TREATMENT OF TUMORS

TECHNICAL FIELD

[0001] The invention relates generally to biotechnology, and more specifically to methods of affecting tumor growth using peptides, such as tri-mers, 4-mers, 5-mers, 6-mers, 7-mers, and methods or treating subjects with a peptide and pharmaceutical compositions containing a peptide.

BACKGROUND

[0002] Cancer is the second leading cause of human death next to coronary disease. Worldwide, millions of people die from cancer every year. In the United States alone, as reported by the American Cancer Society, cancer causes the death of well over a half-million people annually, with over 1.2 million new cases diagnosed per year.

[0003] Worldwide, several cancers stand out as the leading killers. In particular, carcinomas of the lung, prostate, breast, colon, pancreas, and ovary represent the primary causes of cancer death. These and virtually all other carcinomas share a common lethal feature. With very few exceptions, metastatic disease from a carcinoma is fatal. Moreover, even for those cancer subjects who initially survive their primary cancers, common experience has shown that their lives are dramatically altered. Many cancer subjects experience strong anxieties driven by the awareness of the potential for recurrence or treatment failure. Many cancer subjects also experience physical debilitations during or following treatment. Furthermore, many cancer subjects experience a recurrence.

[0004] Due to the recurrence rates and side effects of current cancer treatments, improved cancer treatments represent a great need in society. Preferrably, those treatments are small molecules that are easily adsorbed by the body, cheap and easy to manufacture, effective, and do not have many of the side effect associated with current cancer treatments.

DISCLOSURE OF THE INVENTION

[0005] Where it was generally thought that the smallest breakdown products of proteins have no specific biological function on their own, it now emerges that the body may

utilize the normal process of proteolytic breakdown to generate important compounds. In particular, certain short breakdown products of hCG (*i.e.*, short peptides, derivates, or functional analogues which can easily be synthesized and used in a pharmaceutical composition) can be used to limit the progression of tumors.

[0006] The current invention relates to understanding and/or predicting the body's innate way of responding to small molecules and builds on insights reported in PCT International Publications WO99/59617, WO01/72831, and WO03/29292, the contents of the entirety of all of which are incorporated herein by this reference. These applications describe small gene-regulatory peptides that are present in pregnant women that are derived from proteolytic breakdown of placental gonadotropins, such as hCG. These breakdown products are often only about 3 to 6 amino acids long and were shown to have unsurpassed immunological activity that is exerted by regulating expression of genes encoding inflammatory mediators such as cytokines. Surprisingly, it was found that breakdown of hCG provides a cascade of peptides that helps maintain a pregnant woman's immunological homeostasis. These peptides balance the immune system to assure that the mother stays immunologically sound while her fetus does not get prematurely rejected during pregnancy, but instead is safely carried until its time of birth. Other peptides known in the art have the antigenic binding activity of human chorionic gonadotropin (hCG). *See e.g.* U.S. Patent 5,380,668 to Herron (Jan. 10, 1995), the contents of the entirety of which are incorporated by this reference. The oligopeptides disclosed therein are disclosed generally for use in diagnostic methods.

[0007] Other patents and patent applications, relate to the use of short polypetides to modulate biological systems. Fo example the patents an applications to Gallo *et al.* (*e.g.*, U.S. Patent 5,677,275 (corresponding to WO 96/04008 A1), U.S. Patent 5,877,148 (also corresponding to WO 96/04008 A1), WO 97/49721 A1, U. S. Patent 6,319,504 (corresponding to WO 97/49373), U.S. Patent Application 2003/0049273 A1 (also corresponding to WO 97/49373), U.S. Patent 5,968,513 (corresponding to WO 97/49418), U.S. Patent 5,997,871 (corresponding to WO 97/49432), U.S. Patent 6,620,416, U.S. Patent 6,596,688, WO 01/11048 A2, WO 01/10907 A2., and U.S. Patent 6,583,109),disclose various oligopeptides and their use in, among other things, "inhibiting HIV infection", "treating or preventing HIV infection", "treating or preventing cancer", "treating or preventing a condition characterized by loss of body cell mass", "treating or preventing a condition associated with

pathological angiogenesis", "treating or preventing hematopoietic deficiency", "ex vivo gene therapy", "expanding blood cells in vitro", and/or "providing blood cells to a subject".

[0008] In an exemplary embodiment, the present invention provides a method for identifying one or more peptides; and/or determining the activity of one or more peptides, comprising, for instance, screening a peptide to determine the activity of the peptide; analyzing the results; and/or identifying one or more peptide having anti-tumor activity.

[0009] In a further embodiment, derivates or functional anologues of anti-tumor peptides may be created.

[0010] The invention provides methods for reducting tumor growth by administering a pharmaceutical composition comprising a pharmacologically effective amount of at least one anti-tumor peptide or a derivative or a functional analogue thereof together with a pharmaceutically acceptable diluent to the subject. A particular useful pharmaceutically acceptable diluent is sterile water or an isotonic salt solution such as 0.9% saline or phosphate buffered salt (PBS). In a preferred embodiment, the invention provides the treatment of a subject suffering or believed to be suffering from cancer by mucosal, preferably oral administration of a pharmaceutical composition comprising a pharmacologically effective amount of two or more anti-tumor peptides, derivatives, or functional analogues thereof together with a pharmaceutically acceptable diluent to the subject.

[0011] The invention thus provides use of an anti-tumor peptide pharmaceutical composition for application to a subject for reducing tumor size and/or inhibiting tumor progression. Useful examples of such an anti-tumor peptides can be selected from the group of oligopeptides LQG, LAG, LQGV, AQGV, LAGV, VLPALP, and functional analogues or derivatives thereof. Functional analogues can for example be found in urinary fractions derived from pregnant woman or in commercial preparations of hCG; at least in those commercial preparations that contain substantial amounts of breakdown products of hCG.

[0012] A preferred size of an anti-tumor peptide for inclusion in a pharmaceutical composition according to the invention is at most 15 amino acids, preferably at most 7 amino acids, although much smaller molecules of 3, 4, 5, or 6 amino acids in length are particularly effective.

[0013] The invention also provides use of a peptide of smaller than 30 amino acids for the production of a pharmaceutical composition for the treatment a subject suffering

from or believed to be suffering from cancer. It is preferred that said peptide be smaller than 15 amino acids. When peptides are used repeatedly, for example as is provided herein for the treatment of cancer, from a safety viewpoint it is preferred that said peptide is smaller than 7 amino acids, such a peptide generally not binding to the MHC receptors, thereby decreasing the risk of the development of autoimmunity initiated by an immune response against administered peptide.

