertebrate source, including mammals such as primates (e.g. humans and monkeys) and rodents (e.g., mice and rats), unless otherwise indicated. The term encompasses "full-length," unprocessed KIT as

well as any form of KIT that results from processing in the cell. The term also encompasses naturally occurring variants of KIT, e.g., splice variants, allelic variants, and other isoforms. The term also encompasses fragments or variants of a native KIT that maintain at least one biological activity of KIT.

5 The term “KDR,” as used herein, refers to any native kinase insert domain receptor from any vertebrate source, including mammals such as primates (e.g. humans and monkeys) and rodents (e.g., mice and rats), unless otherwise indicated. The term encompasses “full-length,” unprocessed KDR as well as any form of KDR that results from processing in the cell. The term also encompasses naturally occurring variants of KDR, e.g., splice variants,
10 allelic variants, and other isoforms. The term also encompasses fragments or variants of a native KDR that maintain at least one biological activity of KDR.

 The term “PRO” refers to any of PDGFRA, KIT, or KDR, unless otherwise indicated.

 The terms “cell proliferative disorder” and “proliferative disorder” refer to disorders that are associated with some degree of abnormal cell proliferation. In one embodiment, the
15 cell proliferative disorder is cancer.

 “Tumor,” as used herein, refers to all neoplastic cell growth and proliferation, whether malignant or benign, and all pre-cancerous and cancerous cells and tissues. The terms “cancer,” “cancerous,” “cell proliferative disorder,” “proliferative disorder” and “tumor” are not mutually exclusive as referred to herein.

20 The terms “cancer” and “cancerous” refer to or describe the physiological condition in mammals that is typically characterized by unregulated cell growth/proliferation. Examples of cancer include, but are not limited to, carcinoma, lymphoma (e.g., Hodgkin’s and non-Hodgkin’s lymphoma), blastoma, sarcoma, and leukemia. More particular examples of such cancers include squamous cell cancer, small-cell lung cancer, non-small cell lung cancer,
25 adenocarcinoma of the lung, squamous carcinoma of the lung, cancer of the peritoneum, hepatocellular cancer, gastrointestinal cancer, pancreatic cancer, glioma, cervical cancer, ovarian cancer, liver cancer, bladder cancer, hepatoma, breast cancer, colon cancer, rectal cancer, lung cancer, endometrial or uterine carcinoma, salivary gland carcinoma, kidney cancer, liver cancer, prostate cancer, vulval cancer, thyroid cancer, hepatic carcinoma,
30 leukemia and other lymphoproliferative disorders, and various types of head and neck cancer.

The term “lung cancer” refers to any cancer of the lung, including but not limited to small-cell lung carcinoma and non-small cell lung carcinoma, the latter including but not limited to adenocarcinoma, squamous carcinoma, and large cell carcinoma.

5 The term “neoplasm” or “neoplastic cell” refers to an abnormal tissue or cell that proliferates more rapidly than corresponding normal tissues or cells and continues to grow after removal of the stimulus that initiated the growth.

A “lung cancer cell” refers to a lung cancer cell, either in vivo or in vitro, and encompasses cell lines derived from lung cancer cells.

10 As used herein, “treatment” (and variations such as “treat” or “treating”) refers to clinical intervention in an attempt to alter the natural course of the individual or cell being treated, and can be performed either for prophylaxis or during the course of clinical pathology. Desirable effects of treatment include preventing occurrence or recurrence of disease, alleviation of symptoms, diminishment of any direct or indirect pathological consequences of the disease, preventing metastasis, decreasing the rate of disease progression, 15 amelioration or palliation of the disease state, and remission or improved prognosis.

An “individual” is a vertebrate. In certain embodiments, the vertebrate is a mammal. Mammals include, but are not limited to, farm animals (such as cows), sport animals, pets (such as cats, dogs, and horses), primates, mice and rats. In certain embodiments, a mammal is a human.

20 An “effective amount” refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired therapeutic or prophylactic result.

A “therapeutically effective amount” of a substance/molecule of the invention may vary according to factors such as the disease state, age, sex, and weight of the individual, and the ability of the substance/molecule, to elicit a desired response in the individual. A 25 therapeutically effective amount encompasses an amount in which any toxic or detrimental effects of the substance/molecule are outweighed by the therapeutically beneficial effects. A “prophylactically effective amount” refers to an amount effective, at dosages and for periods of time necessary, to achieve the desired prophylactic result. Typically, but not necessarily, since a prophylactic dose is used in subjects prior to or at an earlier stage of disease, the 30 prophylactically effective amount would be less than the therapeutically effective amount.

The term “cytotoxic agent” as used herein refers to a substance that inhibits or prevents a cellular function and/or causes cell death or destruction. The term is intended to

include radioactive isotopes (e.g., At²¹¹, I¹³¹, I¹²⁵, Y⁹⁰, Re¹⁸⁶, Re¹⁸⁸, Sm¹⁵³, Bi²¹², P³², Pb²¹² and radioactive isotopes of Lu), chemotherapeutic agents (e.g., methotrexate, adriamycin, vinca alkaloids (vincristine, vinblastine, etoposide), doxorubicin, melphalan, mitomycin C, chlorambucil, daunorubicin or other intercalating agents, enzymes and fragments thereof such as nucleolytic enzymes, antibiotics, and toxins such as small molecule toxins or enzymatically active toxins of bacterial, fungal, plant or animal origin, including fragments and/or variants thereof, and the various antitumor or anticancer agents disclosed below. Other cytotoxic agents are described below. A "tumoricidal" agent causes destruction of tumor cells.

A "toxin" is any substance capable of having a detrimental effect on the growth or proliferation of a cell.

A "chemotherapeutic agent" is a chemical compound useful in the treatment of cancer. Examples of chemotherapeutic agents include alkylating agents such as thiotepa and CYTOXAN® cyclophosphamide; alkyl sulfonates such as busulfan, improsulfan and piposulfan; aziridines such as benzodopa, carboquone, meturedopa, and uredopa; ethylenimines and methylamelamines including altretamine, triethylenemelamine, triethylenephosphoramidate, triethylenethiophosphoramidate and trimethylolomelamine; acetogenins (especially bullatacin and bullatacinone); delta-9-tetrahydrocannabinol (dronabinol, MARINOL®); beta-lapachone; lapachol; colchicines; betulinic acid; a camptothecin (including the synthetic analogue topotecan (HYCAMTIN®), CPT-11 (irinotecan, CAMPTOSAR®), acetylcamptothecin, scoplectin, and 9-aminocamptothecin); bryostatin; callystatin; CC-1065 (including its adozelesin, carzelesin and bizelesin synthetic analogues); podophyllotoxin; podophyllinic acid; teniposide; cryptophycins (particularly cryptophycin 1 and cryptophycin 8); dolastatin; duocarmycin (including the synthetic analogues, KW-2189 and CB1-TM1); eleutherobin; pancratistatin; a sarcodictyin; spongistatin; nitrogen mustards such as chlorambucil, chlornaphazine, cholophosphamide, estramustine, ifosfamide, mechlorethamine, mechlorethamine oxide hydrochloride, melphalan, novembichin, phenesterine, prednimustine, trofosfamide, uracil mustard; nitrosoureas such as carmustine, chlorozotocin, fotemustine, lomustine, nimustine, and ranimustine; antibiotics such as the enediyne antibiotics (e. g., calicheamicin, especially calicheamicin gammaII and calicheamicin omegaII (see, e.g., Agnew, *Chem Intl. Ed. Engl.*, 33: 183-186 (1994)); dynemicin, including dynemicin A; an esperamicin; as well as neocarzinostatin chromophore and related chromoprotein enediyne antiobiotic

chromophores), aclacinomysins, actinomycin, authramycin, azaserine, bleomycins, cactinomycin, carabycin, carminomycin, carzinophilin, chromomycins, dactinomycin, daunorubicin, detorubicin, 6-diazo-5-oxo-L-norleucine, ADRIAMYCIN® doxorubicin (including morpholino-doxorubicin, cyanomorpholino-doxorubicin, 2-pyrrolino-doxorubicin and deoxydoxorubicin), epirubicin, esorubicin, idarubicin, marcellomycin, mitomycins such as mitomycin C, mycophenolic acid, nogalamycin, olivomycins, peplomycin, porfiromycin, puromycin, quelamycin, rodorubicin, streptonigrin, streptozocin, tubercidin, ubenimex, zinostatin, zorubicin; anti-metabolites such as methotrexate and 5-fluorouracil (5-FU); folic acid analogues such as denopterin, methotrexate, pteropterin, trimetrexate; purine analogs such as fludarabine, 6-mercaptopurine, thiamiprine, thioguanine; pyrimidine analogs such as ancitabine, azacitidine, 6-azauridine, carmofer, cytarabine, dideoxyuridine, doxifluridine, enocitabine, floxuridine; androgens such as calusterone, dromostanolone propionate, epitioestanol, mepitioestane, testolactone; anti-adrenals such as aminogluthethimide, mitotane, trilostane; folic acid replenisher such as frolic acid; aceglutone; aldophosphamide glycoside; aminolevulinic acid; eniluracil; amsacrine; bestabucil; bisantrene; edatraxate; defofamine; demecolcine; diaziqune; elfornithine; elliptinium acetate; an epothilone; etoglucid; gallium nitrate; hydroxyurea; lentinan; lonidainine; maytansinoids such as maytansine and ansamitocins; mitoguazone; mitoxantrone; mopidanmol; nitraerine; pentostatin; phenamet; pirarubicin; losoxantrone; 2-ethylhydrazide; procarbazine; PSK® polysaccharide complex (JHS Natural Products, Eugene, OR); razoxane; rhizoxin; sizofiran; spirogermanium; tenuazonic acid; triaziquone; 2,2',2''-trichlorotriethylamine; trichothecenes (especially T-2 toxin, verracurin A, roridin A and anguidine); urethan; vindesine (ELDISINE®, FILDESIN®); dacarbazine; mannometrine; mitobronitol; mitolactol; pipobroman; gacytosine; arabinoside ("Ara-C"); thiotepa; taxoids, e.g., TAXOL® paclitaxel (Bristol-Myers Squibb Oncology, Princeton, N.J.), ABRAXANE™ Cremophor-free, albumin-engineered nanoparticle formulation of paclitaxel (American Pharmaceutical Partners, Schaumburg, Illinois), and TAXOTERE® docetaxel (Rhône-Poulenc Rorer, Antony, France); chloranbucil; gemcitabine (GEMZAR®); 6-thioguanine; mercaptopurine; methotrexate; platinum analogs such as cisplatin and carboplatin; vinblastine (VELBAN®); platinum; etoposide (VP-16); ifosfamide; mitoxantrone; vincristine (ONCOVIN®); oxaliplatin; leucovorin; vinorelbine (NAVELBINE®); novantrone; edatrexate; daunomycin; aminopterin; ibandronate; topoisomerase inhibitor RFS 2000; difluoromethylornithine (DMFO); retinoids such as

retinoic acid; capecitabine (XELODA®); pharmaceutically acceptable salts, acids or derivatives of any of the above; as well as combinations of two or more of the above such as CHOP, an abbreviation for a combined therapy of cyclophosphamide, doxorubicin, vincristine, and prednisolone, and FOLFOX, an abbreviation for a treatment regimen with oxaliplatin (ELOXATIN™) combined with 5-FU and leucovorin.

Also included in this definition are anti-hormonal agents that act to regulate, reduce, block, or inhibit the effects of hormones that can promote the growth of cancer, and are often in the form of systemic, or whole-body treatment. They may be hormones themselves. Examples include anti-estrogens and selective estrogen receptor modulators (SERMs), including, for example, tamoxifen (including NOLVADEX® tamoxifen), EVISTA® raloxifene, droloxifene, 4-hydroxytamoxifen, trioxifene, keoxifene, LY117018, onapristone, and FARESTON® toremifene; anti-progesterones; estrogen receptor down-regulators (ERDs); agents that function to suppress or shut down the ovaries, for example, leutinizing hormone-releasing hormone (LHRH) agonists such as LUPRON® and ELIGARD® leuprolide acetate, goserelin acetate, buserelin acetate and triptorelin; other anti-androgens such as flutamide, nilutamide and bicalutamide; and aromatase inhibitors that inhibit the enzyme aromatase, which regulates estrogen production in the adrenal glands, such as, for example, 4(5)-imidazoles, aminoglutethimide, MEGASE® megestrol acetate, AROMASIN® exemestane, formestane, fadrozole, RIVISOR® vorozole, FEMARA® letrozole, and ARIMIDEX® anastrozole. In addition, such definition of chemotherapeutic agents includes bisphosphonates such as clodronate (for example, BONEFOS® or OSTAC®), DIDROCAL® etidronate, NE-58095, ZOMETA® zoledronic acid/zoledronate, FOSAMAX® alendronate, AREDIA® pamidronate, SKELID® tiludronate, or ACTONEL® risedronate; as well as troxacitabine (a 1,3-dioxolane nucleoside cytosine analog); antisense oligonucleotides, particularly those that inhibit expression of genes in signaling pathways implicated in aberrant cell proliferation, such as, for example, PKC-alpha, Raf, H-Ras, and epidermal growth factor receptor (EGF-R); vaccines such as THERATOPE® vaccine and gene therapy vaccines, for example, ALLOVECTIN® vaccine, LEUVECTIN® vaccine, and VAXID® vaccine; LURTOTECAN® topoisomerase 1 inhibitor; ABARELIX® rmRH; lapatinib ditosylate (an ErbB-2 and EGFR dual tyrosine kinase small-molecule inhibitor also known as GW572016); and pharmaceutically acceptable salts, acids or derivatives of any of the above.

