PEPTIDES AND PEPTIDOMIMETICS IN COMBINATION USES AND TREATMENTS FOR CANCER PATIENT SUBPOPULATIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 61/838,777 filed June 24, 2013, which application is incorporated herein by reference in its entirety.

TECHNICAL FIELD

This invention relates to compounds including peptides and peptidomimetics having anti-cell proliferative activity alone, and in combination with treatments that either directly or indirectly damage nucleic acid (e.g., DNA). The invention compounds are therefore useful for inhibiting cell proliferation and, as such, for treating cell proliferative disorders including cancer.

INTRODUCTION

The cell cycle comprises S phase (DNA replication), M phase (mitosis), and two gap phases (G1 and G2 phases) between S and M phases. Checkpoints in the cell cycle ensure accurate progression, such as monitoring the state of DNA integrity, DNA replication, cell size, and the surrounding environment (Maller, J.L. Curr. Opin. Cell Biol., 3:26 (1991)). It is especially important for multi-cellular organisms to maintain integrity of genome, and there are multiple checkpoints that monitor the state of genome. Among them are G1 and G2 checkpoints existing before DNA replication and mitosis, respectively. It is crucial to correct DNA damage before entering S phase, because once damaged DNA is replicated it often gives rise to mutations (Hartwell, L. Cell, 71:543 (1992)). Progression through G1 and G2 checkpoints without repairing extensive DNA damage induces apoptosis and/or catastrophe.

Most cancer cells carry abnormalities in G1 checkpoint-related proteins such as p53, Rb, MDM-2, $p16^{INK4}$ and $p19^{ARF}$ (Levine, A.J. Cell, 88:323 (1997)). Alternatively, mutations can cause over-expression and/or over activation of oncogene products, e.g., Ras, MDM-2 and cyclin D, which reduce the stringency of G1 checkpoint. In addition to these mutations, excessive growth factor signaling can be caused by the over expression of growth factors and can reduce the stringency of G1 checkpoint. Together with loss and gain-of-function mutations, continuous activation of growth factor receptors or downstream signal-transducing molecules can cause cell transformation by overriding the

G1 checkpoint. Abrogated G1 checkpoint contributes to higher mutation rates and the many mutations observed in cancer cells. As a result, most cancer cells depend on G2 checkpoint for survival against excessive DNA damage (O'Connor and Fan, Prog. Cell Cycle Res., 2:165 (1996)).

The mechanism that promotes the cell cycle G2 arrest after DNA damage is believed to be conserved among species from yeast to human. In the presence of damaged DNA, Cdc2/Cyclin B kinase is kept inactive because of inhibitory phosphorylation of threonine-14 and tyrosine-15 residues on Cdc2 kinase or the protein level of Cyclin B is reduced. At the onset of mitosis, the dual phosphatase Cdc25 removes these inhibitory phosphates and thereby activates Cdc2/Cyclin B kinase. The activation of Cdc2/Cyclin B is equivalent to the onset of M phase.

In fission yeast, the protein kinase Chk1 is required for the cell cycle arrest in response to damaged DNA. Chk1 kinase acts downstream of several rad gene products and is modified by the phosphorylation upon DNA damage. The kinases Rad53 of budding yeast and Cds1 of fission yeast are known to conduct signals from unreplicated DNA. It appears that there is some redundancy between Chk1 and Cds1 because elimination of both Chk1 and Cds1 culminated in disruption of the G2 arrest induced by damaged DNA. Interestingly, both Chk1 and Cds1 phosphorylate Cdc25 and promote Rad24 binding to Cdc25, which sequesters Cdc25 to cytosol and prevents Cdc2/Cyclin B activation. Therefore Cdc25 appears to be a common target of these kinases implying that this molecule is an indispensable factor in the G2 checkpoint.

In humans, both hChk1, a human homologue of fission yeast Chk1, and Chk2/HuCds1, a human homologue of the budding yeast Rad53 and fission yeast Cds1, phosphorylate Cdc25C at serine-216, a critical regulatory site, in response to DNA damage. This phosphorylation creates a binding site for small acidic proteins 14-3-3s, human homologues of Rad24 and Rad25 of fission yeast. The regulatory role of this phosphorylation was clearly indicated by the fact that substitution of serine-216 to alanine on Cdc25C disrupted cell cycle G2 arrest in human cells. However, the mechanism of G2 checkpoint is not fully understood.

Tumor microenvironment also plays a role in the prevention or promotion of cancer cell growth, invasion, metastasis and anti-tumor immunity, which affects patient prognosis. Macrophages, once expected to work against cancer cells, have been indicated to play both inhibitory and promoting roles in the tumor development. Macrophages with

classical anti-tumor phenotype, referred to as M1, are pro-inflammatory, and those with pro-tumor and anti-inflammatory types are referred to as M2 with at least three major subtypes within this category (Martinez and Gordon, F1000Prime Reports 6:13 (2014)).

Neutrophil extracellular traps (NETs) represent another element of the tumor microenvironment along with leukocytes. While the formation of NETs are useful for neutrophils to fight against invading microorganisms they may contribute to deep vein thrombosis (DVT) (Martinnod and Wanger, Blood (2013)) and tumor cell metastasis (Cools-Lartigue, J., et al. J. Clin. Invest. (2013)) in cancer patients. Thus, NETs may adversely affect patient survival. DVT is common and potentially lethal in cancer patients, and leukocytosis (which leads to high WBC) is a major risk factor (Pabinger, I., et al. Blood 122:12 (2013); Blix, K., et al. PLOS One 4:8 (2013); Wang, T.F., et al. Thromb. Res. 133(1):25 (2014)).

SUMMARY

In accordance with the invention, provided are methods and uses of peptide compounds having one or more activities for inhibiting cell proliferation, stimulating apoptosis or catastrophe, abrogating cell cycle G2 checkpoint of a cell; or treating undesirable cell proliferation or survival, such as that characterized by a cell proliferative disorder. For example, the invention provides methods and uses of inhibiting cell proliferation; abrogating cell cycle G2 checkpoint of a cell; increasing sensitivity of a cell to a nucleic acid damaging agent or treatment; increasing nucleic acid damage to a cell.

In one embodiment, a method or use for increasing nucleic acid damage of a hyperproliferating cell or for the prophylaxis or treatment of a cell proliferative disorder in a mammal (e.g., a human) having a white blood cell count within a normal range, includes administering a peptide compound, wherein the peptide compound comprises any of the following sequences: A) a peptide comprising residues denoted P1-P6, with the structure, P1, P2, P3, P4, P5, P6 or P6, P5, P4, P3, P2, P1; wherein P1 is Cha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), an amino acid that occupies a similar side chain space, or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, quinazoline group in the side chain; wherein P2 is Cha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), Bpa, Phe4NO2, an amino acid that occupies a similar side chain space, or any amino acid with one or two aromatic, piperidine,

pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, or quinazoline group in the side chain; wherein P3, P4, P5 are any amino acid, or wherein one or more of P3, P4, P5 is a simple carbon chain such that the distance between P2 and P6 is about the same as the distance when each of P3, P4, P5 are amino acids; wherein P6 is Bpa, Phe4NO2, any one amino acid and Tyr, any one amino acid and Phe, any amino acid, or nothing; B) or the peptide of A), wherein the amino acid having a simple carbon chain is 11-aminoundecanoic acid, 10-aminodecanoic acid, 9-aminononanoic acid, 8-aminocaprylic acid, 7-aminoheptanoic acid, 6-aminocaproic acid, or a similar structure with one or more unsaturated carbon bonds, and/or wherein the any one amino acid is Ser, and/or wherein P4 is Trp, and/or wherein the amino acid that occupies a similar side chain space is Tyr or Phe; or a peptide comprising residues denoted P1-P12, with any the following structures:

P1, P2, P3, P4, P5, P6 ; P6, P5, P4, P3, P2, P1; P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12; P1, P2, P3, P4, P5, P6, P12, P11, P10, P9, P8, P7; P6, P5, P4, P3, P2, P1, P7, P8, P9, P10, P11, P12; P6, P5, P4, P3, P2, P1, P12, P11, P10, P9, P8, P7; P7, P8, P9, P10, P11, P12, P1, P2, P3, P4, P5, P6; P7, P8, P9, P10, P11, P12, P6, P5, P4, P3, P2, P1; P12, P11, P10, P9, P8, P7, P1, P2, P3, P4, P5, P6; P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1; P12, P11, P6, P9, P8, P7, P2, P1; P12, P11, P10, P6, P9, P4, P7, P2, P1; P1, P2, P7, P8, P9, P6, P11, P12; or P1, P2, P7, P4, P9, P6, P10, P11, P12; wherein P1 is Cha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), Bpa, Phe4NO2, an amino acid that occupies a similar side chain space (e.g. d- or l-Tyr, d- or l-Phe), or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, or quinazoline group in the side chain; wherein P2 is Cha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), or an amino acid that occupies a similar side chain space, or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, quinazoline group in the side chain; wherein P3, P4, P5 are any amino acid, or wherein one or more of P3, P4, P5 is a simple carbon chain such that the distance between P2 and P6 is about the same as the distance when each of P3, P4, P5 are amino acids; wherein P6 is Bpa, Phe4NO2, any one amino acid and Tyr, any one

amino acid and Phe; and wherein at least three of P7, P8, P9, P10, P11, P12 are basic amino acids with the rest being any amino acid or absent; or the peptide of C), wherein the amino acid having a simple carbon chain is 11-aminoundecanoic acid, 10-aminodecanoic acid, 9-amininononanoic acid, 8-aminocaprylic acid, 7-aminoheptanoic acid, 6-aminocaproic acid, or a similar structure with one or more unsaturated carbon bonds, and/or, wherein the any one amino acid is Ser, and/or, wherein P4 is Trp, and/or, wherein the amino acid that occupies a similar side chain space is Tyr or Phe; or a peptide comprising residues denoted P1-P12, with any the following structures: P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12; P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1; P12, P11, P10, P6, P9, P4, P7, P2, P1; or P1, P2, P7, P4, P9, P6, P10, P11, P12; wherein P1 isCha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), Bpa, Phe4NO2, an amino acid that occupies a similar side chain space, or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, or quinazoline group in the side chain; wherein P2 is Cha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), an amino acid that occupies a similar side chain space, or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, quinazoline group in the side chain; wherein P3, P4, P5 are any amino acid, or wherein one or more of P3, P4, P5 is a simple carbon chain such that the distance between P2 and P6 is about the same as the distance when each of P3, P4, P5 are amino acids; wherein P6 is Bpa, Phe4NO2, any one amino acid and Tyr, any one amino acid and Phe, any amino acid, or nothing; and wherein at least three of P7, P8, P9, P10, P11, P12 are basic amino acids with the rest being any amino acid or absent; or the peptide of E), wherein the amino acid having a simple carbon chain is aminoundecanoic acid or 8-aminocaprylic acid, and/or, wherein the any one amino acid is Ser, and/or, wherein the amino acid that occupies a similar side chain space is Tyr or Phe; or a peptide comprising residues denoted P1-P12, with any the following structures: P1, P2, P3, P4, P5, P6 or P6, P5, P4, P3, P2, P1, wherein P1 is Cha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), Bpa, Phe4NO2, Tyr, or Phe; wherein P2 is Cha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), Bpa, Phe4NO2, Tyr, or Phe; wherein P3 is Ser, Arg, Cys, Pro, or Asn; wherein P4 is Trp; wherein P5 is Ser, Arg, or Asn; or wherein

P3, P4, P5 is a single aminoundecanoic acid or a single 8-aminocaprylic acid; and wherein P6 is Bpa, Phe4NO2, (Ser-Tyr), or (Ser-Phe); or

a peptide comprising residues denoted P1-P12, with any the following structures: P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12; P1, P2, P3, P4, P5, P6, P12, P11, P10, P9, P8, P7; P6, P5, P4, P3, P2, P1, P7, P8, P9, P10, P11, P12; P6, P5, P4, P3, P2, P1, P12, P11, P10, P9, P8, P7; P7, P8, P9, P10, P11, P12, P1, P2, P3, P4, P5, P6; P7, P8, P9, P10, P11, P12, P6, P5, P4, P3, P2, P1; P12, P11, P10, P9, P8, P7, P1, P2, P3, P4, P5, P6; P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1; P12, P11, P6, P9, P8, P7, P2, P1; P12, P11, P10, P6, P9, P4, P7, P2, P1; P1, P2, P7, P8, P9, P6, P11, P12; or P1, P2, P7, P4, P9, P6, P10, P11, P12; wherein P1 is Cha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), Bpa, Phe4NO2, Tyr, or Phe; wherein P2 is Cha, Nal(2), (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3), Bpa, Phe4NO2, Tyr, or Phe; wherein P3 is Ser, Arg, Cys, Pro, or Asn; wherein P4 is Trp; wherein P5 is Ser, Arg, or Asn; or wherein P3, P4, P5 is a single aminoundecanoic acid or a single 8-aminocaprylic acid; wherein P6 is Bpa, Phe4NO2, (d-Ser-d-Tyr), or (d-Ser-d-Phe); and wherein at least three of P7, P8, P9, P10, P11, P12 are Arg or Lys with the rest being any amino acid or absent; or

a peptide comprising residues denoted P1-P12, with any the following structures: P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12; P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1; P12, P11, P10, P6, P9, P4, P7, P2, P1; or P1, P2, P7, P4, P9, P6, P10, P11, P12; wherein P1 is Cha, or Nal(2); wherein P2 is (Phe-2,3,4,5,6-F), (Phe-3,4,5F), (Phe-4CF3); wherein P3 is Ser; wherein P4 is Trp; wherein P5 is Ser or Asn; wherein P6 is Bpa, Phe4NO2, (Ser-Tyr), or (Ser-Phe); and wherein at least three of P7, P8, P9, P10, P11, P12 are Arg with the rest being any amino acid or absent; or a peptide comprising residues denoted P1-P12, with any the following structures: P1, P2, P3, P4, P5, P6 or P6, P5, P4, P3, P2, P1; wherein P1 is Cha, or Nal(2); wherein P2 is (Phe-2,3,4,5,6-F), (Phe-3,4,5F) or (Phe-4CF3); wherein P3 is Ser; wherein P4 is Trp; wherein P5 is Ser; and wherein P6 is Bpa, or (Ser-Tyr); or

a peptide comprising residues denoted P1-P12, with any the following structures: P1, P2, P3, P4, P5, P6; P6, P5, P4, P3, P2, P1; P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12; P1, P2, P3, P4, P5, P6, P12, P11, P10, P9, P8, P7; P6, P5, P4, P3, P2, P1, P7, P8, P9, P10, P11, P12; P6, P5, P4, P3, P2, P1, P12, P11, P10, P9, P8, P7; P7, P8, P9, P10, P11, P12, P1, P2, P3, P4, P5, P6; P7, P8, P9, P10, P11, P12, P6, P5, P4, P3, P2, P1; P12, P11, P10, P9, P8, P7, P1, P2, P3, P4, P5, P6; P12, P11, P10, P9, P8, P7, P6, P5, P4, P3,

P2, P1; P12, P11, P6, P9, P8, P7, P2, P1; P12, P11, P10, P6, P9, P4, P7, P2, P1; P1, P2, P7, P8, P9, P6, P11, P12; or P1, P2, P7, P4, P9, P6, P10, P11, P12; wherein P1 is Cha, orNal(2); wherein P2 is (Phe-2,3,4,5,6-F), (Phe-3,4,5F) or (Phe-4CF3); wherein P3 is any amino acid; wherein P4 is d- or l-Trp; wherein P5 is any amino acid; wherein P6 is Bpa or (Ser-Tyr); wherein P7 is Arg; wherein P8 is Arg; wherein P9 is Arg; wherein P10 is Gln or Arg; wherein P11 is Arg; and wherein P12 is d- or l-Arg, or

the peptide of K), wherein the any amino acid is Ser, or Pro; or

a peptide comprising residues denoted P1-P12, with any the following structures: P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12; P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1; P12, P11, P10, P6, P9, P4, P7, P2, P1; or P1, P2, P7, P4, P9, P6, P10, P11, P12; wherein P1 is Cha or Nal(2); wherein P2 is (Phe-2,3,4,5,6-F); wherein P3 is Ser; wherein P4 is Trp; wherein P5 is Ser; wherein P6 is Bpa or (Ser-Tyr); wherein P7 is Arg; wherein P8 is Arg; wherein P9 is Arg; wherein P10 is Gln or Arg; wherein P11 is Arg; and wherein P12 is Arg; or

a prodrug thereof or a pharmaceutically acceptable salt thereof to the mammal, thereby increasing nucleic acid damage of the hyperproliferating cell or prophylaxis or treatment of the cell proliferative disorder.

In particular embodiments, a method or use employs a peptide compound including any the following sequences: (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg) (d-Arg) (d-Arg) (d-Gln)(d-Arg) (d-Arg);

(d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg)(d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F) (d-Cha);

(d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Arg);

(d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha);

(d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser)(d-Trp)(d-Ser) (d-Bpa) (d-Arg) (d-Arg) (d-Arg) (d-Gln)(d-Arg) (d-Arg);

(d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg)(d-Cha)(d-Phe-2,3,4,5,6-F)(d-Ser)(d-Trp)(d-Ser)(d-Bpa);

(d-Cha)(d-Phe-2,3,4,5,6-F)(d-Ser)(d-Trp)(d-Ser)(d-Bpa)(d-Arg)(d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Arg);

(d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Arg) (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser)(d-Trp)(d-Ser) (d-Bpa);

(d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser) (d-Trp)(d-Ser)(d-Bpa);

(d-Cha)(d-Phe-2,3,4,5,6-F) (d-Ser) (d-Trp)(d-Ser)(d-Bpa)(d-Arg)(d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg);

(d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha);

(d-Bpa) (d-Ser) (d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg);

(d-Arg)(d-Arg)(d-Bpa) (d-Arg) (d-Arg) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha);

(d-Cha) (d-Phe-2,3,4,5,6-F) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Arg)(d-Arg);

(d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Arg)(d-Trp) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha);

(d-Cha) (d-Phe-2,3,4,5,6-F) (d-Arg)(d-Trp) (d-Arg) (d-Bpa) (d-Arg) (d-Arg) (d-Arg); (d-Arg)(d-Arg)(d-Arg)(d-Arg)(d-Bpa) (d-Arg)(d-Trp)(d-Arg) (d-Phe-2,3,4,5,6-F) (d-Cha); (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Arg) (d-Trp)(d-Arg) (d-Bpa) (d-Arg) (d-Arg) (d-Arg) (d-Arg);

(d-Arg) (d-Arg)(d-Arg)(d-Bpa)(d-Arg)(d-Arg) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha); or (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Arg) (d-Arg) (d-Arg).

In further particular embodiments, a method or use employs a peptide compound including or consisting of any the following sequences: (d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha)(SEQ ID NO:**1**); (d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg), or (d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg)(d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha).

In additional particular embodiments, a method or use is practiced on a mammal with a white blood cell count of less than about 11,000 white blood cells per microliter (wbc/μl) of blood; a mammal with a white blood cell count between about 4,000 to about 11,000 white blood cells per microliter (wbc/μl) of blood; a mammal with a white blood cell count of less than about 10,000 white blood cells per microliter

(wbc/μl) of blood; a mammal with a white blood cell count of less than about 9,000 white blood cells per microliter (wbc/μl) of blood; a mammal with a white blood cell count between about 4,000 to about 9,000 white blood cells per microliter (wbc/μl) of blood; a mammal with a white blood cell count of less than about 8,000 white blood cells per microliter (wbc/μl) of blood; a mammal with a white blood cell count of less than about 7,000 white blood cells per microliter (wbc/μl) of blood; or a mammal with a white blood cell count of less than upper normal limit by each clinical laboratories white blood cells per microliter (wbc/μl) of blood.

Methods and uses include a peptide compound in a pharmaceutical formulation. Invention methods and uses also include administration by any route. In particular embodiments, a peptide compound is administered locally, regionally or systemically.

Methods and uses include a pharmaceutically acceptable salt of a peptide compound. In particular aspects, a pharmaceutically acceptable salt is any one or a combination of: acetate, sulfonate, sulfate, pyrosulfate, bisulfate, sulfite, bisulfite, phosphate, monohydrogen-phosphate, dihydrogenphosphate, metaphosphate, pyrophosphate, chloride, bromide, iodide, propionate, decanoate, caprylate, acrylate, formate, isobutyrate, caproate, heptanoate, propiolate, oxalate, malonate, succinate, suberate, sebacate, fumarate, maleate, butyne-1,4-dioate, hexyne-1,6-dioate, benzoate, chlorobenzoate, methyl benzoates, dinitrobenzoates, hydroxybenzoates, methoxybenzoates, phthalates, , xylenesulfonate, phenylacetate, phenylpropionate, phenylbutyrate, citrate, lactate, γ-hydroxybutyrate, glycolate, tartrate, methane-sulfonate, propanesulfonate, naphthalene-1-sulfonate, naphthalene-2-sulfonate, and mandelate.

Methods and uses include a peptide compound including or consisting of a length from 6 to 10, 10 to 15, 15 to 20, 20 to 25, 25 to 30, 30 to 40, 40 to 50, 50 to 75, 75 to 100, 100 to 150, 150 to 200, or 200 to 300 amino acid residues.

Methods and uses include a peptide compound including or consisting of a cell penetrating molecule attached or conjugated thereto. In particular non-limiting aspects, a cell penetrating molecule is joined to the peptide compound by a covalent bond, or a peptide or a non-peptide linker. In further particular non-limiting aspects, a cell penetrating peptide comprises an alternating pattern of polar/charged amino acids and non-polar, hydrophobic amino acids. In still further particular non-limiting aspects, a cell penetrating peptide comprises a polycationic or amphipathic alpha-helix structure. In yet additional particular non-limiting aspects, cell penetrating peptide comprises a

poly-Arginine (Arg) sequence (e.g., a peptide including or consisting of (d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg)).

In still further particular aspects, a peptide compound and/or the cell penetrating peptide includes or consists of L- or D-isomer amino acids, or a mixture of L- and D-isomer amino acids.

In additional particular embodiments, a method or use further includes administering a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment. Non-limiting nucleic acid damaging agent, nucleic acid damaging treatment, anti-proliferative agent, or anti-proliferative treatment includes or consists of surgical resection, radiotherapy, ionizing or chemical radiation therapy, chemotherapy, immunotherapy, local or regional thermal (hyperthermia) therapy, vaccination, an alkylating agent, an anti-metabolite, a plant extract, a plant alkaloid, nitrosourea, a hormone, or a nucleoside or nucleotide analogue.

In still further particular embodiments, a method or use further includes or consists of the peptide compound administered prior to, with or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered. In particular aspects, a peptide compound is administered less than 48 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered; a peptide compound is administered less than 24 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered; a peptide compound is administered less than 12 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered; a peptide compound is administered less than 6 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered; a the peptide compound is administered less than 4 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered; a peptide compound is administered less than 2 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered; a

peptide compound is administered less than 1 hour prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered.

Non-limiting examples of a nucleic acid damaging agent or anti-proliferative agent include a drug. Non-limiting examples of a nucleic acid damaging agent or anti-proliferative agent include a platinum containing drug, such as cis-platin, carboplatin, nedaplatin, mitaplatin, satraplatin, picoplatin, triplatin, miriplatin, or oxaliplatin.

More particularly, methods and uses include or consist of administering a platinum containing drug, cis-platin, carboplatin, oxaliplatin, pemetrexed, gemcitabine, 5-fiuorouracil (5-FU), rebeccamycin, adriamycin (ADR), bleomycin (Bleo), pepleomycin, cisplatin, cisplatinum, or *cis*-diamminedichloroplatinum(II) (CDDP), oxaliplatin, or camptotecin (CPT), cyclophosphamide, azathioprine, cyclosporin A, prednisolone, melphalan, chlorambucil, mechlorethamine, busulphan, methotrexate, 6-mercaptopurine, thioguanine, 5-fluorouracil, cytosine arabinoside, AZT, 5-azacytidine (5-AZC) or a 5-azacytidine related compound, actinomycin D, mithramycin, mitomycin C, carmustine, lomustine, semustine, streptozotocin, hydroxyurea, cisplatin, mitotane, procarbazine, dacarbazine, a taxane, vinblastine, vincristine, doxorubicin, dibromomannitol, radiation or a radioisotope. Particular non-limiting examples of radiation include UVradiation, IR radiation, Xray, or alpha-, beta- or gamma-radiation. Particular non-limiting examples of radioisotopes include I^{131}, I^{125}, Sr^{89}, Sm^{153}, Y^{90}, or Lu^{177}.