[0014] Subjects suffering from cancer will already benefit from the anti-inflammatory properties of some of the small peptides identified herein, but surprisingly most benefit will come from the anti-cell cycle activity of the small peptides, notably of the 3- and 4-mer peptides at dosages of above 1 mg/kg, preferably of above 5 mg/kg, more preferably of above 10 mg/kg body weight. Considering the low immunogenic nature of the small peptides (i.e. those of 3 to 4 aa), dosing to up to 100 mg/kg with small peptides, and in some cases when need for treatment is determined to be acute considering the condition of the subject in need of treatment, of up to 200 mg/kg, 500 mg/kg or even 1 g/kg will be possible.

[0015] Furthermore, it is particularly useful that subjects in need of treatment for cancer can now be treated via a subcutaneous or intra-muscular injection, thereby allowing self-treatment with an autoinjector or treatment by non-trained or non-medical personnel.

[0016] Other peptides, especially 3- or 4-mer peptides, can be found by testing for anti-cell cycle activity in proliferation assays, for example by using a plant growth assay as provided herein. Use of a peptide for the production of a pharmaceutical composition for the treatment a subject suffering from or believed to be suffering from cancer wherein said peptide consists of 2 to 6 amino acids is herein particularly provided. From the viewpoint of preventing adverse reactions, such as anaphylactic shock, it is thus preferred that the pharmaceutical composition comprises a peptide that consists of 2 to 6 amino acids, more preferably consists of 3 to 5 amino acids, and most preferably consists of 3 or 4 amino acids. If only from the viewpoint of activity, based on a general insight that activity is broader with increasing peptide size, if only to withstand full proteolysis (after administration) longer whereby metabolic fragments of 3 aa still have activity, it is herein preferred that said peptide consists of 4 amino acids.

[0017] Several useful 3-mer peptides for use in the production of a pharmaceutical composition for treatment of cancer are identified herein as VVC, LAG, and AQG. The invention also provides use of peptide VVC, LAG, or AQG for the production of a

pharmaceutical composition for the treatment of cancer, preferably for the treatment of metastatic carcinoma. Treatment according to the invention with a 3-mer peptide preferably comprises repeated administration, preferably 3-times-weekly or every second day, with a dose of at least 5 mg peptide/kg bodyweight of a patient, more preferably with a dose of at least 17 mg peptide /kg bodyweight, more preferably with a dose of at least 50 mg peptide/kg bodyweight peptide.

[0018] Similarly, several useful 4-mer peptides for treatment of cancer are LQGV, QVVC, MTRV, AQGV, LAGV, LQAV, PGCP, VGQL, RVLQ, EMFQ, AVAL, FVLS, NMWD, LCFL, FSYA, FWVD, AFTV, LGTL, QLLG, YAIT, APSL, ITTL, QALG, GVLC, NLIN, SPIE, LNTI, LHNL, CPVQ, EVVR, MTEV, EALE, EPPE, LGTL, VGGI, RLPG, LQGA, and LCFL, useful 5-mer peptides for treatment of cancer are TLAVE, VEGNL, and LNEAL, useful 6-mer peptides for treatment of cancer are VLPALP, MGGTWA, LTCDDP, useful 7-mer peptides for treatment of cancer are VLPALPQ, VCNYRDV, and CPRGVNP, a useful 8-mer peptide for treatment of cancer is QPLAPLVG and a useful 9-mer peptide for treatment of cancer is DINGFLPAL.

[0019] The invention also provides use of LQGV, QVVC, MTRV, AQGV, LAGV, LQAV, PGCP, VGQL, RVLQ, EMFQ, AVAL, FVLS, NMWD, LCFL, FSYA, FWVD, AFTV, LGTL, QLLG, YAIT, APSL, ITTL, QALG, GVLC, NLIN, SPIE, LNTI, LHNL, CPVQ, EVVR, MTEV, EALE, EPPE, LGTL, VGGI, RLPG, LQGA, or LCFL for the production of a pharmaceutical composition for the treatment of cancer, preferably for the treatment of metastatic carcinoma. Treatment according to the invention with a 4-mer peptide preferably comprises repeated administration, preferably 3-weekly or every second day , with a dose of at least 5 mg peptide/kg bodyweight of a patient, more preferably with a dose of at least 17 mg peptide /kg bodyweight, more preferably with a dose of at least 50 mg peptide/kg bodyweight peptide.

[0020] The invention also provides use of TLAVE, VEGNL, or LNEAL for the production of a pharmaceutical composition for the treatment of cancer, preferably for the treatment of metastatic carcinoma. Treatment according to the invention with a 5-mer peptide preferably comprises repeated administration, preferably 3-weekly or every second day, with a dose of at least 5 mg peptide/kg bodyweight of a patient, more preferably with a dose of at least 17 mg peptide /kg bodyweight, more preferably with a dose of at least 50 mg peptide/kg bodyweight peptide.

[0021] The invention also provides use of VLPALP, MGGTWA, or LTCDDP for the production of a pharmaceutical composition for the treatment of cancer, preferably for the treatment of metastatic carcinoma. Treatment according to the invention with a 6-mer peptide preferably comprises repeated administration, preferably 3-weekly or every second day, with a dose of at least 5 mg peptide/kg bodyweight of a patient, more preferably with a dose of at least 17 mg peptide /kg bodyweight, more preferably with a dose of at least 50 mg peptide/kg bodyweight peptide.

[0022] This size of smaller than 7 amino acids (aa) is also particularly preferred because it was determined (when comparing peptides derived from the human proteome with those derived from pathogen proteomes, in particular of viruses or bacteria (Burroughs et al., Immunogenetics, 2004, 56: 311-320)) that with a peptide size of 7 aa only 3% overlap between self or non-self is found. For peptides of 6 aa, that overlap in human self with pathogen non-self was determined to be 30%, for peptides of 5 aa, 90%, and for 4 aa long (and smaller) peptides, 100% overlap between the peptides present in the human proteome and the peptides present in the proteome of pathogens was determined. Based on these data, it is now herein recognized that when the self-non-self difference is not present, risk of adverse immune reactions, such as anaphylactic shock, is greatly diminished, which is a distinct advantage when treatment against cancer with a peptide according to the invention comprises repeat adaministration, such as repeated injections or 3-weekly injections for a prolonged period of for example 3 weeks as provided herein.

[0023] From the viewpoint of preventing adverse reactions such as anaphylactic shock it is thus preferred that the peptide consists of 2 to 6 amino acids, more preferably consists of 3 to 5 amino acids, and most preferably consists of 3 or 4 amino acids. From the viewpoint of activity, based on a general insight that activity is broader with increasing peptide size, if only to withstand full proteolysis longer whereby metabolic fragments of 3 aa still have activity, it is herein preferred that said peptide consists of 4 amino acids. Above and below described compositions are preferably used for the treatment of cancer.