A "growth inhibitory agent" when used herein refers to a compound or composition which inhibits growth of a cell (such as a cell expressing PRO) either in vitro or in vivo.

Thus, the growth inhibitory agent may be one which significantly reduces the percentage of cells (such as a cell expressing PRO) in S phase. Examples of growth inhibitory agents

5 include agents that block cell cycle progression (at a place other than S phase), such as agents that induce G1 arrest and M-phase arrest. Classical M-phase blockers include the vincas (vincristine and vinblastine), taxanes, and topoisomerase II inhibitors such as doxorubicin, epirubicin, daunorubicin, etoposide, and bleomycin. Those agents that arrest G1 also spill over into S-phase arrest, for example, DNA alkylating agents such as tamoxifen, prednisone, 10 dacarbazine, mechlorethamine, cisplatin, methotrexate, 5-fluorouracil, and ara-C. Further information can be found in *The Molecular Basis of Cancer*, Mendelsohn and Israel, eds., Chapter 1, entitled "Cell cycle regulation, oncogenes, and antineoplastic drugs" by Murakami et al. (WB Saunders: Philadelphia, 1995), especially p. 13. The taxanes (paclitaxel and docetaxel) are anticancer drugs both derived from the yew tree. Docetaxel (TAXOTERE®, 15 Rhone-Poulenc Rorer), derived from the European yew, is a semisynthetic analogue of paclitaxel (TAXOL®, Bristol-Myers Squibb). Paclitaxel and docetaxel promote the assembly of microtubules from tubulin dimers and stabilize microtubules by preventing depolymerization, which results in the inhibition of mitosis in cells.

As used herein, the term "EGFR inhibitor" refers to compounds that bind to or 20 otherwise interact directly with EGFR and prevent or reduce its signaling activity, and is alternatively referred to as an "EGFR antagonist." Examples of such agents include antibodies and small molecules that bind to EGFR. Examples of antibodies which bind to EGFR include MAb 579 (ATCC CRL HB 8506), MAb 455 (ATCC CRL HB8507), MAb 225 (ATCC CRL 8508), MAb 528 (ATCC CRL 8509) (see, US Patent No. 4,943, 533, 25 Mendelsohn *et al.*) and variants thereof, such as chimerized 225 (C225 or Cetuximab; ERBUTIX®) and reshaped human 225 (H225) (see, WO 96/40210, Imclone Systems Inc.); IMC-11F8, a fully human, EGFR-targeted antibody (Imclone); antibodies that bind type II mutant EGFR (US Patent No. 5,212,290); humanized and chimeric antibodies that bind EGFR as described in US Patent No. 5,891,996; and human antibodies that bind EGFR, such 30 as ABX-EGF or Panitumumab (see WO98/50433, Abgenix/Amgen); EMD 55900 (Stragliotto *et al. Eur. J. Cancer* 32A:636-640 (1996)); EMD7200 (matuzumab) a humanized EGFR antibody directed against EGFR that competes with both EGF and TGF-alpha for EGFR

binding (EMD/Merck); human EGFR antibody, HuMax-EGFR (GenMab); fully human antibodies known as E1.1, E2.4, E2.5, E6.2, E6.4, E2.11, E6.3 and E7.6.3 and described in US 6,235,883; MDX-447 (Medarex Inc); and mAb 806 or humanized mAb 806 (Johns *et al.*, *J. Biol. Chem.* 279(29):30375-30384 (2004)). The anti-EGFR antibody may be conjugated

5 with a cytotoxic agent, thus generating an immunoconjugate (see, *e.g.*, EP659,439A2, Merck Patent GmbH). EGFR antagonists include small molecules such as compounds described in US Patent Nos: 5,616,582, 5,457,105, 5,475,001, 5,654,307, 5,679,683, 6,084,095, 6,265,410, 6,455,534, 6,521,620, 6,596,726, 6,713,484, 5,770,599, 6,140,332, 5,866,572, 6,399,602, 6,344,459, 6,602,863, 6,391,874, 6,344,455, 5,760,041, 6,002,008, and 5,747,498,

10 as well as the following PCT publications: WO98/14451, WO98/50038, WO99/09016, and WO99/24037. Particular small molecule EGFR antagonists include OSI-774 (CP-358774, erlotinib, TARCEVA[®] Genentech/OSI Pharmaceuticals); PD 183805 (CI 1033, 2-propenamide, N-[4-[(3-chloro-4-fluorophenyl)amino]-7-[3-(4-morpholinyl)propoxy]-6-quinazolinyl]-, dihydrochloride, Pfizer Inc.); ZD1839, gefitinib (IRESSA[™] 4-(3'-Chloro-4'-fluoroanilino)-7-methoxy-6-(3-morpholinopropoxy)quinazoline, AstraZeneca); ZM 105180 ((6-amino-4-(3-methylphenyl-amino)-quinazoline, Zeneca); BIBX-1382 (N8-(3-chloro-4-fluoro-phenyl)-N2-(1-methyl-piperidin-4-yl)-pyrimido[5,4-d]pyrimidine-2,8-diamine, Boehringer Ingelheim); PKI-166 ((R)-4-[4-[(1-phenylethyl)amino]-1H-pyrrolo[2,3-d]pyrimidin-6-yl]-phenol); (R)-6-(4-hydroxyphenyl)-4-[(1-phenylethyl)amino]-7H-pyrrolo[2,3-d]pyrimidine); CL-387785 (N-[4-[(3-bromophenyl)amino]-6-quinazolinyl]-2-butynamide); EKB-569 (N-[4-[(3-chloro-4-fluorophenyl)amino]-3-cyano-7-ethoxy-6-quinolinyl]-4-(dimethylamino)-2-butenamide) (Wyeth); AG1478 (Pfizer); AG1571 (SU 5271; Pfizer); dual EGFR/HER2 tyrosine kinase inhibitors such as lapatinib (TYKERB[®], GSK572016 or N-[3-chloro-4-[(3 fluorophenyl) methoxy]phenyl]6[5[[

25 [2methylsulfonyl)ethyl]amino]methyl]-2-furanyl]-4-quinazolinamine; Glaxo-SmithKline).

A "tyrosine kinase inhibitor" is a molecule which inhibits tyrosine kinase activity of a tyrosine kinase such as a HER receptor. Examples of such inhibitors include the EGFR-targeted drugs noted in the preceding paragraph; small molecule HER2 tyrosine kinase inhibitor such as TAK165 available from Takeda; CP-724,714, an oral selective inhibitor of

30 the ErbB2 receptor tyrosine kinase (Pfizer and OSI); dual-HER inhibitors such as EKB-569 (available from Wyeth) which preferentially binds EGFR but inhibits both HER2 and EGFR-overexpressing cells; lapatinib (GSK572016; available from Glaxo-SmithKline), an oral

HER2 and EGFR tyrosine kinase inhibitor; PKI-166 (available from Novartis); pan-HER inhibitors such as canertinib (CI-1033; Pharmacia); Raf-1 inhibitors such as antisense agent ISIS-5132 available from ISIS Pharmaceuticals which inhibit Raf-1 signaling; non-HER targeted TK inhibitors such as imatinib mesylate (GLEEVEC™, available from Glaxo
 5 SmithKline); multi-targeted tyrosine kinase inhibitors such as sunitinib (SUTENT®, available from Pfizer); VEGF receptor tyrosine kinase inhibitors such as vatalanib (PTK787/ZK222584, available from Novartis/Schering AG); MAPK extracellular regulated kinase I inhibitor CI-1040 (available from Pharmacia); indolinones (*see, e.g.,* Mohammadi et al. (1997) *Science* 276:955-960); quinazolines, such as PD 153035, 4-(3-chloroanilino)
 10 quinazoline; pyridopyrimidines; pyrimidopyrimidines; pyrrolopyrimidines, such as CGP 59326, CGP 60261 and CGP 62706; pyrazolopyrimidines, 4-(phenylamino)-7H-pyrrolo[2,3-d] pyrimidines; curcumin (diferuloyl methane, 4,5-bis (4-fluoroanilino)phthalimide); tyrphostins containing nitrothiophene moieties; PD-0183805 (Warner-Lambert); 1-*tert*-butyl-3-[6-(3,5-dimethoxy-phenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-
 15 yl]-urea ("PD173074") (*see, e.g.,* Moffa et al. (2004) *Mol. Cancer Res.* 2:643-652); 3-[3-(2-carboxyethyl)-4-methylpyrrol-2-methylidenyl]-2-indolinone ("SU5402," Calbiochem) (*see, e.g.,* Bernard-Pierrot (2004) *Oncogene* 23:9201-9211); antisense molecules (*e.g.* those that bind to HER-encoding nucleic acid); quinoxalines (US Patent No. 5,804,396); tryphostins (US Patent No. 5,804,396); ZD6474 (Astra Zeneca); PTK-787 (Novartis/Schering AG); pan-
 20 HER inhibitors such as CI-1033 (Pfizer); Affinitac (ISIS 3521; Isis/Lilly); imatinib mesylate (GLEEVEC™); PKI 166 (Novartis); GW2016 (Glaxo SmithKline); CI-1033 (Pfizer); EKB-569 (Wyeth); Semaxinib (Pfizer); ZD6474 (AstraZeneca); PTK-787 (Novartis/Schering AG); INC-1C11 (Imclone); or as described in any of the following patent publications: US Patent No. 5,804,396; WO 1999/09016 (American Cyanamid); WO 1998/43960 (American
 25 Cyanamid); WO 1997/38983 (Warner Lambert); WO 1999/06378 (Warner Lambert); WO 1999/06396 (Warner Lambert); WO 1996/30347 (Pfizer, Inc); WO 1996/33978 (Zeneca); WO 1996/3397 (Zeneca); and WO 1996/33980 (Zeneca).

The term "antagonist" is used in the broadest sense, and includes any molecule that partially or fully blocks, inhibits, or neutralizes a biological activity of a polypeptide, such as
 30 PRO, or the transcription or translation thereof. Suitable antagonist molecules include, but are not limited to, antagonist antibodies, polypeptide fragments, oligopeptides, organic molecules (including small molecules), and anti-sense nucleic acids.

"Antibodies" (Abs) and "immunoglobulins" (Igs) refer to glycoproteins having similar structural characteristics. While antibodies exhibit binding specificity to a specific antigen, immunoglobulins include both antibodies and other antibody-like molecules which generally lack antigen specificity. Polypeptides of the latter kind are, for example, produced at low levels by the lymph system and at increased levels by myelomas.

The terms "antibody" and "immunoglobulin" are used interchangeably in the broadest sense and include monoclonal antibodies (*e.g.*, full length or intact monoclonal antibodies), polyclonal antibodies, monovalent antibodies, multivalent antibodies, multispecific antibodies (*e.g.*, bispecific antibodies so long as they exhibit the desired biological activity) and may also include certain antibody fragments (as described in greater detail herein). An antibody can be chimeric, human, humanized and/or affinity matured.

The term "anti-PRO antibody" or "an antibody that binds to PRO" refers to an antibody that is capable of binding PRO with sufficient affinity such that the antibody is useful as a diagnostic and/or therapeutic agent in targeting PRO. Preferably, the extent of binding of an anti-PRO antibody to an unrelated, non-PRO protein is less than about 10% of the binding of the antibody to PRO as measured, *e.g.*, by a radioimmunoassay (RIA). In certain embodiments, an antibody that binds to PRO has a dissociation constant (K_d) of $\leq 1\mu\text{M}$, $\leq 100\text{ nM}$, $\leq 10\text{ nM}$, $\leq 1\text{ nM}$, or $\leq 0.1\text{ nM}$. In certain embodiments, an anti-PRO antibody binds to an epitope of PRO that is conserved among PRO from different species.

The terms "full length antibody," "intact antibody" and "whole antibody" are used herein interchangeably to refer to an antibody in its substantially intact form, not antibody fragments as defined below. The terms particularly refer to an antibody with heavy chains that contain the Fc region.

"Antibody fragments" comprise only a portion of an intact antibody, wherein the portion retains at least one, and as many as most or all, of the functions normally associated with that portion when present in an intact antibody. In one embodiment, an antibody fragment comprises an antigen binding site of the intact antibody and thus retains the ability to bind antigen. In another embodiment, an antibody fragment, for example, one that comprises the Fc region, retains at least one of the biological functions normally associated with the Fc region when present in an intact antibody, such as FcRn binding, antibody half life modulation, ADCC function and complement binding. In one embodiment, an antibody fragment is a monovalent antibody that has an *in vivo* half life substantially similar to an

intact antibody. For example, such an antibody fragment may comprise an antigen binding arm linked to an Fc sequence capable of conferring *in vivo* stability to the fragment.