Invention methods and uses are applicable to a cell proliferative or hyperproliferative disorder or undesirable cell proliferation. In particular embodiments, a cell proliferative disorder comprises a tumor or cancer. In more particular embodiments, a cell proliferative disorder comprises a metastatic tumor or cancer.

Particular non-limiting examples of a tumor or cancer include a lung tumor or cancer, such as a small cell or non-small cell lung cancer, or an adenocarcinoma, squamous cell carcinoma or a large cell carcinoma. Further particular non-limiting examples of a tumor or cancer include a carcinoma, sarcoma, lymphoma, leukemia, adenoma, adenocarcinoma, melanoma, glioma, glioblastoma, meningioma, neuroblastoma, retinoblastoma, astrocytoma, oligodendrocytoma, mesothelioma,

reticuloendothelial, lymphatic or haematopoietic neoplasia, tumor, cancer or malignancy. Additional particular non-limiting examples of tumor or cancer is a lung, thyroid, head or neck, nasopharynx, throat, nose or sinuses, brain, spine, breast, adrenal gland, pituitary gland, thyroid, lymph, gastrointestinal (mouth, esophagus, stomach, duodenum, ileum, jejunum (small intestine), colon, rectum), genito-urinary tract (uterus, ovary, cervix, endometrial, bladder, testicle, penis, prostate), kidney, pancreas, liver, bone, bone marrow, lymph, blood, muscle, or skin neoplasia, tumor, or cancer. Still further particular non-limiting examples of a tumor or cancer include a breast cancer, prostate cancer, pancreas cancer, gastric cancer, pleural mesothelioma, colon cancer, rectal cancer, large bowel cancer, small intestinal cancer, esophageal cancer, duodenal cancer, lingual cancer, pharyngeal cancer, salivary gland cancer, cerebral tumor, schwanoma, liver cancer, kidney cancer, bile duct cancer, endometrial cancer, cervical cancer, uterine body cancer, ovarian cancer, bladder cancer, urethral cancer, skin cancer, angioma, malignant lymphoma, malignant melanoma, thyroid cancer, parathyroid cancer, nasal cancer, paranasal cancer, auditory organ cancer, carcinoma of oral floor, laryngeal cancer, parotid cancer, submandibular cancer, bone tumor, angiofibroma, retinal sarcoma, penile cancer, testicular tumor, pediatric solid cancer, Kaposi's sarcoma, tumor of maxillary sinus, fibrous histiocytoma, leiomyosarcoma, rhabdomyosarcoma, lymphoma, multiple myeloma or leukemia.

Particular non-limiting examples of a sarcoma include a lymphosarcoma, liposarcoma, osteosarcoma, chondrosarcoma, leiomyosarcoma, rhabdomyosarcoma or fibrosarcoma. Particular non-limiting examples of a haematopoietic tumor, cancer or malignancy include a myeloma, lymphoma or leukemia.

Invention methods and uses include administering an amount of a peptide compound effective to treat the tumor or cancer. In poarticualr aspects, a method or use inhibits or reduces relapse, growth, progression, worsening or metastasis of the tumor or cancer; results in partial or complete destruction of the neoplastic, tumor, cancer or malignant cell mass, volume, size or numbers of cells, stimulating, inducing or increasing neoplastic, tumor, cancer or malignant cell necrosis, lysis or apoptosis, reducing neoplasia, tumor, cancer or malignancy volume size, cell mass, inhibiting or preventing progression or an increase in neoplasia, tumor, cancer or malignancy volume, mass, size or cell numbers, or prolonging lifespan; results in reducing or decreasing severity, duration or frequency of an adverse symptom or complication associated with or caused by the

neoplasia, tumor, cancer or malignancy; or method results in reducing or decreasing pain, discomfort, nausea, weakness or lethargy, or results in increased energy, appetite, improved mobility or psychological well being.

Moreover, provided are kits including peptide compounds optionally in combination with a nucleic acid damaging treatment (e.g., a nucleic acid damaging agent), or an anti-proliferative agent. In one embodiment, a kit includes a peptide compound and instructions for use in practicing a method of the invention (e.g., administering to a mammal with a white blood cell count in a normal range, e.g., a mammal with a white blood cell count of less than about 11,000 white blood cells per microliter (wbc/µl) of blood; a mammal with a white blood cell count between about 4,000 to about 11,000 white blood cells per microliter (wbc/µl) of blood; a mammal with a white blood cell count of less than about 10,000 white blood cells per microliter (wbc/µl) of blood; a mammal with a white blood cell count of less than about 9,000 white blood cells per microliter (wbc/µl) of blood; a mammal with a white blood cell count between about 4,000 to about 9,000 white blood cells per microliter (wbc/µl) of blood; a mammal with a white blood cell count of less than about 8,000 white blood cells per microliter (wbc/µl) of blood; a mammal with a white blood cell count of less than about 7,000 white blood cells per microliter (wbc/µl) of blood; or a mammal with a white blood cell count of less than upper normal limit by each clinical laboratories white blood cells per microliter (wbc/µl) of blood).

DESCRIPTION OF DRAWINGS

Figure 1 shows a dose response curve of each compound when used against bleomycin treated Jurkat cells. X-axis indicates the dose and Y-axis indicates the %G2/M cells after treatment.

Figure 2 shows a dose response curve of each compound when used against colchicine treated Jurkat cells. X-axis indicates the dose and Y-axis indicates the %G2/M cells after treatment.

Figures 3A and 3B Human pancreatic cancer derived cell line MIAPaCa2 treated with **(A)** bleomycin (Bleo) or **(B)** adriamycin (ADR) with various doses of compounds. Harvested cells were stained for their DNA and analyzed with flow cytometry. The % population of sub-G1 cells are indicated as dead cells.

Figures 4A to 4C are a schematic diagram of the structure activity relationship of G2 checkpoint abrogator (l-Gly)(l-Arg)(l-Lys)(l-Lys)(l-Arg)(l-Arg)(l-Gln) (l-Arg)

(l-Arg)(l-Cha)(l-Phe-2,3,4,5,6-F)(l-Arg)(l-Ser)(l-Pro)(l-Ser)(l-Tyr)(l-Tyr) (SEQ ID NO:78): **(A)** G2 checkpoint abrogation activity of amino acid substitutions for l-Cha in bleomycin treated Jurkat cells are indicted in order, [l-Cha=l-Nal(2)] > [l-Ala(3-Bzt)=l-Nal(1)=l-Trp=l-Dph] > [l-Ala(tBu)=Cys(tBu)=Leu]; **(B)** M phase checkpoint abrogating activity and/or non specific toxicity of amino acid substitutions for l-Cha in cholchicine treated Jurkat cells in order, [Ala(3-Bzt)=l-Nal(1)=l-Dph] > [l-Cha=l-Nal(2)]; **(C)** G2 checkpoint abrogating activity of amino acid substitution for l-Phe-2,3,4,5,6-F are indicted in order, l-(Phe-2,3,4,5,6-F)=l-(Phe-3,4,5-F)=l-(Phe-4CF3)] > [l-(Phe-3Br,4Cl,5Br) =l-(Phe-4Cl)=l-Tyr].

Figure 5 shows G2 abrogating activity of various arginine rich sequences. Indicated peptides were added to Jurkat cells with or without bleomycin. The %G2/M cells is indicated on the Y-axis. X-axis is as follows: 1, Bleomycin alone; 2, 0.2μg/ml; 3, 0.39 μg/ml; 4, 0.78 μg/ml; 5, 1.56 μg/ml; 6, 3.125 μg/ml; 7, 6.25 μg/ml; 8, 12.5 μg/ml; 9, 25 μg/ml; and 10, 50 μg/ml. Peptide sequences are as follows: rrrqrrkkr, (d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg)(d-Arg) (d-Arg)(d-Gln) (d-Arg) (d-Arg)(d-Lys)(d-Lys)(d-Arg) (SEQ ID NO:79); CBP501, (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg) (d-Arg)(SEQ ID NO:80); no TAT, (d-Bpa) (d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F) (d-Cha) (SEQ ID NO:81); rqrr, (d-Bpa)(d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Gln)(d-Arg) (d-Arg)(SEQ ID NO:82); rrqrr, (d-Bpa)(d-Ser) (d-Trp) (d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg)(d-Arg)(d-Gln) (d-Arg)(d-Arg)(SEQ ID NO:83); rrrq, (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg)(d-Gln)(SEQ ID NO:84); and rrrqr, (d-Bpa)(d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg)(SEQ ID NO:85).

Figure 6 shows G2 abrogating activity of various peptides without (d-Bpa). Indicated peptides were added to Jurkat cells with or without bleomycin. The %G2/M cells is indicated on the Y-axis. X-axis is as follows: 1, Bleomycin alone; 2, 0.2μg/ml; 3, 0.39μg/ml; 4, 0.78μg/ml; 5, 1.56μg/ml; 6, 3.125μg/ml; 7, 6.25μg/ml; 8, 12.5μg/ml; 9, 25μg/ml; and 10, 50μg/ml. Peptide sequences are as follows: CBP0, (d-Arg)(d-Arg) (d-Arg)(d-Gln)(d-Arg) (d-Arg)(SEQ ID NO:86); CBP451, (d-Tyr)(d-Ser)(d-Pro) (l-Trp)(l-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg) (d-Arg)(SEQ ID NO:87); CBP452, (d-Tyr)(d-Ser)(l-Pro)(l-Trp)(l-Ser)(d-Phe-2,3,4,5,6-F) (d-Cha)(d-Arg)(d-Arg) (d-Arg)(d-Gln) (d-Arg) (d-Arg)(SEQ ID NO:88); and CBP501,

(d-Bpa)(d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg)(d-Arg) (SEQ ID NO:80).

Figure 7 shows G2 abrogating activity of various arginine rich and lysine rich peptide sequences. Indicated peptides were added to Jurkat cells as above and the %G2/M cells calculated (Y-axis). Peptide sequences are as follows: CBP603, (d-Bpa)(d-Ser) (d-Trp) (d-Ser)(d-Phe4NO2)(d-Cha)(d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg) (d-Arg)(SEQ ID NO:89); CBP607, (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg)(SEQ ID NO:90); CBP608, (d-Bpa)(d-Ser)(d-Trp)(d-Ser) (d -Phe-2,3,4,5,6-F)(d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg)(SEQ ID NO91:); and CBP609, (d-Bpa)(d-Ser)(d-Trp) (d-Ser) (d-Phe-2,3,4,5,6-F) (d -Cha) (d-Lys) (d-Lys) (d-Lys) (d-Lys) (d-Lys) (d-Lys) (SEQ ID NO:92).

Figure 8 shows that the location of the arginine rich portion of the sequence can be varied. Indicated peptides were added to Jurkat cells as above and the %G2/M cells calculated (Y-axis). Peptide sequences are as follows: CBP501, (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha)(d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:80); CBP510, (d-Arg)(d-Arg) (d-Gln) (d-Arg) (d-Arg)(d-Arg) (d-Cha)(d-Phe-2,3,4,5,6-F) (d-Ser)(d-Trp) (d-Ser) (d-Bpa) (SEQ ID NO:93); CBP511, (d-Arg)(d-Arg) (d-Gln) (d-Arg) (d-Arg)(d-Arg) (d-Bpa)(d-Ser) (d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:94); and CBP512, (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Cha)(d-Phe-2,3,4,5,6-F)(d-Ser)(d-Trp)(d-Ser) (d-Bpa) (SEQ ID NO:95).

Figure 9 shows the structure of several studied substituted peptide sequences. G2 abrogating activity increased with the light shaded substitutions (*), M phase checkpoint abrogating activity and/or non specific toxicity increased with the darker shaded substitutions (**) and remained about the same for the rest of the substitutions.

Figure 10 shows inhibition of tumor growth (human pancreatic carcinoma) in scid mice following treatment with CBP501 and cisplatin. Day0 indicates treatment initiation. Mean tumor sizes with standard deviation for each treatment group are indicated on the Y-axis and the number of days following treatment initiation are indicated on the X-axis.

Figure 11 shows G2 abrogating activity of peptides having a kinase inhibitng sequence region and a sequence region based upon an HIV-TAT transduction sequence, as above. The %G2/M cells is indicated on the Y-axis. X-axis is as follows: 1,

Bleomycin alone; 2, 0.2μg/ml; 3, 0.39 μg/ml; 4, 0.78 μg/ml; 5, 1.56 μg/ml; 6, 3.125 μg/ml; 7, 6.25 μg/ml; 8, 12.5 μg/ml; 9, 25 μg/ml; and 10, 50 μg/ml. Peptide sequences are as follows: CBP501, (d-Bpa)(d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:80); CBP700, (d-Arg)(d-Arg)(d-Bpa) (d-Arg) (d-Arg) (d-Arg) (d-Phe-2,3,4,5,6-F) (d-Cha) (SEQ ID NO:96); CBP701, (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Arg)(d-Trp) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:97); CBP702, (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Arg)(d-Trp) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:98); CBP703, (d-Arg) (d-Arg)(d-Arg)(d-Bpa) (d-Arg) (d-Arg) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:99).

Figure 12 shows a comparison between G2 abrogating activity and M abrogating activity and/or non specific toxicity of peptides with Bleomycin for G2 abrogation analysis and colchicine for M abrogating activity and/or non specific toxicity. Indicated peptides were added to Jurkat cells with bleomycin or colchicine. The %G2/M cells is indicated on the Y-axis. X-axis is as follows: 1, Bleomycin or Colchicine alone; 2, 0.2μg/ml; 3, 0.39 μg/ml; 4, 0.78 μg/ml; 5, 1.56 μg/ml; 6, 3.125 μg/ml; 7, 6.25 μg/ml; 8, 12.5 μg/ml; 9, 25 μg/ml; and 10, 50 μg/ml. Peptide sequence is as follows: CBP501, (d-Bpa)(d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg) (d-Arg).

Figure 13 shows the molecular structure of CBP501, (d-Bpa)(d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg) (d-Arg).

Figure 14 shows Kaplan-Meyer analysis of overall survival in all treated patients in relation to baseline WBC: Kaplan-Meyer survival curves, Median OS and Hazard Ratio in relation to the baseline WBC in all treated patients. The hazard ratio improves as the cut off level decreases and peaks at WBC 8000/μl as cut off level.

Figure 15 shows Kaplan-Meyer analysis of overall survival in ICON enrolled patients in relation to baseline WBC: Kaplan-Meyer survival curves, Median OS and Hazard Ratio in relation to the baseline WBC in ICON enrolled patients. The hazard ratio improves as the cut off level decreases and peaks at WBC 8000/μl as cut off level, and the difference between Arm A and Arm B was statistically significant at the peak.

Figure 16 shows Kaplan-Meyer survival curves, median OS, patient numbers, hazard ratio and p values by Log-rank (Mantel-Cox) test in relation to the WBC, >8000 or <8000, at screening in all treated population shown by the arms.

Figure 17 shows increased NET formation by activated neutrophils with CBP501 treatment.

Figure 18 shows increased thrombin/anti-thrombin complexes by CBP501 in vivo.

Figure 19 shows CBP501 inhibited phagocytosis of both M1 and M2 macrophages in vitro.

Figure 20 shows suppression of TNF release from a mice macrophage cell line (RAW264.7).

DETAILED DESCRIPTION

The invention provides compounds including peptides and peptidomimetics that inhibit cell proliferation. The invention compounds are therefore useful for treating cell proliferative disorders or physiological conditions characterized by undesirable or unwanted cell proliferation, such as benign and malignant tumor cells. The ability of invention peptides and peptidomimetics to inhibit cell proliferation appears to be due at least in part to abrogation of the cell cycle G2 checkpoint. Because cells can be induced to enter the cell cycle G2 checkpoint in response to nucleic acid damage to allow the cell to repair the damage before DNA replication and cell division occurs, by inhibiting the G2 checkpoint, invention peptides and peptidomimetics sensitize cells to nucleic acid damaging agents and treatment protocols. Cells that accumulate enough nucleic acid damage will be unable to complete repair of the damaged nucleic acid because the G2 checkpoint is disrupted. Such cells will exhibit decreased proliferation (e.g., due to mutation of a gene critical for survival that is not repaired) and eventually undergo apoptosis.

Cells having a normal G1 are less susceptible to accumulating damaged nucleic acid since nucleic acid repair can also take place during G1. Thus, normal cells are less susceptible to the effects of the invention compounds. However, cells having an impaired or disrupted cell cycle G1 checkpoint are more likely to accumulate damaged nucleic acid because the G1 checkpoint is impaired or disrupted making it less likely that

the cells can completely repair the damaged nucleic acid. Thus, treating G1 impaired or disrupted cells with an invention peptide or peptidomimetic that disrupts the G2 checkpoint makes the cells even less likely to be able to complete repair of the damaged nucleic acid. G1 impaired or disrupted cells are therefore particularly sensitive to such invention peptides and peptidomimetics. Thus, invention compounds including peptides and peptidomimetics can be used to inhibit or prevent cell proliferation in general and in particular inhibit proliferation of cells having an impaired or disrupted G1 checkpoint.

Cells having an impaired or disrupted G1 cell cycle checkpoint include but are not limited to cells that rapidly proliferate. Cell proliferative disorders and physiological conditions characterized by rapidly growing cells, undesirably growing cells or cells that survive instead of undergoing apoptosis frequently have impaired or disrupted G1 cell cycle checkpoint. Thus, as it appears that the ability of invention peptides and peptidomimetics to inhibit proliferation or stimulate apoptosis is due, at least in part, to disrupting the G2 cell cycle checkpoint, cells that rapidly or undesirably proliferate due to an impaired or disrupted G1 checkpoint are particularly attractive targets.

CBP501 is a cell cycle G2 checkpoint inhibiting peptide TAT-S216A (Suganuma, M., et al. Cancer Res. 59:5887 (1999)). A cell cycle phenotype-based screening method was employed to optimize TAT-S216A to reduce the accumulation of cancer cells in the cell cycle G2 phase in response to DNA damaging agents without affecting cell cycle phenotype of normal cells (Sha, S., et al. Mol. Cancer Ther. 6:147 (2007)). CBP501 was found to increase platinum concentration and platinum-DNA adduct formation in CBP501-sensitive tumor cells and may operate, alternatively, or in addition to G2 checkpoint inhibition/disruption via Calmodulin inhibition (Mine, N., et al. Mol. Cancer Ther. 10:1929 (2011)).

Invention compounds including peptides and peptidomimetics may suppress cell proliferation by themselves without additional treatments that damage nucleic acid or that have anti-proliferative activty since disrupting G2 checkpoint will likely lead to the accumulation of nucleic acid damage as the cells divide. Accordingly, abnormal or undesirably proliferating or surviving cells can be treated with a compound of the invention alone, or in combination with a nucleic acid damaging treatment (e.g., a chemical agent or treatment protocol), to inhibit or prevent proliferation of the cells or to stimulate cell apoptosis/catastrophe.

Unlike conventional anti-cell proliferative agents, which target rapidly proliferating cells irrespective of whether the cells are normal or abnormal (e.g., cancer cell), invention compounds preferentially target cells having an impaired or disrupted cell cycle G1 checkpoint. For example, CBP501, unlike cisplatin, does not affect the growth of HUVEC cells (see, e.g., Table 3). CBP501 also does not affect M phase cell cycle arrest and/or non specific toxicity induced by colchicine (see, e.g., Figure 12). Consequently, invention compounds are less likely to produce excess undesirable side effects associated with conventional anti-cell proliferative treatment agents, such as bone marrow suppression, nausea, loss of appetite, diarrhea, and hair loss. In addition, because the vast majority of cancer cells have an impaired or disrupted cell cycle G1 checkpoint, cancer cells will exhibit increased sensitivity to invention compounds that abrogate cell cycle G2 checkpoint. That normal cells are less susceptible also means that invention compounds including peptides and peptidomimetics can be used in greater amounts.

In accordance with the invention, there are provided compounds including peptides and peptidomimetics having anti-cell proliferative activity and/or that abrogate the G2 cell cycle checkpoint. The peptides or peptidomimetics include sequences that inhibit proliferation of a cell or that stimulate apoptosis of a cell. The peptides or peptidomimetics also include sequences that abrogate cell cycle G2 checkpoint. In one embodiment, a contiguous peptide or peptidomimetic sequence includes the following structure: P1, P2, P3, P4, P5, P6 (SEQ ID NO:1) or P6, P5, P4, P3, P2, P1 (SEQ ID NO:2); wherein P1 is d- or l-Cha, d- or l-Nal(2), d- or l-(Phe-2,3,4,5,6-F), d- or l-(Phe-3,4,5F), d- or l-(Phe-4CF3), an amino acid that occupies a similar side chain space (e.g., d- or l-Tyr, d- or l-Phe), or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene group, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, quinazoline group in the side chain; P2 is d- or l-Cha, d- or l-Nal(2), d- or l-(Phe-2,3,4,5,6-F), d- or l-(Phe-3,4,5F), d- or l-(Phe-4CF3), d- or l-Bpa, d- or l-Phe4NO2, an amino acid that occupies a similar side chain space (e.g. d- or l-Tyr, d- or l-Phe), or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, or quinazoline group in the side chain; P3, P4, P5 are any amino acid or one or more of P3,

P4, P5 is a simple carbon chain such that the distance between P2 and P6 is about the same as the distance when each of P3, P4, P5 are amino acids (d- or l-Trp is an example at P4; P6 is d- or l-Bpa, d- or l-Phe4NO2, any amino acid and d- or l-Tyr (e.g., d-Ser-d-Tyr), any amino acid and d- or l-Phe (e.g., d-Ser-d-Phe), any amino acid, or nothing. In various aspects, the amino acid having a simple carbon chain is d- or l-11-aminoundecanoic acid, d- or l-10-aminodecanoic acid, d- or l-9-aminononanoic acid, d- or l-8-aminocaprylic acid, d- or l-7-aminoheptanoic acid, d- or l- 6-aminocaproic acid, or a similar structure with one or more unsaturated carbon bonds.

In another embodiment, a contiguous peptide or peptidomimetic sequence includes the following structure: P1, P2, P3, P4, P5, P6 (SEQ ID NO:3); P6, P5, P4, P3, P2, P1 (SEQ ID NO:4); P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12 (SEQ ID NO:5); P1, P2, P3, P4, P5, P6, P12, P11, P10, P9, P8, P7 (SEQ ID NO:6); P6, P5, P4, P3, P2, P1, P7, P8, P9, P10, P11, P12 (SEQ ID NO:7); P6, P5, P4, P3, P2, P1, P12, P11, P10, P9, P8, P7 (SEQ ID NO:8); P7, P8, P9, P10, P11, P12, P1, P2, P3, P4, P5, P6 (SEQ ID NO:9); P7, P8, P9, P10, P11, P12, P6, P5, P4, P3, P2, P1 (SEQ ID NO:10); P12, P11, P10, P9, P8, P7, P1, P2, P3, P4, P5, P6 (SEQ ID NO:11); P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1 (SEQ ID NO:12); P12, P11, P6, P9, P8, P7, P2, P1 (SEQ ID NO:13); P12, P11, P10, P6, P9, P4, P7, P2, P1 (SEQ ID NO:14); P1, P2, P7, P8, P9, P6, P11, P12 (SEQ ID NO:15); or P1, P2, P7, P4, P9, P6, P10, P11, P12 (SEQ ID NO:16); wherein P1 is d- or l-Cha, d- or l-Nal(2), d- or l-(Phe-2,3,4,5,6-F), d- or l-(Phe-3,4,5F), d- or l-(Phe-4CF3), d- or l-Bpa, d- or l-Phe4NO2, an amino acid that occupies a similar side chain space (e.g. d- or l-Tyr, d- or l-Phe), or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, or quinazoline group in the side chain; P2 is d- or l-Cha, d- or l-Nal(2), d- or l-(Phe-2,3,4,5,6-F), d- or l-(Phe-3,4,5F), d- or l-(Phe-4CF3), or an amino acid that occupies a similar side chain space (e.g. d- or l-Tyr, d- or l-Phe), or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene group, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, quinazoline group(s) in the side chain; P3, P4, P5 are any amino acid or one or more of P3, P4, P5 is a simple carbon chain such that the distance between P2 and P6 is about the same as the distance when each of P3, P4, P5 are amino acids (d- or l-Trp is an example at P4); P6 is d- or l-Bpa, d-

or l-Phe4NO2, any amino acid and d- or l-Tyr (e.g., d-Ser-d-Tyr), any amino acid and d- or l-Phe (e.g., d-Ser-d-Phe), and at least three of P7, P8, P9, P10, P11, P12 are basic amino acids with the rest being any amino acid or absent. In various aspects, the amino acid having a simple carbon chain is d- or l-11-aminoundecanoic acid, d- or l-10-aminodecanoic acid, d- or l-9-aminononanoic acid , d- or l-8-aminocaprylic acid, d- or l-7-aminoheptanoic acid, d- or l- 6-aminocaproic acid or a a similar structure with one or more unsaturated carbon bonds.