[0024] Very suitable peptides for use in the treatment of cancer according to the invention are VVC, LAG, AQG, LQGV, QVVC, MTRV, AQGV, LAGV, LQAV, PGCP, VGQL, RVLQ, EMFQ, AVAL, FVLS, NMWD, LCFL, FSYA, FWVD, AFTV, LGTL, QLLG, YAIT, APSL, ITTL, QALG, GVLC, NLIN, SPIE, LNTI, LHNL, CPVQ, EVVR, MTEV, EALE,

EPPE, LGTL, VGGI, RLPG, LQGA, LCFL, TLAVE, VEGNL, or LNEAL. Herewith, the invention also provides a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer. The cell cycle is an ordered set of events, culminating in cell growth and division into two daughter cells. The stages of the cell cycle are G1-S-G2-M. The G1 stage stands for "GAP 1". The S stage stands for "Synthesis". This is the stage when DNA replication occurs. The G2 stage stands for "GAP 2". The M stage stands for "mitosis", and is when nuclear (chromosomes separate) and cytoplasmic (cytokinesis) division occur. The term "anti-cell cycle activity" as used herein is meant to indicate that the peptide is capable of altering cell cycle dynamics. For example, it comprises altering, i.e. increasing or reducing, the frequency of cell division. In one embodiment, it refers to an anti-proliferative activity.

[0025] Provided is a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising PGCP, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising VGQL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising RVLQ, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising EMFQ, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising AVAL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising FVLS, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising NMWD, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising LCFL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising FSYA, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising FWVD, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising AFTV, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising LGTL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising QLLG, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising YAIT, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising APSL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising ITTL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising QALG, a

pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising GVLC, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising NLIN, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising SPIE, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising LNTI, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising LHNL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising CPVQ, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising EVVR, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising MTEV, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising EALE, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising EPPE, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising LGTL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising VGGI, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising RLPG, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising LQGA, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising LCFL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising TLAVE, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising VEGNL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising LNEAL, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising MGGTWA, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising LTCDDP, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising VCNYRDV, a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising CPRGVNP, and a pharmaceutical composition having anti-cell cycle activity useful in the treatment of cancer comprising DINGFLPAL.

BRIEF DESCRIPTION OF DRAWINGS

[0026] While the specification concludes with claims particularly pointing out and distinctly claiming that which is regarded as the present invention, the advantages of this invention can be more readily ascertained from the following description of the invention when read in conjunction with the accompanying drawings in which:

[0027] FIG. 1 illustrates tumor volumes of mice treated with exemplary peptides of the invention wherein Peptides A through F correspond to the peptides LAG, LAGV, LQG, LQGV, AQGV, and VLPALP respectively; and

[0028] FIG. 2 illustrates the weight of tumor carrying mice treated with exemplary peptides of the invention wherein Peptides A through F correspond to the peptides LAG, LAGV, LQG, LQGV, AQGV, and VLPALP respectively.

[0029] FIG. 3 Tumor volume of Lewis Lung Carcinoma-bearing C57Bl6 mice treated with escalating doses of peptide LQGV. Doses of 1.7, 5, 17, 50 and 170 mg/kg were tested.

[0030] FIG 4. Tumor growth curves of all individual mice treated with escalating doses of peptide LQGV.

[0031] FIG 5. During the escalating dose experiment toxicity of LQGV was evaluated by evaluation of blood markers for kidney and liver function and leukocyte count.

[0032] Fig 6. During the escalating dose experiment toxicity of LQGV was evaluated by monitoring of animal weight.

BEST MODE FOR CARRYING OUT THE INVENTION

[0033] As used herein, a "purified or isolated" peptide is one that has been purified from a natural or biotechnological source, or, more preferably, is synthesized as described herein.

[0034] "Treating" or "treatment" does not require a complete cure. It means that the symptoms of the underlying disease are at least reduced, and/or that one or more of the underlying cellular, physiological, or biochemical causes or mechanisms causing the symptoms are reduced and/or eliminated. It is understood that reduced, as used in this context, means relative to the state of the disease, including the molecular state of the disease, not just the physiological state of the disease.

[0035] "Composition," as used herein, refers to chemical compounds which contain or consist of a peptide or a derivative or functional analogue thereof. The peptide is preferably isolated before inclusion within the composition. The peptide preferably consists

of three (3) to six (6) amino acids and most prefferedly consists of three (3) or four (4) amino acids.

[0036] As used herein, a "functional analogue" or "derivative" of a peptide includes variations made with regard to a reference peptide, which retains an identifiable relationship to the reference peptide, including variations made by pepscan, ala-scanning, replacement net analysis, methods disclosed in U.S. Patent Application number 10/456,375, as well as non-conservative and/or conservative substitutions relative to a reference sequence, for example, MTRVLQGVLPALPQVVC. Derivatives also include compounds having the same or equivalent sidechains as the particular amino acids used in a peptide, and arranged sequentially in the same order as the peptides, but joined together by non-peptide bonds, for instance, by isosteric linkages such as the keto isostere, hydroxy isostere, diketo isostere, or the keto-difluoromethylene isostere. Once a derivative is produced, such a derivative is a peptide for the purposes of screening, identification of activity, inclusion in a database, production of a pharmaceutical and the like.

[0037] Also included within derivatives or functional analogues are peptidomimetic compounds that functionally or structurally resemble the original peptide taken as the starting point, but that are, for example, composed of non-naturally occurring amino acids or polyamides. With "conservative amino acid substitution", one amino acid residue is substituted with another residue with generally similar properties (size, hydrophobicity, and/or charge), such that the overall functioning of a peptide sequence having such substitution is likely not to be seriously affected. In "non-conservative amino acid substitution", one amino acid residue is substituted with another residue with generally different properties (size, hydrophobicity, and/or charge), such that the overall functioning of a peptide sequence having such substitution is could be seriously affected. A derivative can also be provided by systematically altering at least one amino acid of the reference peptide. This can, for instance, be done by an Alanine scanning (Ala-scan) and/or replacement net analysis, in which each amino acid is replaced in turn with one of the 19 (or 21, if selenocysteine and pyrrolysine are included) other amino acids. With these methods, many different peptides may be generated, based on an original amino acid sequence but each containing a variation or substitution of at least one amino acid residue. This way, many positional variants of the original amino acid sequence are synthesized and/or enzymatically prepared.

[0038] Peptidomimetics further include pseudopeptides having surrogates for the peptide bonds between the original amino acids. (*See e.g.* U.S. Patent 6,689,753 to Soto-Jara). Such surrogates for peptide bonds include, but are not limited to CH_2, CH_2CH_2, CH=CH, C≡C, CH_2NH, $COCH_2$, CH_2S, CH_2SO_2, and NHCO.

[0039] Further included within derivatives or functional analogues are peptides that have been chemically modified through, for example, glycosylation, PEGylation, PEG alkylation, alkylation, acteylation, amidation, glycosyl-phophatdylinositalization, farnesylation, ADP-ribosylation, sulfation, lipid attachment, hydroxylation, and phosphorylation.