Papain digestion of antibodies produces two identical antigen-binding fragments, called "Fab" fragments, each with a single antigen-binding site, and a residual "Fc" fragment, whose name reflects its ability to crystallize readily. Pepsin treatment yields an F(ab')₂ fragment that has two antigen-combining sites and is still capable of cross-linking antigen.

"Fv" is a minimum antibody fragment which contains a complete antigen-binding site. In one embodiment, a two-chain Fv species consists of a dimer of one heavy- and one light-chain variable domain in tight, non-covalent association. In a single-chain Fv (scFv) species, one heavy- and one light-chain variable domain can be covalently linked by a flexible peptide linker such that the light and heavy chains can associate in a "dimeric" structure analogous to that in a two-chain Fv species. It is in this configuration that the three CDRs of each variable domain interact to define an antigen-binding site on the surface of the VH-VL dimer.

Collectively, the six CDRs confer antigen-binding specificity to the antibody. However, even a single variable domain (or half of an Fv comprising only three CDRs specific for an antigen) has the ability to recognize and bind antigen, although at a lower affinity than the entire binding site.

The Fab fragment contains the heavy- and light-chain variable domains and also contains the constant domain of the light chain and the first constant domain (CH1) of the heavy chain. Fab' fragments differ from Fab fragments by the addition of a few residues at the carboxy terminus of the heavy chain CH1 domain including one or more cysteines from the antibody hinge region. Fab'-SH is the designation herein for Fab' in which the cysteine residue(s) of the constant domains bear a free thiol group. F(ab')₂ antibody fragments originally were produced as pairs of Fab' fragments which have hinge cysteines between them. Other chemical couplings of antibody fragments are also known.

"Single-chain Fv" or "scFv" antibody fragments comprise the VH and VL domains of antibody, wherein these domains are present in a single polypeptide chain. Generally, the scFv polypeptide further comprises a polypeptide linker between the VH and VL domains which enables the scFv to form the desired structure for antigen binding. For a review of scFv see Pluckthun, in *The Pharmacology of Monoclonal Antibodies*, vol. 113, Rosenberg and Moore eds., Springer-Verlag, New York, pp. 269-315 (1994).

The term “diabodies” refers to small antibody fragments with two antigen-binding sites, which fragments comprise a heavy-chain variable domain (VH) connected to a light-chain variable domain (VL) in the same polypeptide chain (VH-VL). By using a linker that is too short to allow pairing between the two domains on the same chain, the domains are forced to pair with the complementary domains of another chain and create two antigen-binding sites. Diabodies may be bivalent or bispecific. Diabodies are described more fully in, for example, EP 404,097; WO93/1161; Hudson et al. (2003) *Nat. Med.* 9:129-134; and Hollinger et al., *Proc. Natl. Acad. Sci. USA* 90: 6444-6448 (1993). Triabodies and tetrabodies are also described in Hudson et al. (2003) *Nat. Med.* 9:129-134.

The term “monoclonal antibody” as used herein refers to an antibody obtained from a population of substantially homogeneous antibodies, i.e., the individual antibodies comprising the population are identical except for possible mutations, e.g., naturally occurring mutations, that may be present in minor amounts. Thus, the modifier “monoclonal” indicates the character of the antibody as not being a mixture of discrete antibodies. In certain embodiments, such a monoclonal antibody typically includes an antibody comprising a polypeptide sequence that binds a target, wherein the target-binding polypeptide sequence was obtained by a process that includes the selection of a single target binding polypeptide sequence from a plurality of polypeptide sequences. For example, the selection process can be the selection of a unique clone from a plurality of clones, such as a pool of hybridoma clones, phage clones, or recombinant DNA clones. It should be understood that a selected target binding sequence can be further altered, for example, to improve affinity for the target, to humanize the target binding sequence, to improve its production in cell culture, to reduce its immunogenicity *in vivo*, to create a multispecific antibody, etc., and that an antibody comprising the altered target binding sequence is also a monoclonal antibody of this invention. In contrast to polyclonal antibody preparations which typically include different antibodies directed against different determinants (epitopes), each monoclonal antibody of a monoclonal antibody preparation is directed against a single determinant on an antigen. In addition to their specificity, monoclonal antibody preparations are advantageous in that they are typically uncontaminated by other immunoglobulins.

The modifier “monoclonal” indicates the character of the antibody as being obtained from a substantially homogeneous population of antibodies, and is not to be construed as requiring production of the antibody by any particular method. For example, the monoclonal

antibodies to be used in accordance with the present invention may be made by a variety of techniques, including, for example, the hybridoma method (e.g., Kohler et al., *Nature*, 256: 495 (1975); Harlow et al., *Antibodies: A Laboratory Manual*, (Cold Spring Harbor

Laboratory Press, 2nd ed. 1988); Hammerling et al., in: *Monoclonal Antibodies and T-Cell*

- 5 *Hybridomas* 563-681 (Elsevier, N.Y., 1981)), recombinant DNA methods (see, e.g., U.S. Patent No. 4,816,567), phage display technologies (see, e.g., Clackson et al., *Nature*, 352: 624-628 (1991); Marks et al., *J. Mol. Biol.* 222: 581-597 (1992); Sidhu et al., *J. Mol. Biol.* 338(2): 299-310 (2004); Lee et al., *J. Mol. Biol.* 340(5): 1073-1093 (2004); Fellouse, *Proc. Natl. Acad. Sci. USA* 101(34): 12467-12472 (2004); and Lee et al., *J. Immunol. Methods* 10
284(1-2): 119-132(2004), and technologies for producing human or human-like antibodies in animals that have parts or all of the human immunoglobulin loci or genes encoding human immunoglobulin sequences (see, e.g., WO98/24893; WO96/34096; WO96/33735; WO91/10741; Jakobovits et al., *Proc. Natl. Acad. Sci. USA* 90: 2551 (1993); Jakobovits et al., *Nature* 362: 255-258 (1993); Bruggemann et al., *Year in Immunol.* 7:33 (1993); U.S. Patent Nos. 5,545,807; 5,545,806; 5,569,825; 5,625,126; 5,633,425; 5,661,016; Marks et al., 15
Bio.Technology 10: 779-783 (1992); Lonberg et al., *Nature* 368: 856-859 (1994); Morrison, *Nature* 368: 812-813 (1994); Fishwild et al., *Nature Biotechnol.* 14: 845-851 (1996); Neuberger, *Nature Biotechnol.* 14: 826 (1996) and Lonberg and Huszar, *Intern. Rev. Immunol.* 13: 65-93 (1995).

- 20 The monoclonal antibodies herein specifically include "chimeric" antibodies in which a portion of the heavy and/or light chain is identical with or homologous to corresponding sequences in antibodies derived from a particular species or belonging to a particular antibody class or subclass, while the remainder of the chain(s) is identical with or homologous to corresponding sequences in antibodies derived from another species or belonging to another antibody class or subclass, as well as fragments of such antibodies, so long as they exhibit the 25
desired biological activity (U.S. Patent No. 4,816,567; and Morrison *et al.*, *Proc. Natl. Acad. Sci. USA* 81:6851-6855 (1984)).

- "Humanized" forms of non-human (e.g., murine) antibodies are chimeric antibodies that contain minimal sequence derived from non-human immunoglobulin. In one 30
embodiment, a humanized antibody is a human immunoglobulin (recipient antibody) in which residues from a hypervariable region of the recipient are replaced by residues from a hypervariable region of a non-human species (donor antibody) such as mouse, rat, rabbit, or

nonhuman primate having the desired specificity, affinity, and/or capacity. In some instances, framework region (FR) residues of the human immunoglobulin are replaced by corresponding non-human residues. Furthermore, humanized antibodies may comprise residues that are not found in the recipient antibody or in the donor antibody. These modifications may be made to further refine antibody performance. In general, a humanized antibody will comprise substantially all of at least one, and typically two, variable domains, in which all or substantially all of the hypervariable loops correspond to those of a non-human immunoglobulin, and all or substantially all of the FRs are those of a human immunoglobulin sequence. The humanized antibody optionally will also comprise at least a portion of an immunoglobulin constant region (Fc), typically that of a human immunoglobulin. For further details, see Jones *et al.*, *Nature* 321:522-525 (1986); Riechmann *et al.*, *Nature* 332:323-329 (1988); and Presta, *Curr. Op. Struct. Biol.* 2:593-596 (1992). See also the following review articles and references cited therein: Vaswani and Hamilton, *Ann. Allergy, Asthma & Immunol.* 1:105-115 (1998); Harris, *Biochem. Soc. Transactions* 23:1035-1038 (1995); Hurle and Gross, *Curr. Op. Biotech.* 5:428-433 (1994).

A “human antibody” is one which comprises an amino acid sequence corresponding to that of an antibody produced by a human and/or has been made using any of the techniques for making human antibodies as disclosed herein. Such techniques include screening human-derived combinatorial libraries, such as phage display libraries (see, e.g., Marks *et al.*, *J. Mol. Biol.*, 222: 581-597 (1991) and Hoogenboom *et al.*, *Nucl. Acids Res.*, 19: 4133-4137 (1991)); using human myeloma and mouse-human heteromyeloma cell lines for the production of human monoclonal antibodies (see, e.g., Kozbor *J. Immunol.*, 133: 3001 (1984); Brodeur *et al.*, *Monoclonal Antibody Production Techniques and Applications*, pp. 51-63 (Marcel Dekker, Inc., New York, 1987); and Boerner *et al.*, *J. Immunol.*, 147: 86 (1991)); and generating monoclonal antibodies in transgenic animals (e.g., mice) that are capable of producing a full repertoire of human antibodies in the absence of endogenous immunoglobulin production (see, e.g., Jakobovits *et al.*, *Proc. Natl. Acad. Sci USA*, 90: 2551 (1993); Jakobovits *et al.*, *Nature*, 362: 255 (1993); Bruggermann *et al.*, *Year in Immunol.*, 7: 33 (1993)). This definition of a human antibody specifically excludes a humanized antibody comprising antigen-binding residues from a non-human animal.

An “affinity matured” antibody is one with one or more alterations in one or more CDRs thereof which result in an improvement in the affinity of the antibody for antigen,

compared to a parent antibody which does not possess those alteration(s). In one embodiment, an affinity matured antibody has nanomolar or even picomolar affinities for the target antigen. Affinity matured antibodies are produced by procedures known in the art. Marks *et al.* *Bio/Technology* 10:779-783 (1992) describes affinity maturation by VH and VL domain shuffling. Random mutagenesis of HVR and/or framework residues is described by: 5 Barbas *et al.* *Proc Nat. Acad. Sci. USA* 91:3809-3813 (1994); Schier *et al.* *Gene* 169:147-155 (1995); Yelton *et al.* *J. Immunol.* 155:1994-2004 (1995); Jackson *et al.*, *J. Immunol.* 154(7):3310-9 (1995); and Hawkins *et al.*, *J. Mol. Biol.* 226:889-896 (1992).

A "blocking" antibody or an "antagonist" antibody is one which inhibits or reduces a 10 biological activity of the antigen it binds. Certain blocking antibodies or antagonist antibodies partially or completely inhibit the biological activity of the antigen.

Antibody "effector functions" refer to those biological activities attributable to the Fc region (a native sequence Fc region or amino acid sequence variant Fc region) of an antibody, and vary with the antibody isotype. Examples of antibody effector functions include: C1q 15 binding and complement dependent cytotoxicity; Fc receptor binding; antibody-dependent cell-mediated cytotoxicity (ADCC); phagocytosis; down regulation of cell surface receptors (*e.g.* B cell receptor); and B cell activation.

"Fc receptor" or "FcR" describes a receptor that binds to the Fc region of an antibody. In some embodiments, an FcR is a native human FcR. In some embodiments, an FcR is one 20 which binds an IgG antibody (a gamma receptor) and includes receptors of the FcγRI, FcγRII, and FcγRIII subclasses, including allelic variants and alternatively spliced forms of those receptors. FcγRII receptors include FcγRIIA (an "activating receptor") and FcγRIIB (an "inhibiting receptor"), which have similar amino acid sequences that differ primarily in the cytoplasmic domains thereof. Activating receptor FcγRIIA contains an immunoreceptor 25 tyrosine-based activation motif (ITAM) in its cytoplasmic domain. Inhibiting receptor FcγRIIB contains an immunoreceptor tyrosine-based inhibition motif (ITIM) in its cytoplasmic domain (see Daëron, *Annu. Rev. Immunol.* 15:203-234 (1997)). FcRs are reviewed in Ravetch and Kinet, *Annu. Rev. Immunol* 9:457-92 (1991); Capel *et al.*, *Immunomethods* 4:25-34 (1994); and de Haas *et al.*, *J. Lab. Clin. Med.* 126:330-41 (1995). 30 Other FcRs, including those to be identified in the future, are encompassed by the term "FcR" herein.