In a further embodiment, a contiguous peptide or peptidomimetic sequence includes the following structure: P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12 (SEQ ID NO:17); P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1 (SEQ ID NO:18); P12, P11, P10, P6, P9, P4, P7, P2, P1 (SEQ ID NO:19); or P1, P2, P7, P4, P9, P6, P10, P11, P12 (SEQ ID NO:20); wherein P1 is d- or l-Cha, d- or l-Nal(2), d- or l- (Phe-2,3,4,5,6-F), d- or l- (Phe-3,4,5F), d- or l- (Phe-4CF3), d- or l-Bpa, d- or l-Phe4NO2, an amino acid that occupies a similar side chain space (e.g. d- or l-Tyr, d- or l-Phe), or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, or quinazoline group in the side chain; P2 is d- or l-Cha, d- or l-Nal(2), d- or l- (Phe-2,3,4,5,6-F), d- or l- (Phe-3,4,5F), d- or l- (Phe-4CF3), an amino acid that occupies a similar side chain space (e.g. d- or l-Tyr, d- or l-Phe), or any amino acid with one or two aromatic, piperidine, pyrazine, pyrimidine, piperazine, morpholine or pyrimidine group(s), or one indole, pentalene, indene, naphthalene, benzofuran, benzothiophene, quinoline, indoline, chroman, quinoxaline, quinazoline group in the side chain; P3, P4, P5 are any amino acid or one or more of P3, P4, P5 is a simple carbon chain such that the distance between P2 and P6 is about the same as the distance when each of P3, P4, P5 are amino acids (d- or l-Trp is an example at P4); P6 is d- or l-Bpa, d- or l-Phe4NO2, any amino acid and d- or l-Tyr (e.g., d-Ser-d-Tyr), any amino acid and d- or l-Phe (e.g., d-Ser-d-Phe), any amino acid, or nothing; and at least three of P7, P8, P9, P10, P11, P12 are basic amino acids with the rest being any amino acid or absent. In various aspects, the amino acid having a simple carbon chain is d- or l-aminoundecanoic acid or d- or l-8-aminocaprylic acid.

In yet another embodiment, a contiguous peptide or peptidomimetic sequence includes the following structure: P1, P2, P3, P4, P5, P6 (SEQ ID NO:21) or P6, P5, P4, P3, P2, P1 (SEQ ID NO:22); wherein P1 is d- or l-Cha, d- or l-Nal(2), d- or l-

(Phe-2,3,4,5,6-F), d- or l- (Phe-3,4,5F), d- or l- (Phe-4CF3), d- or l-Bpa, d- or l-Phe4NO2, d- or l-Tyr, or d- or l-Phe; P2 is d- or l-Cha, d- or l-Nal(2), d- or l- (Phe-2,3,4,5,6-F), d- or l- (Phe-3,4,5F), d- or l- (Phe-4CF3), d- or l-Bpa, d- or l-Phe4NO2, d- or l-Tyr, or d- or l-Phe; P3 is d- or l-serine, d- or l-arginine, d- or l-cysteine, d- or l-proline, or d- or l-asparagine; P4 is d- or l-tryptophan; and P5 is d- or l-serine, d- or l-arginine, or d- or l-asparagine; or P3, P4, P5 is a single d- or l-aminoundecanoic acid or a single d- or l-8-aminocaprylic acid; P6 is d- or l-Bpa, d- or l-Phe4NO2, (d-Ser-d-Tyr), or (d-Ser-d-Phe).

In still another embodiment, a contiguous peptide or peptidomimetic sequence includes the following structure: P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12 (SEQ ID NO:23); P1, P2, P3, P4, P5, P6, P12, P11, P10, P9, P8, P7 (SEQ ID NO:24); P6, P5, P4, P3, P2, P1, P7, P8, P9, P10, P11, P12 (SEQ ID NO:25); P6, P5, P4, P3, P2, P1, P12, P11, P10, P9, P8, P7 (SEQ ID NO:26); P7, P8, P9, P10, P11, P12, P1, P2, P3, P4, P5, P6 (SEQ ID NO:27); P7, P8, P9, P10, P11, P12, P6, P5, P4, P3, P2, P1 (SEQ ID NO:28); P12, P11, P10, P9, P8, P7, P1, P2, P3, P4, P5, P6 (SEQ ID NO:29); P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1 (SEQ ID NO:30); P12, P11, P6, P9, P8, P7, P2, P1 (SEQ ID NO:31); P12, P11, P10, P6, P9, P4, P7, P2, P1 (SEQ ID NO:32); P1, P2, P7, P8, P9, P6, P11, P12 (SEQ ID NO:33); or P1, P2, P7, P4, P9, P6, P10, P11, P12 (SEQ ID NO:34); wherein P1 is d- or l-Cha, Nal(2), d- or l- (Phe-2,3,4,5,6-F), d- or l- (Phe-3,4,5F), d- or l- (Phe-4CF3), d- or l-Bpa, d- or l-Phe4NO2, d- or l-Tyr, or d- or l-Phe; P2 is d- or l-Cha, d- or l-Nal(2), d- or l- (Phe-2,3,4,5,6-F), d- or l- (Phe-3,4,5F), d- or l- (Phe-4CF3), d- or l-Bpa, d- or l-Phe4NO2, d- or l-Tyr, or d- or l-Phe; P3 is d- or l-serine, d- or l-arginine, d- or l-cysteine, d- or l-proline, or d- or l-asparagine; P4 is d- or l-tryptophan; P5 is d- or l-serine, d- or l-arginine, or d- or l-asparagine; or P3, P4, P5 is a single d- or l-aminoundecanoic acid or a single d- or l-8-aminocaprylic acid; P6 is d- or l-Bpa, d- or l-Phe4NO2, (d-Ser-d-Tyr), or (d-Ser-d-Phe); and at least three of P7, P8, P9, P10, P11, P12 are d- or l-Arg or d- or l-Lys with the rest being any amino acid or absent.

In an additional embodiment, a contiguous peptide or peptidomimetic sequence includes the following structure: P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12 (SEQ ID NO:35); P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1 (SEQ ID NO:36); P12, P11, P10, P6, P9, P4, P7, P2, P1(SEQ ID NO:37); or P1, P2, P7, P4, P9, P6, P10, P11, P12 (SEQ ID NO:38); wherein P1 is d- or l-Cha, or d- or l-Nal(2); P2 is d- or l- (Phe-2,3,4,5,6-F), d- or l- (Phe-3,4,5F), d- or l- (Phe-4CF3); and at least three of P7, P8,

P9, P10, P11, P12 are d- or l-Arg with the rest being any amino acid or absent; P3 is d- or l-serine; P4 is d- or l-tryptophan; P5 is d- or l-serine or d- or l-asparagine; P6 is d- or l-Bpa, d- or l-Phe4NO2, (d- or l-Ser-d- or l-Tyr), or (d- or l-Ser-d- or l-Phe).

In yet an additional embodiment, a contiguous peptide or peptidomimetic sequence includes the following structure: P1, P2, P3, P4, P5, P6 (SEQ ID NO:39) or P6, P5, P4, P3, P2, P1 (SEQ ID NO:40); wherein P1 is d- or l-Cha, or d- or l-Nal(2); P2 is (d- or l-Phe-2,3,4,5,6-F), (d- or l-Phe-3,4,5F) or (d- or l-Phe-4CF3); P3 is d- or l-Ser; P4 is d- or l-Trp; P5 is d- or l-Ser; P6 is d- or l-Bpa, or (d- or l-Ser-d- or l-Tyr).

In a further embodiment, a contiguous peptide or peptidomimetic sequence includes the following structure: P1, P2, P3, P4, P5, P6 (SEQ ID NO:41); P6, P5, P4, P3, P2, P1 (SEQ ID NO:42); P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12 (SEQ ID NO:43); P1, P2, P3, P4, P5, P6, P12, P11, P10, P9, P8, P7 (SEQ ID NO:44); P6, P5, P4, P3, P2, P1, P7, P8, P9, P10, P11, P12 (SEQ ID NO:45); P6, P5, P4, P3, P2, P1, P12, P11, P10, P9, P8, P7 (SEQ ID NO:46); P7, P8, P9, P10, P11, P12, P1, P2, P3, P4, P5, P6 (SEQ ID NO:47); P7, P8, P9, P10, P11, P12, P6, P5, P4, P3, P2, P1 (SEQ ID NO:48); P12, P11, P10, P9, P8, P7, P1, P2, P3, P4, P5, P6 (SEQ ID NO:49); P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1 (SEQ ID NO:50); P12, P11, P6, P9, P8, P7, P2, P1 (SEQ ID NO:51); P12, P11, P10, P6, P9, P4, P7, P2, P1 (SEQ ID NO:52); P1, P2, P7, P8, P9, P6, P11, P12 (SEQ ID NO:53); or P1, P2, P7, P4, P9, P6, P10, P11, P12 (SEQ ID NO:54); wherein P1 is d- or l-Cha, or d- or l-Nal(2); P2 is (d- or l-Phe-2,3,4,5,6-F), (d- or l-Phe-3,4,5F) or (d- or l-Phe-4CF3); P3 is any amino acid (e.g., d- or l-Ser, or d- or l-Pro); P4 is d- or l-Trp; P5 is any amino acid (e.g., d- or l-Ser); P7 is d- or l-Arg; P8 is d- or l-Arg; P9 is d- or l-Arg; P10 is d- or l-Gln or d- or l-Arg; P11 is d- or l-Arg; P12 is d- or l-Arg; P6 is d- or l-Bpa or (d- or l-Ser-d- or l-Tyr).

In still another embodiment, a contiguous peptide or peptidomimetic sequence includes the following structure: P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12 (SEQ ID NO:55); P12, P11, P10, P9, P8, P7, P6, P5, P4, P3, P2, P1 (SEQ ID NO:56); P12, P11, P10, P6, P9, P4, P7, P2, P1 (SEQ ID NO:57); or P1, P2, P7, P4, P9, P6, P10, P11, P12 (SEQ ID NO:58); wherein P1 is d- or l-Cha or d- or l-Nal(2); P2 is (d- or l-Phe-2,3,4,5,6-F); P3 is d- or l-Ser; P4 is d- or l-Trp; P5 is d- or l-Ser; P7 is d- or l-Arg; P8 is d- or l-Arg; P9 is d- or l-Arg; P10 is d- or l-Gln or d- or l-Arg; P11 is d- or l-Arg; P12 is d- or l-Arg; P6 is d- or l-Bpa or (d- or l-Ser-d- or l-Tyr).

In still further embodiments, a contiguous peptide or peptidomimetic sequence includes the following structure: (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha)(d-Arg) (d-Arg) (d-Arg) (d-Gln)(d-Arg) (d-Arg) (SEQ ID NO:99); (d-Arg) (d-Arg) (d-Arg) (d-Gln)(d-Arg) (d-Arg) (d-Bpa)(d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha) (SEQ ID NO:100); (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Arg) (SEQ ID NO:59); (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha) (SEQ ID NO:60); (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser)(d-Trp)(d-Ser) (d-Bpa) (d-Arg) (d-Arg) (d-Arg) (d-Gln)(d-Arg) (d-Arg) (SEQ ID NO:61); (d-Arg) (d-Arg) (d-Arg) (d-Gln)(d-Arg) (d-Arg) (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser)(d-Trp)(d-Ser) (d-Bpa) (SEQ ID NO:62); (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser) (d-Trp) (d-Ser) (d-Bpa) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Arg) (SEQ ID NO:63); (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Arg) (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser)(d-Trp)(d-Ser) (d-Bpa) (SEQ ID NO:64); (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser) (d-Trp)(d-Ser) (d-Bpa) (SEQ ID NO:65); (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser)(d-Trp)(d-Ser) (d-Bpa) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (SEQ ID NO:66); (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:67); (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (SEQ ID NO:68); (d-Arg)(d-Arg)(d-Bpa) (d-Arg) (d-Arg) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:69); (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Arg)(d-Arg) (SEQ ID NO:70); (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Arg)(d-Trp) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:71); (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Arg)(d-Trp) (d-Arg) (d-Bpa) (d-Arg) (d-Arg) (d-Arg) (SEQ ID NO:72); (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Arg)(d-Trp) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:73); (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Arg)(d-Trp) (d-Arg) (d-Bpa) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (SEQ ID NO:74); (d-Arg) (d-Arg)(d-Arg)(d-Bpa)(d-Arg)(d-Arg) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:75); or (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Arg) (d-Arg) (d-Arg) (d-Bpa) (d-Arg)(d-Arg)(d-Arg) (SEQ ID NO:76).

In still additional embodiments, a contiguous peptide or peptidomimetic sequence includes the following structure:
(d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg)(d-Arg)(d-Arg)(d-Gln)

(d-Arg)(d-Arg) (SEQ ID NO:77).

Invention peptides and peptidomimetics optionally contain a poly-lys and/or arg sequence in order to assist traversing the cell membrane. Because other amino acid sequences (e.g., HIV tat, ligands for cell surface receptors/proteins, etc.) are capable of traversing the membrane and other molecules can be used to facilitate cell entry of G2 abrogating peptides and peptidomimetics (e.g., liposomes, micelles and other lipid molecules, viral and other vectors, electroporation, etc.), including poly-lys and/or poly-arg sequences is optional. Thus, in additional embodiments, the peptides and peptidomimetics do not have a poly-lys and/or arg sequence that assists with cell entry. For example, in two particular embodiments, a minimum sequence without a poly-lys/arg sequence assisting with cell membrane traversal includes P6, P5, P4, P3, P2, P1 e.g., d-Bpa, d-Ser, d-Trp, d-Ser, d-Phe-2,3,4,5,6F, d-Cha (SEQ ID NO:101); and d-Tyr, d-Ser, d-Pro, d-Trp, d-Ser, d-Phe-2,3,4,5,6F, d-Cha (SEQ ID NO:102). In two additional particular embodiments, a minimum sequence without a poly-lys/arg sequence assisting with cell membrane traversal includes, for example, d-Bpa, d-Cys, d-Trp, d-Ser, d-Phe-2,3,4,5,6F, d-Cha, d-Cys (SEQ ID NO:103); and d-Tyr, d-Cys, d-Pro, d-Trp, d-Ser, d-Phe-2,3,4,5,6F, d-Cha, d-Cys (SEQ ID NO:104); the Cys residues are optionally cyclized.

As discussed, invention compounds have anti-cell proliferative activity or G2 abrogating activity alone. Anti-cell proliferative activity can be increased by combining such invention compounds with treatments that directly or indirectly cause nucleic acid damage. Anti-cell proliferative activity also can be increased by combining such invention compounds with treatments that inhibit cell proliferation whether or not the treatments damage nucleic acid. The invention therefore further provides compositions including a compound of the invention (e.g., a peptide or peptidomimetic sequence) and a nucleic acid damaging agent, and compositions including a compound of the invention (e.g., a peptide or peptidomimetic sequence) and an anti-proliferative agent.

As used herein, the terms “abrogate the cell cycle G2 checkpoint,” “disrupt the cell cycle G2 checkpoint,” “impair the cell cycle G2 checkpoint” and grammatical variations thereof, means inhibiting a cell to arrest cell cycle at the G2 checkpoint. A cell in which the cell cycle G2 checkpoint is abrogated exhibits a decrease in the length of time that the cell is in the G2 checkpoint, which can range from absence of G2 checkpoint altogether to a G2 checkpoint having a decrease in duration of minutes, hours, days,

weeks or longer under appropriate conditions. Thus, a cell contacted with an invention compound has a G2 checkpoint time shorter in length than the cell normally would have in the absence of the compound. For example, a decrease in the length of G2 checkpoint time would mean that a cell which is in G2 for a certain time, e.g., 4 hours, when contacted with an invention compound, is in G2 for less than 4 hours, e.g., 3.5, 3, 2.5, 2, 1 or fewer hours.

As used herein, the term "apoptosis" refers to programmed cell death, and assciated changes in cell physiology, e.g., nucleic acid fragmentation, caspase activation, etc., as is understood in the art. The term "catastrophe" means cell death resulting from an error in the mitotic process. In catastrophe, there are fewer features present that are characteristic of apoptosis e.g., caspase activation, chromosome condensation, etc.

As used herein, the terms "peptide," "polypeptide" and "protein" are used interchangeably and refer to two or more amino acids covalently linked by an amide bond or non-amide equivalent. The peptides of the invention can be of any length. For example, the peptides can have from about 5 to 100 or more residues, such as, 5 to 12, 12 to 15, 15 to 18, 18 to 25, 25 to 50, 50 to 75, 75 to 100, or more in length. The peptides of the invention include l- and d-isomers, and combinations of l- and d-isomers. The peptides can include modifications typically associated with post-translational processing of proteins, for example, cyclization (*e.g.*, disulfide or amide bond), phosphorylation, glycosylation, carboxylation, ubiquitination, myristylation, or lipidation.

Peptides disclosed herein further include compounds having amino acid structural and functional analogues, for example, peptidomimetics having synthetic or non-natural amino acids or amino acid analogues, so long as the mimetic has one or more functions or activities. The compounds of the invention therefore include "mimetic" and "peptidomimetic" forms.

As used herein, the terms "mimetic" and "peptidomimetic" refer to a synthetic chemical compound which has substantially the same structural and/or functional characteristics of the peptides of the invention. The mimetic can be entirely composed of synthetic, non-natural amino acid analogues, or can be a chimeric molecule including one or more natural peptide amino acids and one or more non-natural amino acid analogs. The mimetic can also incorporate any number of natural amino acid conservative substitutions as long as such substitutions do not destroy the mimetic's activity. As with polypeptides of the invention which are conservative variants, routine testing can be used

to determine whether a mimetic has the requisite activity, e.g., that it has detectable cell cycle G2 checkpoint abrogating activity. A mimetic, when administered to a subject or contacted on a cell, that detectably disrupts the G2 cell cycle checkpoint, would therefore have G2 checkpoint abrogating activity.

Peptide mimetic compositions can contain any combination of non-natural structural components, which are typically from three structural groups: a) residue linkage groups other than the natural amide bond ("peptide bond") linkages; b) non-natural residues in place of naturally occurring amino acid residues; or c) residues which induce secondary structural mimicry, i.e., induce or stabilize a secondary structure, e.g., a beta turn, gamma turn, beta sheet, alpha helix conformation, and the like. For example, a polypeptide can be characterized as a mimetic when one or more of the residues are joined by chemical means other than an amide bond. Individual peptidomimetic residues can be joined by amide bonds, non-natural and non-amide chemical bonds other chemical bonds or coupling means including, for example, glutaraldehyde, N-hydroxysuccinimide esters, bifunctional maleimides, N,N'-dicyclohexylcarbodiimide (DCC) or N,N'-diisopropylcarbodiimide (DIC). Linking groups alternative to the amide bond include, for example, ketomethylene (e.g., -C(=O)-CH_2- for -C(=O)-NH-), aminomethylene (CH_2-NH), ethylene, olefin (CH=CH), ether (CH_2-O), thioether (CH_2-S), tetrazole (CN_4-), thiazole, retroamide, thioamide, or ester (see, e.g., Spatola (1983) in Chemistry and Biochemistry of Amino Acids, Peptides and Proteins, Vol. 7, pp 267-357, "Peptide and Backbone Modifications," Marcel Decker, NY).

As discussed, a peptide can be characterized as a mimetic by containing one or more non-natural residues in place of a naturally occurring amino acid residue. Non-natural residues are known in the art. Particular non-limiting examples of non-natural residues useful as mimetics of natural amino acid residues are mimetics of aromatic amino acids include, for example, D- or L- naphylalanine; D- or L-phenylglycine; D- or L-2 thieneylalanine; D- or L-1, -2, 3-, or 4- pyreneylalanine; D- or L-3 thieneylalanine; D- or L-(2-pyridinyl)-alanine; D- or L-(3-pyridinyl)-alanine; D- or L-(2-pyrazinyl)-alanine; D- or L-(4-isopropyl)-phenylglycine; D-(trifluoromethyl)-phenylglycine; D-(trifluoromethyl)-phenylalanine; D-p-fluoro-phenylalanine; D- or L-p-biphenylphenylalanine; K- or L-p-methoxy-biphenylphenylalanine; D- or L-2-indole(alkyl)alanines; and D- or L-alkylainines, where alkyl can be substituted or unsubstituted methyl, ethyl, propyl,

hexyl, butyl, pentyl, isopropyl, iso-butyl, sec-isotyl, iso-pentyl, or a non-acidic amino acid. Aromatic rings of a non-natural amino acid that can be used in place a natural aromatic rings include, for example, thiazolyl, thiophenyl, pyrazolyl, benzimidazolyl, naphthyl, furanyl, pyrrolyl, and pyridyl aromatic rings.

Mimetics of acidic amino acids can be generated by substitution with non-carboxylate amino acids while maintaining a negative charge; (phosphono)alanine; and sulfated threonine. Carboxyl side groups (e.g., aspartyl or glutamyl) can also be selectively modified by reaction with carbodiimides (R'-N-C-N-R') including, for example, 1-cyclohexyl-3(2-morpholinyl-(4-ethyl) carbodiimide or 1-ethyl-3(4-azonia-4,4- dimetholpentyl) carbodiimide. Aspartyl or glutamyl groups can also be converted to asparaginyl and glutaminyl groups by reaction with ammonium ions.

Mimetics of basic amino acids can be generated by substitution, for example, in addition to lysine and arginine, with the amino acids ornithine, citrulline, or (guanidino)-acetic acid, or (guanidino)alkyl-acetic acid, where alkyl can be substituted or unsubstituted methyl, ethyl, propyl, hexyl, butyl, pentyl, isopropyl, iso-butyl, sec-isotyl, iso-pentyl, or a non-acidic amino acid. Nitrile derivative (e.g., containing the CN-moiety in place of COOH) can be substituted for asparagine or glutamine. Asparaginyl and glutaminyl residues can be deaminated to the corresponding aspartyl or glutamyl residues.

Arginine mimetics can be generated by reacting arginyl with one or more reagents including, for example, phenylglyoxal, 2,3-butanedione, 1,2-cyclohexanedione, or ninhydrin, optionally under alkaline conditions. Tyrosine residue mimetics can be generated by reacting tyrosyl with aromatic diazonium compounds or tetranitromethane. N-acetylimidizol and tetranitromethane can be used to form O-acetyl tyrosyl species and 3-nitro derivatives, respectively.

Lysine mimetics can be generated (and amino terminal residues can be altered) by reacting lysinyl with succinic or other carboxylic acid anhydrides. Lysine and other alpha-amino-containing residue mimetics can also be generated by reaction with imidoesters, such as methyl picolinimidate, pyridoxal phosphate, pyridoxal, chloroborohydride, trinitrobenzenesulfonic acid, O-methylisourea, 2,4, pentanedione, and transamidase-catalyzed reactions with glyoxylate.

Methionine mimetics can be generated by reaction with methionine sulfoxide. Proline mimetics of include, for example, pipecolic acid, thiazolidine carboxylic acid, 3-

or 4- hydroxy proline, dehydroproline, 3- or 4-methylproline, and 3,3,-dimethylproline. Histidine mimetics can be generated by reacting histidyl with diethylprocarbonate or para-bromophenacyl bromide. Other mimetics include, for example, those generated by hydroxylation of proline and lysine; phosphorylation of the hydroxyl groups of seryl or threonyl residues; methylation of the alpha-amino groups of lysine, arginine and histidine; acetylation of the N-terminal amine; methylation of main chain amide residues or substitution with N-methyl amino acids; or amidation of C-terminal carboxyl groups.