[0040] A derivative or analogue can also be, for instance, generated by substitution of an L-amino acid residue with a D-amino acid residue or other non-natural residues. Such a substitution may improve a property of an amino acid sequence, for example, to provide a peptide sequence of known activity of all D-amino acids in retro inversion format, thereby allowing for retained activity and increased half-life values. By generating many positional variants (derivatives) of an original amino acid sequence and screening for a specific activity, an improved peptide, for example, comprising D-amino acids, can be identified and used according to the invention.

[0041] Furthermore, a compound could, in one embodiment be:
NT Xaa_1 Xaa_2 Xaa_3 Xaa_4 CT

wherein NT at the N-terminus is selected from the group of H--, CH3--, an acyl group, or a general protective group; and CT at the C-terminus is selected from the group of small (for instance, 1 to 5 amino acids) peptides, --OH, --OR^1, --NH_2, --NHR^1, --NR^1 R^2, or --$N(CH_2)_{1\text{-}6}$ NR^1 R^2, wherein R^1 and R^2, when present, are independently selected from H, alkyl, aryl, (ar)alkyl, and wherein R^1 and R^2 can be cyclically bonded to one another. Such modifications constitute derivatives of the reference peptide.

[0042] "Alkyl" as used herein, is preferably a saturated branched or unbranched hydrocarbon having one to six carbon atoms, for instance, methyl, ethyl, and isopentyl.

[0043] "Aryl" as used herein, is an aromatic hydrocarbon group, preferably having 6 to 10 carbon atoms, such as phenyl or naphthyl.

[0044] "(Ar)alkyl", as used herein, is an arene group (having both aliphatic and aromatic portions), preferably having from 7 to 13 carbon atoms such as benzyl, ethylbenzyl, n-propylbenzyl, and isobutylbenzyl.

[0045] "Peptide," as used herein, means peptides having from 3 to about 50 amino acids joined together by peptide bonds.

[0046] "Composition" also includes, for example, an acceptable salt of the oligopeptide or a labeled peptide. As used herein, "acceptable salt" refers to salts that retain the desired activity of the peptide or equivalent compound, but preferably do not detrimentally affect the activity of the peptide or other component of a system, which uses the peptide. Examples of such salts are acid addition salts formed with inorganic acids, for example, hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, nitric acid, and the like. Salts may also be formed with organic acids such as, for example, acetic acid, oxalic acid, tartaric acid, succinic acid, maleic acid, fumaric acid, gluconic acid, citric acid, malic acid, ascorbic acid, benzoic acid, tannic acid, pamoic acid, alginic acid, polyglutamic acid, and the like. Salts may be formed with polyvalent metal cations such as zinc, calcium, bismuth, barium, magnesium, aluminum, copper, cobalt, nickel and the like or with an organic cation formed from N,N'-dibenzylethylenediamine or ethylenediamine, or combinations thereof (for instance, a zinc tannate salt).

[0047] The composition can be administered or introduced *in-vivo* systemically, topically, orally, or locally. The composition can be administered as a pharmaceutically acceptable acid- or base-addition salt, formed by reaction with an inorganic acid (such as hydrochloric acid, hydrobromic acid, perchloric acid, nitric acid, thiocyanic acid, sulfuric acid, and phosphoric acid); or with an organic acid (such as formic acid, acetic acid, propionic acid, glycolic acid, lactic acid, pyruvic acid, oxahc acid, malonic acid, succinic acid, maleic acid, and fumaric acid); or by reaction with an inorganic base (such as sodium hydroxide, ammonium hydroxide, potassium hydroxide); or with an organic base (such as mono-, di-, trialkyl and aryl amines and substituted ethanolamines). A peptide may also be conjugated to sugars, lipids, other peptides, nucleic acids and PNA; and function *in situ* as a conjugate or be released locally after reaching a targeted tissue or organ.

[0048] The compounds according to the invention may be prepared by methods known in the art (for example, *see*, U.S. Patent Application number 10/456,375). For example, by peptide synthesis methods known in the art, including, suitable N alpha protection (and side-chain protection if reactive side-chains are present). The amino acid derivatives or peptides are activated and coupled to suitably carboxyl protected amino acid or peptide derivatives either in solution or on a solid support. Protection of the α-amino group may utilize an acid-labile tertiary-butyloxycarbonyl group ("Boc"), benzyloxycarbonyl

("Z") group or substituted analogs or the base-labile 9-fluoremyl-methyloxycarbonyl ("Fmoc") group. The Z group can also be removed by catalytic hydrogenation, other suitable protecting groups include Nps, Bmv, Bpoc, Aloc, MSC, etc. A good overview of amino protecting groups is given in *The peptides, Analysis, Synthesis, Biology*, Vol. 3 E. Gross and J. Meienhofer, eds., (Academic Press, New York, 1981). Protection of carboxyl groups can take place by ester formation, for example, base-labile esters like methyl or ethyl, acid labile esters like tertiary butyl or, substituted, benzyl esters or hydrogenolytically. Protection of side-chain functions like those of lysine and glutamic or aspartic acid can take place using the aforementioned groups. Protection of thiol, and although not always required, of guanidino, alcohol and imidazole groups can take place using a variety of reagents such as those described in *The Peptides, Analysis, Synthesis, Biology*, or in *Pure and Applied Chemistry*, 59(3), 331-344 (1987). Activation of the carboxyl group of the suitably protected amino acids or peptides can take place by the azide, mixed anhydride, active ester, or carbodiimide method especially with the addition of catalytic and racemization-suppressing compounds like 1-N-N-hydroxybenzotriazole, N-hydroxysuccinimide, 3-hydroxy-4-oxo-3,4-dihydro-1,2,3,-benzotriazine, N-hydroxy-5 norbornene-2,3-dicarboxyimide. Also the anhydrides of phosphorus based acids can be used. *See, e.g., The Peptides, Analysis, Synthesis, Biology, supra* and *Pure and Applied Chemistry*, 59(3), 331-344 (1987).

[0049] It is also possible to prepare the compounds by the solid phase method of Merrifield. Different solid supports and different strategies are known *see, e.g.* Barany and Merrifield in *The Peptides, Analysis, Synthesis, Biology*, Vol. 2, E. Gross and J. Meienhofer, eds., (Acad. Press, New York, 1980), Kneib-Cordonier and Mullen *Int. J. Peptide Protein Res.*, 30, 705-739 (1987) and Fields and Noble *Int. J. Peptide Protein Res.*, 35, 161-214 (1990). The synthesis of compounds in which a peptide bond is replaced by an isostere, can, in general, be performed using the previously described protecting groups and activation procedures. Procedures to synthesize the modified isosteres are described in the literature for instance, for the --CH_2 --NH-- isostere and for the --CO--CH_2 -- isostere.

[0050] Removal of the protecting groups, and, in the case of solid phase peptide synthesis, the cleavage from the solid support may be performed by means known in the art (*see, e.g.* volumes 3, 5 and 9 of the series on *The Peptides Analysis, Synthesis, Biology, supra*).