The term "Fc receptor" or "FcR" also includes the neonatal receptor, FcRn, which is responsible for the transfer of maternal IgGs to the fetus (Guyer *et al.*, *J. Immunol.* 117:587 (1976) and Kim *et al.*, *J. Immunol.* 24:249 (1994)) and regulation of homeostasis of immunoglobulins. Methods of measuring binding to FcRn are known. Binding to human FcRn in vivo and serum half life of human FcRn high affinity binding polypeptides can be assayed, e.g., in transgenic mice or transfected human cell lines expressing human FcRn, or in primates administered with Fc variant polypeptides.

WO00/42072 (Presta) describes antibody variants with improved or diminished binding to FcRs. The content of that patent publication is specifically incorporated herein by reference. See, also, Shields *et al.* *J. Biol. Chem.* 9(2): 6591-6604 (2001).

"Human effector cells" are leukocytes which express one or more FcRs and perform effector functions. In certain embodiments, the cells express at least FcγRIII and perform ADCC effector function(s). Examples of human leukocytes which mediate ADCC include peripheral blood mononuclear cells (PBMC), natural killer (NK) cells, monocytes, cytotoxic T cells and neutrophils. The effector cells may be isolated from a native source, e.g., from blood.

"Antibody-dependent cell-mediated cytotoxicity" or "ADCC" refers to a form of cytotoxicity in which immunoglobulin bound to Fc receptors (FcRs) present on certain cytotoxic effector cells (e.g. Natural Killer (NK) cells, neutrophils, and macrophages) enables those cytotoxic effector cells to bind specifically to an antigen-bearing target cell and subsequently kill the target cell with cytotoxins. The primary cells for mediating ADCC, NK cells, express FcγRIII only, whereas monocytes express FcγRI, FcγRII and FcγRIII. FcR expression on hematopoietic cells is summarized in Table 3 on page 464 of Ravetch and Kinet, *Annu. Rev. Immunol* 9:457-92 (1991). To assess ADCC activity of a molecule of interest, an *in vitro* ADCC assay, such as that described in US Patent No. 5,500,362 or 5,821,337 or Presta U.S. Patent No. 6,737,056 may be performed. Useful effector cells for such assays include peripheral blood mononuclear cells (PBMC) and Natural Killer (NK) cells. Alternatively, or additionally, ADCC activity of the molecule of interest may be assessed *in vivo*, e.g., in an animal model such as that disclosed in Clynes *et al.* *PNAS (USA)* 95:652-656 (1998).

"Complement dependent cytotoxicity" or "CDC" refers to the lysis of a target cell in the presence of complement. Activation of the classical complement pathway is initiated by

the binding of the first component of the complement system (C1q) to antibodies (of the appropriate subclass) which are bound to their cognate antigen. To assess complement activation, a CDC assay, *e.g.* as described in Gazzano-Santoro *et al.*, *J. Immunol. Methods* 202:163 (1996), may be performed.

5 Polypeptide variants with altered Fc region amino acid sequences and increased or decreased C1q binding capability are described in US Patent No. 6,194,551B1 and WO99/51642. The contents of those patent publications are specifically incorporated herein by reference. See, also, Idusogie *et al.* *J. Immunol.* 164: 4178-4184 (2000).

The term “Fc region-comprising polypeptide” refers to a polypeptide, such as an
10 antibody or immunoadhesin, which comprises an Fc region. The C-terminal lysine (residue 447 according to the EU numbering system) of the Fc region may be removed, for example, during purification of the polypeptide or by recombinant engineering the nucleic acid encoding the polypeptide. Accordingly, a composition comprising a polypeptide having an Fc region according to this invention can comprise polypeptides with K447,
15 removed, or a mixture of polypeptides with and without the K447 residue.

A “cytotoxic antibody” is an antibody that is capable of an effector function and/or inducing cell death upon binding to its target antigen.

An “immunoconjugate” refers to an antibody conjugated to one or more cytotoxic agents.

20 As used herein, the term “immunoadhesin” designates antibody-like molecules which combine the binding specificity of a heterologous protein (an “adhesin”) with the effector functions of immunoglobulin constant domains. Structurally, the immunoadhesins comprise a fusion of an amino acid sequence with the desired binding specificity which is other than the antigen recognition and binding site of an antibody (*i.e.*, is “heterologous”), and an
25 immunoglobulin constant domain sequence. The adhesin part of an immunoadhesin molecule typically is a contiguous amino acid sequence comprising at least the binding site of a receptor or a ligand. The immunoglobulin constant domain sequence in the immunoadhesin may be obtained from any immunoglobulin, such as IgG-1, IgG-2, IgG-3, or IgG-4 subtypes, IgA (including IgA-1 and IgA-2), IgE, IgD or IgM.

30 A “small molecule” or “small organic molecule” is defined herein as an organic molecule having a molecular weight below about 500 Daltons.

An "PRO-binding oligopeptide" or an "oligopeptide that binds PRO" is an oligopeptide that is capable of binding PRO with sufficient affinity such that the oligopeptide is useful as a diagnostic and/or therapeutic agent in targeting PRO. In certain embodiments, the extent of binding of a PRO-binding oligopeptide to an unrelated, non-PRO protein is less than about 10% of the binding of the PRO-binding oligopeptide to PRO as measured, e.g., by a surface plasmon resonance assay. In certain embodiments, a PRO-binding oligopeptide has a dissociation constant (K_d) of $\leq 1\mu\text{M}$, $\leq 100\text{ nM}$, $\leq 10\text{ nM}$, $\leq 1\text{ nM}$, or $\leq 0.1\text{ nM}$.

An "PRO-binding organic molecule" or "an organic molecule that binds PRO" is an organic molecule other than an oligopeptide or antibody as defined herein that is capable of binding PRO with sufficient affinity such that the organic molecule is useful as a diagnostic and/or therapeutic agent in targeting PRO. In certain embodiments, the extent of binding of a PRO-binding organic molecule to an unrelated, non-PRO protein is less than about 10% of the binding of the PRO-binding organic molecule to PRO as measured, e.g., by a surface plasmon resonance assay. In certain embodiments, a PRO-binding organic molecule has a dissociation constant (K_d) of $\leq 1\mu\text{M}$, $\leq 100\text{ nM}$, $\leq 10\text{ nM}$, $\leq 1\text{ nM}$, or $\leq 0.1\text{ nM}$.

The dissociation constant (K_d) of any molecule that binds a target polypeptide may conveniently be measured using a surface plasmon resonance assay. Such assays may employ a BIAcoreTM-2000 or a BIAcoreTM-3000 (BIAcore, Inc., Piscataway, NJ) at 25°C with immobilized target polypeptide CM5 chips at ~10 response units (RU). Briefly, carboxymethylated dextran biosensor chips (CM5, BIAcore Inc.) are activated with *N*-ethyl-*N*'-(3-dimethylaminopropyl)-carbodiimide hydrochloride (EDC) and *N*-hydroxysuccinimide (NHS) according to the supplier's instructions. Target polypeptide is diluted with 10 mM sodium acetate, pH 4.8, to 5 $\mu\text{g/ml}$ (~0.2 μM) before injection at a flow rate of 5 $\mu\text{l/minute}$ to achieve approximately 10 response units (RU) of coupled protein. Following the injection of target polypeptide, 1 M ethanolamine is injected to block unreacted groups. For kinetics measurements, two-fold serial dilutions of the binding molecule (0.78 nM to 500 nM) are injected in PBS with 0.05% Tween 20 (PBST) at 25°C at a flow rate of approximately 25 $\mu\text{l/min}$. Association rates (k_{on}) and dissociation rates (k_{off}) are calculated using a simple one-to-one Langmuir binding model (BIAcore Evaluation Software version 3.2) by simultaneously fitting the association and dissociation sensorgrams. The equilibrium dissociation constant (K_d) is calculated as the ratio $k_{\text{off}}/k_{\text{on}}$. See, e.g., Chen, Y., et al., (1999) *J. Mol. Biol.* 293:865-881. If the on-rate of an antibody exceeds $10^6\text{ M}^{-1}\text{ s}^{-1}$ by the

surface plasmon resonance assay above, then the on-rate can be determined by using a fluorescent quenching technique that measures the increase or decrease in fluorescence emission intensity (excitation = 295 nm; emission = 340 nm, 16 nm band-pass) at 25°C of a 20 nM antibody (Fab form) in PBS, pH 7.2, in the presence of increasing concentrations of antigen as measured in a spectrometer, such as a stop-flow equipped spectrophotometer (Aviv Instruments) or a 8000-series SLM-Aminco spectrophotometer (ThermoSpectronic) with a stirred cuvette.

A "liposome" is a small vesicle composed of various types of lipids, phospholipids and/or surfactant which is useful for delivery of an agent, e.g., a drug, to a mammal. The components of the liposome are commonly arranged in a bilayer formation, similar to the lipid arrangement of biological membranes.

The word "label" when used herein refers to a detectable compound or composition. The label may be detectable by itself (e.g., radioisotope labels or fluorescent labels) or, in the case of an enzymatic label, may catalyze chemical alteration of a substrate compound or composition which results in a detectable product. Radionuclides that can serve as detectable labels include, for example, I-131, I-123, I-125, Y-90, Re-188, Re-186, At-211, Cu-67, Bi-212, and Pd-109.

An "isolated" biological molecule, such as a nucleic acid, polypeptide, or antibody, is one which has been identified and separated and/or recovered from at least one component of its natural environment.

II. EMBODIMENTS OF THE INVENTION

Methods and compositions for the diagnosis and treatment of cancers associated with gene amplification are provided. In one aspect, methods and compositions for the diagnosis and treatment of a lung cancer are provided. Those methods and compositions are based, in part, on the discovery that a region of chromosome 4 comprising the PRO gene is amplified in particular lung cancer samples.

Each PRO polypeptide described herein is a receptor tyrosine kinase. The following additional features of each PRO polypeptide are noted:

- PDGFRA is a receptor for members of the platelet derived growth factor (PDGF) family.

- KIT is a cellular counterpart of a viral oncogene. Accordingly, KIT is a “protooncogene” that may be converted into an oncogenic form. The ligand for KIT is stem cell factor (SCF).
- KDR is a receptor for vascular endothelial growth factor (VEGF), an endothelial cell mitogen. VEGF and KDR play a role in angiogenesis induced by certain tumors.

Receptor tyrosine kinases generally comprise an extracellular ligand binding domain; a transmembrane domain; and an intracellular domain having tyrosine kinase activity.

A. Methods of Diagnosis and Detection

In one aspect, methods of diagnosing lung cancer are provided. As described below in the Examples, lung tumors were discovered in which a region of chromosome 4 was amplified. The PRO gene falls within the region of amplification, as shown in Figures 1 and 2, and is thus an attractive target for lung cancer diagnostics and therapeutics.

Accordingly, in one aspect, a method of diagnosing the presence of a lung cancer in a mammal is provided, the method comprising detecting whether the PRO gene is amplified in a test lung sample from the mammal relative to a control sample, wherein amplification of the PRO gene indicates the presence of lung cancer in the mammal. As used herein, the term “detecting” encompasses quantitative or qualitative detection. A “test lung sample” is a biological sample derived from lung tissue that may or may not be cancerous, e.g., a sample of lung cells suspected of being cancerous or a whole cell extract or fractionated cell extract (such as a membrane preparation) derived from lung cells. A “control sample” is a biological sample derived from (a) normal tissue, e.g., normal lung cells or a whole cell extract or fractionated cell extract (such as a membrane preparation) derived from such cells, or (b) lung cancer tissue in which the PRO gene is known not to be amplified or overexpressed, or a whole cell extract or fractionated cell extract derived therefrom. The PRO gene is said to be “amplified” if the copy number of the PRO gene is increased by at least 2-, 3-, 5-, 7-, 10-, 15-, 20-, 25-, 30-, 35-, 40-, 45-, or 50-fold in the test lung sample relative to the control sample.

In certain embodiments, detecting amplification of the PRO gene is achieved using certain techniques known to those skilled in the art. For example, comparative genome hybridization may be used to produce a map of DNA sequence copy number as a function of chromosomal location. See, e.g., Kallioniemi et al. (1992) *Science* 258:818-821.

Amplification of the PRO gene may also be detected, e.g., by Southern hybridization using a probe specific for the PRO gene or by real-time quantitative PCR.

In certain embodiments, detecting amplification of the PRO gene is achieved by directly assessing the copy number of the PRO gene, for example, by using a probe that hybridizes to the PRO gene. In certain embodiments, detecting amplification of the PRO gene is achieved by indirectly assessing the copy number of the PRO gene, for example, by assessing the copy number of a chromosomal region that lies outside the PRO gene but is co-amplified with the PRO gene. Guidance for selecting such a region is provided, e.g., in Figure 2.