One or more residues can also be replaced by an amino acid (or peptidomimetic residue) of the opposite chirality. Thus, any amino acid naturally occurring in the L-configuration (which can also be referred to as R or S, depending upon the structure of the chemical entity) can be replaced with the same amino acid or a mimetic, but of the opposite chirality, referred to as the D- amino acid, but which can additionally be referred to as the R- or S- form.

Invention peptides and peptidomimetics further include modified forms of the sequences set forth herein, provided that the modified form retains, at least a part of, the function of the unmodified or reference peptide or peptidomimetic. For example, a modified peptide or peptidomimetic will retain at least a part of cell proliferative inhibiting or G2 abrogating activity, but may have increased or decreased cell proliferative inhibiting or G2 abrogating activity relative to reference peptide or peptidomimetic.

Modified peptides and peptidomimetics can have one or more amino acid residues substituted with another residue, added to the sequence or deleted from the sequence. In one embodiment, the modified peptide or peptidomimetic has one or more amino acid substitutions, additions or deletions (e.g., 1-3, 3-5, 5-10 or more). In one aspect, the substitution is with an amino acid or mimetic whose side chain occupies a similar space with the reference amino acid or mimetic (the amino acid or mimetic that is being substituted). In still another aspect, the substitution is with a non-human amino acid which is structurally similar to the human residue. In a particular aspect, the substitution is a conservative amino acid substitution.

As used herein, the term "similar space" means a chemical moiety that occupies a three-dimensional space similar in size to a reference moiety. Typically, a moiety that occupies a similar space will be similar in size to the reference moiety. An amino acid or mimetic that "occupies a similar side chain space" has a side chain that occupies a

three-dimensional space similar in size to the reference amino acid or mimetic. Specific examples for d-(Phe-2,3,4,5,6-F), l-(Phe-2,3,4,5,6-F), d-(Phe-3,4,5F), l-(Phe-3,4,5F), d-(Phe-4CF3) or l-(Phe-4CF3), are (l or d-Phe-2R1,3R2,4R3,5R4,6R5) where R1,R2,R3,R4,R5 can be chloride, bromide, fluoride, iodide, hydrogen, hydrogen oxide or absent. For small molecules, e.g., fluoride which has a size of about 1 Angstrom, similar space may be absence of a moiety.

The term "conservative substitution" means the replacement of one amino acid by a biologically, chemically or structurally similar residue. Biologically similar means that the substitution is compatible with biological activity, e.g., anti-cell proliferative or G2 abrogating activity. Structurally similar means that the amino acids have side chains with similar length, such as alanine, glycine and serine, or having similar size. Chemical similarity means that the residues have the same charge or are both hydrophilic or hydrophobic. Particular examples include the substitution of one hydrophobic residue, such as isoleucine, valine, leucine or methionine for another, or the substitution of one polar residue for another, such as the substitution of arginine for lysine, glutamic for aspartic acids, or glutamine for asparagine, serine for threonine, and the like.

Invention peptides and peptidomimetics therefore include peptides and peptidomimetics having a sequence that is not identical to a sequence of peptides and peptidomimetics sequences set forth in Table 1. In one embodiment, a peptide or peptidomimetic has a sequence having 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95%, or more identity with a sequence set forth in Table 1. In one aspect, the identity is over a defined area of the sequence, e.g., the amino or carboxy terminal 3-5 residues.

The compounds of the invention, including peptides and peptidomimetics can be produced and isolated using any method known in the art. Peptides can be synthesized, whole or in part, using chemical methods known in the art (see, e.g., Caruthers (1980) Nucleic Acids Res. Symp. Ser. 215-223; Horn (1980) Nucleic Acids Res. Symp. Ser. 225-232; and Banga, A.K., Therapeutic Peptides and Proteins, Formulation, Processing and Delivery Systems (1995) Technomic Publishing Co., Lancaster, PA). Peptide synthesis can be performed using various solid-phase techniques (see, e.g., Roberge (1995) Science 269:202; Merrifield (1997) Methods Enzymol. 289:3-13) and automated synthesis may be achieved, e.g., using the ABI 431A Peptide Synthesizer (Perkin Elmer) in accordance with the manufacturer's instructions.

Individual synthetic residues and polypeptides incorporating mimetics can be synthesized using a variety of procedures and methodologies known in the art (see, e.g., Organic Syntheses Collective Volumes, Gilman, et al. (Eds) John Wiley & Sons, Inc., NY). Peptides and peptide mimetics can also be synthesized using combinatorial methodologies. Techniques for generating peptide and peptidomimetic libraries are well known, and include, for example, multipin, tea bag, and split-couple-mix techniques (ses, for example, al-Obeidi (1998) Mol. Biotechnol. 9:205-223; Hruby (1997) Curr. Opin. Chem. Biol. 1:114-119; Ostergaard (1997) Mol. Divers. 3:17-27; and Ostresh (1996) Methods Enzymol. 267:220-234). Modified peptides can be further produced by chemical modification methods (see, for example, Belousov (1997) Nucleic Acids Res. 25:3440-3444; Frenkel (1995) Free Radic. Biol. Med. 19:373-380; and Blommers (1994) Biochemistry 33:7886-7896).

Peptides can also be synthesized and expressed as fusion proteins with one or more additional domains linked thereto for producing a more immunogenic peptide, to more readily isolate a recombinantly synthesized peptide, or to identify and isolate antibodies or antibody-expressing B cells. Domains facilitating detection and purification include, for example, metal chelating peptides such as polyhistidine tracts and histidine-tryptophan modules that allow purification on immobilized metals; protein A domains that allow purification on immobilized immunoglobulin; and the domain utilized in the FLAGS extension/affinity purification system (Immunex Corp, Seattle WA). The inclusion of a cleavable linker sequence such as Factor Xa or enterokinase (Invitrogen, San Diego CA) between a purification domain and the peptide can be used to facilitate peptide purification. For example, an expression vector can include a peptide-encoding nucleic acid sequence linked to six histidine residues followed by a thioredoxin and an enterokinase cleavage site (see e.g., Williams (1995) Biochemistry 34:1787-1797; Dobeli (1998) Protein Expr. Purif. 12:404-14). The histidine residues facilitate detection and purification of the fusion prtein while the enterokinase cleavage site provides a means for purifying the peptide from the remainder of the fusion protein. Technology pertaining to vectors encoding fusion proteins and application of fusion proteins is known in the art (see e.g., Kroll (1993) DNA Cell. Biol., 12:441-53).

The invention further provides nucleic acids encoding the peptides of the invention. In particular embodiments, a nucleic acid encodes invention peptide

sequences having a length of about 8 to 12, 12 to 15, 15 to 18, 15 to 20, 18 to 25, 20 to 25, 25 to 35, 25 to 50 or 50 to 100 amino acids or more in length.

The terms "nucleic acid" and "polynucleotide" are used interchangeably herein to refer to all forms of nucleic acid, including deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). The nucleic acids can be double, single strand, or triplex, linear or circular. Nucleic acids include genomic DNA, cDNA, and antisense. RNA nucleic acid can be spliced or unspliced mRNA, rRNA, tRNA or antisense (*e.g.*, RNAi). Nucleic acids of the invention include naturally occurring, synthetic, as well as nucleotide analogues and derivatives. Such altered or modified polynucleotides include analogues that provide nuclease resistance, for example. Nucleic acid lengths also can be less than the exemplified peptide sequences. For example, a subsequence of any of the peptide sequences can encode a peptide having anti-proliferative or G2 abrogating activity.

Nucleic acid can be produced using any of a variety of well known standard cloning and chemical synthesis methods and can be altered intentionally by site-directed mutagenesis or other recombinant techniques known to those skilled in the art. Purity of polynucleotides can be determined through sequencing, gel electrophoresis and the like.

Nucleic acids of the invention may be inserted into a nucleic acid construct in which expression of the nucleic acid is influenced or regulated by an "expression control element," the combination referred to as an "expression cassette." The term "expression control element" means one or more sequence elements that regulates or influences expression of a nucleic acid sequence to which it is operatively linked. An expression control element operatively linked to a nucleic acid sequence controls transcription and, as appropriate, translation of the nucleic acid sequence.

The term "operatively linked" refers to a functional juxtaposition wherein the components so described are in a relationship permitting them to function in their intended manner. Typically expression control elements are juxtaposed at the 5' or at the 3' ends of the gene but can also be intronic. Promoters are generally positioned 5' of the coding sequence. A "promoter" is meant a minimal sequence element sufficient to direct transcription.

Expression control elements include promoters, enhancers, transcription terminators, gene silencers, a start codon (*e.g.*, ATG) in front of a protein-encoding gene. Expression control elements activate constitutive transcription, inducible transcription (*i.e.*, require an external signal for activation), or derepress transcription (*i.e.*, a signal

turns transcription off; removing the signal activates transcription). Expression cassettes can also include control elements sufficient to render gene expression controllable for specific cell-types or tissues (i.e., tissue-specific control elements).

Nucleic acids of the invention may be inserted into a plasmid for propagation into a host cell and for subsequent genetic manipulation. A plasmid is a nucleic acid that can be stably propagated in a host cell; plasmids optionally contain expression control elements in order to drive expression of the nucleic acid encoding peptide in the host cell. The term "vector" is used herein synonymously with a plasmid and may also include an expression control element for expression in a host cell. Plasmids and vectors generally contain at least an origin of replication for propagation in a cell and a promoter. Plasmids and vectors are therefore useful for genetic manipulation of peptide encoding nucleic acids, for producing peptides, and for expressing the peptides in host cells or whole organisms, for example.

Peptides may therefore be expressed in bacterial systems using constitutive promoters such as T7, or inducible promoters such as pL of bacteriophage λ, plac, ptrp, ptac (ptrp-lac hybrid promoter); in yeast systems using constitutive promoters such as ADH or LEU2 or an inducible promoter such as GAL (see, *e.g.*, Ausubel et al., In: Current Protocols in Molecular Biology, Vol. 2, Ch. 13, ed., Greene Publish. Assoc. & Wiley Interscience, 1988; Grant et al. Methods in Enzymology, 153:516 (1987), eds. Wu & Grossman; Bitter Methods in Enzymology, 152:673 (1987), eds. Berger & Kimmel, Acad. Press, N.Y.; and, Strathern et al., The Molecular Biology of the Yeast Saccharomyces (1982) eds. Cold Spring Harbor Press, Vols. I and II; R. Rothstein In: DNA Cloning, A Practical Approach, Vol.11, Ch. 3, ed. D.M. Glover, IRL Press, Wash., D.C., 1986); in insect cell systems using constitutive or inducible promoters such as ecdysone; and in mammalian cell systems using constitutive promoters such as SV40, RSV, or inducible promoters derived from the genome of mammalian cells such as metallothionein IIA promoter, heat shock promoter, or derived from mammalian virus such as adenovirus late promoter or the inducible mouse mammary tumor virus long terminal repeat. Peptide expression systems further include vectors designed for *in vivo* use including adenoviral vectors (U.S. Patent Nos. 5,700,470 and 5,731,172), adeno-associated vectors (U.S. Patent No. 5,604,090), herpes simplex virus vectors (U.S. Patent No. 5,501,979) and retroviral vectors (U.S. Patent Nos. 5,624,820, 5,693,508 and 5,674,703 and WIPO publications WO92/05266 and WO92/14829). Bovine papilloma

virus (BPV) has also been employed in gene therapy (U.S. Patent No. 5,719,054). Such gene therapy vectors also include CMV based vectors (U.S. Patent No. 5,561,063).

The invention therefore also provides nucleic acids encoding peptides of the invention inserted into host cells. In one embodiment, the host cell is a prokaryotic cell. In another embodiment, the host cell is a eukaryotic cell. In various aspects, the eukaryotic cell is a yeast or mammalian (*e.g.*, human, primate, etc.) cell.

As used herein, a "host cell" is a cell into which a nucleic acid is introduced that can be propagated, transcribed, or encoded peptide expressed. The term also includes any progeny of the subject host cell.

Host cells include but are not limited to microorganisms such as bacteria or yeast; and plant, insect and mammalian cells. For example, bacteria transformed with recombinant bacteriophage nucleic acid, plasmid nucleic acid or cosmid nucleic acid expression vectors; yeast transformed with recombinant yeast expression vectors; plant cell systems infected with recombinant virus expression vectors (*e.g.*, cauliflower mosaic virus, CaMV; tobacco mosaic virus, TMV) or transformed with recombinant plasmid expression vectors (*e.g.*, Ti plasmid); insect cell systems infected with recombinant virus expression vectors (*e.g.*, baculovirus); or animal cell systems infected with recombinant virus expression vectors (*e.g.*, retroviruses, adenovirus, vaccinia virus), or transformed animal cell systems engineered for stable expression, are provided.

The expression vector also can contain a nucleic acid encoding a selectable marker conferring resistance to a selective pressure or identifiable marker (*e.g.*, β-galactosidase), thereby allowing cells having the vector to be identified, grown and expanded. Alternatively, a selectable marker can be on a second vector which is cotransfected into a host cell with a first vector containing an invention polynucleotide. A number of selection systems may be used, including, but not limited to the herpes simplex virus thymidine kinase gene (Wigler et al., Cell 11:223 (1977)), hypoxanthine-guanine phosphoribosyltransferase gene (Szybalska et al., Proc. Natl. Acad. Sci. USA 48:2026 (1962)), and the adenine phosphoribosyltransferase (Lowy et al., Cell 22:817 (1980)) genes can be employed in tk-, hgprt$^-$ or aprt$^-$ cells respectively. Antimetabolite resistance can be used as the basis of selection for *dhfr*, which confers resistance to methotrexate (O'Hare et al., Proc. Natl. Acad. Sci. USA 78:1527 (1981)); the *gpt* gene, which confers resistance to mycophenolic acid (Mulligan et al., Proc. Natl. Acad. Sci. USA 78:2072 (1981)); the *neomycin* gene, which confers resistance to the

aminoglycoside G-418 (Colberre-Garapin et al., J. Mol. Biol. 150:1(1981)); and the *hygromycin* gene, which confers resistance to hygromycin (Santerre et al., Gene 30:147 (1984)). Additional selectable genes include trpB, which allows cells to utilize indole in place of tryptophan; hisD, which allows cells to utilize histinol in place of histidine (Hartman et al., Proc. Natl. Acad. Sci. USA 85:8047 (1988)); and ODC (ornithine decarboxylase), which confers resistance to the ornithine decarboxylase inhibitor, 2-(difluoromethyl)-DL-ornithine, DFMO (McConlogue (1987) In: Current Communications in Molecular Biology, Cold Spring Harbor Laboratory).

As used herein, the terms "nucleic acid damaging treatment" and "nucleic acid damaging agent" means any treatment regimen that directly or indirectly damages nucleic acid (e.g., DNA, cDNA, genomic DNA, mRNA, tRNA or rRNA). Specific examples of such agents include alkylating agents, nitrosoureas, anti-metabolites, plant alkaloids, plant extracts and radioisotopes. Specific examples of agents also include nucleic acid damaging drugs, for example, 5-fluorouracil (5-FU), capecitabine, S-1 (Tegafur, 5-chloro-2,4-dihydroxypyridine and oxonic acid), 5-ethynyluracil, arabinosyl cytosine (ara-C), 5-azacytidine (5-AC), 2',2'-difluoro-2'-deoxycytidine (dFdC), purine antimetabolites (mercaptopurine, azathiopurine, thioguanine), gemcitabine hydrochloride (Gemzar), pentostatin, allopurinol, 2-fluoro-arabinosyl-adenine (2F-ara-A), hydroxyurea, sulfur mustard (bischloroetyhylsulfide), mechlorethamine, melphalan, chlorambucil, cyclophosphamide, ifosfamide, thiotepa, AZQ, mitomycin C, dianhydrogalactitol, dibromoducitol, alkyl sulfonate (busulfan), nitrosoureas (BCNU, CCNU, 4-methyl CCNU or ACNU), procarbazine, decarbazine, rebeccamycin, anthracyclins such as doxorubicin (adriamycin; ADR), daunorubibcin (Cerubicine), idarubicin (Idamycin) and epirubicin (Ellence), anthracyclin analogues such as mitoxantrone, actinimycin D, non intercalating topoisomerase inhibitors such as epipodophyllotoxins (etoposide=VP16, teniposide=VM-26), podophylotoxin, bleomycin (Bleo), pepleomycin, compounds that form adducts with nucleic acid including platinum derivatives (e.g., cisplatin (CDDP), trans analogue of cisplatin, carboplatin, iproplatin, tetraplatin and oxaliplatin), camptothecin, topotecan, irinotecan (CPT-11), and SN-38. Specific examples of nucleic acid damaging treatments include radiation (e.g., ultraviolet (UV), infrared (IR), or alpha-, beta- or gamma-radiation) and environmental shock (e.g., hyperthermia).

As used herein, the terms "anti-proliferative treatment" and "anti-proliferative agent" means any treatment regimen that directly or indirectly inhibits proliferation of a

cell, virus, bacteria or other unicellular or multicellular organism regardless of whether or not the treatment or agent damages nucleic acid. Particular examples of anti-proliferative agents are anti-tumor and anti-viral drugs, which inhibit cell proliferation or virus proliferation or replication. Specific examples include, *inter alia*, cyclophosphamide, azathioprine, cyclosporin A, prednisolone, melphalan, chlorambucil, mechlorethamine, busulphan, methotrexate, 6-mercaptopurine, thioguanine, cytosine arabinoside, taxol, vinblastine, vincristine, doxorubicin, actinomycin D, mithramycin, carmustine, lomustine, semustine, streptozotocin, hydroxyurea, cisplatin, mitotane, procarbazine, dacarbazine and dibromomannitol. Anti proliferative agents that cause nucleic acid replication errors or inhibit nucleic acid replication such as nucleoside and nucleotide analogues (e.g., AZT or 5-AZC).

Invention peptides and peptidomimetics can also augment the anti-cell proliferative activity of microtubule stabilizing or destabilizing agents such as vinca alkaloids (vinblastine=VLB, vincristin=VCR, vinorelbine=VRLB, vinflunine=VFL), and taxanes (paclitaxel and docetaxel=taxotare). Thus, such agents may be further included in the compositions of the invention and used in the methods of the invention.

Cells that may be treated with the compounds of the invention include any cell whose proliferation it is desired to inhibit or prevent in vitro, ex vivo or in vivo. Particular target cells exhibit a shorter than normal cell cycle G1 checkpoint time or have an impaired cell cycle G1 checkpoint such that the cells exit the G1 checkpoint before enough time has passed to complete nucleic acid repair. Candidate cells therefore include cells that rapidly proliferate whether the cells are normal or abnormal. Specific examples are benign or tumorous, metastatic or non-metastatic cells. Additional candidate cells can be identified by measuring their proliferation rate or the length of time that the cells remain in G1 phase. Candidate cells can also be identified by contacting a test cell with an invention compound alone, or in combination with a nucleic acid damaging treatment, and determining if the contacted cell exhibits decreased proliferation or increased cell death or apoptosis/catastrophe.

Invention compounds are therefore useful for inhibiting cell proliferation in vitro, *ex vivo* and *in vivo*. As such, subjects having or at risk of having a disorder or physiological condition characterized by abnormal or undesirable or unwanted cell proliferation or cell survival, or abnormal or deficient cell differentiation, can be treated

with an invention compound alone or in combination with a treatment that directly or indirectly causes nucleic acid damage or an anti-proliferative treatment.

Thus, in accordance with the invention, there are provided methods for inhibiting cell proliferation, methods for increasing sensitivity of a cell to a nucleic acid damaging agent or treatment and methods for increasing nucleic acid damage to a cell in vitro, *ex vivo* and *in vivo*. In one embodiment, a method includes contacting a cell (e.g., a cultured cell or a cell present in a subject) with an amount of an invention peptide or peptidomimetic sufficient to inhibit proliferation of the cell. In another embodiment, a method includes contacting the cell with an amount of an invention peptide or peptidomimetic sufficient to increase sensitivity of the cell to a nucleic acid damaging agent or treatment. In yet another embodiment, a method includes contacting a cell with an amount of an invention peptide or peptidomimetic sufficient to increase nucleic acid damage of the cell. In various aspects, a method further includes contacting the cell with a nucleic acid damaging agent or exposing the cell to a nucleic acid damaging treatment.

Further provided are methods of treating a cell proliferative disorder or differentiative disorder in a subject, including conditions characterized by undesirable or unwanted cell proliferation or cell survival, conditions characterized by deficient or aberrant apoptosis, conditions characterized by aberrant or deficient cell survival, as well as conditions characterized by aberrant or deficient cell differentiation. In one embodiment, a method includes administering to a subject having or at risk of having a cell proliferative disorder, an amount of an invention peptide or peptidomimetic effective to treat the cell proliferative disorder. In one aspect, the amount is sufficient to improve the subjects condition. In particular aspects, the improvement includes, in at least a portion of the target cells (e.g., abnormally proliferating cells), decreased cell proliferation, decreased numbers of cells, inhibiting increases in the number of cells, increased apoptosis, or decreased survival. In yet another aspect, the subject is administered an invention compound prior to, contemporaneously with, or after administering a treatment that inhibits cell proliferation. In additional particular aspects, at least a part of the cells of the cell proliferative disorder are located in blood, breast, lung, thyroid, head or neck, brain, lymph, gastrointestinal tract, genito-urinary tract, kidney, pancreas, liver, bone, muscle, or skin.

In another embodiment, a method includes administering an amount of compound to the subject to treat a solid tumor. In yet another embodiment, a method includes administering an amount of compound to the subject to treat a liquid tumor. In various aspects, the subject having the tumor is administered with an invention compound prior to, contemporaneously with, or after another anti-tumor therapy.

As used herein, the terms "proliferative disorder" and "proliferative condition" mean any pathological or non-pathological physiological condition characterized by aberrant or undesirable proliferation (e.g., of a cell, virus, bacteria, fungus, etc.). The terms "cell proliferative disorder" and "cell proliferative condition" mean any pathological or non-pathological physiological condition characterized by aberrant or undesirable cell proliferation, as well as including conditions characterized by undesirable or unwanted cell proliferation or cell survival (*e.g.*, due to deficient apoptosis), conditions characterized by deficient or aberrant or deficient apoptosis, as well as conditions characterized by aberrant or undesirable or unwanted cell survival. The term "differentiative disorder" means any pathological or non-pathological physiological condition characterized by aberrant or deficient differentiation.

Proliferative or differentiative disorders amenable to treatment include diseases and non-pathological physiological conditions, both benign and neoplastic, characterized by abnormal or undesirable cell numbers, cell growth or cell survival. Such disorders or conditions may therefore constitute a disease state and include all types of cancerous growths or oncogenic processes, metastatic tissues or malignantly transformed cells, tissues, or organs, or may be non-pathologic, *i.e.*, a deviation from normal but which is not typically associated with disease. A specific example of a non-pathologic condition that may be treated in accordance with the invention is tissue re-growth from wound repair that results in scarring.

Cells comprising the proliferative or differentiative disorder may be aggregated in a cell mass or be dispersed. The term "solid tumor" refers to neoplasias or metastases that typically aggregate together and form a mass. Particular examples include visceral tumors such as gastric or colon cancer, hepatomas, venal carcinomas, lung and brain tumors/cancers. A "liquid tumor" refers to neoplasias of the haematopoetic system, such as lymphomas, myelomas and leukemias, or neoplasias that are diffuse in nature, as they do not typically form a solid mass. Particular examples of leukemias include acute and chronic lymphoblastic, myeolblasitc and multiple myeloma.

Such disorders include neoplasms or cancers, which can affect virtually any cell or tissue type, *e.g.*, carcinoma, sarcoma, melanoma, metastatic disorders or haematopoietic neoplastic disorders. A metastatic tumor can arise from a multitude of primary tumor types, including but not limited to breast, lung, thyroid, head and neck, brain, lymphoid, gastrointestinal (mouth, esophagus, stomach, small intestine, colon, rectum), genito-urinary tract (uterus, ovary, cervix, bladder, testicle, penis, prostate), kidney, pancreas, liver, bone, muscle, skin, etc.