[0051] Another possibility is the application of enzymes in synthesis of such compounds; for reviews see, *e.g.*, H. D. Jakubke in *The Peptides, Analysis, Synthesis, Biology*, Vol. 9, S. Udenfriend and J. Meienhofer, eds., (Acad. Press, New York, 1987). For example, by modifications such as glycosylation, phosphorylation and other modifications known in the art.

[0052] Peptides according to the invention may also be made according to recombinant DNA methods. Such methods involve the preparation of the desired peptide by means of expressing recombinant polynucleotide sequence which codes for one or more of the oligopeptides in a suitable host cell. Generally, the process involves introducing into a cloning vehicle (for instance, a plasmid, phage DNA, or other DNA sequence able to replicate in a host cell) a DNA sequence coding for the particular oligopeptide or oligopeptides, introducing the cloning vehicle into a suitable eucaryotic or procaryotic host cell, and culturing the host cell thus transformed. When a eucaryotic host cell is used, the compound may include a glycoprotein portion.

[0053] Pharmaceutical compositions containing the peptides described herein are administered to a subject suffering from or believed to be suffering from cancer. In therapeutic applications, compositions are administered to a subject in an amount sufficient to cause regression of the tumor, or at least partially arrest the tumorgenesis and metastasis. An amount adequate to accomplish this is defined as a "therapeutically effective dose." Amounts effective for this use will depend on, for instance, the nature of the peptide (specific activity, etc.), the manner of administration, the stage and severity of the cancer, the weight and general state of health of the subject, and the judgment of the prescribing physician.

[0054] Single or multiple administrations of a peptide composition can be carried out with dose levels and pattern being selected by a treating physician. In any event, the pharmaceutical formulations should provide a quantity of peptide sufficient to effectively treat the subject. Administration should begin at the first indication of undesirable cellular proliferation or shortly after diagnosis, and continue until symptoms are substantially abated and for a period thereafter. In well established cases of cancer, loading doses followed by maintenance doses may be required.

[0055] The pharmaceutical compositions for therapeutic treatment are intended for parenteral, topical, oral or local administration. The invention provides compositions for parenteral administration which comprise a solution of an anti-tumor peptide dissolved or

suspended in an acceptable carrier, preferably an aqueous carrier. A variety of aqueous carriers can be used, for instance, water, buffered water, 0.4% saline, 0.3% glycine, hyaluronic acid and the like. These compositions can be sterilized by conventional, well known sterilization techniques, or can be sterile filtered. The resulting aqueous solutions can be packaged for use as is, or lyophilized, the lyophilized preparation being combined with a sterile solution prior to administration. The compositions can contain pharmaceutically acceptable auxiliary substances as required to approximate physiological conditions, such as pH adjusting and buffering agents, tonicity adjusting agents, wetting agents and the like, for example, sodium acetate, sodium lactate, sodium chloride, potassium chloride, calcium chloride, sorbitan monolaurate, triethanolamine oleate, etc.

[0056] Other methods for preparing pharmaceutical compositions will be known or apparent to those skilled in the art and are described in more detail in for example, *Remington's Pharmaceutical Science,* 19th ed., Mack Publishing Company, Easton, Pa. (1990), which is incorporated herein by reference.

[0057] For solid compositions of the peptides of the invention, conventional nontoxic solid carriers can be used which include, for example, pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, sodium saccharin, talcum, cellulose, glucose, sucrose, magnesium carbonate, and the like. For oral administration, a pharmaceutically acceptable nontoxic composition is formed by incorporating any of the normally employed excipients, such as those carriers previously listed, and generally 10-95% of active ingredient, that is, one or more anti-tumor peptides, more preferably at a concentration of 25%-75%.

[0058] The present invention also includes a medicament that comprises at least one pharmaceutical agent contained within packaging material. The pharmaceutical agent is therapeutically effective for treating a tumor and may be selected from the group of peptides disclosed herein.

[0059] While most new drugs are intended to be administered orally, peptide based drugs may be subject to undesirable degradation, making alternative delivery methods, such as, intranasal administration or transdermal administration, more desirable, however, even with peptide based drugs, oral delivery is desirable (for instance, have good bioavailability).

[0060] As described in PCT International Publication No. WO 03/029292 A2 (published April 10, 2003), PCT International Publication No. WO 01/72831 A2 (published

October 4, 2001), and U.S. Patent Application Publications 20020064501 A1 (published May 30, 2002), 20030119720 A1 (published June 26, 2003), 20030113733 A1 (published June 19, 2003), and 20030166556 A1 (published September 4, 2003), the contents of all of which are incorporated by this reference, compositions containing purified or isolated oligopeptides described therein have immunoregulatory activity useful in, for example, the treatment of sepsis and other disease states and conditions. They also have gene regulatory activities.

[0061] The invention includes a method of screening compounds, including a purified or isolated peptide consisting of particular four to eight amino acid segments of the sequence MTRVLQGVLPALPQVVC; and derivatives thereof. Anti-tumor activity may be determined by treating a mouse challenged with a tumor and monitoring the tumor over time. In one embodiment, the amino acid segment includes a tetrameric sequence (for instance, corresponding to the LQVG) portion of MTRVLQGVLPALPQVVC, *i.e.*,

Xaa_1 Xaa_2 Xaa_3 Xaa_4

wherein Xaa_1 is a substituted or unsubstituted non-polar amino acid selected from the group consisting of Ala and Leu; Xaa_2 is a substituted or unsubstituted amino acid selected from the group consisting of Gln, Pro, and Ala; Xaa_3 is a substituted or unsubstituted Gly; and Xaa_4 is a substituted or unsubstituted non-polar amino acid selected from the group consisting of Val and Ala. For instance, the peptide could be selected from the group consisting of LQGV, the derivative AQGV, the derivative LQGA, the derivative LAGV, and the derivative LPGC.

[0062] In another embodiment, the segment is six amino acids long, and comprises the sequence

Xaa_1 Xaa_2 Pro Ala Xaa_2 Xaa_3

wherein Xaa_1 is substituted or unsubstituted Val or Ala, wherein Xaa_2 is independently selected from substituted or unsubstituted Leu or Ala, and wherein Xaa_3 is a substituted or unsubstituted Pro or Ala.

[0063] In such an embodiment, the peptide can have a formula selected from the group consisting of VLPALP, the derivative ALPALP, the derivative VAPALP, the derivative ALPALPQ, the derivative VLPAAPQ, the derivative VLPALAQ, the derivative VLPALA, VLPALPQ, the derivative VLPALPA, the derivative GVLPALP, and the derivative VLAALP.