In another aspect, a method of diagnosing the presence of a lung cancer in a mammal is provided, the method comprising detecting expression of the PRO gene in a test lung sample from the mammal, wherein a higher level of PRO gene expression in the test lung sample relative to a control sample indicates the presence of lung cancer in the mammal. In certain embodiments, expression of the PRO gene is detected by determining the level of mRNA transcription from the PRO gene. Levels of mRNA transcription may be determined, either quantitatively or qualitatively, by various methods known to those skilled in the art. Levels of mRNA transcription may also be determined directly or indirectly by detecting levels of cDNA generated from the mRNA. Exemplary methods for determining levels of mRNA transcription include, but are not limited to, real-time quantitative RT-PCR and hybridization-based assays, including microarray-based assays and filter-based assays such as Northern blots. In certain embodiments, “a higher level of PRO gene expression” means at least a 2-, 3-, 5-, 7-, 10-, 15-, 20-, 25-, 30-, 35-, 40-, 45-, or 50-fold increase in mRNA transcription from the PRO gene.

In other embodiments, expression of the PRO gene is detected by determining the level of PRO. Levels of PRO may be determined, either quantitatively or qualitatively, by certain methods known to those skilled in the art, including antibody-based detection methods. In one embodiment, detecting expression of the PRO gene in a test lung sample comprises contacting the test lung sample with an anti-PRO antibody and determining the level of expression (either quantitatively or qualitatively) of PRO in the test lung sample by detecting binding of the anti-PRO antibody to PRO. In certain embodiments, binding of an anti-PRO antibody to PRO may be detected by various methods known to those skilled in the art including, but not limited to, fluorescence activated cell sorting, Western blot,

radioimmunoassay, ELISA, and the like. In certain embodiments, “a higher level of PRO gene expression” means at least a 2-, 3-, 5-, 7-, 10-, 15-, 20-, 25-, 30-, 35-, 40-, 45-, or 50-fold increase in PRO levels.

For any of the above methods, the stated purpose of “diagnosing the presence of a lung cancer in a mammal” is nonlimiting and encompasses classifying the type of lung cancer present in a mammal by detecting whether the PRO gene is amplified and/or expressed at a higher level in a test sample of lung cancer relative to a control sample. Classifying a lung cancer based on whether or not the PRO gene is amplified and/or overexpressed is useful, e.g., for determining whether the individual having the lung cancer will respond to a therapeutic that targets PRO or the PRO gene, and thus, for selecting the optimal regimen for treating the lung cancer, as further described below. For example, a method is provided herein for determining whether an individual having lung cancer will respond to a therapeutic that targets PRO or the PRO gene, the method comprising determining whether the PRO gene is amplified and/or overexpressed in the lung cancer (e.g., by using any of the methods described above), wherein amplification and/or overexpression of the PRO gene indicates that the individual will respond to the therapeutic. A “therapeutic that targets PRO or the PRO gene” means any agent that affects the expression and/or an activity of PRO or the PRO gene including, but not limited to, any of the PRO antagonists, cytotoxic antibodies, or immunoconjugates described below, Part B, including such therapeutics that are already known in the art as well as those that are later developed.

B. Compositions and Pharmaceutical Formulations

Pharmaceutical formulations for treating lung cancer are provided. In certain embodiments, a pharmaceutical formulation comprises at least one PRO antagonist, a pharmaceutically acceptable carrier, and optionally, at least one additional therapeutic agent. In certain embodiments, a PRO antagonist comprises an anti-PRO antibody, an oligopeptide, an organic molecule, a soluble PRO receptor, or an antisense nucleic acid. In certain embodiments, a pharmaceutical formulation comprises at least one cytotoxic anti-PRO antibody, a pharmaceutically acceptable carrier, and optionally, at least one additional therapeutic agent. In certain embodiments, a pharmaceutical formulation comprises at least one immunoconjugate, wherein the immunoconjugate comprises an antibody that binds PRO and a cytotoxic agent; a pharmaceutically acceptable carrier; and optionally, at least one additional therapeutic agent.

1. *PRO* antagonists

In one aspect, a *PRO* antagonist is an anti-*PRO* antibody. In certain embodiments, an anti-*PRO* antagonist antibody is a “blocking antibody,” e.g., an antibody that fully or partially blocks the interaction of *PRO* with its ligand. In certain embodiments, an anti-*PRO* antibody binds to the extracellular domain of a *PRO*. In certain embodiments, an anti-*PRO* antibody binds to or otherwise occludes all or a portion of the ligand binding domain of a *PRO*.

Certain antagonist anti-*PRO* antibodies are known in the art. Such antibodies are described, e.g., in Ludwig et al. (2003) *Oncogene* 22:9097-9106 (describing IMC-1C11, an anti-KDR antagonist antibody); MacDonald et al. (2001) *Nat. Genet.* 29:143-152 (describing antagonist monoclonal antibodies to PDGFRA); and Hines et al. (1995) *Cell Growth Diff.* 6:769-779 (describing antagonist antibodies to KIT).

In various embodiments of the invention, an anti-*PRO* antibody (including antagonist anti-*PRO* antibodies and cytotoxic anti-*PRO* antibodies, discussed below, Part 2) is a monoclonal antibody. In various embodiments, an anti-*PRO* antibody is an antibody fragment, e.g., a Fab, Fab'-SH, Fv, scFv, or (Fab')₂ fragment, or a single domain antibody (Domantis, Inc., Waltham, MA; see, e.g., US Pat. No. 6,248,516 B1). In certain embodiments, an anti-*PRO* antibody is a bispecific antibody (see, e.g., WO94/04690 and Suresh et al. (1986) *Methods in Enzymology* 121:210). In certain embodiments, an anti-*PRO* antibody is a chimeric, humanized, or human antibody.

In another aspect, a *PRO* antagonist is an oligopeptide that binds to a *PRO*. In one embodiment, an oligopeptide binds to the extracellular domain of a *PRO*. In one such embodiment, an oligopeptide binds to or otherwise occludes a region of the ligand binding domain. In another embodiment, an oligopeptide binds to the tyrosine kinase domain of a *PRO* and/or reduces the activity of the tyrosine kinase domain of a *PRO*.

The above oligopeptides may be chemically synthesized using known oligopeptide synthesis methodology or may be prepared and purified using recombinant technology. Such oligopeptides are usually at least about 5 amino acids in length, alternatively at least about 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, or 100 amino acids in length.

Such oligopeptides may be identified without undue experimentation using well known techniques. In this regard, it is noted that techniques for screening oligopeptide libraries for oligopeptides that are capable of specifically binding to a polypeptide target are well known in the art (see, e.g., U.S. Patent Nos. 5,556,762, 5,750,373, 4,708,871, 4,833,092, 5,223,409, 5,403,484, 5,571,689, 5,663,143; PCT Publication Nos. WO 84/03506 and WO84/03564; Geysen et al., *Proc. Natl. Acad. Sci. U.S.A.*, 81:3998-4002 (1984); Geysen et al., *Proc. Natl. Acad. Sci. USA*, 82:178-182 (1985); Geysen et al., in *Synthetic Peptides as Antigens*, 130-149 (1986); Geysen et al., *J. Immunol. Meth.*, 102:259-274 (1987); Schoofs et al., *J. Immunol.*, 140:611-616 (1988), Cwirla, S. E. et al. (1990) *Proc. Natl. Acad. Sci. USA*, 87:6378; Lowman, H.B. et al. (1991) *Biochemistry*, 30:10832; Clackson, T. et al. (1991) *Nature*, 352:624; Marks, J. D. et al. (1991), *J. Mol. Biol.*, 222:581; Kang, A.S. et al. (1991) *Proc. Natl. Acad. Sci. USA*, 88:8363, and Smith, G. P. (1991) *Current Opin. Biotechnol.*, 2:668). In certain embodiments, an oligopeptide may be conjugated to a cytotoxic agent.

In yet another aspect, a PRO antagonist is an organic molecule that binds to PRO, other than an oligopeptide or antibody as described herein. An organic molecule may be, for example, a small molecule. In one embodiment, an organic molecule binds to the extracellular domain of a PRO. In one such embodiment, an organic molecule binds to or otherwise occludes a region of the ligand binding domain. In another embodiment, an organic molecule binds to the tyrosine kinase domain and/or reduces the activity of the tyrosine kinase domain of a PRO.

An organic molecule that binds to PRO may be identified and chemically synthesized using known methodology (see, e.g., PCT Publication Nos. WO00/00823 and WO00/39585). Such organic molecules are usually less than about 2000 daltons in size, alternatively less than about 1500, 750, 500, 250 or 200 daltons in size, wherein such organic molecules that are capable of binding to PRO may be identified without undue experimentation using well known techniques. In this regard, it is noted that techniques for screening organic molecule libraries for molecules that are capable of binding to a polypeptide target are well known in the art (see, e.g., PCT Publication Nos. WO00/00823 and WO00/39585). In certain embodiments, an organic molecule may be conjugated to a cytotoxic agent.

Certain small molecule antagonists that bind to PRO and inhibit the tyrosine kinase activity of PRO are known in the art. Such molecules include, e.g., 3-[2,4-dimethylpyrrol-5-yl)methylidene]-indolin-2-one ("SU5416"), an inhibitor of KDR and KIT; and imatinib

(Gleevec®), a 2-phenylaminopyrimidine that inhibits PDGFRA and KIT. In certain embodiments, a PRO antagonist is a tyrosine kinase inhibitor, as defined herein.

In yet another aspect, a PRO antagonist is a soluble form of PRO, i.e., a form of PRO that is not anchored to the plasma membrane. Such soluble forms of PRO may compete with
5 membrane-bound PRO for binding to a PRO ligand. In certain embodiments, a soluble form of PRO may comprise all or a ligand-binding portion of an extracellular domain of PRO. In any of the above embodiments, a soluble form of PRO may or may not further comprise a tyrosine kinase domain.

In yet another aspect, a PRO antagonist is an antisense nucleic acid that decreases
10 expression of the PRO gene (i.e., that decreases transcription of the PRO gene and/or translation of PRO mRNA). In certain embodiments, an antisense nucleic acid binds to a nucleic acid (DNA or RNA) encoding PRO. In certain embodiments, an antisense nucleic acid is an oligonucleotide of about 10-30 nucleotides in length (including all points between those endpoints). In certain embodiments, an antisense oligonucleotide comprises a modified
15 sugar-phosphodiester backbones (or other sugar linkages, including phosphorothioate linkages and linkages as described in WO 91/06629), wherein such modified sugar-phosphodiester backbones are resistant to endogenous nucleases. In one embodiment, an antisense nucleic acid is an oligodeoxyribonucleotide, which results in the degradation and/or reduced transcription or translation of PRO mRNA.

In certain embodiments, an antisense nucleic acid is an RNA that reduces expression
20 of a target nucleic acid by "RNA interference" ("RNAi"). For review of RNAi, see, e.g., Novina et al. (2004) *Nature* 430:161-164. Such RNAs are derived from, for example, short interfering RNAs (siRNAs) and microRNAs. siRNAs, e.g., may be synthesized as double stranded oligoribonucleotides of about 18-26 nucleotides in length. *Id.* Thus, antisense
25 nucleic acids that decrease expression of PRO are well within the skill in the art.

2. Cytotoxic Antibodies

In one aspect, cytotoxic antibodies are provided. In certain embodiments, a cytotoxic antibody is an anti-PRO antibody, such as those provided above, which effects an effector function and/or induces cell death. In certain embodiments, a cytotoxic anti-PRO antibody
30 binds to the extracellular domain of a PRO.

3. Immunoconjugates

Immunoconjugates, or “antibody-drug conjugates,” are useful for the local delivery of cytotoxic agents in the treatment of cancer. See, e.g., Syrigos et al. (1999) *Anticancer Research* 19:605-614; Niculescu-Duvaz et al. (1997) *Adv. Drug Deliv. Rev.* 26:151-172; U.S. Pat. No. 4,975,278. Immunoconjugates allow for the targeted delivery of a drug moiety to a tumor, whereas systemic administration of unconjugated cytotoxic agents may result in unacceptable levels of toxicity to normal cells as well as the tumor cells sought to be eliminated. See Baldwin et al. (Mar. 15, 1986) *Lancet* pp. 603-05; Thorpe (1985) "Antibody Carriers Of Cytotoxic Agents In Cancer Therapy: A Review," in *Monoclonal Antibodies '84: Biological and Clinical Applications* (A. Pinchera et al., eds.) pp. 475-506.

In one aspect, an immunoconjugate comprises an antibody that binds PRO (or an extracellular domain thereof), such as those provided above, and a cytotoxic agent, such as a chemotherapeutic agent, a growth inhibitory agent, a toxin (e.g., an enzymatically active toxin of bacterial, fungal, plant, or animal origin, or fragments thereof), or a radioactive isotope (i.e., a radioconjugate).

Chemotherapeutic agents useful in the generation of immunoconjugates are described above. Enzymatically active toxins and fragments thereof that can be used include diphtheria A chain, nonbinding active fragments of diphtheria toxin, exotoxin A chain (from *Pseudomonas aeruginosa*), ricin A chain, abrin A chain, modeccin A chain, alpha-sarcin, *Aleurites fordii* proteins, dianthin proteins, *Phytolacca americana* proteins (PAPI, PAPII, and PAP-S), momordica charantia inhibitor, curcin, crotin, sapaonaria officinalis inhibitor, gelonin, mitogellin, restrictocin, phenomycin, enomycin, and the tricothecenes. A variety of radionuclides are available for the production of radioconjugated antibodies. Examples include ^{212}Bi , ^{131}I , ^{131}In , ^{90}Y , and ^{186}Re .