Carcinomas refer to malignancies of epithelial or endocrine tissue, and include respiratory system carcinomas, gastrointestinal system carcinomas, genitourinary system carcinomas, testicular carcinomas, breast carcinomas, prostatic carcinomas, endocrine system carcinomas, and melanomas. Exemplary carcinomas include those forming from the cervix, lung, prostate, breast, head and neck, colon, liver and ovary. The term also includes carcinosarcomas, *e.g.*, which include malignant tumors composed of carcinomatous and sarcomatous tissues. Adenocarcinoma includes a carcinoma of a glandular tissue, or in which the tumor forms a gland like structure.

Sarcomas refer to malignant tumors of mesenchymal cell origin. Exemplary sarcomas include for example, lymphosarcoma, liposarcoma, osteosarcoma, and fibrosarcoma.

As used herein, the term "haematopoietic proliferative disorder" means a disease involving hyperplastic/neoplastic cells of haematopoietic origin, *e.g.*, arising from myeloid, lymphoid or erythroid lineages, or precursor cells thereof. Typically, the diseases arise from poorly differentiated acute leukemias, *e.g.*, erythroblastic leukemia and acute megakaryoblastic leukemia. Additional exemplary myeloid disorders include, but are not limited to, acute promyeloid leukemia (APML), acute myelogenous leukemia (AML) and chronic myelogenous leukemia (CML); lymphoid malignancies include, but are not limited to, acute lymphoblastic leukemia (ALL), which includes B-lineage ALL and T-lineage ALL, chronic lymphocytic leukemia (CLL), prolymphocytic leukemia (PLL), hairy cell leukemia (HLL) and Waldenstrom's macroglobulinemia (WM). Additional malignant lymphomas include, but are not limited to, non-Hodgkin lymphoma and variants thereof, peripheral T cell lymphomas, adult T cell leukemia/lymphoma (ATL), cutaneous T-cell lymphoma (CTCL), large granular lymphocytic leukemia (LGF), Hodgkin's disease and Reed-Sternberg disease.

Treatments for use in combination with the invention compounds include any anti-proliferative, nucleic acid damaging or anti-tumor treatment as disclosed herein or known in the art. For example, an anti-cell proliferative or anti-tumor treatment may comprise radiation treatment or surgical resection optionally in combination with drug treatment. The treatment may comprise administration of a chemical substance, such as a radioisotope, a drug, such as a chemotherapeutic agent, or genetic therapy, such as an anti-oncogene (*e.g.*, Rb, DCC, p53, etc.), a dominant negative oncogene or an antisense to an oncogene. The compounds can be administered prior to, contemporaneously with or following other treatment protocols. For example, a candidate subject for anti-cell proliferative therapy (*e.g.*, radiation therapy, chemotherapy, gene therapy, surgical resection, etc.) can be administered an invention compound prior to initiating the anti-cell proliferative therapy. Thus, prophylactic treatment methods are provided.

The term "subject" refers to animals, typically mammalian animals, such as primates (humans, apes, gibbons, chimpanzees, orangutans, macaques), domestic animals (dogs and cats), farm animals (horses, cattle, goats, sheep, pigs) and experimental animals (mouse, rat, rabbit, guinea pig). Subjects include animal disease models (e.g., tumor bearing mice).

Subjects appropriate for treatment include those currently undergoing or are candidates for treatment for a proliferative or differentiative disorder or (*e.g.*, anti-tumor therapy). Additional candidate subjects include, for example, subjects at risk of developing a cell proliferative disorder. The invention methods are therefore applicable to treating a subject who is at risk of developing a cell proliferative disorder but who has not yet exhibited overt symptoms of the disorder. At risk subjects can be identified as having a genetic predisposition or family history to developing a cell proliferative disorder. For example, subjects having an activated oncogene or having a mutation or deletion of a tumor suppressor gene are candidate subjects. At risk subjects can therefore be identified using routine genetic screening for the presence of the genetic lesion, or inquiry into the subjects' family history to establish that they are at risk of the disorder. A particular example of an at risk subject would be one with a family history or other genetic characteristic indicating predisposition to a cancer in which the neoplastic or drug-resistant neoplastic cells express CD40. A particular specific example of a genetic disease is retinoblastoma, which is caused by a defect in the *Rb* tumor suppresor gene.

Amounts administered are typically in an "effective amount" or "sufficient amount" that is an amount sufficient to produce the desired affect. Effective amounts therefore include one or more of: decreasing cell proliferation, decreasing numbers of cells, inhibiting increased proliferation, inhibiting increased numbers of cells, increasing apoptosis, or decreasing survival, of at least a portion of the cells comprising the proliferating cells (e.g., at least some of the target cells). Thus, for example, where it is desired to inhibit cell proliferation, an effective amount will be an amount that detectably decreases cell proliferation or numbers of proliferating cells, or increases cell apoptosis or decreases cell survival. The amount can therefore be sufficient to reduce target cell numbers, stabilize target cell numbers or inhibit increases in target cell numbers. For example, where the disorder comprises a solid tumor, reducing tumor size, stabilizing tumor size, or preventing further growth of the tumor, of at least a portion of the tumor (*e.g.* inhibiting growth of 5-10% of the cells, or 10-20% or more of the cells comprising the tumor mass) is a satisfactory clinical endpoint. Where the disorder comprises a liquid tumor, reducing numbers of tumor cells, stabilizing tumor cell numbers or inhibiting further increases in tumor cell numbers, of at least a subpopulation of the tumor cells (*e.g.* inhibiting growth of 5-10% of the cells, or 10-20% or more of the cells) is a satisfactory clinical endpoint.

In addition, amounts considered effective can prevent or inhibit progression of the condition or disorder. For example, certain tumors as they progress become increasingly aggressive, including progressing to metastatic forms. Thus, amounts also considered effective would result in reducing or preventing the tumors from becoming increasingly aggressive or from metastasizing. Accordingly, inhibiting or preventing a worsening of the disorder or condition, i.e., stabilizing the condition is an additional satisfactory clinical endpoint.

Examination of a biological sample containing a liquid tumor (*e.g.*, blood or a tissue sample), can establish whether tumor cell mass or numbers have been reduced, or inhibition of tumor cell proliferation has occurred. For a solid tumor, invasive and non-invasive imaging methods can ascertain a reduction in tumor size, or inhibiting increases in the tumor size. Decreasing counts of receptor of a receptor positive tumor, can be used to assess reduction or inhibition of tumor cell proliferation. Amounts of hormone of a hormone producing tumor, *e.g.*, breast, testicular, or ovarian cancers, can be used to assess a reduction or inhibition of proliferation of the tumor.

Effective amounts can also objectively or subjectively reduce or decrease the severity or frequency of symptoms associated with the disorder or condition. For example, an amount of an invention compound that reduces pain, nausea or other discomfort, or increases appetite or subjective well being is a satisfactory clinical endpoint.

Effective amounts also include a reduction of the amount (e.g., dosage) or frequency of treatment with another protocol, which is considered a satisfactory clinical endpoint. For example, a cancer patient treated with an invention compound may require less nucleic acid damaging treatment in order to inhibit cancer cell proliferation. In this example, an effective amount would include an amount that reduces the dosage frequency or amount of a nucleic acid damaging agent that the subject is administered in comparison to the dosage frequency or amount administered without treatment with a compound of the invention.

Methods of the invention that lead to an improvement in the subject's condition or a therapeutic benefit may be relatively short in duration, e.g., the improvement may last several hours, days or weeks, or extend over a longer period of time, e.g., months or years. An effective amount need not be a complete ablation of any or all symptoms of the condition or disorder. Thus, a satisfactory clinical endpoint for an effective amount is achieved when there is a subjective or objective improvement in the subjects' condition as determined using any of the foregoing criteria or other criteria known in the art appropriate for determining the status of the disorder or condition, over a short or long period of time. An amount effective to provide one or more beneficial effects, as described herein or known in the art, is referred to as an "improvement" of the subject's condition or "therapeutic benefit" to the subject.

An effective amount of an invention compound can be determined based upon animal studies or optionally in human clinical trials. The skilled artisan will appreciate the various factors that may influence the dosage and timing required to treat a particular subject including, for example, the general health, age, or gender of the subject, the severity or stage of the disorder or condition, previous treatments, susceptibility to undesirable side effects, clinical outcome desired and the presence of other disorders or conditions. Such factors may influence the dosage and timing required to provide an amount sufficient for therapeutic benefit. The dosage regimen also takes into consideration the pharmacokinetics, i.e., the pharmaceutical composition's rate of

absorption, bioavailability, metabolism, and clearance (see, e.g., Egleton (1997) "Bioavailability and transport of peptides and peptide drugs into the brain" Peptides 18:1431-1439; and Langer (1990) Science 249:1527-1533). In addition, doses or treatment protocols may be specifically tailored to the subject or modified based on pharmacogenomic data.

The compounds of the invention can therefore be administered alone or as a pharmaceutical composition, systemically, regionally (e.g., directed towards an organ or tissue, e.g., by injection into the portal vein for treating a cell proliferative disorder of the liver), or locally (e.g., directly into a tumor mass), in accordance with any protocol or route that achieves the desired effect. The compounds and pharmaceutical compositions can be administered as a single or multiple dose each day (*e.g.*, at a low dose), or intermittently (*e.g.*, every other day, once a week, etc. at a higher dose). The compounds and pharmaceutical compositions can be administered via inhalation (e.g., intra-tracheal), orally, intravenously, intraarterially, intravascularly, intrathecally, intraperitonealy, intramuscularly, subcutaneously, intracavity, transdermally (e.g., topical), transmucosally (e.g., buccal, bladder, vaginal, uterine, rectal, or nasal), by multiple administrations, sustained release (e.g., gradual perfusion over time) or a single bolus. Implantable devices, including microfabricated devices, for administering drugs are well known and are also applicable for delivering compounds of the invention to a subject.

Compounds administered intravenously (IV) would be at about 0.01 mg/hr to about 1.0 mg/hr over several hours (typically 1, 3, or 6 hours), which can be repeated for one or more weeks with intermittent cycles. Considerably higher dosages (e.g., ranging up to about 10 mg/ml) can be used, particularly when the drug is administered to a secluded site and not into the blood stream, such as into a body cavity or into a lumen of an organ, e.g., the cerebrospinal fluid (CSF).

The invention therefore further provides pharmaceutical compositions. Such pharmaceutical compositions are useful for administration to a subject *in vivo* or *ex vivo*, and for treating a subject with the invention compounds, for example.

As used herein the term "pharmaceutically acceptable" and "physiologically acceptable" includes solvents (aqueous or non-aqueous), solutions, emulsions, dispersion media, coatings, isotonic and absorption promoting or delaying agents, compatible with pharmaceutical administration. A "pharmaceutical composition" or "pharmaceutical formulation" therefore refers to a composition suitable for pharmaceutical use in a subject.

The pharmaceutical compositions and formulations include an amount of an invention compound, for example, an effective amount of a peptide or peptidomimetic, nucleic acid encoding same, vector, or cell of the invention, and a pharmaceutically or physiologically acceptable carrier.

Pharmaceutical compositions can be formulated to be compatible with a particular route of administration, systemic or local. Thus, pharmaceutical compositions include carriers, diluents, or excipients suitable for administration by various routes.

Formulations or enteral (oral) administration can be contained in a tablet (coated or uncoated), capsule (hard or soft), microsphere, emulsion, powder, granule, crystal, suspension, syrup or elixir. Conventional nontoxic solid carriers which include, for example, pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, sodium saccharin, talcum, cellulose, glucose, sucrose, magnesium carbonate, can be used to prepare solid formulations. Supplementary active compounds (e.g., preservatives, antibacterial, antiviral and antifungal agents) can also be incorporated into the formulations. A liquid formulation can also be used for enteral administration. The carrier can be selected from various oils including petroleum, animal, vegetable or synthetic, for example, peanut oil, soybean oil, mineral oil, sesame oil. Suitable pharmaceutical excipients include e.g., starch, cellulose, talc, glucose, lactose, sucrose, gelatin, malt, rice, flour, chalk, silica gel, magnesium stearate, sodium stearate, glycerol monostearate, sodium chloride, dried skim milk, glycerol, propylene glycol, water, ethanol.

Pharmaceutical compositions for enteral, parenteral, or transmucosal delivery include, for example, water, saline, phosphate buffered saline, Hank's solution, Ringer's solution, dextrose/saline, and glucose solutions. The formulations can contain auxiliary substances to approximate physiological conditions, such as buffering agents, tonicity adjusting agents, wetting agents, detergents and the like. Additives can also include additional active ingredients such as bactericidal agents, or stabilizers. For example, the solution can contain sodium acetate, sodium lactate, sodium chloride, potassium chloride, calcium chloride, sorbitan monolaurate or triethanolamine oleate. Additional parenteral formulations and methods are described in Bai (1997) J. Neuroimmunol. 80:65-75; Warren (1997) J. Neurol. Sci. 152:31-38; and Tonegawa (1997) J. Exp. Med. 186:507-515. The parenteral preparation can be enclosed in ampules, disposable syringes or multiple dose vials made of glass or plastic.

Pharmaceutical compositions for intradermal or subcutaneous administration can include a sterile diluent, such as water, saline solution, fixed oils, polyethylene glycols, glycerine, propylene glycol or other synthetic solvents; antibacterial agents such as benzyl alcohol or methyl parabens; antioxidants such as ascorbic acid, glutathione or sodium bisulfite; chelating agents such as ethylenediaminetetraacetic acid; buffers such as acetates, citrates or phosphates and agents for the adjustment of tonicity such as sodium chloride or dextrose.

Pharmaceutical compositions for injection include aqueous solutions (where water soluble) or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersion. For intravenous administration, suitable carriers include physiological saline, bacteriostatic water, Cremophor EL™ (BASF, Parsippany, NJ) or phosphate buffered saline (PBS). The carrier can be a solvent or dispersion medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyetheylene glycol, and the like), and suitable mixtures thereof. Fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. Antibacterial and antifungal agents include, for example, parabens, chlorobutanol, phenol, ascorbic acid and thimerosal. Isotonic agents, for example, sugars, polyalcohols such as manitol, sorbitol, sodium chloride may be included in the composition. The resulting solutions can be packaged for use as is, or lyophilized, the lyophilized preparation can later be combined with a sterile solution prior to administration.

Pharmaceutically acceptable carriers can contain a compound that stabilizes, increases or delays absorption or clearance. Such compounds include, for example, carbohydrates, such as glucose, sucrose, or dextrans; low molecular weight proteins; compositions that reduce the clearance or hydrolysis of peptides; or excipients or other stabilizers and/or buffers. Agents that delay absorption include, for example, aluminum monostearate and gelatin. Detergents can also be used to stabilize or to increase or decrease the absorption of the pharmaceutical composition, including liposomal carriers. To protect from digestion the compound can be complexed with a composition to render it resistant to acidic and enzymatic hydrolysis, or the compound can be complexed in an appropriately resistant carrier such as a liposome. Means of protecting compounds from digestion are known in the art (see, e.g., Fix (1996) Pharm Res. 13:1760-1764; Samanen

(1996) J. Pharm. Pharmacol. 48:119-135; and U.S. Patent 5,391,377, describing lipid compositions for oral delivery of therapeutic agents).

For transmucosal or transdermal administration, penetrants appropriate to the barrier to be permeated are used in the formulation. Such penetrants are generally known in the art, and include, for example, for transmucosal administration, detergents, bile salts, and fusidic acid derivatives. Transmucosal administration can be through nasal sprays or suppositories (see, e.g., Sayani (1996) "Systemic delivery of peptides and proteins across absorptive mucosae" Crit. Rev. Ther. Drug Carrier Syst. 13:85-184). For transdermal administration, the active compound can be formulated into ointments, salves, gels, or creams as generally known in the art. Transdermal delivery systems can also be achieved using patches.

For inhalation delivery, the pharmaceutical formulation can be administered in the form of an aerosol or mist. For aerosol administration, the formulation can be supplied in finely divided form along with a surfactant and propellant. In another embodiment, the device for delivering the formulation to respiratory tissue is in which the formulation vaporizes. Other delivery systems known in the art include dry powder aerosols, liquid delivery systems, inhalers, air jet nebulizers and propellant systems (see, e.g., Patton (1998) Biotechniques 16:141-143; Dura Pharmaceuticals, San Diego, CA; Aradigm, Hayward, CA; Aerogen, Santa Clara, CA; and Inhale Therapeutic Systems, San Carlos, CA).

Biodegradable, biocompatable polymers can be used, such as ethylene vinyl acetate, polyanhydrides, polyglycolic acid, collagen, polyorthoesters, and polylactic acid. Methods for preparation of such formulations are known to those skilled in the art. The materials can also be obtained commercially from Alza Corporation and Nova Pharmaceuticals, Inc. Liposomal suspensions (including liposomes targeted to cells or tissues using antibodies or viral coat proteins) can also be used as pharmaceutically acceptable carriers. These can be prepared according to methods known in the art, for example, as described in U.S. Patent Nos. 4,235,871; 4,501,728; 4,522,811; 4,837,028; 6,110,490; 6,096,716; 5,283,185; 5,279,833; Akimaru (1995) Cytokines Mol. Ther. 1:197-210; Alving (1995) Immunol. Rev. 145:5-31; and Szoka (1980) Ann. Rev. Biophys. Bioeng. 9:467). Biodegradeable microspheres or capsules or other biodegradeable polymer configurations capable of sustained delivery of small molecules including peptides are known in the art (see, e.g., Putney (1998) Nat. Biotechnol. 16:153-157).

Compounds of the invention can be incorporated within micelles (see, e.g., Suntres (1994) J. Pharm. Pharmacol. 46:23-28; Woodle (1992) Pharm. Res. 9:260-265). Peptides can be attached to the surface of the lipid monolayer or bilayer. For example, peptides can be attached to hydrazide- PEG- (distearoylphosphatidyl) ethanolamine- containing liposomes (see, e.g., Zalipsky (1995) Bioconjug. Chem. 6:705-708). Alternatively, any form of lipid membrane, such as a planar lipid membrane or the cell membrane of an intact cell, e.g., a red blood cell, can be used. Liposomal and lipid-containing formulations can be delivered by any means, including, for example, intravenous, transdermal (see, e.g., Vutla (1996) J. Pharm. Sci. 85:5-8), transmucosal, or oral administration.

A pharmaceutically acceptable formulation can incorporate about 1% to 99.9% of active ingredient (e.g., peptide or peptidomimetic). The pharmaceutical compositions can be sterilized by conventional, well-known sterilization techniques, or can be sterile filtered.

Additional pharmaceutical formulations and delivery systems are known in the art and are applicable in the methods and compositions of the invention (see, *e.g.*, Remington's Pharmaceutical Sciences (1990) 18th ed., Mack Publishing Co., Easton, PA; The Merck Index (1996) 12th ed., Merck Publishing Group, Whitehouse, NJ; Pharmaceutical Principles of Solid Dosage Forms, Technonic Publishing Co., Inc., Lancaster, Pa., (1993); and Poznansky et al., Drug Delivery Systems, R. L. Juliano, ed., Oxford, N.Y. (1980), pp. 253-315)

The pharmaceutical formulations can be packaged in unit dosage form for ease of administration and uniformity of dosage. "Unit dosage form" as used herein refers to physically discrete unitary dosages for administration to the subject to be treated; each unit contains a predetermined quantity of compound that produces a desired effect in combination with a pharmaceutical carrier or excipient.

The following are abbreviations used herein:

Cha: cyclohexyl-alanine

Phe-2,3,4,5,6-F: Fluorides are at position 2,3,4,5,6,on Phenyl residue of Phenylalanine

F: Fluoride

Bpa: Benzoyl-phenylalanine

Nal(2): 2-Naphthyl-alanyl

Ala(3-Bzt): (3-Benzothienyl)-Alanine

Nal(1): 1-Naphthyl-alanyl

Dph: Diphenyl-Alanine

Ala(tBu): t-Butyl-alanyl

Cys(tBu): t-Butyl-cysteine

Phe-3,4,5-F: Fluorides are at position 3,4,5 on the Phenyl of Phenylalanine

Phe-4CF3: CF3 is at position 4 on Phenyl residue of Phenylalanine

Phe-3Br,4Cl,5Br: Bromide is at position 3, Chloride is at position 4, and Bromide is at position 5 on the Phenyl of Phenylalanine

Phe-4Cl: Chloride is at position 4 on the Phenyl of Phenylalanine

P1, P2, P3, P4, P5, P6, etc., and (P1, P2, P3, P4, P5, P6, etc.); and P7, P8, P9, P10, P11, P12, etc., and (P7, P8, P9, P10, P11, P12, etc.): contiguous sequence of P1, P2, P3, P4, P5, P6, etc.; and P7, P8, P9, P10, P11, P12, respectively.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described herein.

All publications, patents and other references cited herein are incorporated by reference in their entirety. In case of conflict, the present specification, including definitions, will control.

As used herein, the singular forms "a", "and," "the" and "is" include plural referents unless the context clearly indicates otherwise. Thus, for example, reference to a "compound" includes a plurality of compounds and reference to "a residue" or an "amino acid" includes reference to one or more residues and amino acids.

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, the following examples are intended to illustrate but not limit the scope of invention described in the claims.

EXAMPLES

Example 1

This example describes materials and several methods. This example also describes the sequences of analyzed peptides/peptidomimetics.

Chemicals and reagents Bleomycin was purchased from Wako Pure Chemical Co. (Osaka, Japan) and it was dissolved in distilled H_2O to 10 mg/ml. Propidium iodide (PI) and adriamycin were purchased from Sigma (St. Louis, MO).

Cell culture A human T-cell leukemia-derived cell line, Jurkat, was cultured in RPMI 1640 (Sigma) supplemented with 10% fetal calf serum (IBL: Immuno-Biological Laboratories, Gunma, Japan) at 37°C/5% CO_2. Human pancreatic cancer derived cell line, MIAPaCa2 was cultured in DMEM with 10% fetal calf serum at 37°C/5% CO_2.

Cell-cycle analysis The cell cycle status of the cells treated with bleomycin or adriamcin were analyzed by flow cytometry as described by Kawabe (1997) Nature 385:454-458. In brief, two million cells were re-suspended and incubated in 200 µl Krishan's solution (0.1% Sodium citrate, 50 µg/ml PI, 20 µg/ml RNase A and 0.5% NP-40) for 1 hr at 4°C and analyzed by a flow cytometry, FACScan™ (Beckton Dickinson, Mountain View, CA) with the program CELLQuest™ (Beckton Dickinson).

Table 1. Sequences and Corresponding Code Names of exemplary peptides/peptidomimetics.