[0064] In another embodiment, the composition has no more than eight amino acids, and includes an amino acid sequence consisting of:

Xaa_1 Xaa_2 Xaa_3 Xaa_4

wherein Xaa_1 is a substituted or unsubstituted amino acid selected from the group of amino acids consisting of Ala, Leu, and Met, wherein Xaa_2 is a substituted or unsubstituted amino acid selected from the group of amino acids consisting of Gln, Thr, Ala, and Pro, wherein Xaa_3 is substituted or unsubstituted Gly or Arg, and wherein Xaa_4 is a substituted or unsubstituted amino acid selected from the group of amino acids consisting of Cys, Ala, and Val. Anti-tumor activity may be determined by treating a mouse challenged with a tumor and monitoring the tumor over time.

[0065] In such an embodiment, the sequence may be selected from the group consisting of Leu Gln Gly Val, Ala Gln Gly Val, Leu Gln Gly Ala, Leu Ala Gly Val, Leu Pro Gly Cys, or Met Thr Arg Val, or a derivative thereof.

[0066] In another embodiment, the segment may be the tetramer MTRV or QVVC or a derivative thereof.

[0067] The invention further includes a pharmaceutical composition comprising a purified or isolated peptide, or acid addition salt thereof, the purified or isolated peptide having anti-tumor activity.

[0068] The invention provides a method for the identification of a peptide useful in the treatment of a tumor comprising administering to a subject believed to be in need of such treatment a composition comprising a peptide, derivative or functional analogue thereof, the particular molecule capable of anti-tumor activity.

[0069] In another embodiment, the composition comprises at least two peptides or derivatives thereof. For example, each peptide being capable of anti-tumor activity. By way of example, the at least two oligopeptides may be selected from the group LQGV, AQGV, and VLPALP or peptides identified by a method described herein.

[0070] The invention also provides use of a composition according to the invention for the preparation of a pharmaceutical composition or medicament and methods of treating various medical conditions, such as an immune-mediated disorder.

[0071] The invention is further explained with the aid of the following illustrative examples.

EXAMPLES

Example I

[0072] MATERIAL AND METHODS

[0073] PEPTIDE SYNTHESIS: The peptides as mentioned herein such as LQG, AQG, LQGV, AQGV, LQGA, VLPALP, ALPALP, VAPALP, ALPALPQ, VLPAAPQ, VLPALAQ, LAGV, VLAALP, VLPALA, VLPALPQ, VLAALPQ, VLPALPA, GVLPALP, VVCNYRDVRFESIRLPGCPRGVNPVVSYAVALSCQCAL, RPRCRPINATLAVEKEGCPVCITVNTTICAGYCPT, SKAPPPSLPSPSRLPGPS, LQGVLPALPQVVC, SIRLPGCPRGVNPVVS, LPGCPRGVNPVVS, LPGC, MTRV, MTR, and VVC were prepared by solid-phase synthesis (R.B. Merrifield, *J. Am. Chem. Soc.*, 85:2149-2165 (1963)) using the fluorenylmethoxycarbonyl (Fmoc)/tert-butyl-based methodology (Atherton, 1985) with 2-chlorotrityl chloride resin (Barlos et al., *Int. J. Peptide Protein res.*, 37:513-520 (1991)) as the solid support.

[0074] The side-chain of glutamine was protected with a trityl function. The peptides were synthesized manually. Each coupling consisted of the following steps: (i) removal of the alpha-amino Fmoc-protection by piperidine in dimethylformamide (DMF), (ii) coupling of the Fmoc amino acid (3 eq) with diisopropylcarbodiimide (DIC)/1-hydroxybenzotriazole (HOBt) in DMF/N-methylformamide (NMP) and (iii) capping of the remaining amino functions with acetic anhydride/diisopropylethylamine (DIEA) in DMF/NMP. Upon completion of the synthesis, the peptide resin was treated with a mixture of trifluoroacetic acid (TFA)/H_2O/triisopropylsilane (TIS) 95:2.5:2.5. After 30 minutes, TIS was added until decolorization. The solution was evaporated *in vacuo* and the peptide precipitated with diethylether.

[0075] The crude peptides were dissolved in water (50-100 mg/ml) and purified by reverse-phase high-performance liquid chromatography (RP-HPLC). HPLC conditions were: column: Vydac TP21810C18 (10 x 250 mm); elution system: gradient system of 0.1% TFA in water v/v (A) and 0.1% TFA in acetonitrile (ACN) v/v (B); flow rate 6 ml/min; absorbance was detected from 190-370 nm. There were different gradient systems used. For example, for peptides LQG and LQGV: 10 minutes 100% A followed by linear gradient 0-10% B in 50 minutes. For example for peptides VLPALP and VLPALPQ: 5 minutes 5% B followed by linear gradient 1% B/minute. The collected fractions were concentrated to about 5 ml by rotation film evaporation under reduced pressure at 40°C. The remaining TFA was exchanged against acetate by eluting two times over a column with anion exchange resin (Merck II) in acetate form. The eluate was concentrated and lyophilized in 28 hours. Peptides later were prepared for use by dissolving them in PBS.

Example II

[0076] *Animals and tumor model.* Mice (C57Bl6) are transplanted with the syngeneic Lewis Lung Carcinoma (LLC) subcutaneously.

[0077] *Treatment modalities:* mice are treated with small peptides or control substances beginning on the day of transplantation by i.p. injection. Mice are injected on Monday, Wednesday and Friday, until end of experiment. Experiment ends are based on: tumor size >20 mm, suffering of the animal, weight loss over 20%, ulcerations etc. Otherwise the experiment is terminated 8 weeks after start.

Method of efficacy evaluation.

[0078] *Assessment of tumor response*

[0079] Tumor diameter is measured in two directions by caliper measurements and tumor volume (V) is calculated using the formula $V = 0.4(A^2XB)$ (where B represents the largest diameter and A the diameter perpendicular to B). The classification of tumor response is: progressive disease (PD), increase of tumor volume (> 50 %) within 7 days (between day 3 and day 10 after begin of treatrment); stable disease, tumor volume equal to volume at day 3 in a range of -25 % and + 25 %; partial remission (R), tumor volume -25 % to -90 %, and complete response CR, (no) measurable tumor at 56 days after start of treatment.

[0080] Tumor growth evaluation is terminated when a tumor diameter of 20 mm is reached.

[0081] *Assessment of side-effects*

[0082] Side-effects are monitored on daily basis and classified according to protocol. A) Weight of the animals is monitored daily.

B) Behavior of the animals.

C) Animals are checked for possible side effects such as diarrhea.

Results

[0083] Tumor response

[0084] Mice were treated with i.p. injections of peptides 24 h after implantation of LLC tumor. In all mice receiving PBS tumor developed which reached on average a tumor volume of 1600 mm^3 in 21 days. Approximately tumor diameter was at that time point 16

mm. Thalidomide was used as a positive control. On day 21 an average tumor volume of 340 mm^3 was observed, while 3/6 mice showed complete tumor control for 56 days.

[0085] Administration of peptides LQG, LQGV, AQGV, and VLPALP induced a tumor growth delay (with LQG and LQGV comparable to Thalidomide) (Table 1). Administration of peptide LQGV resulted in strong tumor growth delay.