Conjugates of the antibody and cytotoxic agent may be made using a variety of bifunctional protein-coupling agents such as N-succinimidyl-3-(2-pyridyldithiol) propionate (SPDP), iminothiolane (IT), bifunctional derivatives of imidoesters (such as dimethyl adipimidate HCL), active esters (such as disuccinimidyl suberate), aldehydes (such as glutaraldehyde), bis-azido compounds (such as bis (p-azidobenzoyl) hexanediamine), bis-diazonium derivatives (such as bis-(p-diazoniumbenzoyl)-ethylenediamine), diisocyanates (such as tolyene 2,6-diisocyanate), and bis-active fluorine compounds (such as 1,5-difluoro-2,4-dinitrobenzene). For example, a ricin immunotoxin can be prepared as described in

Vitetta *et al.*, *Science*, 238: 1098 (1987). Carbon-14-labeled 1-isothiocyanatobenzyl-3-methyldiethylene triaminepentaacetic acid (MX-DTPA) is an exemplary chelating agent for conjugation of radionucleotide to the antibody. See WO94/11026.

Maytansine and maytansinoids

5 In one embodiment, an immunoconjugate comprises an anti-PRO antibody conjugated to one or more maytansinoid molecules. Maytansinoids are mitototic inhibitors which act by inhibiting tubulin polymerization. Maytansine was first isolated from the east African shrub *Maytenus serrata* (U.S. Patent No. 3,896,111). Subsequently, it was discovered that certain microbes also produce maytansinoids, such as maytansinol and C-3 maytansinol esters (U.S. 10 Patent No. 4,151,042). Synthetic maytansinol and derivatives and analogues thereof are disclosed, for example, in U.S. Patent Nos. 4,137,230; 4,248,870; 4,256,746; 4,260,608; 4,265,814; 4,294,757; 4,307,016; 4,308,268; 4,308,269; 4,309,428; 4,313,946; 4,315,929; 4,317,821; 4,322,348; 4,331,598; 4,361,650; 4,364,866; 4,424,219; 4,450,254; 4,362,663; and 4,371,533, the disclosures of which are hereby expressly incorporated by reference.

15 In an attempt to improve their therapeutic index, maytansine and maytansinoids have been conjugated to antibodies that bind to antigens on the surface of tumor cells. Immunoconjugates containing maytansinoids and their therapeutic use are disclosed, for example, in U.S. Patent Nos. 5,208,020, 5,416,064 and European Patent EP 0 425 235 B1, the disclosures of which are hereby expressly incorporated by reference. Liu *et al.*, *Proc. Natl. Acad. Sci. USA* 93:8618-8623 (1996) described immunoconjugates comprising a 20 maytansinoid designated DM1 linked to the monoclonal antibody C242 directed against human lung cancer. The conjugate was found to be highly cytotoxic towards cultured colon cancer cells, and showed antitumor activity in an *in vivo* tumor growth assay. Chari *et al.*, *Cancer Research* 52:127-131 (1992) described immunoconjugates in which a maytansinoid 25 was conjugated via a disulfide linker to the murine antibody A7 binding to an antigen on human colon cancer cell lines, or to another murine monoclonal antibody TA.1 that binds the HER-2/*neu* oncogene. The cytotoxicity of the TA.1-maytansinoid conjugate was tested *in vitro* on the human breast cancer cell line SK-BR-3, which expresses 3×10^5 HER-2 surface antigens per cell. The drug conjugate achieved a degree of cytotoxicity similar to the free 30 maytansinoid drug, which could be increased by increasing the number of maytansinoid molecules per antibody molecule. The A7-maytansinoid conjugate showed low systemic cytotoxicity in mice.

Anti-PRO antibody-maytansinoid conjugates are prepared by chemically linking an anti-PRO antibody to a maytansinoid molecule without significantly diminishing the biological activity of either the antibody or the maytansinoid molecule. An average of 3-4 maytansinoid molecules conjugated per antibody molecule has shown efficacy in enhancing cytotoxicity of target cells without negatively affecting the function or solubility of the antibody, although even one molecule of toxin per antibody would be expected to enhance cytotoxicity over the use of naked antibody. Maytansinoids are well known in the art and can be synthesized using known techniques or isolated from natural sources. Suitable maytansinoids are disclosed, for example, in U.S. Patent No. 5,208,020 and in the other patents and nonpatent publications referred to hereinabove. Preferred maytansinoids are maytansinol and maytansinol analogues modified in the aromatic ring or at other positions of the maytansinol molecule, such as various maytansinol esters.

There are many linking groups known in the art for making antibody-maytansinoid conjugates, including, for example, those disclosed in U.S. Patent No. 5,208,020 or EP Patent 0 425 235 B1, and Chari et al., *Cancer Research* 52:127-131 (1992). The linking groups include disulfide groups, thioether groups, acid labile groups, photolabile groups, peptidase labile groups, or esterase labile groups, as disclosed in the above-identified patents, disulfide and thioether groups being preferred.

Conjugates of the antibody and maytansinoid may be made using a variety of bifunctional protein coupling agents such as N-succinimidyl-3-(2-pyridyldithio) propionate (SPDP), succinimidyl-4-(N-maleimidomethyl) cyclohexane-1-carboxylate, iminothiolane (IT), bifunctional derivatives of imidoesters (such as dimethyl adipimidate HCL), active esters (such as disuccinimidyl suberate), aldehydes (such as glutaraldehyde), bis-azido compounds (such as bis (p-azidobenzoyl) hexanediamine), bis-diazonium derivatives (such as bis-(p-diazoniumbenzoyl)-ethylenediamine), diisocyanates (such as toluene 2,6-diisocyanate), and bis-active fluorine compounds (such as 1,5-difluoro-2,4-dinitrobenzene). Certain coupling agents, including N-succinimidyl-3-(2-pyridyldithio) propionate (SPDP) (Carlsson et al., *Biochem. J.* 173:723-737 [1978]) and N-succinimidyl-4-(2-pyridylthio)pentanoate (SPP), provide for a disulfide linkage.

The linker may be attached to the maytansinoid molecule at various positions, depending on the type of the link. For example, an ester linkage may be formed by reaction with a hydroxyl group using conventional coupling techniques. The reaction may occur at the

C-3 position having a hydroxyl group, the C-14 position modified with hydroxymethyl, the C-15 position modified with a hydroxyl group, and the C-20 position having a hydroxyl group. In a preferred embodiment, the linkage is formed at the C-3 position of maytansinol or a maytansinol analogue.

5 **Auristatins and dolastatins**

 In some embodiments, an immunoconjugate comprises an anti-PRO antibody conjugated to a dolastatin or dolostatin peptidic analog or derivative, e.g., an auristatin (US Patent Nos. 5635483; 5780588). Dolastatins and auristatins have been shown to interfere with microtubule dynamics, GTP hydrolysis, and nuclear and cellular division (Woyke et al
10 (2001) *Antimicrob. Agents and Chemother.* 45(12):3580-3584) and have anticancer (US Pat. No. 5663149) and antifungal activity (Pettit et al (1998) *Antimicrob. Agents Chemother.* 42:2961-2965). The dolastatin or auristatin drug moiety may be attached to the antibody through the N (amino) terminus or the C (carboxyl) terminus of the peptidic drug moiety (WO 02/088172).

15 Exemplary auristatin embodiments include the N-terminus linked monomethylauristatin drug moieties DE and DF, disclosed in "Monomethylvaline Compounds Capable of Conjugation to Ligands," US Patent Application Publication No. US 2005-0238649 A1, the disclosure of which is expressly incorporated by reference in its entirety.

20 Typically, peptide-based drug moieties can be prepared by forming a peptide bond between two or more amino acids and/or peptide fragments. Such peptide bonds can be prepared, for example, according to the liquid phase synthesis method (see E. Schröder and K. Lübke, "The Peptides", volume 1, pp 76-136, 1965, Academic Press) that is well known in the field of peptide chemistry. The auristatin/dolastatin drug moieties may be prepared
25 according to the methods of: US 5635483; US 5780588; Pettit et al (1989) *J. Am. Chem. Soc.* 111:5463-5465; Pettit et al (1998) *Anti-Cancer Drug Design* 13:243-277; Pettit, G.R., et al. *Synthesis*, 1996, 719-725; and Pettit et al (1996) *J. Chem. Soc. Perkin Trans. 1* 5:859-863. See also Doronina (2003) *Nat. Biotechnol.* 21(7):778-784; US Patent Application Publication No. 2005-0238649 A1, hereby incorporated by reference in its entirety (disclosing, e.g.,
30 linkers and methods of preparing monomethylvaline compounds such as MMAE and MMAF conjugated to linkers).

Calicheamicin

Another immunoconjugate of interest comprises an anti-PRO antibody conjugated to one or more calicheamicin molecules. The calicheamicin family of antibiotics are capable of producing double-stranded DNA breaks at sub-picomolar concentrations. For the preparation of conjugates of the calicheamicin family, see U.S. patents 5,712,374, 5,714,586, 5,739,116, 5,767,285, 5,770,701, 5,770,710, 5,773,001, 5,877,296 (all to American Cyanamid Company). Structural analogues of calicheamicin which may be used include, but are not limited to, γ_1^I , α_2^I , α_3^I , N-acetyl- γ_1^I , PSAG and θ_1^I (Hinman et al., *Cancer Research* 53:3336-3342 (1993), Lode et al., *Cancer Research* 58:2925-2928 (1998) and the aforementioned U.S. patents to American Cyanamid). Another anti-tumor drug to which the antibody can be conjugated is QFA which is an antifolate. Both calicheamicin and QFA have intracellular sites of action and do not readily cross the plasma membrane. Therefore, cellular uptake of these agents through antibody mediated internalization greatly enhances their cytotoxic effects.

Other cytotoxic agents

Other antitumor agents that can be conjugated to an anti-PRO antibody include BCNU, streptozocin, vincristine and 5-fluorouracil, the family of agents known collectively as LL-E33288 complex described in U.S. patents 5,053,394, 5,770,710, as well as esperamicins (U.S. patent 5,877,296).

Enzymatically active toxins and fragments thereof which can be used include diphtheria A chain, nonbinding active fragments of diphtheria toxin, exotoxin A chain (from *Pseudomonas aeruginosa*), ricin A chain, abrin A chain, modeccin A chain, alpha-sarcin, *Aleurites fordii* proteins, dianthin proteins, *Phytolaca americana* proteins (PAPI, PAPII, and PAP-S), momordica charantia inhibitor, curcin, crotin, sapaonaria officinalis inhibitor, gelonin, mitogellin, restrictocin, phenomycin, enomycin and the tricothecenes. See, for example, WO 93/21232 published October 28, 1993.

In another aspect, an immunoconjugate may comprise an anti-PRO antibody and a compound with nucleolytic activity (e.g., a ribonuclease or a DNA endonuclease such as a deoxyribonuclease; DNase).

For selective destruction of a tumor, an immunoconjugate may comprise an anti-PRO antibody and a highly radioactive atom. A variety of radioactive isotopes are available for the production of radioconjugated anti-PRO antibodies. Examples include At^{211} , I^{131} , I^{125} , Y^{90} ,

Re¹⁸⁶, Re¹⁸⁸, Sm¹⁵³, Bi²¹², P³², Pb²¹² and radioactive isotopes of Lu. When the conjugate is used for diagnosis, it may comprise a radioactive atom for scintigraphic studies, for example tc^{99m} or I¹²³, or a spin label for nuclear magnetic resonance (NMR) imaging (also known as magnetic resonance imaging, mri), such as iodine-123 again, iodine-131, indium-111, fluorine-19, carbon-13, nitrogen-15, oxygen-17, gadolinium, manganese or iron.

The radio- or other labels may be incorporated in the immunoconjugate in known ways. For example, the peptide may be biosynthesized or may be synthesized by chemical amino acid synthesis using suitable amino acid precursors involving, for example, fluorine-19 in place of hydrogen. Labels such as tc^{99m} or I¹²³, Re¹⁸⁶, Re¹⁸⁸ and In¹¹¹ can be attached via a cysteine residue in the peptide. Yttrium-90 can be attached via a lysine residue. The IODOGEN method (Fraker et al (1978) *Biochem. Biophys. Res. Commun.* 80: 49-57 can be used to incorporate iodine-123. "Monoclonal Antibodies in Immunoscintigraphy" (Chatal, CRC Press 1989) describes other methods in detail.

Conjugates of an antibody and one or more small molecule toxins, such as a calicheamicin, maytansinoids, a trichothene, and CC1065, and the derivatives of these toxins that have toxin activity, are also contemplated herein.

4. Additional Therapeutic Agents

Pharmaceutical formulations may optionally comprise at least one additional therapeutic agent (i.e., in addition to a PRO antagonist, cytotoxic antibody, or immunoconjugate). Such additional therapeutic agents are described in further detail below, Part C.