(l-Tyr)(l-Gly)(l-Arg)(l-Lys)(l-Lys)(l-Arg)(l-Arg)(l-Gln)(l-Arg)(l-Arg)(l-Arg)(l-Cha)(l-Phe-2,3,4,5,6-F)(l-Arg)(l-Ser)(l-Pro)(l-Ser)(l-Tyr)(l-Tyr) (SEQ ID NO:105)	BP413
(l-Tyr)(l-Gly)(l-Arg)(l-Lys)(l-Lys)(l-Arg)(l-Arg)(l-Gln)(l-Arg)(l-Arg)(l-Arg)(l-Cha)(l-Phe-2,3,4,5,6-F)(l-Arg)(l-Ser)(l-Pro)(l-Ser)(l-Tyr) (SEQ ID NO:106)	BP420
(l-Arg)(l-Arg)(l-Arg)(l-Cha)(l-Phe-2,3,4,5,6-F)(l-Arg)(l-Ser)(l-Pro)(l-Ser)(l-Tyr)(l-Tyr) (SEQ ID NO:107)	BP430
(l-Arg)(l-Arg)(l-Gln)(l-Arg)(l-Arg)(l-Arg)(l-Cha)(l-Phe-2,3,4,5,6-F)(l-Arg)(l-Ser)(l-Pro)(l-Ser)(l-Tyr)(l-Tyr) (SEQ ID NO:108)	BP431
(l-Arg)(l-Arg)(l-Gln)(l-Arg)(l-Arg)(l-Arg)(l-Cha)(l-Phe-2,3,4,5,6-F)(d-Ser)(d-Trp)(l-Pro)(l-Ser)(l-Tyr) (SEQ ID NO:109)	BP432
(l-Tyr)(l-Gly)(l-Arg)(l-Lys)(l-Lys)(l-Arg)(l-Arg)(l-Gln)(l-Arg)(l-Arg)(l-Arg)(l-Cha)(l-Phe-2,3,4,5,6-F)(l-aminoundecanoic acid)(l-Tyr)(l-Tyr) (SEQ ID NO:110)	BP440
(d-Tyr)(d-Tyr)(d-Ser)(l-Gly)(d-Ser)(d-Arg)(d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg)(d-Lys)(d-Lys)(d-Arg)(l-Gly)(d-Tyr) (SEQ ID NO:111)	BP450
(d-Tyr)(d-Ser)(d-Pro)(l-Trp)(l-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg) (SEQ ID NO:87)	BP451
(d-Tyr)(d-Ser)(l-Pro)(l-Trp)(l-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg)(d-Arg) (SEQ ID NO:88)	BP452
(d-Tyr)(d-Ser)(d-Pro)(l-Trp)(l-Ser)(d-Phe-2,3,4,5,6-F)(d-Pro) (d-Arg)(d-Arg)(d-Arg) (d-Gln) (d-Arg)(d-Arg) (SEQ ID NO:112)	BP454
(d-Tyr)(d-Ser)(l-Pro)(l-Trp)(l-Ser)(d-Phe-2,3,4,5,6-F)(l-Pro) (d-Arg)(d-Arg) (d-Arg) (d-Gln) (d-Arg)(d-Arg) (SEQ ID NO:113)	BP455
(l-Tyr)(l-Tyr)(l-aminoundecanoic acid)(d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg) (d-Arg) (d-Gln) (d-Arg)(d-Arg) (d-Lys)(d-Lys)(d-Arg)(l-Gly)(d-Tyr) (SEQ ID NO:114)	BP460
(l-Tyr)(l-aminoundecanoic acid)(d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg) (d-Lys)(d-Lys)(d-Arg) (l-Gly)(d-Tyr) (SEQ ID NO:115)	BP461
(l-Tyr)(l-aminoundecanoic acid)(d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:116)	BP462
(l-aminoundecanoic acid) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Lys)(d-Lys)(d-Arg) (l-Gly)(d-Tyr) (SEQ ID NO:117)	BP463
(l-aminoundecanoic acid)(d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:118)	BP464
(l-aminoundecanoic acid)(d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:119)	BP465
(l-8-aminocaprylic acid)(d-Cha)(d-Phe-2,3,4,5,6-F) (d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:120)	BP466
(d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:121)	BP470
(d-Cha)(d-Phe-2,3,4,5,6-F) (d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg) (SEQ ID NO:122)	BP471
(d-Tyr)(d-Ser)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg) (d-Gln) (d-Arg)(d-Arg) (SEQ ID NO:123)	BP481
(d-Tyr)(d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg)(d-Arg)(d-Arg)(d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:124)	BP500
(d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:80)	BP501
(d-Bpa)(l-8-aminocaprylic acid)(d-Cha)(d-Phe-2,3,4,5,6-F) (d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:125)	BP502

(d-Bpa)(l-8-aminocaprylic acid)(d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:126)	BP503
(d-Asp) (d-Bpa) (d-Ser) (d-Trp) (d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:127)	BP504
(d-Bpa) (d-Asp) (d-Ser) (d-Trp) (d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:128)	BP505
(d-Bpa) (d-Ser) (d-Trp) (d-Ser) (d-Asp) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:129)	BP506
(d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser) (d-Trp) (d-Ser) (d-Bpa) (SEQ ID NO:93)	BP510
(d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (d-Bpa) (d-Ser) (d-Trp) (d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha) (SEQ ID NO:94)	BP511
(d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Cha) (d-Phe-2,3,4,5,6-F) (d-Ser) (d-Trp) (d-Ser) (d-Bpa) (SEQ ID NO:95)	BP512
(d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Bpa)(d-Cha)(d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:130)	BP601
(d-Bpa)(l-8-aminocaprylic acid) (d-Bpa) (d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:131)	BP602
(d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe4No2)(d-Cha)(d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:89)	BP603
(d-Bpa)(d-Pro)(d-Trp)(d-Pro)(d-Phe4NO2)(d-Cha)(d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:132)	BP604
(d-Bpa)(d-Pro)(d-Trp)(d-Pro)(d-Phe4NO2)(d-Nal2)(d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:133)	BP605
(d-Phe4NO2)(d-Pro)(d-Trp)(d-Pro)(d-Phe4NO2)(d-Cha)(d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:134)	BP606
(d-Bpa) (d-Ser) (d-Trp) (d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha)(d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (SEQ ID NO:90)	BP607
(d-Bpa) (d-Ser) (d-Trp) (d-Ser) (d-Phe-2,3,4,5,6-F) (d-Cha)(d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Arg) (SEQ ID NO:91)	BP608
(d-Bpa)(d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Lys)(d-Lys)(d-Lys)(d-Lys) (d-Lys) (d-Lys) (SEQ ID NO:92)	BP609
(d-Arg) (d-Arg) (d-Bpa)(d-Arg) (d-Arg) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:96)	BP700
(d-Arg) (d-Arg) (d-Arg) (d-Bpa)(d-Arg)(d-Trp)(d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:97)	BP701
(d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Bpa)(d-Arg)(d-Trp)(d-Arg)(d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:98)	BP702
(d-Arg) (d-Arg) (d-Arg)(d-Bpa)(d-Arg) (d-Arg) (d-Arg)(d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:99)	BP703
(d-Bpa)(d-Cys)(d-Trp)(d-Arg)(d-Phe-2,3,4,5,6F)(d-Cha)(d-Cys) (SEQ ID NO:135)	BP524
(d-Tyr)(d-Cys)(d-Pro)(d-Trp)(d-Arg)(d-Phe-2,3,4,5,6F)(d-Cha)(d-Cys) (SEQ ID NO:136)	BP721

Example 2

This example describes data indicating the G2 abrogating activity of various peptides, and the effect of various sequence permutations on activity including the effect of decreasing sequence length.

Flow cytometry analysis of G2 checkpoint abrogation was performed using human leukemia derived Jurkat cell line. In brief, cultured cells were treated with various doses of peptide/peptidomimetic and 40μg/ml bleomycine for 24 hr. The DNA of the cells was stained with propidium iodide and analyzed by flow cytometry. These results are summarized in Table 2.

A dose response curve of each peptide/peptidomimetic when used against bleomycin treated Jurkat cells are shown in Figures 1, 5, 6, 7, 8, 11 and 12; the Y-axis indicates the %G2/M Jurkat cells 24hrs after the treatment.

Flow cytometry analysis of M phase checkpoint abrogation by the compounds was performed using human T cell leukemia Jurkat cell line treated with colchicine (5μg/ml or 0.5μg/ml) and various doses of peptide/peptidomimetics for 24 hr (Figure 12). The DNA of the cells was stained and analyzed by flow cytometry as described above. These results are also summarized in Table 2.

Dose response curves of each peptide/peptidomimetic when used against colchicine treated Jurkat cells are shown in Figures 2 and 14; the Y-axis indicates the %G2/M Jurkat cells 24hrs after the treatment.

Table 2. Doses of compounds that induce G2 checkpoint abrogation or side effect

Code name	Appearance of side effect when used alone (μM)	G2 abrogating dose (μM)	Appearance of side effect when used with Colchicine (μM)
CBP 441	>50	>50	>50
CBP 462	>50	>50	>50
CBP 464	>50	>50	>50
CBP 470	>50	>50	>50
CBP 430	>50	50	>50
CBP 481	>50	>6.25	>12.5
CBP 431	>50	≥3.125	>50
CBP 420	>50	≥1.56	≥50
CBP 440	>12.5	≥1.56	>3.125
CBP 413	>25	≥1.56	>25
CBP 450	>6.25	≥0.78	>6.25
CBP 460	>3.125	≥0.39	>3.125
CBP 461	>6.25	≥0.39	>6.25
CBP 463	>6.25	≥0.39	>6.25
CBP 500	>50	≥0.39	>12.5
CBP 501	>50	≥0.39	>25

The "Appearance of side effect when used alone" indicates the peptide/peptidomimetic dose that produced Jurkat cell cycle disturbance, i.e., the appearance of significant amounts of SubG1 cells (dead cells) or cells in which the DNA content of each varies more than usual. For example, G1 cells usually exhibit a sharp peak in FACS analysis, but following treatment the peak becomes broader and lower when the cell cycle is disturbed indicating improper cell cycle progression or the beginning of cell death. The "G2 abrogating dose" indicates the peptide/peptidomimetic dose with 40μg/ml bleomycine that produced detectable G2 checkpoint abrogation activity following treatment for 24 hours. The "Appearance of side effect when used with colchicine" indicates the peptide/peptidomimetic dose with 5μg/ml colchicine that produced Jurkat cell cycle disturbance following treatment for 24 hours.

The G2 checkpoint abrogating activity of CBP501 when combined with cis-platin was studied in various cells lines. Briefly, cis-platin (3μg/ml) and CBP501 (0.4, 2 and 10μM) were simultaneously added to the cell culture which was incubated 3hr at 37 degree with 5% CO_2. The medium was aspirated, fresh medium without these compounds was added and the cells were incubated for an additional 45hr. The cells including floating cells were harvested using trypsin-EDTA solution, incubated with Krishan's solution and analyzed for DNA content by flow cytometry as previously described. These results are summarized in Table 3. Shaded highlighting, other than HUVEC, denote cell lines having a significant loss of G2 population and increased subG1 population, indicating G2 checkpoint abrogation and sensitization to cisplatin by CBP501. The observation that HUVEC cells, which are cells having a normal G1 checkpoint, were not sensitized, at least up to 50μM CBP501, indicates that CBP501 is specific for the G2 checkpoint rather than non specific.

Table 3. G2 checkpoint abrogating doses of CBP501 against various cell lines.

CBP501	origin	cis-platin
HUVEC	umbilical vein endothelium	>50
HT-29	colon	<2

MIAPaCa2	pancreas	0.4 <<2
SK-OV-3	ovary, hMLH1	50
HCT116	colon, hMLH1	<2
Panc1	pancreas	>10
MK45	stomach	>10
SW620	colon	>10
NCI-H226	lung, SCC	0.4
SW900	lung, SCC	>10
NCI-H520	lung, SCC	>10
DU-145	prostate, MLH1	0.4
MCF-7	mammary gland	>10

The G2 checkpoint abrogating activity of various compounds at different doses on human pancreatic cancer derived cell line MIAPaCa2 treated with bleomycine (Bleo) or adriamycin (ADR) was studied. Briefly, cells were incubated with the compounds and bleomycine (10μg/ml) or adriamycin (1μg/ml) for 3 hours. The medium was changed and incubated for an additional 21 hours. Harvested cells were stained for DNA by propium iodide and analyzed with flow cytometry as previously described. The % of the sub-G1 cell population is indicated as dead cells in Figure 3. The results indicate that CBP501 sensitized MIAPaCa2 cells to both bleomycin and adriamycin in a dose dependent manner.

Figure 4A and 4C are a summary of the G2 checkpoint abrogating activity performed with pairs of peptides in which one amino acid residue is different from the other. The G2 checkpoint abrogating activity of these peptides was analyzed using bleomycin treated Jurkat cells as described above. Figure 4B is a summary of M checkpoint abrogating activity and/or non specific toxicity analysis performed with pairs of peptides in which one amino acid residue is different from the other. The M checkpoint abrogating activity and/or non specific toxicity of these peptides was analyzed using colchicine treated Jurkat cells as described above.

The G2 checkpoint abrogating activity of various arginine rich sequences at different doses on cells treated with bleomycine was studied. Briefly, peptides were added to culture medium of Jurkat cells with bleomycin (40μg/ml) at 0.2μg/ml, 0.39 μg/ml, 0.78 μg/ml, 1.56 μg/ml, 3.125 μg/ml, 6.25 μg/ml, 12.5 μg/ml, 25 μg/ml and 50 μg/ml. Cells were subsequently harvested after 24 hours, stained with Krishan's solution, and analyzed with flow cytometry as previously described. The %G2/M cells (Y-axis) was plotted against the peptide doses (X-axis) in Figure 5. The data indicate that the "(d-Arg) (d-Arg) (d-Arg)(d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:137)" basic residue rich sequence is the best sequence compared to sequences having fewer or greater numbers of residues.

The G2 checkpoint abrogating activity of peptides without (D-Bpa) at different doses on cells treated with bleomycine was studied. Briefly, peptides were added to culture medium of Jurkat cells with bleomycin (40μg/ml) at 0.2μg/ml, 0.39 μg/ml, 0.78 μg/ml, 1.56 μg/ml, 3.125 μg/ml, 6.25 μg/ml, 12.5 μg/ml, 25 μg/ml and 50 μg/ml. Cells were subsequently harvested and analyzed with flow cytometry as previously described. The %G2/M cells (Y-axis) was plotted against the peptide doses (X-axis) in Figure 6. This result indicates that the sequence (Tyr)(Ser)(Pro)(Trp)(Ser) (Phe-2,3,4,5,6F)(Cha) (SEQ ID NO:138) has comparable G2 checkpoint abrogating activity to the sequence (Bpa)(Ser)(Trp)(Ser)(Phe-2,3,4,5,6F)(Cha) (SEQ ID NO:139).

The G2 checkpoint abrogating activity of arginine rich and lysine rich sequences at different doses on cells treated with bleomycine was studied. Briefly, peptides were added to culture medium of Jurkat cells with bleomycin (40μg/ml) at the indicated dose (X-axis). Cells were subsequently harvested and analyzed with flow cytometry as previously described. The %G2/M cells (Y-axis) was plotted against the peptide doses in Figure 7. The results indicate that Arg sequences appear to provide better activity than

Lys sequences for the basic amino acid rich sequence and that Gln is not essential for function of the sequence.

The G2 checkpoint abrogating activity of sequences in which the location of the arginine rich region is varied was studied. Briefly, peptides were added to culture medium of Jurkat cells with bleomycin (40μg/ml) at the indicated dose (X-axis) for 24 hours. Cells were subsequently harvested and analyzed with flow cytometry as previously described. The %G2/M cells (Y-axis) was plotted against the peptide doses in Figure 8.

The data indicate that the G2 abrogating activity of the peptides is not significantly altered by changing the location of the arginine rich region. In addition, CBP501 was soluble in water, whereas CBP511 was not. This difference can be advantageous for particular drug delivery systems, since some systems prefer water insoluble compounds.

Figure 9 illustrates a summary of the analysis performed with various peptide pairs in which only one amino acid residue was different between the pairs. The G2 checkpoint abrogating activity of these peptides was analyzed using bleomycin treated Jurkat cells as described.

The size, charge and hydrophobicity of each amino acid determine how effectively the sequence fits into a target molecule. The side chain of the peptide or peptidomimetic would move freely, so even with one or two unfavorable side chains the peptide or peptidomimetic could fit a pocket or groove of the target molecule. The summary indicates that there are preferable sizes for each side chain which suggest the size of the binding region (pocket or groove) of the target protein for each side chain. For example, side chains with a ring structure such as benzene, indole and cyclohexane, determine the strength of G2 abrogation or M abrogation and/or non specific toxicity; see Figures 9 and 4, where ring structures larger than 5 membered affect the G2 abrogating activity (moderate size at P1 and P2 increase G2 abrogating activity, whereas, too large of a structure (P1, P5 and P6) increase M abrogation and/or non specific toxicity.

Side chains without a ring structure appear neutral. So, to attain better activity a proper sized ring structure at P1, P2, P4 and P6, and either no ring structure at P3 and P5 or a ring structure less than 6 members is desired. A proper ring for P1, P2, and P6 is from a one to a 6 membered ring through fusion of two rings with either 5 or 6 membered. For P4, a proper size ring is a fusion of two rings, each of which are 5 or 6 membered. Thus, for P1, Cha or Nal(2) appear to be the best fits; for P2, Phe-2,3,4,5,6F, Phe-3,4,5F

or Phe-CF3 appear best. These side chain sizes indicate that there are either two pockets or a single larger pocket in the target molecule where this region interacts. For P3 and P5, a small side chain such as Ser or Pro is acceptable and a larger side chain such as Arg is also acceptable, indicating that there is no pocket in this region of target molecule, so side chains can just lay opposite to target. However, it is possbile that a ring structure might enable the peptide or peptidomimetic to interact with another molecule (i.e., other than a target molecule) which may in turn increase side effect. For P6, Bpa or Ser-Tyr appear better than Tyr alone or a smaller side chain, indciating a deeper groove that lay horizontally in the target. There also may be a shallow and wider pocket for P4 in the target based on the sizes of the residues for P4.

The following peptides were analyzed using Jurkat and bleomycin as described. Sequences of peptides are as follows: CBP501, (d-Bpa) (d-Ser)(d-Trp)(d-Ser) (d-Phe-2,3,4,5,6-F)(d-Cha) (d-Arg) (d-Arg) (d-Arg) (d-Gln) (d-Arg) (d-Arg) (SEQ ID NO:80); CBP700, (d-Arg) (d-Arg) (d-Bpa)(d-Arg) (d-Arg) (d-Arg) (d-Phe-2,3,4,5,6-F) (d-Cha) (SEQ ID NO:96); CBP701, (d-Arg) (d-Arg) (d-Arg) (d-Bpa)(d-Arg)(d-Trp) (d-Arg) (d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:97); CBP702, (d-Arg) (d-Arg) (d-Arg) (d-Arg) (d-Bpa)(d-Arg)(d-Trp)(d-Arg)(d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:98); and CBP703, (d-Arg) (d-Arg) (d-Arg)(d-Bpa)(d-Arg) (d-Arg) (d-Arg)(d-Phe-2,3,4,5,6-F) (d-Cha) (SEQ ID NO:99). The results indicate that CBP700, 701, 702, 703, although shorter than other exemplified peptides, retain G2 checkpoint abrogating activity comparable to other peptides having significant G2 checkpoint abrogating activity (Figure 11).

A comparison between G2 checkpoint abrogating activity and non specific toxicity (M checkpoint abrogation) by CB501 was performed. In brief, Jurkat cells were treated with 40μg/ml bleomycin or 0.5μg/ml colchicine for G2 checkpoint abrogating activity and non specific toxicity, respectively. The DNA amount in each of the treated cells was analyzed by flow cytometry, as previously described. The data indicate that G2 checkpoint was abrogated in a dose dependent manner for CBP501 while non specific toxicity was absent up to 50μM of peptide, as determined by the unchanged percentage of M phase arrested cells (Figure 12).

Example 3

This example describes peptide/peptidomimetic kinase inhibition activity and serum stability analysis of various peptides.

Since two kinases, Chk1 and Chk2, are important for G2 checkpoint mechanism, kinase inhibition analysis of both enzymes was performed. In vitro kinase inhibition analysis was performed using "PepTag (R) Non-Radioactive Protein Kinase Assays", Promega, according to company's protocol, except purified CHK2 kinase was used instead of PKC. Purified PKC was purchased from Upstate Biotechnology, Inc. These results are shown in Table 4A.

Table 4A Kinase inhibition analysis of the compounds

IC_{50} in μM	PKA	CHK2
CBP450	>400	10
CBP440	180	8

In vitro kinase inhibition analysis was performed by CycLex, Co. Ltd., Nagano, Japan. Briefly, baculovirus derived recombinant human full length Chk1 with histidine tag or E.Coli derived recombinant human full length Chk2 fused with GST were used as kinases. E.Coli derived recombinant GST-Cdc25C (amino acis 167-267) was used as a substrate. Reaction conditions were 20mM Hepes-KOH (pH7.5), 1mM DTT, 80μg/ml BSA, 10mM $MgCl_2$ and 50mM ATP at 30 degree for 60min. The phosphorylation of serine 216 on GST-Cdc25C was detected by anti-Cdc25C-phosphorylated S216 antibody with enzyme linked immune assay. These results are shown in Table 4B.

Table 4B Kinase inhibition analysis of peptides.

	CHK1	CHK2
CBP500	5.6	8

CBP501	7.9	18.6
CBP505	63.4	>100
CBP506	37.6	67
CBP603	15.5	18.1

The data indicate that both Chk1 and Chk2 kinase inhibition occur at a dose higher than the G2 abrogating dose (IC_{50} for G2 abrogation by CBP500, 501, 505, 506, 603 are all less than 1μM). These results suggest that these peptides have a mechanism of action in addition to inhibiting Chk1/2 molecules. Alternatively, the peptides possibly accumulate within cells such that their concentration is greater within cells than in the surrounding medium.

Serum analysis was performed to determine the stability of peptides in mouse and human serum. Briefly, peptides (10mM or 2.5mM) were incubated with freshly prepared human serum at 37 degrees for 1hr. CBP501 (10mM) was incubated with freshly prepared mouse serum for 1hr at 37 degree. Jurkat cells were treated with the serum with or without peptides and bleomycin (40μg/ml) and incubated for 24hr. The population of G2 phase cells was determined by flow cytometry as previously described. The residual G2 checkpoint abrogating activity of serum treated peptides were determined by comparing the %G2 cells of the treated serum and the standard curve produced with medium treated peptides, bleomycin and Jurkat cells (Table 5A). The residual CBP501 quantity was determined with HPLC after deproteinating with ethanol treatment (Table 5B). The data indicate that peptide with d-type amino acids such as CBP501 and CBP603 are more stable in serum than peptide with l-type amino acid such as CBP413.

Table 5A Human serum treatment analysis

	Residual activity of peptide after 1hr human serum treatment
CBP	<0.4% of original

P413	
CB P501	>50% of original
CB P603	>50% of original

Table 5B Mouse serum treatment analysis

	Residual peptide after 1hr human serum treatment
CB P501	>90%

Example 4

This example describes the anti-cell proliferative activity of CBP501 on cultured cells. This example also describes data demonstrating *in vivo* activity of the peptides/peptidomimetics.

To demonstrate anti-cell proliferative activity of the compounds, cultured MIAPaCa2 human pancreatic carcinoma cells were treated with CBP501 (10μmM), cisplatin (1, 3 or 9 μg/ml) and oxaliplatin (1, 3 or 9 μg/ml) alone, and in combination. Briefly, cells were plated at 300 cells/well in 6 well plates, incubated overnight, and treated with the compounds for three hours. The medium was changed and cultured for an additional 10days. Cells were subsequently fixed with 70% methanol, stained with 0.1% crystal violet and visualized. The colony formation analysis results indicated that CBP501 enhanced the cyto-toxic activity of both cisplatin and oxaliplatin against MIAPaCa2 cells.

Similar studies were performed using normal human umbilical endothelial cells (HUVEC). Since normal cells do not form colonies, they were plated 3000 cell /well instead of 300 cell/well. The results indciate that peptide by itself does not disturb the growth of normal cells nor did the peptide augument cytotoxic activity of cisplatin and oxaliplatin towards the cell. The peptides therefore do not appear to exhibit significant

G2 abrogating activity against normal cells subjected to nucleic acid damaging treatment, incontrast to hyperoliferating cells such as cancer cells, which are sensitized to nucleic acid damaging treatment. The results indicate the specificity of the peptide in sensitizing proliferating cells but not normal cells against nucleic acid damaging treatment.

Table 6 Growth inhibition analysis of MIAPaCa2 using alamar blue.

	IC50		
	24hr	48hr	72hr
cisplatin	16μM	31μM	46μM
CBP501	6 μM	10μM	13μM
CBP501 with 10uM cisplatin	0.6μM	1 μM	6 μM

AlamarBlue analysis was performed to analyze the growth inhibiting activity of CBP501 with and without cisplatin. Briefly, MIAPaCa2 cells were exposed to 1, 3, 10, 30, 100μM of cisplatin or 0.22, 0.67, 2, 6, and 18μM of CBP501 with or without 10μM cisplatin for three hours in 96 well plates at 2500cell /well in duplicate manner. The medium was changed and incubated an additional 24, 48 or 72hour. Following incubation, 20μl of alamarBlue 90% reagent was added to each well for another 6 hours for detection of cell viability by fluorescent intensity. Fluorescent intensity was measured using a Spectrafluor Plus plate reader with exitation 530nm and emission 590nm. The IC_{50} was calculated (Table 6).