Table 1. Tumor response in mice bearing LLC tumor during and after treatment with small peptides.

group	treatment	volume day 21	tumor control	Response rate			
				PD	NC	PR	CR
1	Sham	1600	0/6	6			
2	peptide LAG	1550	2/6	4		1	1
3	peptide LAGV	1600	2/6	3	1	1	1
4	peptide LQG	620	3/6		4		2
5	peptide LQGV	270	2/6	1	2	1	2
6	peptide AQGV	1030	2/6	3	1	2	
7	peptide VLPALP	880	3/6	1	2	1	2
8	thalidomide	340	3/6		3	1	2

[0086] In mice treated with Thalidomide, as well as peptide LQG, a tumor response (meaning maximally a growth of 25% within 7 days) was obtained in all animals. In animals treated with peptides LQGV and VLPALP five out of six mice showed a response. Due to the small animal numbers we found no significances concerning volume. However, response rate of animals treated with peptides LQG, LQGV, and VLPALP as well as thalidomide (T), was significantly improved as compared to sham treated mice (LQG and T: $p < 0.002$, LQGV and VLPALP: $p < 0.015$).

[0087] From these results it becomes clear that administration of peptides resulted in tumor growth delay or tumor control. As is shown in FIG. 1, comparable tumor growth curves were obtained when mice were treated with anti-tumor peptides LQG and LQGV or thalidomide.

[0088] Side effects

[0089] As shown in FIG. 2, no effect was observed on body weight in the mice treated with small peptides. Also no other side effects as mentioned were observed.

[0090] All references, including database accession numbers, publications, patents, and patent applications, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[0091] **Example III**

[0092] Method of testing.

[0093] Animals and tumor model. Mice (C57Bl6) are transplanted with the syngeneic Lewis Lung Carcinoma (LLC) subcutaneously. Treatment is stared 24 h after implantation. The number of animals is 8 per group to increase the power of this study. As we are starting the treatment when no tumor is palpable the change of error is larger compared to a study with established tumors. Treatment modalities: mice are treated with small peptides or sham control beginning one day after transplantation by i.p. injection. Mice will be injected on Monday, Wednesday and Friday, until end of experiment. Experiment ends based on criteria as tumor size >20 mm, suffering of the animal, weight loss over 20%, ulcerations. Otherwise the experiment will be terminated 8 weeks after start.Method of efficacy evaluation.

[0094] Assessment of tumor response.

[0095] Tumor diameter is measured in two directions by caliper measurements and tumor volume (V) is calculated using the formula V = 0.4(A2XB) (where B represents the largest diameter and A the diameter perpendicular to B). The classification of tumor response is: progressive disease (PD), increase of tumor volume (> 25 %) within 7 days; no change (NC), tumor volume equal to volume at start of treatment in a range of -25 % and + 25 %; partial remission (PR), decrease of tumor volume between -25% and -90 %; complete remission (CR), tumor volume less than 10% of initial volume. Tumor growth evaluation is terminated when a tumor diameter of 20 mm is reached.

[0096] Assessment of side-effects. Side-effects are monitored on daily basis. a) Weight of the animals is monitored daily.b) Behavior of the animals is observed. c) Animals are checked for possible side effects such as diarrhea.

[0097] Statistics.

[0098] Tumor volumes were analyzed using non-parametric testing for multiple groups (Kruskal Wallis) and pair wise comparison of the different groups using Mann Whitney.

[0099] Results.

Tumor response.

Mice were treated with escalating doses of peptide as described in Materials and Methods. At a dose of 5 mg/kg a delay in tumor growth was observed (Figure 1). This delay was more pronounced in the higher dosages. Especially administration of 50 mg/kg strongly inhibited tumor growth. Control mice (negative: sham) demonstrated progressive tumor growth. Mice treated with Thalidomide (positive control) showed only some tumor growth delay. An overview of the individual tumor growth curves is presented in Figure 4. Statistical analysis is depicted in Table 2.

Table 2. Statistical analysis of tumor volumes and tumor response in different peptide treatment groups. Tumor volumes at day 20 were compared. Upper right: tumor volumes. Lower left: tumor response (see table 3).

	Sham	**1.7 mg/kg**	**5 mg/kg**	**17 mg/kg**	**50 mg/kg**	**170 mg/kg**
Sham	-	**0.45**	**0.57**	**0.15**	**0.50**	**0.33**
1.7 mg/kg	**0.62**	-	**0.70**	**0.01**	**0.002**	**0.06**
5 mg/kg	**0.09**	**0.03**	-	**0.51**	**0.55**	**0.54**
17 mg/kg	**0.01**	**0.004**	**0.35**	-	**0.63**	**0.94**
50 mg/kg	**0.09**	**0.03**	**1.00**	**0.35**	-	**1.00**
170 mg/kg	**0.09**	**0.03**	**1.00**	**0.35**	**1.00**	-

Table 3 Tumor response rates

Treatment	PD	TR	RR
Sham	8	3	27%
1.7 mg/kg	9	2	18%
5 mg/kg	4	7	64%
17 mg/kg	2	9	82%
50 mg/kg	4	7	64%
170 mg/kg	4	7	64%

Tumor response.

Tumor response was evaluated slightly differently from proposed. As we start shortly after tumor induction, shrinkage of the tumor compared to before treatment cannot be made. Next to that, we did not observe a tumor size reduction after initial outgrowth. So during the experimental time-frame outgrowth (progressive disease, PD) and tumor response (TR, growth delay till day 20) was evaluated. In Table 3 response rates are depicted.

Toxicity.

During the experiment toxicity of the administered peptides was evaluated by monitoring of animal weight (figure 6) and by evaluation of blood markers for kidney and liver function and leukocyte count (figure 5). At all doses, no effect on animal weight was observed. Administration of the peptides had no effect on leukocyte number and did not affect the liver and kidney parameters. It is important to compare not only between the groups but also within the groups between individual mice. These results show no effect of peptide administration on all parameters tested.

[00100] Example IV

To further study anti-cell cycle activity of various oligopeptides a proliferation experiment in *Arabidopsis thaliana* seedlings was performed. The aim was to test a group of 140 oligopeptides of varying length for their effect on plant marker gene expression during

rapid growth when avid cell division occurs. Both marker genes are related to the cell-cycle process, wherein high marker activity reflects a high cell-cycle activity and no marker activity reflects no cell-cycle activity and hence no proliferation.