5. Preparation of Pharmaceutical Formulations

Pharmaceutical formulations comprising any of the above agents are prepared for storage by mixing the agent having the desired degree of purity with optional physiologically acceptable carriers, excipients or stabilizers (*Remington's Pharmaceutical Sciences* 16th edition, Osol, A. Ed. (1980)) in the form of aqueous solutions or lyophilized or other dried formulations. Acceptable carriers, excipients, or stabilizers are nontoxic to recipients at the dosages and concentrations employed, and include buffers such as phosphate, citrate, histidine and other organic acids; antioxidants including ascorbic acid and methionine; preservatives (such as octadecyldimethylbenzyl ammonium chloride; hexamethonium chloride; benzalkonium chloride, benzethonium chloride); phenol, butyl or benzyl alcohol; alkyl parabens such as methyl or propyl paraben; catechol; resorcinol; cyclohexanol; 3-

pentanol; and m-cresol); low molecular weight (less than about 10 residues) polypeptides; proteins, such as serum albumin, gelatin, or immunoglobulins; hydrophilic polymers such as polyvinylpyrrolidone; amino acids such as glycine, glutamine, asparagine, histidine, arginine, or lysine; monosaccharides, disaccharides, and other carbohydrates including glucose, mannose, or dextrans; chelating agents such as EDTA; sugars such as sucrose, mannitol, trehalose or sorbitol; salt-forming counter-ions such as sodium; metal complexes (*e.g.*, Zn-protein complexes); and/or non-ionic surfactants such as TWEENTM, PLURONICSTM or polyethylene glycol (PEG). Pharmaceutical formulations to be used for *in vivo* administration are generally sterile. This is readily accomplished by filtration through sterile filtration membranes.

An agent may also be entrapped in microcapsule prepared, for example, by coacervation techniques or by interfacial polymerization, for example, hydroxymethylcellulose or gelatin-microcapsule and poly-(methylmethacrylate) microcapsule, respectively, in colloidal drug delivery systems (for example, liposomes, albumin microspheres, microemulsions, nano-particles and nanocapsules) or in macroemulsions. Such techniques are disclosed in *Remington's Pharmaceutical Sciences* 16th edition, Osol, A. Ed. (1980).

Sustained-release preparations may be prepared. Suitable examples of sustained-release preparations include semipermeable matrices of solid hydrophobic polymers containing the agent of interest, which matrices are in the form of shaped articles, *e.g.*, films, or microcapsule. Examples of sustained-release matrices include polyesters, hydrogels (for example, poly(2-hydroxyethyl-methacrylate), or poly(vinylalcohol)), polylactides (U.S. Pat. No. 3,773,919), copolymers of L-glutamic acid and γ ethyl-L-glutamate, non-degradable ethylene-vinyl acetate, degradable lactic acid-glycolic acid copolymers such as the LUPRON DEPOTTM (injectable microspheres composed of lactic acid-glycolic acid copolymer and leuprolide acetate), and poly-D-(-)-3-hydroxybutyric acid. While polymers such as ethylene-vinyl acetate and lactic acid-glycolic acid enable release of molecules for over 100 days, certain hydrogels release proteins for shorter time periods. When encapsulated agents remain in the body for a long time, they may denature or aggregate as a result of exposure to moisture at 37°C, resulting in a loss of biological activity and, for antibodies, possible changes in immunogenicity. Rational strategies can be devised for stabilization depending on the mechanism involved. For example, if the aggregation mechanism is discovered to be

intermolecular S-S bond formation through thio-disulfide interchange, stabilization may be achieved by modifying sulfhydryl residues, lyophilizing from acidic solutions, controlling moisture content, using appropriate additives, and developing specific polymer matrix compositions.

5 C. Methods of Treatment and Related Methods

Therapeutic methods using a PRO antagonist, a cytotoxic antibody, or an immunoconjugate are provided. Such methods include in vitro, ex vivo, and/or in vivo therapeutic methods, unless otherwise indicated.

In one aspect, the invention provides a method of inhibiting the proliferation of a lung cancer cell, the method comprising exposing the cell to 1) a PRO antagonist, 2) a cytotoxic anti-PRO antibody, or 3) an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent. In certain embodiments, the PRO gene is amplified or overexpressed in the lung cancer cell. In certain embodiments, the lung cancer cell is derived from a lung tumor, e.g., a lung tumor in which the PRO gene is amplified or overexpressed. In certain
10 embodiments, the lung cancer cell may be of any of the following cell lines: NCI-H1395, NCI-H1437, NCI-H2009, NCI-H2087, NCI-H2122, NCI-H2126, NCI-H1770 (non-small cell lung carcinoma-derived); and NCI-H82, NCI-H209, and NCI-H2171 (small cell lung carcinoma-derived). "Inhibiting the proliferation" means decreasing a cell's proliferation by at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, or 100%, and includes
15 inducing cell death. Inhibition of cell proliferation may be measured using methods known to those skilled in the art. For example, a convenient assay for measuring cell proliferation is the CellTiter-Glo™ Luminescent Cell Viability Assay, which is commercially available from Promega (Madison, WI). That assay determines the number of viable cells in culture based on quantitation of ATP present, which is an indication of metabolically active cells. See
20 Crouch et al (1993) *J. Immunol. Meth.* 160:81-88, US Pat. No. 6602677. The assay may be conducted in 96- or 384-well format, making it amenable to automated high-throughput screening (HTS). See Cree et al (1995) *AntiCancer Drugs* 6:398-404. The assay procedure involves adding a single reagent (CellTiter-Glo® Reagent) directly to cultured cells. This results in cell lysis and generation of a luminescent signal produced by a luciferase reaction.
25 The luminescent signal is proportional to the amount of ATP present, which is directly proportional to the number of viable cells present in culture. Data can be recorded by

luminometer or CCD camera imaging device. The luminescence output is expressed as relative light units (RLU).

In another aspect, a method of treating a lung cancer is provided, the method comprising administering to an individual having the lung cancer an effective amount of a pharmaceutical formulation comprising 1) a PRO antagonist, 2) a cytotoxic anti-PRO antibody, or 3) an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent. In certain embodiments, the lung cancer is associated with amplification or overexpression of the PRO gene. In certain embodiments, the individual is a non-human animal model for lung cancer. Mouse models of lung cancer are discussed in detail in Meuwissen et al. (2005) *Genes Dev.* 19:643-664. In certain embodiments, the individual is a human. In certain embodiments, an effective amount of the pharmaceutical formulation results in any one of the following: reduction in the number of cancer cells or elimination of the cancer cells; reduction in the tumor size; full or partial inhibition of cancer cell infiltration into peripheral organs, including the spread of cancer into soft tissue and bone; full or partial inhibition of tumor metastasis; full or partial inhibition of tumor growth; and/or full or partial relief of one or more of the symptoms associated with the cancer; and reduced morbidity and mortality.

In certain embodiments, a pharmaceutical formulation comprising 1) a PRO antagonist, 2) a cytotoxic anti-PRO antibody, or 3) an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent is administered in combination with at least one additional therapeutic agent and/or adjuvant. In certain embodiments, an additional therapeutic agent is a cytotoxic agent, a chemotherapeutic agent, or a growth inhibitory agent. In one of such embodiments, a chemotherapeutic agent is an agent or a combination of agents used in the treatment of lung cancer. Such agents include, but are not limited to, paclitaxel, carboplatin, cisplatin, and vinorelbine, either singly or in any combination, e.g., paclitaxel plus carboplatin; paclitaxel plus cisplatin; and vinorelbine plus cisplatin.

Such combination therapies noted above encompass combined administration (where two or more therapeutic agents are included in the same or separate formulations), and separate administration, in which case, administration of a PRO antagonist, cytotoxic antibody, or immunoconjugate can occur prior to, simultaneously, and/or following, administration of the additional therapeutic agent and/or adjuvant. A PRO antagonist, cytotoxic antibody, or immunoconjugate can also be used in combination with radiation therapy.

A PRO antagonist, cytotoxic antibody, or immunoconjugate (and any additional therapeutic agent or adjuvant) can be administered by any suitable means, including parenteral, subcutaneous, intraperitoneal, intrapulmonary, and intranasal, and, if desired for local treatment, intralesional administration. Parenteral infusions include intramuscular, intravenous, intraarterial, intraperitoneal, or subcutaneous administration. In addition, the PRO antagonist, cytotoxic antibody, or immunoconjugate is suitably administered by pulse infusion, particularly with declining doses of the PRO antagonist, cytotoxic antibody, or immunoconjugate. Dosing can be by any suitable route, e.g. by injections, such as intravenous or subcutaneous injections, depending in part on whether the administration is brief or chronic.

Where the PRO antagonist is an antisense nucleic acid, guidance for dosage and in vivo administration of antisense nucleic acids may be found in Khan et al. (2004) *J. Drug Targeting* 12:393-404.

Where the therapeutic agent is an anti-PRO antibody or immunoconjugate thereof, the appropriate dosage of the antibody or immunoconjugate (when used alone or in combination with one or more other additional therapeutic agents, such as chemotherapeutic agents) will depend on the particular antibody or immunoconjugate, the severity and course of the disease, whether the antibody or immunoconjugate is administered for preventive or therapeutic purposes, previous therapy, the patient's clinical history and response to the antibody or immunoconjugate, and the discretion of the attending physician. The antibody or immunoconjugate is suitably administered to the patient at one time or over a series of treatments. Depending on the type and severity of the disease, about 1 µg/kg to 15 mg/kg (e.g. 0.1mg/kg-10mg/kg) of antibody or immunoconjugate can be an initial candidate dosage for administration to the patient, whether, for example, by one or more separate administrations, or by continuous infusion. One typical daily dosage might range from about 1 µg/kg to 100 mg/kg or more, depending on the factors mentioned above. For repeated administrations over several days or longer, depending on the condition, the treatment would generally be sustained until a desired suppression of disease symptoms occurs. One exemplary dosage of an antibody or immunoconjugate would be in the range from about 0.05 mg/kg to about 10 mg/kg. Thus, one or more doses of about 0.5 mg/kg, 2.0 mg/kg, 4.0 mg/kg or 10 mg/kg (or any combination thereof) may be administered to the patient. Such doses may be administered intermittently, e.g. every week or every three weeks (e.g. such that the

patient receives from about two to about twenty, or, *e.g.*, about six doses of the antibody or immunoconjugate). An initial higher loading dose, followed by one or more lower doses may be administered. An exemplary dosing regimen comprises administering an initial loading dose of about 4 mg/kg, followed by a weekly maintenance dose of about 2 mg/kg of the antibody or immunoconjugate. However, other dosage regimens may be useful.

III. EXAMPLES

Ninety-two fresh frozen lung tumor samples, each from a different human patient, were analyzed. Each tumor sample had greater than 75% neoplastic cell content, as estimated by a pathologist. From each tumor sample, DNA was extracted and purified by standard methods.

A. DNA copy number analysis

The GeneChip® Human Mapping 500K Array Set (Affymetrix, Santa Clara, CA) was used to measure DNA copy number changes in the lung tumor samples. The Gene Chip® Human Mapping 500K Array Set consists of two arrays (the 250K “Sty I” array and the 250K “Nsp I” array), each containing probes specific for approximately 250,000 SNPs, for a total of approximately 500,000 SNPs. The SNPs are distributed throughout the genome, thereby permitting a genome-wide analysis of DNA copy number. Each array in the array set includes more than 6.5 million features, with each feature consisting of over 1 million copies of a 25-bp oligonucleotide of defined sequence.

From each tumor sample, DNA was amplified, labeled, and digested with either Sty I or Nsp I as per Affymetrix’s standard protocols, and the resulting preparation was allowed to hybridize to both arrays of the GeneChip® Human Mapping 500K Array Set.

Hybridization to the microarrays was detected according to Affymetrix’s standard protocols, and intensity values for each feature were generated. Intensity values were normalized to a reference set of normal genomic DNA. Features were then mapped to the corresponding coding regions (open reading frames) in the human genome. Thus, each of the normalized intensity values reflected the DNA copy number for a particular coding region.

B. Results

Of the 92 lung tumor samples analyzed, five non-small cell lung carcinomas showed amplification of a particular region of chromosome 4. Figures 1 and 2 show the results of the copy number analysis of chromosome 4, with Figure 2 focusing on the region of chromosome 4 from about nucleotide 50,000,000 to 60,000,000. Tumor samples are listed by numerical

designation (e.g., “HF-11763”), indicated at the left of the graphs in Figures 1 and 2, and by tumor type (e.g., “Squamous”), indicated at the right of the graph in Figure 2. The graphs in each figure show the normalized intensity values from the DNA copy number analysis for each tumor, with each feature being represented as a vertical line. For each tumor, the vertical lines are plotted along a horizontal axis, which represents the region of chromosome 4 indicated on the scale above each graph. The height of each vertical line reflects the normalized intensity value, which is a measure of the DNA copy number at that point on the chromosome. A spike of signal intensity was observed from about 54,500,000 to about 57,000,000 nucleotides for each tumor. The normalized intensity value at that region was increased by at least about 2-10 fold.

As shown in the bottom panel of Figure 2, the genes encoding PDGFRA, KIT, and KDR fall within the region of increased copy number. Amplification of those genes suggests that the encoded receptor tyrosine kinases are overexpressed, thereby promoting the growth and proliferation of lung tumor cells.