This study indicates that CBP501 alone inhibits cell growth better than cisplatin in molar dose. CBP501 suppressed cell growth at a much lower dose when combined with 10μM of cisplatin, which is approximately the dose of cisplatin used for cancer treatment. Furthermore, growth suppressing activity of CBP501 was longer than cisplatin; the IC_{50} at 72 hour was much better when CBP501 was used than cisplatin.

The *in vivo* half life of CBP501 was determined by quantifying CBP501 in mouse serum 1, 3 and 6hr following intra-peritoneal injection of CBP501 (40mg/kg). The residual intact CBP501 quantity was determined with HPLC after deproteinating mouse serum drawn from injected mice with ethanol treatment (Table 7).

Table 7 *in vivo* half life of CBP501

	Half-life after 40mg/kg intra-peritoneal injection
CBP501	3hr

To determine tolerance to peptides, groups of ten mice were intravenously injected once with CBP501 (5, 8 or 10mg/kg) or intra-peritonealy injected once with CBP501 (50, 80 or 100mg/kg). Injected mice were observed for a week for their survival (Table 8).

Table 8 Maximal tolerated dose in mouse by single injection

	MTD (iv)	MTD (ip)
CBP413	14 mg/kg	146.7 mg/kg
CBP501	10 mg/kg	98.8 mg/kg

To study *in vivo* efficacy of the compounds, MIAPaCa2 human pancreatic carcinoma cells were implanted subcutaneously in scid mice. The treatment was initiated when the size of the primary tumor became 0.1cm3 (Day0) or larger, e.g., 7 or 8 mm in diameter. CDDP (3 mg/kg) and CBP 501 (10 or 40 mg/kg) were intra-peritoneally administered alone or in combination. Tumor sizes were measured using calipers three times a week, and volumes were calculated using the formula: weight(mg) = [width

(mm)2xlength (mm)]/2. Mean tumor sizes for each treatment group are plotted (n=4) against the days after the start of treatment (Figure 10).

The results indciate that CBP501 treatment alone suppresses the growth of human pancreatic cancer cell *in vivo*. The results further indicate that CBP501 increased the anti-tumor activity of cisplatin.

Example 5

This example includes a description of lung cancer and studies using CBP501.

Lung cancer is the leading cause of adult cancer deaths in western countries. In the USA, 219,440 new cases were diagnosed in 2009 and 159,390 deaths occurred due to this disease, accounting for about 29% of all cancer deaths (see, e.g., American cancer society, Cancer Facts & Figures 2009). Eighty-seven percent (87%) of all new lung cancer cases are non small cell lung cancer (NSCLC) histologies, of which there are three major types: adenocarcinoma, squamous cell (epidermoid) carcinoma and, large cell carcinoma (American cancer society, Cancer Facts & Figures 2009). Despite improvements in surgical techniques and combined therapies, the prognosis for patients diagnosed with NSCLC remains poor. The five-year survival rate is 47% for cases detected in the early stage, when the disease is still localized, but the majority of NSCLC patients (68%) (see, e.g., AJCC Cancer Staging Manual. In: Fleming ID, editor. Philadelphia: Lippincott-Raven; 2002) are diagnosed with advanced disease (stage III) or metastatic disease (stage IV) requiring chemotherapy. The 5-year survival rates are 8.4% for those patients with stage III disease and 1.6% for stage IV, with the majority of patients with advanced NSCLC, succumbing to disease within 2 years (see, e.g., American cancer society, Cancer Facts & Figures 2009; AJCC Cancer Staging Manual. In: Fleming ID, editor. Philadelphia: Lippincott-Raven; 2002.) The introduction of new therapeutics that can produce significant improvement in patient survival and quality of life is an unmet need.

Patients with advanced stage (IIIb or IV) NSCLC who have a good performance status can obtain benefit from chemotherapy (see, e.g., Souquet, PJ., et al., Lancet 342:19-21, 1993 ; Marino, P., et al., Chest 106:861-865, 1994 ; Marino, P., et al., Cancer 76:593-601, 1995 ; Helsing, M., et al., Eur J Cancer 34:1036-1044, 1998; Cullen, MH., et al., J Clin Oncol 17:3188-3194, 1999; Pfister, DG., et al., J Clin Oncol 22:330-353, 2004). Chemotherapy doublets have been shown to improve survival when compared with single

agents or no chemotherapy (see, e.g., Bunn, PA., et al., J Clin Oncol 20:23S-33S, 2002). Currently recommended first line chemotherapy regimens in advanced NSCLC include platinum compounds (cisplatin [CDDP] or carboplatin) in combination with gemcitabine, vinorelbine, or taxanes (paclitaxel or docetaxel), irinotecan, etoposide, vinblastine, and/or pemetrexed as reference regimens (Pfister, DG., et al., J Clin Oncol 22:330-353, 2004).

Randomized trials have shown that the various platinum-doublet combinations are all of similar efficacy although regimens differ slightly in terms of toxicity, convenience and cost. Results found overall response rates (ORRs) of between 17% and 32%, median survival times of 7 to 10 months, and 1-year survival rates of 30 to 45% (see, e.g., Scagliotti, G., et al., Semin Oncol 32:S5-S8, 2005; Schiller, JH., et al., N Engl J Med 346:92-98, 2002; Scagliotti, G., et al., J Clin Oncol 20:4285-4291, 2002; Kelly, K., et al., J Clin Oncol 19:3210-3218, 2001; Fossella, F., et al., J Clin Oncol 21:3016-3024, 2003).

Most instances of triplet chemotherapy have so far not resulted in further increased survival, but instead increased toxicity. A recent study of carboplatin + paclitaxel + bevacizumab, however, did show some survival benefit (see, e.g., Sandler, A., et al., N Engl J Med 355:2542-2550, 2006), suggesting that the addition of a targeted agent with non-overlapping toxicities may improve doublet chemotherapy. Active attempts to optimize the benefit of chemotherapy are being pursued through the use of molecular markers predictive of antitumor activity. Genes predictive of chemotherapeutic efficacy in NSCLC are beginning to emerge (see, e.g., Bepler, G., et al., ASCO Educational Book :350-352, 2008; Sommers, K., et al., Proc Am Soc Clin Oncol 26 2008). Noteworthy among these are markers such as ERCC1, BRCA1/2, RRM1 and TS (Table 9).

Table 9. Molecular Markers Predictive of Chemotherapeutic Efficacy in NSCLC

Marker	Expression	Sensitivity	Resistance
ERCC1	↑		Platinum agents
	↓	Platinum Agents	
BRCA1/2	↓	Platinum Agents	Taxane
RRM1	↑		Gemcitabine
	↓	Gemcitabine	
TS	↑		Pemetrexed or 5-FU
	↓	Pemetrexed or 5-FU	

Example 6

This example includes a description of data indicating that certain human patient subpopulations respond favorably to combinations of peptides and chemotherpauetic (nucleic acid damaging) agents. Unexpectedly, the data show that a sub-group of the patient population of a clinical study on non-squamous non-small cell lung cancer NSCLC) having less than 10,000 white blood cell (WBC) counts per cubic millimeter of blood before the treatment with CBP501 received benefit by the administration of CBP501.

CBP501 is a synthetic dodecapeptide that is comprised entirely of D-amino acids (Figure 13). It is an evolved version of TAT-S216A, which was optimized for its activity to reduce the accumulation of G2 (4N) cells in response to treatment with DNA-damaging agents, in a DNA content flow cytometry-based assay.

Two phase I dose-ranging and pharmacokinetic studies have been conducted to investigate CBP501 in a total of 78 patients: a monotherapy study of CBP501, administered as a 60-min i.v. infusion on days 1, 8, and 15, repeated every 4 weeks, and a combination therapy study with cisplatin with administration once every 3 weeks (see, e.g., Shapiro, GI., et al., Clin Cancer Res. May 15;17(10):3431-42, 2011).

Phase I single-agent study (CBP04-01): This was a first in man, single-agent phase I dose escalation trial, exploring a regimen of three injections (days 1-8-15) every

28 days, in a patient population with advanced solid tumors. A total of 68 cycles were administered, the median number of cycles per patient was 2 (range 1-8). Two patients achieved 7 cycles of treatment with stable disease, one with a diagnosis of pancreas cancer and the other with ovarian cancer. The majority of patients (87%) discontinued the study due to disease progression. No patients discontinued due to toxicity (see, e.g., Shapiro, GI., et al., Clin Cancer Res. May 15;17(10):3431-42, 2011).

Phase I study of CBP501 in combination with cisplatin (CBP06-01): The main goal of this phase I study was to determine the MTD and RD of CBP501 and cisplatin when administered in combination once every 21 days. CBP501 was administered first, as a 1-hour infusion, followed by cisplatin two hours after treatment start. Patients were also given prophylactic treatment for allergic reactions according to the same regimen developed for the phase I single-agent study (loratadine, dexamethasone, ranitidine and diphenhydramine).

A total of 48 patients were treated in three US centers and a total of 182 cycles were administered, the median number of cycles per patient was 4 (range 1-13). CBP501 was explored in a range of doses from 3.6 mg/m² to 36.4 mg/m². The highest dose level studied was CBP501 36.4 mg/m² and cisplatin 75 mg/m². At this dose level, two out of six patients experienced allergic reactions judged by the investigators as dose limiting (grade 3). The MTD was considered as the dose level immediately below, which was CBP501 24.3 mg/m² and cisplatin 75 mg/m². Hints of activity were documented in several patients (see, e.g., Shapiro, GI., et al., Clin Cancer Res. May 15;17(10):3431-42, 2011).

Cisplatin (cis-diamminodichloroplatinum), an inorganic platinum coordination complex, reacts preferentially at the N7 position of guanine and adenine residues of DNA to form a variety of monofunctional and bifunctional adducts. These adducts contribute to the drug's cytotoxicity, by impeding various cellular processes that require the separation of both DNA strands such as replication and transcription.

Cisplatin has been assessed clinically against a variety of tumors because of its solid antineoplastic activity against testicular and ovarian cancers. Since its approval, cisplatin has been a critical chemotherapeutic agent and has been widely used, either alone or in combination with other antineoplastic agents. Cisplatin is also known to confer a substantial palliative effect in patients presenting with other tumor types, e.g.

lung cancer, bladder carcinoma and head and neck carcinoma, and it is included in most chemotherapy regimens used in these diseases.

Pemetrexed disodium is a structurally novel antifolate possessing a unique 6-5 fused pyrrolo[2,3-d]pyrimidine nucleus, and which inhibits the function of folate-dependent enzymes involved in the synthesis of substrates necessary for cell growth and division such as thymidylate synthase, dihydrofolate reductase, and glycinamide ribonucleotide formyltransferase (see, e.g., Taylor, EC., et al., J Med Chem 35:4450-4454, 1992; Schultz, RM., et al., Anticancer Res 19:437-443, 1999).

Pemetrexed has demonstrated activity in clinical trials in a large variety of tumor types, including lung, breast, colon, pleura, pancreas, stomach, bladder, head and neck, and cervix. Pemetrexed in combination with cisplatin was approved by the FDA on February 4, 2004 for the treatment of patients with MPM whose disease is either unresectable or who are otherwise not candidates for curative surgery.

In phase II studies in chemotherapy-naïve patients with NSCLC, pemetrexed in combination with cisplatin or carboplatin has yielded efficacy results comparable with other platinum doublets (see, e.g., Scagliotti, G., et al., Clin Cancer Res 11:690-696, 2005 ; Zinner R., et al., Cancer 104:2449-2456, 2005 ; Manegold, C., et al., Ann Oncol 11:435-440, 2000; Shepherd, FA., et al., Cancer 92:595-600, 2001). In addition, pemetrexed has an excellent safety profile and a convenient administration schedule.

A recent randomized phase III study compared, in a non inferiority design trial, the overall survival (OS) between 1725 chemotherapy-naïve patients with stage III or IV NSCLC treated with cisplatin plus gemcitabine or cisplatin plus pemetrexed every 3 weeks for up to six cycles (see, e.g., Scagliotti, G., et al., J Clin Oncol 26:3543-3551, 2008 ; Pimentel, F., et al., Proc Am Soc Clin Oncol 26 (Part I of II):448s, 2008, (Suppl. 15S)(abstr) #448s). The OS for cisplatin plus pemetrexed was not inferior to cisplatin plus gemcitabine (median survival, 10.3 months for both treatments). OS was statistically superior for cisplatin plus pemetrexed versus cisplatin/gemcitabine in patients with adenocarcinoma (n= 847; 12.6 months and 10.9 months, respectively) and large cell carcinoma histology (n= 153; 10.4 months and 6.7 months, respectively). For cisplatin plus pemetrexed, rates of grade 3 or 4 neutropenia, anemia, and thrombocytopenia; febrile neutropenia; and alopecia were significantly lower than for the cisplatin/gemcitabine treatment arm, whereas grade 3 or 4 nausea was more common.

PATIENTS AND METHODS:

Clinical Study design: Open-label, multicenter, phase II randomized, two-arm, comparative study. The protocol evaluated full-dose cisplatin and pemetrexed with or without CBP501. Patients were randomized in a 1:1 ratio to pemetrexed, cisplatin and CBP501 (Arm A) or pemetrexed and cisplatin (Arm B). Randomization was stratified according to baseline stage of disease (IIIb vs IV), presence of brain metastasis and whether or not patients were eligible for bevacizumab therapy.

Investigator / trial location: Approximately 40 centers in the USA, Russia, Canada, Brazil, Argentina and Peru.

Study Objectives:

Primary: To compare the efficacy, progression free survival, of cisplatin and pemetrexed with or without CBP501 in patients with locally advanced (stage IIIB with malignant pleural effusion or pericardial effusion) or metastatic (stage IV) non-squamous NSCLC.

Secondary: To characterize the safety profile of the study regimen and the efficacy parameters other than progression free survival such as overall survival.

Study Population:

Inclusion criteria:

1. Signed informed consent obtained prior to initiation of any study-specific procedures

2. Histologically or cytologically confirmed diagnosis of non-squamous non small cell lung cancer (NSCLC), not amenable for radical resection, stage IIIB with pleural or pericardial effusion or stage IV, who has not received previous chemotherapy or other systemic treatment

3. At least one unidimensionally measurable lesion according to the Response Evaluation Criteria in Solid Tumors (RECIST)

4. Male or female patients aged at least 18 years

5. ECOG Performance Status (PS): 0-1

6. Life expectancy > 3 months

7. Prior local radiotherapy is allowed if it was completed ≥ 3 weeks prior to the first dose of the study medication

8. Concomitant palliative radiotherapy to an existing bone lesion for pain control is allowed

9. Prior surgery is allowed if it is performed at least 4 weeks prior to the first dose of study medication and patient should be fully recovered

10. Adequate organ function, including the following:

· Bone marrow: white blood cell (WBC) count ≥ 4 x 109/L, absolute neutrophil count (ANC) ≥ 1.5 x 109/L, platelet count ≥ 100 x 109/L, hemoglobin ≥ 9 g/dL

· Hepatic: Bilirubin ≤ 1.5 x the upper limit of normal (ULN), aspartate transaminases (AST/SGOT) and alanine transaminases (ALT/SGPT) ≤ 2.5 x ULN (or ≤ 5 x ULN if liver metastases are present), INR ≤ 1.5 x ULN, albumin ≤ 3.0 g/dL

· Renal: Serum creatinine ≤ 1.5 mg/dL or creatinine clearance ≥ 45 mL/min (calculated according to the Cockroft and Gault formula)

11. Female patients of child-bearing potential must have a negative pregnancy test and be using at least one form of contraception as approved by the Investigator for 4 weeks prior to the study and 4 months after the last dose of study drug. For the purposes of this study, child-bearing potential is defined as: "All female patients unless they are post-menopausal for at least one year or are surgically sterile"

12. Male patients must use a form of barrier contraception approved by the Investigator during the study and for 4 months after the last dose of study drug

13. Ability to cooperate with the treatment and follow-up

Exclusion criteria:

1. Radiation therapy to more than 30% of the bone marrow prior to entry into the study

2. Presence of neuroendocrine features in the tumor sample

3. Previous treatment with chemotherapy, new biological therapies (small molecules, antibodies), immunotherapy

4. Absence of measurable lesions

5. An ongoing or active infection, symptomatic congestive heart failure, unstable angina pectoris, symptomatic or poorly controlled cardiac arrhythmia, uncontrolled thrombotic or hemorrhagic disorder, or any other serious uncontrolled medical disorders in the opinion of the Investigator

6. Any previous history of another malignancy within 5 years of study entry (other than cured basal cell carcinoma of the skin or cured in-situ carcinoma of the cervix)

7. Presence of any significant central nervous system (CNS) or psychiatric disorder(s) that would hamper the patient's compliance

8. Evidence of peripheral neuropathy > grade 1 according to NCI-CTCAE Version 3

9. Treatment with any other investigational agent, or participation in another clinical trial within 28 days prior to study entry

10. Pregnant or breast-feeding patients or any patient with childbearing potential not using adequate contraception

11. Known HIV, HBV, HCV infection

12. Presence of symptomatic brain metastasis. Patients with brain metastases must:

·Have stable neurologic status following local therapy (surgery or radiation) for at least 2 weeks after completion of the definitive therapy and have discontinued use of corticosteroids for 1 week prior to the study entry.

· Be without neurologic dysfunction that would confound the evaluation of neurologic and other AEs

13. Inability or unwillingness to take folic acid, vitamin B12 or corticosteroids

14. Inability to interrupt aspirin or other nonsteroidal anti-inflammatory agents, other than aspirin dose ≤ 1.3 grams per day, for a 5-day period (8-day period for long-acting agents, such piroxicam)

15. Significant weight loss (≥ 10% body weight during preceding 6 weeks)

16. Presence of clinically significant (by physical exam) third space fluid collections, e.g., ascites or pleural effusions that cannot be controlled by drainage or other procedures prior to study entry

Number of patients:

A total of 195 patients were treated in which 97 patients were treated with CBP501, cisplatin and pemetrexed (Arm A) and 98 patients were treated with pemetrexed and cisplatin (Arm B).

Study drug:

Formulation: CBP501 for injection was provided in single dose vials (20 mg) containing a sterile lyophilized powder comprising CBP501 peptide acetate salt (peptide base units). For administration, vial contents were reconstituted in 5% Dextrose Injection, USP, and added to a 100 mL i.v. bag of 5% Dextrose Injection, USP.

Pemetrexed: A commercial formulation of pemetrexed was used, with reconstitution in 20 mL 0.9% sodium chloride solution for injection, then dilution to 100 mL.

Cisplatin: A commercial formulation of cisplatin was used and was diluted in 250 mL of normal saline for administration.

Dose regimen and route of administration:

CBP501, pemetrexed and cisplatin was administered on the same day (Day 1), every 3 weeks for a maximum of six cycles. A cycle was considered to be 3 weeks (21 days).

Arm A

1. CBP501 25 mg/m² was administered as an i.v. infusion of 1 hour.

2. Pemetrexed 500 mg/m² was administered as an i.v. infusion over 10 minutes, immediately after the CBP501 infusion.

3. Cisplatin 75 mg/m² was administered as a 1-hour i.v. infusion immediately after the pemetrexed infusion.

Arm B

1. Pemetrexed 500 mg/m² was administered as an i.v. infusion over 10 minutes.

2. Cisplatin 75 mg/m² was administered as a 1-hour i.v. infusion immediately after the pemetrexed infusion.

Each combination was administered via a central or peripheral venous access.

Prophylactic treatment:

All patients enrolled received:

1. Vitamin supplementation: all patients were instructed to take a low-dose oral folic acid preparation or multivitamin with folic acid on a daily basis. At least 5 daily doses of folic acid must have been taken during the 7-day period preceding the first dose of pemetrexed, and dosing should continue during the full course of therapy and for 21 days after the last dose of pemetrexed. The suggested dose of folic acid was in the range 350-1000 µg. Patients must have also received one (1) intramuscular injection of vitamin B12 during the week preceding the first dose of pemetrexed and every 3 cycles thereafter. Subsequent vitamin B12 injections may have been given the same day as pemetrexed. The dose of vitamin B12 was 1000 µg.

2. Dexamethasone 4 mg orally, twice per day, the day before, the day of treatment administration and the day after.

3. Prophylactic antiemetic treatment: consisting of 5HT3 antagonists + steroids according to standard treatment center protocols. Patients were given further oral antiemetics as needed.

· The following hydration protocol was suggested in patients without cardiovascular impairment. Similar protocols routinely administered in the investigator centers could have been implemented:

1. Patients received a total of 1.5-2.0 liters hydration (5% dextrose or ½ normal saline) with 20 mEq KCl/liter and 1 g MgSO4/liter, ran at 500 mL/hour.

2. After the patient had received 1-hour of the hydration infusion, 12.5 g of mannitol was administered by IV push.

3. The cisplatin infusion (mixed in normal saline at 1 mg/mL) was then infused over 1 hour, while continuing the hydration infusion.

4. Additional mannitol was administered (12.5-50.0 g by IV push), if necessary to maintain urinary output at 250 mL/hour over the duration of the hydration.

· For patients treated with CBP501 (Arm A), it was recommended that they receive the following prophylactic regimen to reduce the incidence and severity of symptoms due to histamine release:

1. Diphenhydramine (DPH) 50 mg IV and Ranitidine 50 mg IV (or another histamine H2 antagonist) before each CBP501 infusion.

2. Loratadine (10 mg) PO the day before (day -1), the day of CBP501 administration (day 0) and the day after (day 1).

Duration of study period per patient:

Patients will receive a maximum of six cycles of study treatment unless any of the following are observed earlier:

- disease progression
- unacceptable toxicity
- withdrawal of consent
- serious protocol violation
- treatment delay > 2 weeks (except in the case of potential or perceived patient benefit)

Following treatment discontinuation, patients will be followed every 8 weeks until disease progression or initiation of further systemic anticancer therapy, and then every 6 months until death.

Informed Consent

The Investigator thoroughly explained to the patient the purpose and methods of the study, as well as any expected effects and adverse reactions, before any study specific screening procedures were conducted. The patient was provided with an information sheet and was given sufficient time and opportunity to inquire about the details of the trial and to decide whether or not to participate. The patient and the person with whom they discuss the informed consent signed and dated the consent form.

The Investigator explained that the patient was completely free to refuse to enter the study or to withdraw from it at any time and for any reason. Similarly, the Investigator and/or Sponsor were free to withdraw the patient at any time for safety or administrative reasons. Any other requirements necessary for the protection of the human rights of the patient was explained, according to current CFR (21, parts 312D, 50 and 56) and ICH (ICH E6 1997) GCP guidelines and the Declaration of Helsinki, 1964 (as clarified in Tokyo in 2004).

Assignment of Patient Numbers

Patient randomization and assignment to a treatment arm were centrally managed.

Statistical analysis:

Cox proportional hazards model was employed to estimate the hazard ratio (HR) for PFS between the 2 treatment arms. The model included the treatment arm as a factor as well as the randomization stratification factors. The following covariates were explored: age, gender, race (Caucasian/non-Caucasian), prior surgery/procedure (yes/no), prior radiotherapy (yes/no), x-ray interpretation (normal/abnormal), ECG interpretation (normal/abnormal), bone scan (normal/abnormal), and time from diagnosis. Any continuous variables such as age and time from diagnosis to study treatment could have been converted into categorical variables by specifying 2 or several classes of values if a better model fit would result. The exploratory variables were entered using a stepwise regression algorithm using the following criteria: a variable must be significant at the 0.25 level to be entered into the model and significant at 0.15 level to remain in the model. For the final model, the point estimate of the hazard ratios were provided along with 95% CIs.

Subgroup analyses were conducted for patients that had WBC < 10000 µL at screening. Additional subgroup analysis was performed with a software GraphPad Prism 5 with raw data on each patients analyzed.

Efficacy Results:

The Cox proportional hazards model analysis without exploring other covariates on progression free survival (PFS) indicated that Arm A (the arm with CBP501) had a higher hazard than Arm B (HR = 1.20 [0.88, 1.65]), but it was not statistically significant (P = 0.25). The same model exploring other covariates also indicated that Arm A had a higher hazard than Arm B (HR = 1.21 [0.85, 1.73]), but it was not statistically significant (P = 0.30).