Method

The peptides were re-suspended in 1x Phosphate Buffer Saline (PBS) pH8 to a final concentration of 5 mg/ml. The obtained solutions were then divided through 96-well round bottom plates (Corning Incorporated) at 40 microl per well. Plates were stored before use at –200C for four days. Seeds of *Arabidopsis thaliana* ecotype Ws-0 were surface sterilized in 2% commercial bleach (Glorix) for 10 minutes and washed five times with sterile MQ water. The seeds were then re-suspended with 0.1% agar and plated on MS20 plates supplemented with 80 mg/l Kanamycin.
The plates were placed at 40°C for 2 nights, and then transferred to a climate room at 210°C and a 16/8 hrs photoperiod. After four days of growth, the seedlings were transferred to 96-well plates containing the peptide solutions (4 seedlings per well) and incubated for 4 and 8 hours.

For this experiment *Arabidopsis* homozygous seedlings harbouring two reporter genes fused to GUS were used. The first reporter gene used was a cell cycle marker, pCDG (Carmona et al., The Plant Journal, 1999, 20(4), 503-508), and the second an auxin responsive marker, DR5::GUS (Ulmasov et al., The Plant Cell, Vol. 9, 1963-1971). After incubation with the compounds, the seedlings were stained for GUS. The staining reaction was performed in 100 mM sodium phosphate buffer (pH 7.0) that contained 10 mM EDTA, 10% DMSO, 0.1% Triton X-100, 2 mM X-Gluc, 0.5 mM $K_3Fe(CN)_6$ and 0.5 mM $K_4Fe(CN)_6$ at 37°C for 16 hours. To stop the GUS reaction and remove chlorophyl, the seedlings were subsequently treated for one hour with 96% ethanol and then stored in 70% ethanol. Stained seedlings were observed under a stereomicroscope and slides were made with seedlings showing an effect of the compound treatment. Seedlings were fixed and cleared in chloral hydrate solution for detailed microscopic observation and photography under a microscope equipped with DIC optics.

Results

Peptides were tested for an effect on marker gene expression on rapidly growing Arabidopsis young seedlings. This was monitored by changes on GUS distribution in different organs: root, root-hypocotyl transition zone and cotyledons.

From the 140 compounds tested, a total of 43 showed a clear effect on the expression of both markers tested. Surprisingly, the effects were clearly related to the length of the various peptides tested. As can be seen in Table 4 below, anti-cell cycle activity was over-represented in the short peptides, none of the peptides longer than 9 amino acids gave reduction of cell cycle activity. Of the peptides of 5 to 9 amino acids in length, about 22% showed reduction, but of the trimers and tetramers tested more than 50% showed reduction of cell cycle activity.

Table 4

Frequency distribution of peptides tested positive/peptide length as found in cell cycle test in *Arabidopsis thaliana*. #AA = peptide length in amino acids; # = number tested; #+ = number found positive; %+ = percentage positive

#AA	3	4	5	6	7	8	9	10	12	13	>14
#	6	65	9	11	10	2	17	7	3	5	5
#+	3	38	3	3	3	1	1	0	0	0	0
%+	**50%**	**58%**	**33%**	**27%**	**30%**	**50%**	**6%**	**0%**	**0%**	**0%**	**0%**

Results

From cell-cycle studies in plants and *in vivo* reduction of tumor growth in mice cells, useful 3-mer peptides for treatment of cancer were identified, VVC, LAG, AQG. Similarly, useful 4-mer peptides for treatment of cancer are LQGV, QVVC, MTRV, AQGV, LAGV, LQAV, PGCP, VGQL, RVLQ, EMFQ, AVAL, FVLS, NMWD, LCFL, FSYA, FWVD, AFTV, LGTL, QLLG, YAIT, APSL, ITTL, QALG, GVLC, NLIN, SPIE, LNTI, LHNL, CPVQ, EVVR, MTEV, EALE, cancer are TLAVE, VEGNL, LNEAL, useful 6-mer peptides for treatment of

cancer are VLPALP, MGGTWA, LTCDDP, useful 7-mer peptides for treatment of cancer are VLPALPQ, VCNYRDV, CPRGVNP, a useful 8-mer peptide for treatment of cancer is QPLAPLVG and a useful 9-mer peptide for treatment of cancer is DINGFLPAL.

CLAIMS:

1. A composition comprising:

a therapeutically effective amount of an anti-tumor peptide, functional analogue of the anti-tumor peptide, derivative of the anti-tumor peptide, or acceptable salt of the anti-tumor peptide together with a pharmaceutically acceptable diluent, wherein the anti-tumor peptide is selected from the group consisting of VVC, LAG, AQG, QVVC (SEQ ID NO:5), MTRV (SEQ ID NO:6), LAGV (SEQ ID NO:3), LQAV (SEQ ID NO:7), PGCP (SEQ ID NO:8), VGQL (SEQ ID NO:9), RVLQ (SEQ ID NO:10), EMFQ (SEQ ID NO:11), AVAL (SEQ ID NO:12), FVLS (SEQ ID NO:13), NMWD (SEQ ID NO:14), LCFL (SEQ ID NO:15), FSYA (SEQ ID NO:16), FWVD (SEQ ID NO:17), AFTV (SEQ ID NO:18), LGTL (SEQ ID NO:19), QLLG (SEQ ID NO:20), YAIT (SEQ ID NO:21), APSL (SEQ ID NO:22), ITTL (SEQ ID NO:23), QALG (SEQ ID NO:24), GVLC (SEQ ID NO:25), NLIN (SEQ ID NO:26), SPIE (SEQ ID NO:27), LNTI (SEQ ID NO:28), LHNL (SEQ ID NO:29), CPVQ (SEQ ID NO:30), EVVR (SEQ ID NO:31), MTEV (SEQ ID NO:32), EALE (SEQ ID NO:33), TLAVE (SEQ ID NO:38), VEGNL (SEQ ID NO:39), LNEAL (SEQ ID NO:40), MGGTWA (SEQ ID NO:41), LTCDDP (SEQ ID NO:42), VLPALPQ (SEQ ID NO:43), VCNYRDV (SEQ ID NO:44), CPRGVNP (SEQ ID NO:45), QPLAPLVG (SEQ ID NO:46), and DINGFLPAL (SEQ ID NO:47), wherein the therapeutically effective amount is an amount sufficient to impede or cease tumor growth in a subject to whom the composition is administered.

2. The composition of claim 1, wherein said anti-tumor peptide is smaller than seven (7) amino acids.

3. The composition of claim 2, wherein said peptide is from two (2) to six (6) amino acids long.

4. The composition of claim 3, wherein said peptide is three (3) or four (4) amino acids long.

5. The composition of claim 3, wherein the anti-tumor peptide is a three (3) to six (6) amino acid long fragment of MTRVLQGVLPALPQVVC (SEQ ID NO:48).

6. The composition of claim 1, configured as repeating dosage units of the anti-tumor peptide.

7. The composition of claim 6, wherein each repeated dosage unit comprises at least 5 mg peptide/kg bodyweight of a subject.

8. The composition of claim 7, wherein each repeated dosage unit comprises at least 50 mg peptide/kg bodyweight of a subject.

9. The composition of claim 6, wherein the repeated dosage unit comprises dosages for three weekly administrations.