Although the foregoing invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, the descriptions and examples should not be construed as limiting the scope of the invention. The disclosures of all patent and scientific literatures cited herein are expressly incorporated in their entirety by reference.

WHAT IS CLAIMED IS:

1. A method of diagnosing the presence of a lung cancer in a mammal, the method comprising detecting whether the PRO gene is amplified in a test lung sample from the mammal relative to a control sample, wherein amplification of the PRO gene indicates the presence of lung cancer in the mammal.
2. The method of claim 1, wherein detecting whether the PRO gene is amplified comprises detecting whether the copy number of the PRO gene is increased by at least 5-fold.
3. A method of diagnosing the presence of a lung cancer in a mammal, the method comprising detecting expression of the PRO gene in a test lung sample from the mammal, wherein a higher level of PRO gene expression in the test lung sample relative to a control sample indicates the presence of lung cancer in the mammal.
4. The method of claim 3, wherein detecting expression of the PRO gene comprises determining the level of mRNA transcription from the PRO gene.
5. The method of claim 4, wherein a higher level of PRO gene expression comprises at least a 5-fold increase in mRNA transcription from the PRO gene in the test lung sample relative to the control sample.
6. The method of claim 3, wherein detecting expression of the PRO gene comprises determining the level of PRO.
7. The method of claim 6, wherein detecting expression of the PRO gene comprises contacting the test lung sample with an anti-PRO antibody and determining the level of expression of PRO in the test lung sample by detecting binding of the anti-PRO antibody to PRO.
8. The method of claim 6, wherein a higher level of PRO gene expression comprises at least a 5-fold increase in PRO levels.
9. A method of inhibiting the proliferation of a lung cancer cell, the method comprising exposing the cell to a PRO antagonist.
10. The method of claim 9, wherein the PRO antagonist is an anti-PRO antibody.
11. The method of claim 10, wherein the anti-PRO antibody binds to the extracellular domain of PRO.

12. The method of claim 10, wherein the anti-PRO antibody is an antibody fragment.

13. The method of claim 10, wherein the anti-PRO antibody is a chimeric or humanized antibody.

14. The method of claim 10, wherein the anti-PRO antibody is a human antibody.

5 15. The method of claim 9, wherein the PRO antagonist is an organic molecule that binds to PRO.

16. The method of claim 9, wherein the PRO antagonist is an oligopeptide that binds to PRO.

17. The method of claim 9, wherein the PRO antagonist is a soluble form of PRO.

10 18. The method of claim 9, wherein the PRO antagonist is an antisense nucleic acid of 10-30 nucleotides in length that binds to and reduces expression of a nucleic acid encoding PRO.

19. A method of inhibiting the proliferation of a lung cancer cell, the method comprising exposing the cell to (a) a cytotoxic anti-PRO antibody or (b) an immunoconjugate
15 comprising an anti-PRO antibody and a cytotoxic agent.

20. The method of claim 19, wherein the method comprises exposing the cell to a cytotoxic anti-PRO antibody.

21. The method of claim 19, wherein the method comprises exposing the cell to an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent.

20 22. The method of claim 21, wherein the cytotoxic agent is a maytansinoid or an auristatin.

23. A method of treating a lung cancer associated with amplification or overexpression of the PRO gene, the method comprising administering to an individual having the lung cancer an effective amount of a pharmaceutical formulation comprising a
25 PRO antagonist.

24. The method of claim 23, wherein the PRO antagonist is an anti-PRO antibody.

25. The method of claim 24, wherein the anti-PRO antibody binds to the extracellular domain of PRO.

26. The method of claim 24, wherein the anti-PRO antibody is an antibody fragment.

27. The method of claim 24, wherein the anti-PRO antibody is a chimeric or humanized antibody.

28. The method of claim 24, wherein the anti-PRO antibody is a human antibody.

5 29. The method of claim 23, wherein the PRO antagonist is an organic molecule that binds to PRO.

30. The method of claim 23, wherein the PRO antagonist is an oligopeptide that binds to PRO.

31. The method of claim 23, wherein the PRO antagonist is a soluble form of PRO.

10 32. The method of claim 23, wherein the PRO antagonist is an antisense nucleic acid of 10-30 nucleotides in length that binds to and reduces expression of a nucleic acid encoding PRO.

33. A method of treating a lung cancer associated with amplification or overexpression of the PRO gene, the method comprising administering to an individual
15 having the lung cancer an effective amount of a pharmaceutical formulation comprising (a) a cytotoxic anti-PRO antibody or (b) an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent.

34. The method of claim 33, comprising administering to an individual having the lung cancer an effective amount of a pharmaceutical formulation comprising a cytotoxic anti-
20 PRO antibody.

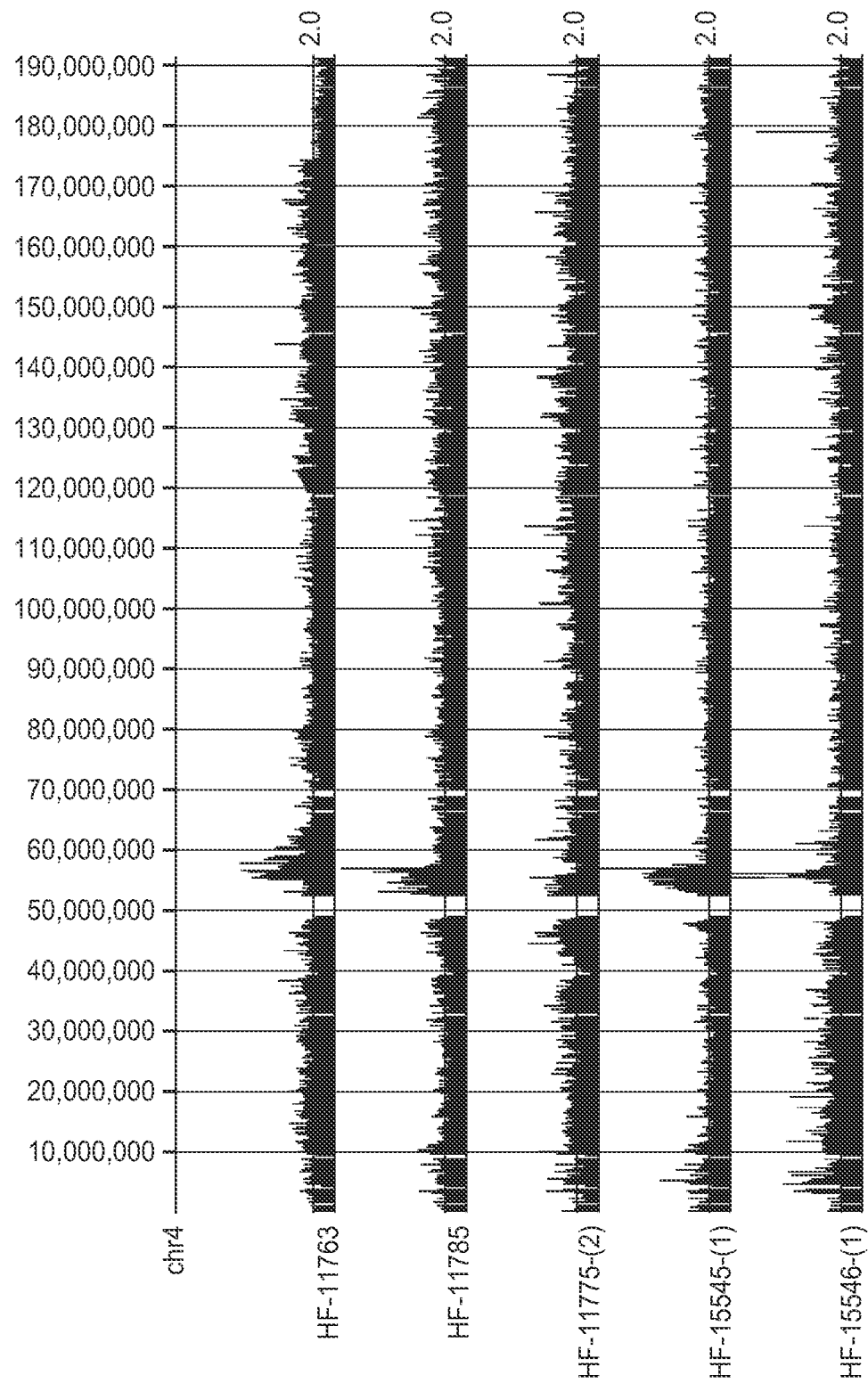
35. The method of claim 33, comprising administering to an individual having the lung cancer an effective amount of a pharmaceutical formulation comprising an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent.

36. The method of claim 35, wherein the cytotoxic agent is a maytansinoid or an
25 auristatin.

37. A method for determining whether an individual having a lung cancer will respond to a therapeutic that targets PRO or the PRO gene, the method comprising determining whether the PRO gene is amplified in the lung cancer, wherein amplification of the PRO gene indicates that the individual will respond to the therapeutic.

38. The method of claim 37, wherein the therapeutic is selected from (a) a PRO antagonist, (b) a cytotoxic anti-PRO antibody, or (c) an immunoconjugate comprising an anti-PRO antibody and a cytotoxic agent.

1 / 2

**FIG. 1**

2 / 2

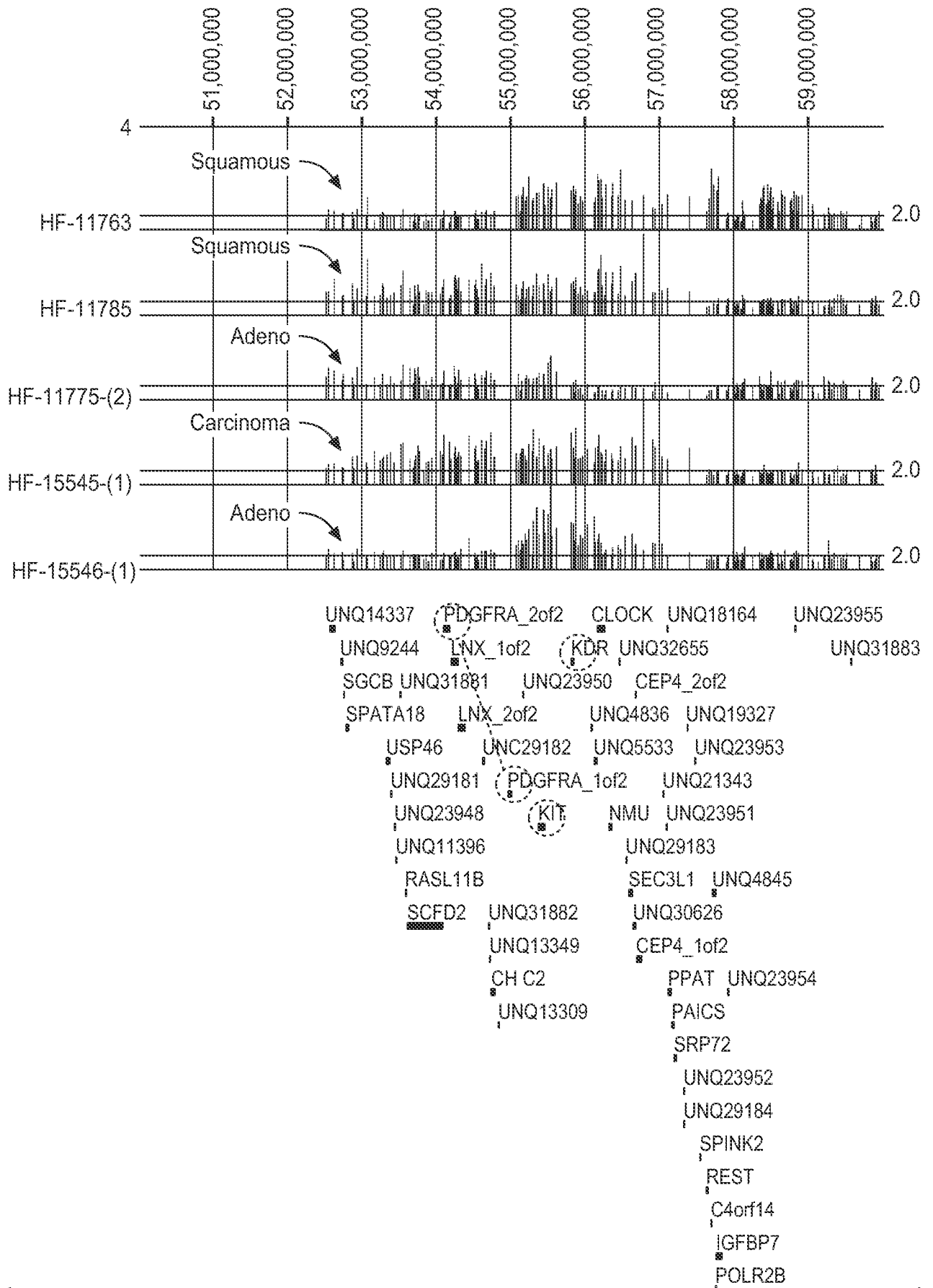


FIG. 2