For patients that had WBC<10000/µL at screening, the Cox proportional hazards model analysis without exploring other covariates indicated that Arm A had a higher hazard than Arm B (HR = 1.04 [0.73, 1.49]), but it was not statistically significant (P = 0.81). The same model exploring other covariates also indicated that Arm A had a higher hazard than Arm B (HR = 1.06 [0.71, 1.59]), but it was not statistically significant (P = 0.78).

It was noted that the hazard ratio for PFS improves for Arm A when the analysis was restricted to patients who had WBC <10000/µL at screening in both of the analysis (Tables A, B).

Table A Cox covariates analysis on PFS without exploring other covariates

PFS with independent radiological review

Cox covariates analysis without exploring other covariates

	Hazard Ratio	P-value
ALL treated	1.20	0.25
WBC<10000	1.04	0.81

Table B Cox covariates analysis on PFS exploring other covariates

Exploring other covariates

	Hazard Ratio	P-value

ALL treated	1.21	0.30
WBC<10000	1.06	0.78

Cox Proportional Hazards Model analysis on overall survival (OS) on all Treated Population

Arm A had a lower hazard than Arm B without and with exploring other covariates (HR=0.96 and 0.77). The difference was not statistically significant (P=0.82 and 0.25).

Cox Proportional Hazards Model analysis on OS on Patients that had WBC < 10000/μL at Screening

For OS on patients that had WBC < 10000/μL at screening in the Treated Population, Arm A had a lower hazard than Arm B without and with exploring other covariates (HR=0.80 and 0.69); the difference was not statistically significant (P=0. 32 and 0.16).

It was noted that the hazard ratio for OS improves for Arm A when the analysis was restricted to patients who had WBC <10000/μL at screening in all of the analysis (Tables C, D).

Table C Cox covariates analysis on OS without exploring other covariates

Cox covariates analysis on overall survival without exploring other covariates

	Hazard Ratio	P-value
ALL treated	0.96	0.82
WBC<10000	0.80	0.32

Table D Cox covariates analysis on OS exploring other covariates

Exploring other covariates

	Hazard Ratio	P-value
ALL treated	0.77	0.25
WBC<10000	0.69	0.16

Figure 14 shows Kaplan-Meyer survival curves, median OS and hazard ratio in relation to the WBC at screening (baseline) in all treated patients. The hazard ratio improves as the cut off level decreases and peaks at WBC 8000/μl as cut off level.

Referring to **Figure 17**, Neutrophils were purified with EasySep neutrophil enrichment kit (Stemcell technol.) from human peripheral blood after removal of red blood cells with Hetasep (Stemcell technol.). Purified neutrophils ($1x10^6$ cell/well, 24 well plates were cultured with or without 1 μM of CBP501 for 15 minutes (terminated reaction by adding EDTA) and further four hours with 1nM PMA, 3 or 10μM A23187, or 100 or 1000ng/ml LPS. The wells were washed two times and incubated with DNase for 15 min and the supernatants were collected, incubated with Elastase substrate for 2 hours, and then analyzed to detect elastase activity.

Referring to **Figure 18**, C57BL/6 mice, 8 weeks of age, were intravenously injected with or without LPS 2.5, 5, or 10ug/ml 30 minutes before the injection of diphenhydramine. CBP501 (7.5mg/kg) was injected 30 minutes after diphenhydramine injection. The thrombin/antithrombin complex was quantified with ELISA in the plasma that was separated from the blood drawn 3 hours after the CBP501 or mock injection. The data were obtained in each condition out of four animals.

Referring to **Figure 19**, macrophages were obtained by stimulating human peripheral blood mononuclear cells by 0.32uM of PMA and removing all suspension cells 48 hours of PMA stimulation. The cells were further incubated with 50ng/ml IFN-gamma, 10ng/ml LPS to obtain M1 phenotype, and 20ng/ml IL-4 to obtaine M2 macrophages. Both treatment was with or without CBP501. The phagocytic activity was monitored by using fluorescent labelled beads and flow cytometry.

Referring to **Figure 20**, a macrophage cell line RAW264.7 was incubated with or without 0.1 or 1μM of CBP501 for 3-6 hours, and then further incubated with or without 10 or 1000ng/ml LPS for 4 hours. The released TNF were measured by ELISA.

CBP501 showed potential as an effective anti-tumor agent in preclinical (Sha, S., et al. Mol. Cancer Ther. 6:147 (2007)) and Phase I clinical studies (Shapiro, G.I., et al. Clin. Cancer Res. (2011)). CBP501 may operate under two mechanisms of action, *e.g.* via cell cycle G2 checkpoint abrogation (Sha, S., et al. Mol. Cancer Ther. 6:147 (2007)) and platinum concentration in tumor cells or through Calmodulin inhibition (Mine, N., et al. Mol. Cancer Ther. 10:1929 (2011)).

As demonstrated herein, it was unexpectedly discovered by way of sub-group analysis on the patient population of a Phase II clinical study on non-squamous non-small cell lung cancer patients that there was a statistically significant ($p<0.0001$) difference in the survival of groups of patients between that with high white blood cell count (WBC) at screening and that with normal or low WBC.

Further as indicated by the results herein, CBP501, in addition to direct action on tumor cells, may also act on the tumor micro-environment, such as macrophages, by inhibiting calmodulin and increasing the neutrophil extracellular traps (NETs) when patients are inflamed by reducing clearance/phagocytosis of NETs by macrophages. This may increase the chance of having deep vein thrombosis (DVT) and metastasis, and thus potentially affect patient survival adversely. On the contrary, inhibition of M2 type macrophage in patients may prevent the positive action of macrophages on the tumor growth, angiogenesis, metastasis and tumor immune evasion, all of those promotes tumor metastasis which may shorten survival of patients.

Consistent with this observation, increased NETs formation of activated neutrophils by CBP501 treatment in vitro and increased thrombin/Anti-thrombin complex formation in LPS stimulated mice have been demonstrated. Inhibition of cytokine secretion and phagocytosis of both M1 and M2 types of macrophages by CBP501 has also been indicated.

While clinical studies have indicated CBP501 operating by enhancing cisplatin's cytotoxicity against tumor cells, results herein demonstrate an unexpected finding by a sub-group analysis done on the Phase II study on non-squamous NSCLC patients indicating that groups of patients with high white blood cell counts (WBC) at screening of the clinical study survived shorter and the other groups of patients with normal or low WBC survived longer in response to the regimen with CBP501, and the difference was statistically highly significant with a p value calculated on a Kaplan-Meyer's curves on the overall survival by Log-rank (Mantel-Cox) test was less than 0.0001.

It was thus unexpectedly found that patients with normal or low WBC before treatment benefited from CBP501 treatment, while the patients with high WBC could have been adversely affected by the same treatment. CBP501's inhibitory activity on Calmodulin suggests that the effect on a variety of micro-environmental cells, such as macrophages, leukocytes and lymphocytes, may have inhibited or modulated their activity which could have prompted the bidirectional results because, for example, by just

inhibiting macrophages, if it inhibited M1 type macrophages it may have adversely affected patient survival and if it inhibited M2 macrophages it would prolong patient survival.

Calmodulin inhibitors have been reported to inhibit multiple functions of macrophages (Horwitz, S.B., et al. J. Cell Biol. 91:798 (1981); Takenawa, T., et al. Biochem J. 15:208 (1982); Westra, J., et al. BMC Musculoskelet. Disord. 30:11 (2010)), leukocytes (Naccache, P.H., et al. Biochem. Biophys. Res. Commun. 97(1):62 (1980); Takeshige, K., et al. Biochem. Biophys. Res. Commun. 99(2):484 (1981); Jones, H.P., et al. Biochem Biophys. Acta. 714(1):152 (1982); Jones, H.P., et al. Methods Enzymol. 015:389 (1984); Verploegen, S., et al. Eur. J. Biochem. 269(18) 4625 (2002)) and lymphocytes (Salisbury, J.L., et al. Nature 12:294 (1981); Boubali, S., et al. Mol. Immunol. 52(2):51 (2012)). The patients with high WBC will tend to have M1 macrophages as they are pro-inflammatory type and the patients with normal or low WBC with tumor will tend to have M2 macrophages (Hao, N., et al. Clin. Dev. Immunol. (2012)). Also, patients with high WBC are known to be more prone to have deep vein thrombosis (DVT) (Pabinger, I., et al. Blood 122:12 (2013); Blix, K., et al. PLOS One 4:8 (2013); Wang, T.F., et al. Thromb. Res. 133(1):25 (2014)), which is a cause of death for significant number of cancer patients. Those patients tend to have more NETs, and NETs promote tumor metastasis (Cools-Lartigue, J., et al. J. Clin. Invest. (2013)) which is one reason for short prognosis of many cancer patients including those with lung cancer.

In this Example there was no statistically significant survival benefit detected from the addition of CBP501 to the standard regimen, pemetrexed plus cisplatin, when it was analyzed in all treated population. However, it was unexpectedly identified by sub-group analysis that the addition of CBP501 provided a benefit to a group of people who showed normal or low counts of white blood cell (WBC) at the screening for the clinical trial. The normal value of the WBC varies by sites and countries. The upper normal WBC limits could be from 8000/μl to 11000/μl.

It was surprising that patients with normal range of WBC benefited from CBP501, and those with high WBC at screening performed worse than the patients treated with cisplatin and pemetrexed, although both of the differences were not statistically significant when compared to control arm, cisplatin and pemetrexed treated population.

While the precise reason of this potentially bidirectional action of CBP501 is not evident, CBP501's inhibitory action of Calmodulin indicates that the inhibition of Calmodulin in a variety of microenviromental cells, such as macrophages, leukocytes and lymphocytes, inhibits or modulates their activity which prompted the bidirectional result because, for example, if it inhibited M1 type macrophages it would adversely affected patient survival by inhibiting anti-tumor activity of macrophages and/or inhibiting clearance of NET, as NET promotes thrombo-genesis and metastasis, and if it inhibited pro-tumor M2 macrophages it would prolong patient survival. In addition, cisplatin is known to skew macrophages from M1 to M2 type (Dijkgraaf, E.M., et al. Cancer Res. 15:73(8):2480 (2013)), and chemotherapy by itself is known to promote tumor metastasis (Haas, M.J. SciBX 1-3 (2011)), thus the presence of CBP501 while chemotherapy is on might have significant impact on the tumor metastasis. Calmodulin inhibitors are known to be able to inhibit multiple functions of macrophages (Horwitz, S.B., et al. J. Cell Biol. 91:798 (1981); Takenawa, T., et al. Biochem J. 15:208 (1982); Westra, J., et al. BMC Musculoskelet. Disord. 30:11 (2010)), leukocytes (Naccache, P.H., et al. Biochem. Biophys. Res. Commun. 97(1):62 (1980); Takeshige, K., et al. Biochem. Biophys. Res. Commun. 99(2):484 (1981); Jones, H.P., et al. Biochem Biophys. Acta. 714(1):152 (1982); Jones, H.P., et al. Methods Enzymol. 015:389 (1984); Verploegen, S., et al. Eur. J. Biochem. 269(18) 4625 (2002)) and lymphocytes (Salisbury, J.L., et al. Nature 12:294 (1981); Boubali, S., et al. Mol. Immunol. 52(2):51 (2012)). The patients with high WBC will tend to have more M1 macrophages as they are pro-inflammatory and the patients with normal or low WBC with tumor will tend to have M2 macrophases (Hao, N., et al. Clin. Dev. Immunol. (2012)). Also, patients with high WBC would tend to have more NETs. If the phagocytosis of NETs was prevented by CBP501, patients would be more on the risk of having DVT and metastasis both of which would reduce survival time.

Alternatively, as calmodulin is involved in normal functions of white blood cells (Horwitz, S.B., et al. J. Cell Biol. 91:798 (1981); Takenawa, T., et al. Biochem J. 15:208 (1982); Westra, J., et al. BMC Musculoskelet. Disord. 30:11 (2010); Naccache, P.H., et al. Biochem. Biophys. Res. Commun. 97(1):62 (1980); Takeshige, K., et al. Biochem. Biophys. Res. Commun. 99(2):484 (1981); Jones, H.P., et al. Biochem Biophys. Acta. 714(1):152 (1982); Jones, H.P., et al. Methods Enzymol. 015:389 (1984); Verploegen, S., et al. Eur. J. Biochem. 269(18) 4625 (2002); Salisbury, J.L., et al. Nature 12:294 (1981); Boubali, S., et al. Mol. Immunol. 52(2):51 (2012); Hao, N., et al. Clin. Dev. Immunol.

(2012)). CBP501 may interfere and set off its beneficial activity on overall survival by the potential harm to the function of WBC when they were excessively required, e.g. the situation when patients were suffered from active infection which will increase white blood cell count.

Calmodulin inhibition may also affect anti-cancer immunity by acting on lymphocytes, as it has been suggested that Calmodulin may induce T cell anergy (Boubali, S., et al. Mol. Immunol. 52(2):51 (2012)).

Pre-treatment or base line WBC count has been indicated to be a prognosis factor for patients with NSCLC treated with platinum based therapy (Teramukai, S., et al. Eur. J. Cancer (45(11:1950 (2009); Kim, J.W., et al. Cancer Res. Trest. 45:4):325 (2013)) CBP501 may enhance this effect by modulating cisplatin's activity. Since every patient will get the laboratory analysis of WBC counts as a universally approved standard procedure before the treatments, patients may be selected based on WBC counts.

Calmodulin inhibition by CBP501 may also directly inhibit tumor migration and metastasis, independent of the platinum concentration, as calmodulin has been shown to play important role in migration (Wang, H., et al. Nat. Commun. 4:1354 (2013)).

Claims

1. The use of a peptide compound comprising (d-B pa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha) (SEQ ID NO:1) or salt thereof in the manufacture of a medicament for the treatment of a cell proliferative disorder in a mammal;

wherein the peptide compound further comprises a cell penetrating molecule attached or conjugated thereto;

wherein the mammal has been identified to have a white blood cell count of less than about 11,000 white blood cells per microliter (wbc/μl) of blood;

wherein the cell proliferative disorder comprises a tumor or cancer, or metastatic tumor or cancer.

2. The use of claim **1**, wherein the mammal has been identified to have a white blood cell count between about 4,000 to about 11,000 white blood cells per microliter (wbc/μl) of blood.

3. The use of claim **1**, wherein the mammal has been identified to have a white blood cell count of less than about 10,000 white blood cells per microliter (wbc/μl) of blood.

4. The use of claim **1**, wherein the mammal has been identified to have a white blood cell count of less than about 9,000 white blood cells per microliter (wbc/μl) of blood.

5. The use of claim **1**, wherein the mammal has been identified to have a white blood cell count between about 4,000 to about 9,000 white blood cells per microliter (wbc/μl) of blood.

6. The use of claim **1**, wherein the mammal has been identified to have a white blood cell count of less than about 8,000 white blood cells per microliter (wbc/μl) of blood.

7. The use of claim **1**, wherein the mammal has been identified to have a white blood cell count of less than about 7,000 white blood cells per microliter (wbc/μl) of blood.

8. The use of claim **1**, wherein the medicament is in the form of a pharmaceutical formulation.

9. The use of claim **1**, wherein the salt thereof is selected from acetate, sulfonate, sulfate, pyrosulfate, bisulfate, sulfite, bisulfite, phosphate, monohydrogen-phosphate, dihydrogenphosphate, metaphosphate, pyrophosphate, chloride, bromide, iodide, propionate, decanoate, caprylate, acrylate, formate, isobutyrate, caproate, heptanoate, propiolate, oxalate, malonate, succinate, suberate, sebacate, fumarate, maleate, butyne-1,4-dioate, hexyne-1,6-dioate,

benzoate, chlorobenzoate, methyl benzoates, dinitrobenzoates, hydroxybenzoates, methoxybenzoates, phthalates, xylenesulfonate, phenylacetate, phenylpropionate, phenylbutyrate, citrate, lactate, -hydroxybutyrate, glycolate, tartrate, methane-sulfonate, propanesulfonate, naphthalene-1-sulfonate, naphthalene-2-sulfonate, and mandelate.

10. The use of claim **1**, wherein the peptide compound has a length from 6 to 10, 10 to 15, 15 to 20, 20 to 25, 25 to 30, 30 to 40 or 40 to 50amino acid residues.

11. The use of claim **1**, wherein the cell penetrating molecule is joined to the peptide compound by a covalent bond, or a peptide or a non-peptide linker.

12. The use of claim **1**, wherein the cell penetrating molecule comprises an alternating pattern of polar/charged amino acids and non-polar, hydrophobic amino acids.

13. The use of claim **1**, wherein the cell penetrating molecule comprises a polycationic or amphipathic alpha-helix structure.

14. The use of claim **1**, wherein the cell penetrating molecule comprises L- or D-isomer amino acids, or a mixture of L- and D-isomer amino acids.

15. The use of claim **1**, wherein the cell penetrating molecule comprises a poly-Arginine (Arg) sequence.

16. The use d of claim **1**, wherein the cell penetrating molecule comprises or consists of (d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg).

17. The use of claim **1**, wherein the medicament is to be administered with a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment.

18. The use of claim **17**, wherein the nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or anti-proliferative treatment comprises surgical resection, radiotherapy, ionizing or chemical radiation therapy, chemotherapy, immunotherapy, local or regional thermal (hyperthermia) therapy, vaccination, an alkylating agent, an anti-metabolite, a plant extract, a plant alkaloid, nitrosourea, a hormone, or a nucleoside or nucleotide analogue.

19. The use of claim **1**, wherein the peptide compound is to be administered prior to, with or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered.

20. The use of claim **1**, wherein the peptide compound is to be administered less than 48 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered.

21. The use of claim **1**, wherein the peptide compound is to be administered less than 24 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered.

22. The use of claim **1**, wherein the peptide compound is to be administered less than 12 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered.

23. The use of claim **1**, wherein the peptide compound is to be administered less than 6 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered.

24. The use of claim **1**, wherein the peptide compound is to be administered less than 4 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered.

25. The use of claim **1**, wherein the peptide compound is to be administered less than 2 hours prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered.

26. The use of claim **1**, wherein the peptide compound is to be administered less than 1 hour prior to or after a nucleic acid damaging agent, a nucleic acid damaging treatment, an anti-proliferative agent, or an anti-proliferative treatment is administered.

27. The use of any one of claims **17 to 26**, wherein the nucleic acid damaging agent or anti-proliferative agent comprises a drug.

28. The use of any one of claims **17 to 26**, wherein the nucleic acid damaging agent or anti-proliferative agent comprises a platinum containing drug.

29. The use of any one of claims **17 to 26**, wherein the nucleic acid damaging agent or anti-proliferative agent comprises cis-platin, carboplatin, nedaplatin, mitaplatin, satraplatin, picoplatin, triplatin, miriplatin, or oxaliplatin.

30. The use of claim **1**, further comprising a platinum containing drug, cis-platin, carboplatin, oxaliplatin, pemetrexed, gemcitabine, 5-fiuorouracil (5-FU), rebeccamycin, adriamycin (ADR), bleomycin (Bleo), pepleomycin, cisplatin, cisplatinum, or cis-

diamminedichloroplatinum(II) (CDDP), oxaliplatin, or camptotecin (CPT), cyclophosphamide, azathioprine, cyclosporin A, prednisolone, melphalan, chlorambucil, mechlorethamine, busulphan, methotrexate, 6-mercaptopurine, thioguanine, 5-fluorouracil, cytosine arabinoside, AZT, 5-azacytidine (5-AZC) or a 5-azacytidine related compound, actinomycin D, mithramycin, mitomycin C, carmustine, lomustine, semustine, streptozotocin, hydroxyurea, cisplatin, mitotane, procarbazine, dacarbazine, a taxane, vinblastine, vincristine, doxorubicin, dibromomannitol, radiation or a radioisotope which is also to be administered.

31. The use of claim **30**, wherein the radiation comprises UV radiation, IR radiation, Xray, or alpha-, beta- or gamma-radiation.

32. The use of claim **30**, wherein the radioisotope comprises I^{131}, I^{125}, Sr^{89}, Sm^{153}, Y^{90}, or Lu^{177}.

33. The use of claim **1**, wherein the tumor or cancer comprises a lung tumor or cancer.

34. The use of claim **1**, wherein the lung tumor or cancer comprises a small cell or non-small cell lung cancer.

35. The use of claim **1**, wherein the lung tumor or cancer comprises an adenocarcinoma, squamous cell carcinoma or a large cell carcinoma.

36. The use of claim **1**, wherein the tumor or cancer comprises a carcinoma, sarcoma, lymphoma, leukemia, adenoma, adenocarcinoma, melanoma, glioma, glioblastoma, meningioma, neuroblastoma, retinoblastoma, astrocytoma, oligodendrocytoma, mesothelioma, reticuloendothelial, lymphatic or haematopoietic neoplasia, tumor, cancer or malignancy.

37. The use of claim **1**, wherein the sarcoma comprises a lymphosarcoma, liposarcoma, osteosarcoma, chondrosarcoma, leiomyosarcoma, rhabdomyosarcoma or fibrosarcoma.

38. The use of claim **36**, wherein the haematopoietic neoplasia, tumor, cancer or malignancy comprises a myeloma, lymphoma or leukemia.

39. The use of claim **1**, wherein the tumor or cancer comprises a lung, thyroid, head or neck, nasopharynx, throat, nose or sinuses, brain, spine, breast, adrenal gland, pituitary gland, thyroid, lymph, gastrointestinal (mouth, esophagus, stomach, duodenum, ileum, jejunum (small intestine), colon, rectum), genito-urinary tract (uterus, ovary, cervix, endometrial, bladder,

testicle, penis, prostate), kidney, pancreas, liver, bone, bone marrow, lymph, blood, muscle, or skin neoplasia, tumor, or cancer.

40. The use of claim **1**, wherein the tumor or cancer comprises a breast cancer, prostate cancer, pancreas cancer, gastric cancer, pleural mesothelioma, colon cancer, rectal cancer, large bowel cancer, small intestinal cancer, esophageal cancer, duodenal cancer, lingual cancer, pharyngeal cancer, salivary gland cancer, cerebral tumor, schwanoma, liver cancer, kidney cancer, bile duct cancer, endometrial cancer, cervical cancer, uterine body cancer, ovarian cancer, bladder cancer, urethral cancer, skin cancer, angioma, malignant lymphoma, malignant melanoma, thyroid cancer, parathyroid cancer, nasal cancer, paranasal cancer, auditory organ cancer, carcinoma of oral floor, laryngeal cancer, parotid cancer, submandibular cancer, bone tumor, angiofibroma, retinal sarcoma, penile cancer, testicular tumor, pediatric solid cancer, Kaposi's sarcoma, tumor of maxillary sinus, fibrous histiocytoma, leiomyosarcoma, rhabdomyosarcoma, lymphoma, multiple myeloma or leukemia.

41. The use of claim **1**, wherein the mammal is a human.

42. The use of claim **1**, wherein the peptide compound comprises: (d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha)(d-Arg) (d-Arg)(d-Arg)(d-Gln)(d-Arg)(d-Arg), or (d-Arg)(d-Arg)(d-Arg)(d-Gln)(d-Arg) (d-Arg)(d-Bpa)(d-Ser)(d-Trp)(d-Ser)(d-Phe-2,3,4,5,6-F)(d-Cha).

43. The use of claim **1**, wherein the peptide compound to be used is 5 mg/kg to 100 mg/kg.

44. The use of claim **1**, wherein the medicament to be administered inhibits or reduces relapse, growth, progression, worsening or metastasis of the tumor or cancer.

45. The use of claim **1**, wherein the medicament to be administered results in partial or complete destruction of the neoplastic, tumor, cancer or malignant cell mass, volume, size or numbers of cells, stimulating, inducing or increasing neoplastic, tumor, cancer or malignant cell necrosis, lysis or apoptosis, reducing neoplasia, tumor, cancer or malignancy volume size, cell mass, inhibiting or preventing progression or an increase in neoplasia, tumor, cancer or malignancy volume, mass, size or cell numbers, or prolonging lifespan.

46. The use of claim **1**, wherein the medicament to be administered results in reducing or decreasing severity, duration or frequency of an adverse symptom or complication associated with or caused by the neoplasia, tumor, cancer or malignancy.

47. The use of claim **1**, wherein the medicament to be administered results in reducing or decreasing pain, discomfort, nausea, weakness or lethargy, or results in increased energy, appetite, improved mobility or psychological well being.